Sovereign Risk and Bank Balance Sheets: the Role of Macroprudential Policies

Emine Boz Pablo D'Erasmo Bora Durdu

IMF FRB of Philadelphia FRB

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  - They are also one of the major holders of domestic sovereign debt.
- **Question:** What are the effects of changes in risk-weighted capital requirements and the introduction of leverage ratios (as in Basel III) on credit, sovereign risk and welfare?

Financial Sector - Sovereign risk link

- Recent crisis in Eurozone periphery
  - Domestic financial institutions own a large portion of country sovereign debt
  - Government bond spreads rose.
  - Banks charged higher rates for loans to nonfinancial corporations and cut back on lending.
- 1998 Russian default
- 2001 Argentinean default

Exposure to Domestic Sovereign Debt

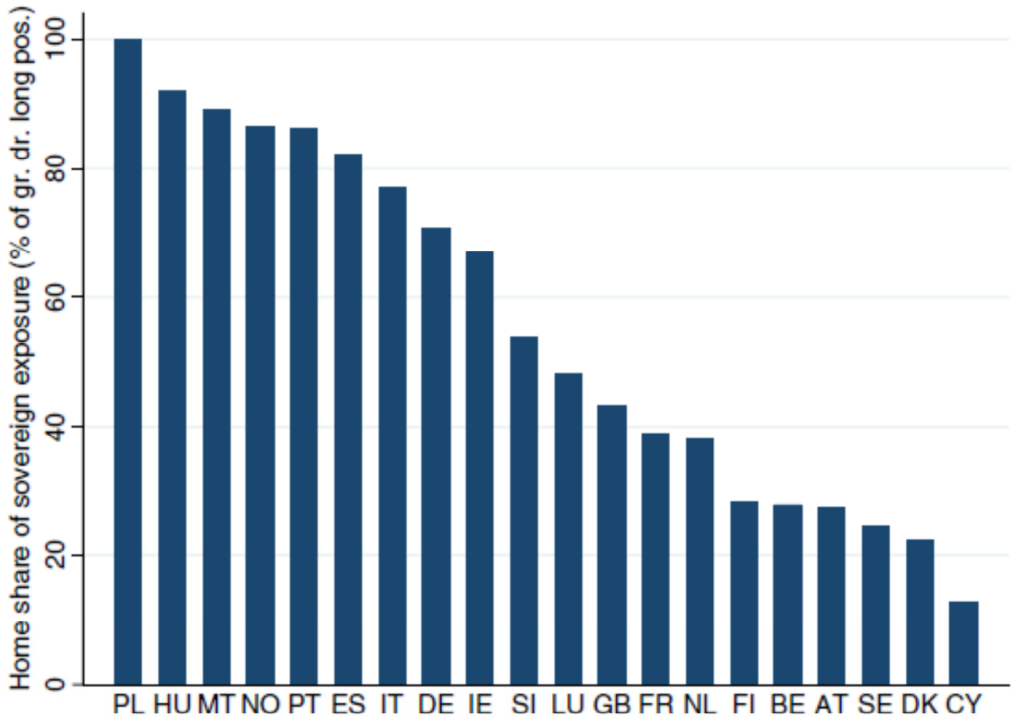
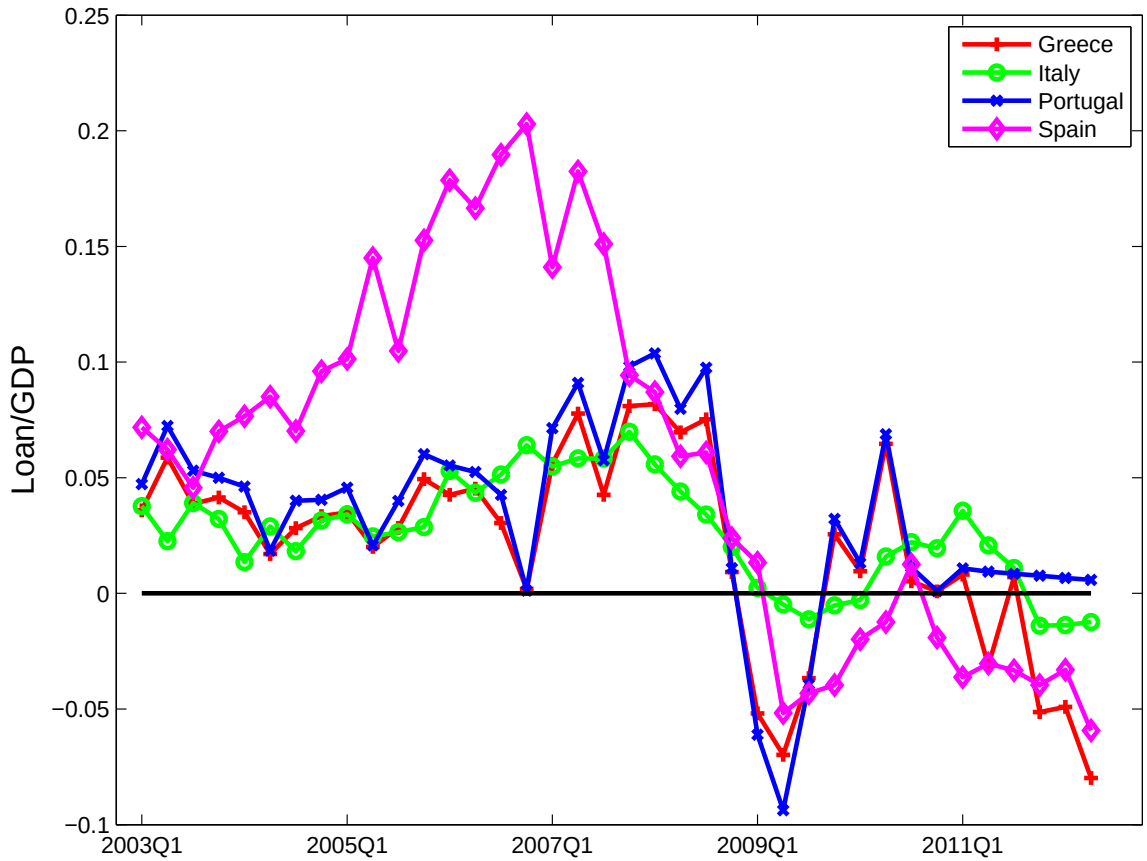


Figure 1 This graph uses data from the European bank stress test in 2011 to show the fraction of sovereign debt held in the form of domestic sovereign debt, aggregating across the banks in the data sample in each country. Country key: PL Poland, HU Hungary, MT Malta, NO Norway, PT Portugal, ES Spain, IT Italy, DE Germany, IE Ireland, SI Slovenia, LU Luxembourg, GB United Kingdom, FR France, NL Netherlands, FI Finland, BE Belgium, AT Austria, SE Sweden, DK Denmark, CY Cyprus

Stress in Banking Sector

Figure: Net Loans to Nonfinancial Corporations



Background: Capital Regulation

- Basel II:
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  - Adds a leverage ratio that takes into account *total assets*.

Model Ingredients

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- Foreign Investors Buy bonds and take deposits.

Results: Workings of the Model

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  - After a default, capital requirement is more likely to bind
- Endogenous cost of default.
  - A rise in default risk leads to a decline in bank lending to firms.
  - The reduction in loan supply increases financing costs for firms, hampers investment and induces a drop in output.
  - The decline in output increases default risk further

Policy Counterfactuals

- Higher capital requirement *and* a leverage ratio improves welfare.
  - Sovereign issues fewer bonds and the bank holds more of them
  - Yet, the default probability goes up
    - Risk-weighted capital ratios are higher which results in smaller decline in loans during default.
    - A smaller decline in consumption and output
    - Overall, consumption variability goes down.
- Replacing the capital adequacy requirement with a leverage ratio seems to lower welfare.

Related Literature

- **Sovereign default:**
  - Quantitative models: Aguiar and Gopinath (2006), Arellano (2008), Mendoza and Yue (2012)
  - Models with financial sector: Bolton and Jeanne (2010), Gennaioli, Martin and Rossi (2010), Basu (2010), Sosa-Padilla (2012), Bocola (2013), Chari, Dovis, Kehoe (2014)
- **Banking:**
  - Bank capital requirement: Kashyap and Stein (1995), Van den Heuvel (2002,2008), Gertler and Kiyotaki (2012)
  - Quantitative models of banks: Corbae and D'Erasmo (2011, 2012), Bianchi and Biggio (2013), Guerrieri, Iacoviello and Minetti (2012)

Households

- Standard preferences: $u(c,h) = \left(c_t - \frac{h_t^\eta}{\eta}\right)^{1-\sigma} / (1-\sigma)$
- Endowed with a unit of labor, h_t and $\bar{d}$ units of perishable good
- Supply labor at a wage rate, w_t,
- Deposit d^b to domestic banks (at rate r^d) and d^i to foreign investors (at rate r)
- Buy/sell shares S_t of domestic banks.
- Receive firm profits π^f and transfers from the government, T_t.

Firms

- One period lived heterog. firms with access to an investment project
- Projects require a unit of loan from the bank at rate r^{ℓ}
- The return to investment is

$$f(z_{t+1}, a^i, h_{t+1}) = \begin{cases} z_{t+1} a^i h_{t+1}^{\alpha} & \text{with prob } p(z_{t+1}) \\ 0 & \text{with prob } 1 - p(z_{t+1}) \end{cases}$$

where

- $a^i \sim \mathcal{A}$ is idiosyncratic productivity.
- z_{t+1} is agg. prod. with trans. matrix $F(z_t, z_{t+1})$)

Firms (cont.)

- There is limited liability
- At the beginning of the period: observe a^i, decide to invest or not.
- If invest and successful decide whether to operate or not.
  - Operating firms are a subset of those that invested/successful (p_t^+)
- Firm expected profits are

$$\pi_t^f = E\left[\max\left\{\max_{h_{t+1}\geq 0}\{z_{t+1}a^i h_{t+1}^{\alpha} - w_{t+1}h_{t+1} - r_t^{\ell}\}, 0\right\}\right]$$

Banking Sector

- Banks maximize expected discounted dividends
- At the beginning of the period
  - Extend loans to firms, ℓ_t (monopolist in the domestic loan market)
  - Purchase bonds b_{t+1}, if the bond market is open, at price q_t (acts competitively in the bond market)
  - Using deposits, d_t, government bonds b_t (if the sovereign did not default) and external funds, $-\tilde{s}_t$ at a cost $\phi(\tilde{s}_t)$
- Feasibility constraint in case of no default:

$$\ell_t + q_t b_{t+1} = d_t^b + b_t - \tilde{s}_t.$$

Bank capital and regulation

- At this point, we can define bank equity capital

$$e_t = \underbrace{\ell_t + q_t b_{t+1}}_{assets} - \underbrace{d_t}_{liabilities}$$

- Minimum capital requirements (risk-weighted)

$$e_t \geq \varphi(\ell_t + \omega q_t b_{t+1})$$

- Leverage ratio

$$e_t \geq \varphi^{lev}(\ell_t + q_t b_{t+1})$$

Banking Sector (cont.)

- At the end of the period, z_{t+1} realizes, and firm success/failure shocks are realized
  - Receives returns on loans to firms (p^+_{t+1} fraction pays back)
  - Pays interest on deposits,
- Net available funds:

$$s_{t+1} = \tilde{s}_t + p^+_{t+1}(1 + r^\ell_t)\ell_t - (1 + r^b)d_t - \phi(\tilde{s}_t)$$

- Net payment to shareholders is

$$\Pi_{t+1} \quad = \quad s_{t+1} - \phi(s_{t+1}).$$

Sovereign

- Maximizes utility of domestic households and has access to international bond markets
- It is not committed to repay, it chooses whether to default or not every period.
- If does not default, it issues debt, B_{t+1}, at a discount price q_t,
- Transfers the proceeds as a lump-sum to households T_t
- In case of default, the sovereign remains in autarky for a stochastic period of time (returns to credit markets with prob. μ)

International Investors

- They are risk-neutral and have unlimited access to funds at interest rate equal to $r \geq 0$.
- Expected profits on a loan of size B_{t+1} at price q_t are equal to

$$\Omega_t = -q_t(-B_{t+1}) + \frac{(1-\lambda_t)}{(1+r)}(-B_{t+1}),$$

where λ_t is the probability of default

Timing

Initial sub-period:

1. Starting in state $\{b_t, B_t, z_t\}$, firms draw a^i.
2. If credit markets are open, government chooses $D_t = \{0, 1\}$.
   - If $D_t = 0$, government decides B_{t+1} and bank b_{t+1} at price q_t.
   - If $D_t = 1$, move into financial autarky and no bonds are issued.
3. The bank collects d_t, extends loans ℓ_t and decides on $\tilde{s}_t$.
4. Firms choose whether to invest or not. Loan demand and supply determine r^ℓ.

Timing (cont.)

Final sub-period:

1. z_{t+1} is realized and $p(z_{t+1})$ is determined.
2. Successful projects decide whether to operate or not: p^+.
3. HH's decide labor supply. Labor demand and supply determine w_t.
4. Total output and bank profits are determined.
5. Households receive government transfers, wages, payments from the bank and the corporate sector and consume.

Households' Problem

Households maximize lifetime utility

$$\max_{\{d_t^b, d_t^i, h_t, S_{t+1}\}_{t=0}^{\infty}} E_0 \left[\sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - \frac{h_t^\eta}{\eta} \right)^{1-\sigma}}{1-\sigma} \right]$$

s.t.

$$\begin{aligned} d_t^b + d_t^i &= \bar{d} \\ c_t + P_t S_{t+1} &= w_t h_t + (1+r)\bar{d} + (P_t + \Pi_t^b) S_t + \Pi_t^f - T_t. \end{aligned}$$

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FOC

$$P = E_{z''|z'} \left[\tilde{R} \cdot \left(\Pi'^b + P' \right) \right],$$

where $\tilde{R} = \beta E_{z''|z'} \left[\left(c' - \frac{h'^\eta}{\eta} \right)^{-\sigma} / \left(c - \frac{h^\eta}{\eta} \right)^{-\sigma} \right]$

Firms' Problem

- The investment threshold $a^*(z, r^\ell, w)$ can be obtained from

$$\pi^f(a^*, z, r^\ell, w) = 0$$

- The operating threshold $a^+(z, z', r^\ell, w)$ can be determined from

$$\pi^+(\hat{a}, z', r^\ell, w) = \max_{h \geq 0}\{z' a h^\alpha - wh - r^\ell\} = 0$$

and

$$a^+(z, z', r^\ell, w) = \max\{\hat{a}(z', r^\ell, w), a^*(z, r^\ell, w))\}$$

Firms' Problem (cont.)

- Aggregate loan demand is

$$\ell^d(z, r^\ell, w) = \int_{a^*(z,r^\ell,w)}^{\overline{a}} d\mathcal{A}(a) = 1 - \mathcal{A}(a^*(z, r^\ell, w)).$$

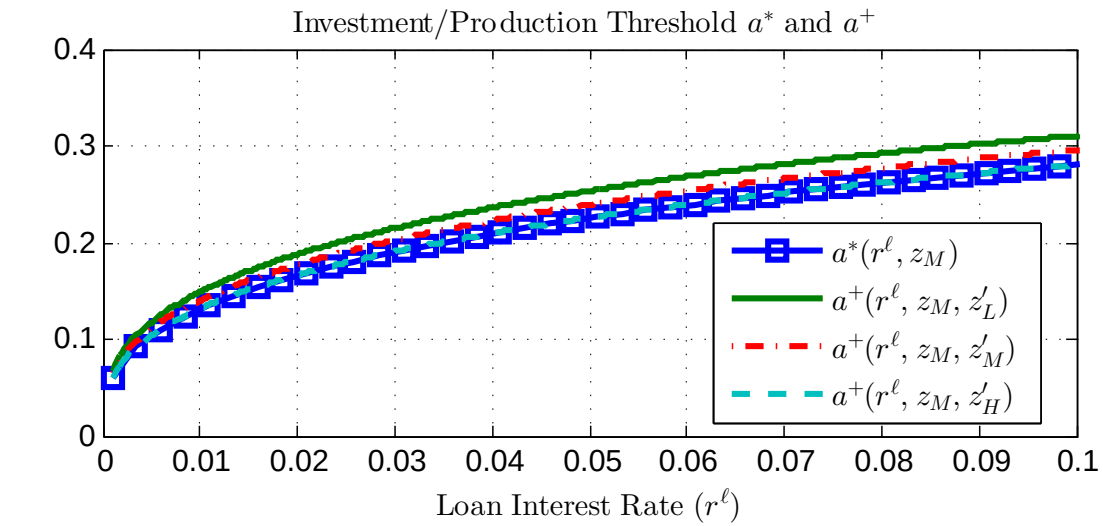
- The fraction of firms that repays the loan is

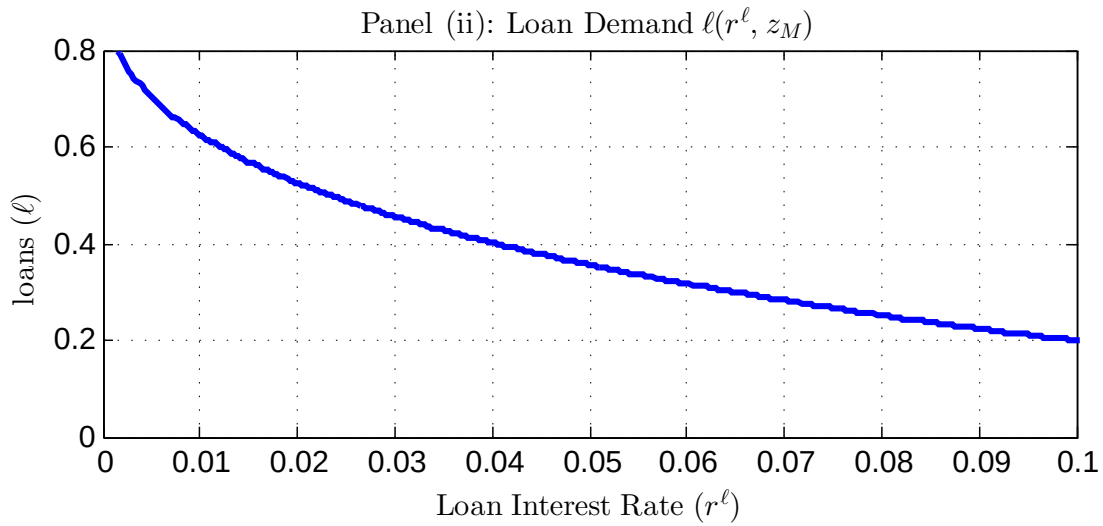
$$p^+(z, w, r^\ell, z') = p(z') \frac{1 - \mathcal{A}(a^+(z, w, r^\ell, z'))}{1 - \mathcal{A}(a^*(z, w, r^\ell))}.$$

- Similarly, labor demand is

$$H^d(z, w, r^\ell, z') = p(z') \int_{a^+(z,w,r^\ell,z')}^{\overline{a}} h(a, w, z') d\mathcal{A}(a).$$

Investment Threshold and Loan Demand





Domestic Bank Problem when $D = 0$

$$W^{D=0}(b, B, z) = \max_{\ell, d \in [0, \bar{d}], b', \tilde{s}} E\left[\tilde{R}^{-1}\left(\Pi^b + W(b', B', z')\right)\right]$$

s.t.

$$\begin{aligned}
\tilde{s} &= d + b - \ell - q(b', B', z)b', \\
e &= \ell + q(b', B', z)b' - d^b, \\
e &\geq \varphi\left(\ell + \omega q(b', B', z)b'\right), \\
s' &= \tilde{s} + p^+(z, r^\ell, z')(1 + r^\ell)\ell - (1 + r)d - \phi(\tilde{s}), \\
\Pi^b(s') &= s' - \phi(s'), \\
\ell &= \ell^d(z, w, r^\ell)
\end{aligned}$$

Domestic Bank Problem (cont.)

$$W^{D=1}(z) = \max_{\ell, d \in [0,\bar{d}], \tilde{s}} E\left[\tilde{R}^{-1}\left(\Pi^b + \mu W^{D=0}(0,0,z') + (1-\mu)W^{D=1}(z)\right)\right]$$

s.t.

$$\begin{aligned}
\tilde{s} &= d - \ell, \\
e &= \ell - d \geq \varphi\ell, \\
s' &= \tilde{s} + p^+(z, r^\ell, z')(1 + r^\ell)\ell - (1+r)d - \phi(\tilde{s}), \\
\Pi^b(s') &= s' - \phi(s'), \\
\ell &= \ell^d(z, w, r^\ell)
\end{aligned}$$

$$W(b, B, z) = D(b, B, z)W^{D=1}(z) + (1 - D(b, B, z))W^{D=0}(b, B, z).$$

Sovereign

- Default decision is given by:

$$V(b, B, z) = \max_{D\{0,1\}} \left\{ V^{D=0}(b, B, z), V^{D=1}(z) \right\}.$$

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- Value of repayment is

$$V^{D=0}(b,B,z) = \max_{B'} E\beta \left\{ U(c',h^*) + V(b',B',z') \right\}$$

$$\begin{aligned} c' &= p^+(z,r^\ell,z')z'(h^*)^\alpha + (B+b) \\ &\quad -q(b',B',z)(B'+b') - \phi(\tilde{s}) - \phi(s') - (1-p^+(z,r^\ell,z')\ell \end{aligned}$$

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- Value of default is

$$V^{D=1}(z) = E\beta \left\{ U(c', h^*) + \left[\mu V^{D=0}(0, 0, z') + (1 - \mu) V^{D=1}(z') \right] \right\}.$$

$$c' = p^+(z, r^\ell, z') z' (h^*)^\alpha - \phi(\tilde{s}) - \phi(s') - (1 - p^+(z, r^\ell, z')\ell$$

Foreign Lenders

- Foreign lenders make zero expected profits.
- The equilibrium schedule of prices is

$$q(b', B', z) = \frac{1 - \lambda(b', B', z)}{(1 + r)}.$$

Recursive Competitive Equilibrium

A recursive competitive equilibrium is defined as a set of policy functions $\left[c, h, \ell, b', d, \tilde{s}, s', B', D, \Pi^b, \pi^f\right]$, thresholds $\{a^*, a+\}$ and prices $\left[q, r^\ell, w\right]$ such that

- The allocations $[c, h]$ solve the household's problem
- Policy functions $\left[b', d, \tilde{s}, s', \Pi^b\right]$ are consistent with bank optimization
- $\left[\pi^f, a^*, a+\right]$ are derived from the solution to firm's problem
- Default D, bond B' and transfers T policies are the solution to government's problem
- Markets for loans, labor, shares and goods clear
- The price schedule q is such that investors make zero expected profits and the default probability is consistent with D

Quantitative Analysis

- Calibration using Spanish data.
  - Still rough
- Positive analysis: capital requirement a la Basel II
  - Decision rules
  - Long-run statistics and default event study
- Normative analysis: Policy counterfactuals

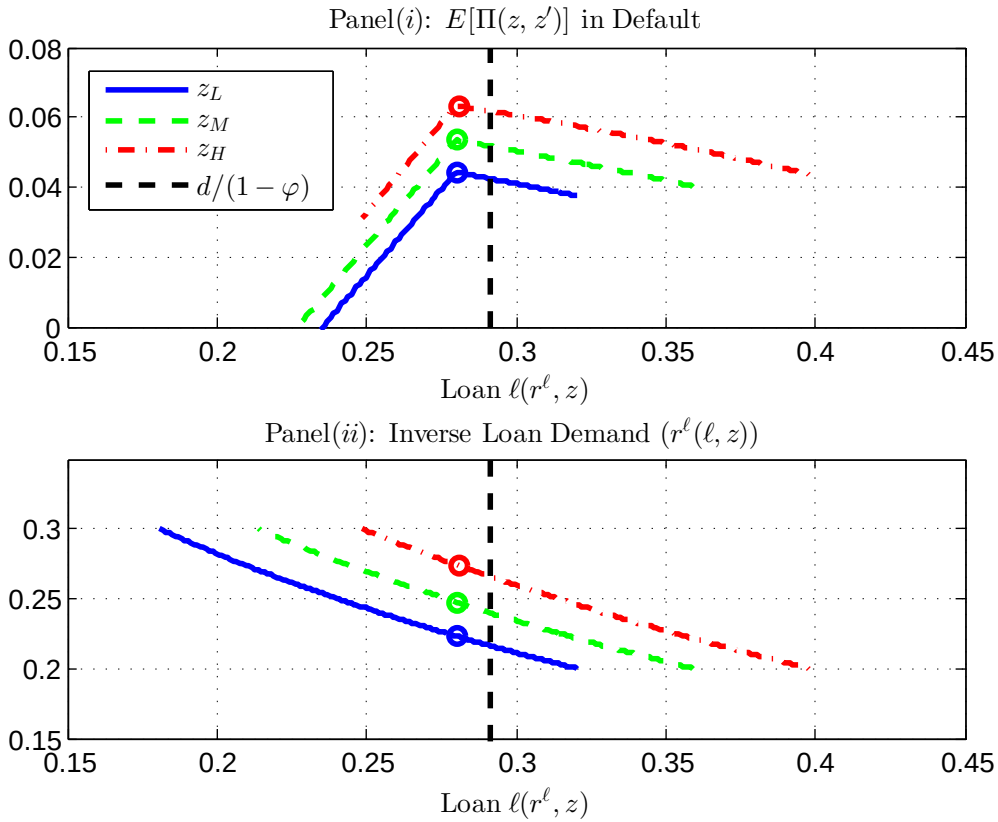
Calibration

Parameter		Value	Target
Risk-Aversion	σ	2	Standard Value
Disc. Factor	β	0.96	Standard Value
Reentry prob.	μ	0.25	Recent sovereign defaults
Labor Supply Elast.	η	1.30	Standard Value
Avg. Agg. Prod.	$\overline{z}$	2.41	Normalization
Labor Share	α	0.66	Standard Value
Risk-free rate	r	0.02	Bond yields Germany
Dep interest rate	r^b	0.02	Eq. condition
Autocorrelation z	ρ	0.54	Spain TFP
Min. failure prob.	$p(z^{min})$	0.96	Impaired Loans / Loans
Max. failure prob.	$p(z^{max})$	0.99	Impaired Loans / Loans
Capital Requirement	φ	0.04	Basel II
Risk-weight	ω	0.00	Basel II
Std. Dev. TFP (%)	σ_ε	2.56	Std. Dev. Ouput
Max. value deposits	$\bar{d}$	0.28	Dep. to Loan Ratio
Equity issuance	$\phi_0^{D=0}$	0.20	Equity to assets ratio
Equity issuance	$\phi_0^{D=1}$	0.18	Avg. spreads Spain
Min prod.	$\underline{a}$	0.20	bond to assets ratio
Max prod.	$\overline{a}$	0.45	Bank bonds to Gov. Bond ratio

Calibration Targets

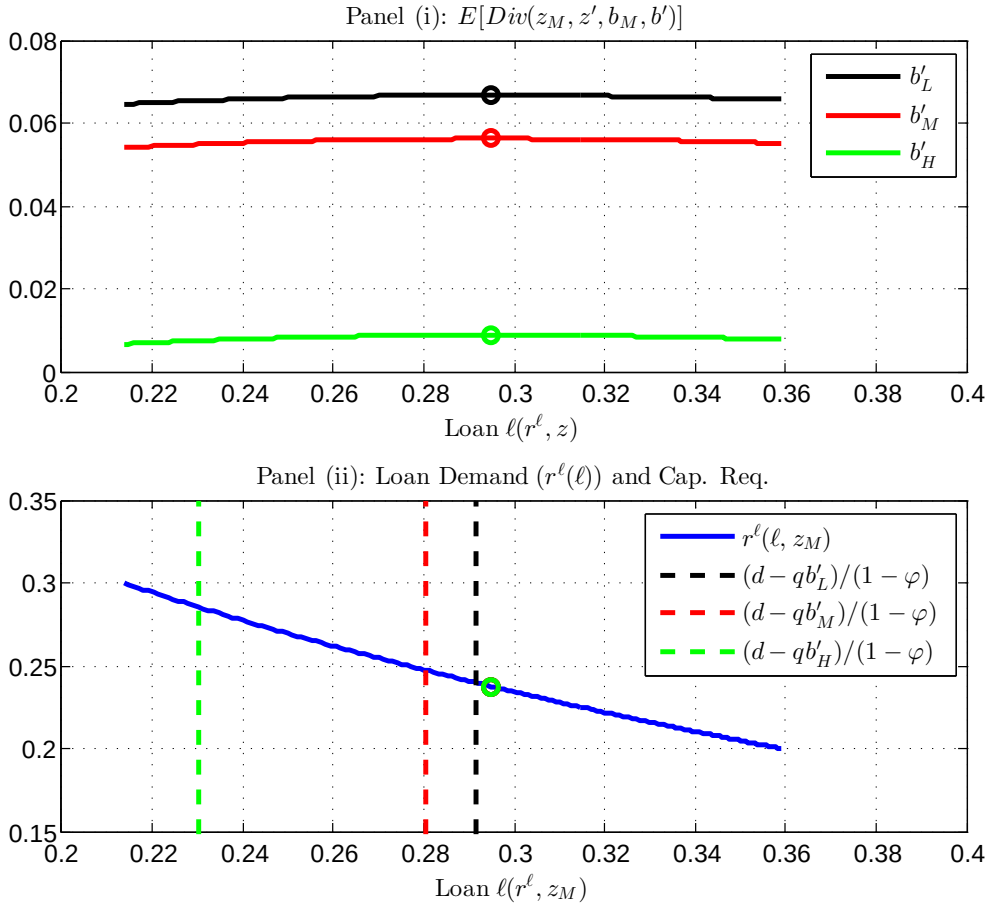
Moment	Model	Data
Std. Dev. Ouput	2.58	3.13
Deposit to Loan Ratio	95.69	94.83
Loans to Asset Ratio	63.69	84.62
Bank Equity to Asset Ratio	12.33	19.13
Bank bonds to Gov. Bond ratio	43.00	79.15
Avg. spreads in Spain	1.49	1.96

Capital Requirements in Periods of Distress



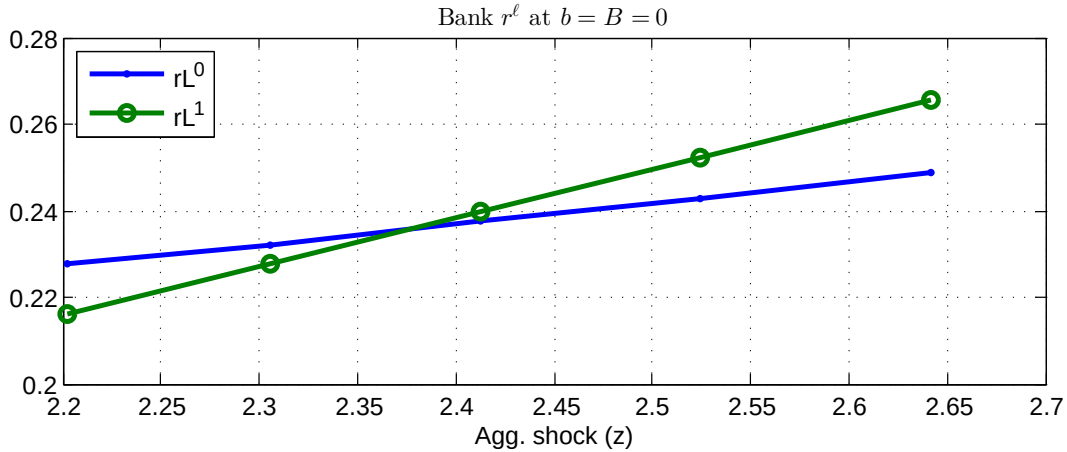
- Capital requirement restricts banks leverage ratio $\ell \geq d/(1-\varphi)$
- Costly equity issuance results in a binding capital requirement

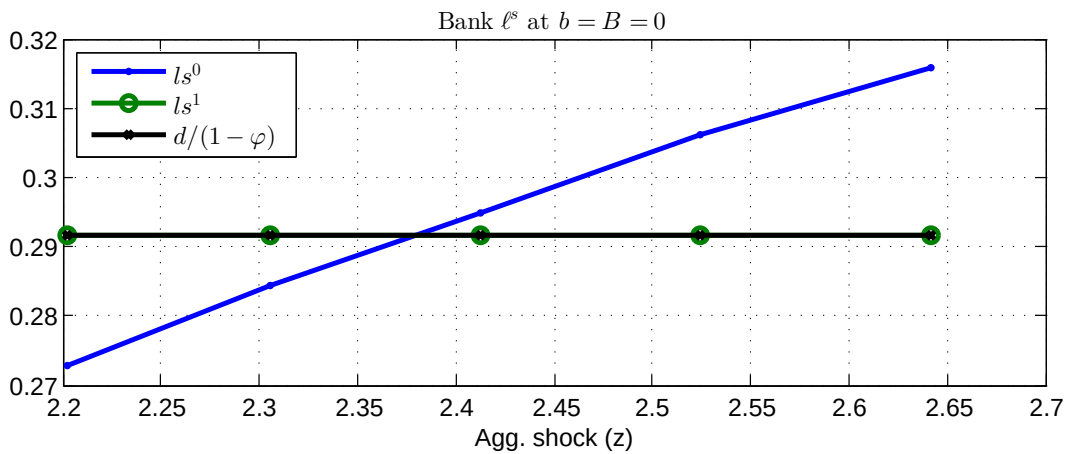
Role of Bank's Bond Holdings and Cap. Req.



- Holdings of sovereign bonds expands the sources of funds
- New savings relaxes the capital requirement constraint
- When government debt is risk-free loan mkt eq. not affected

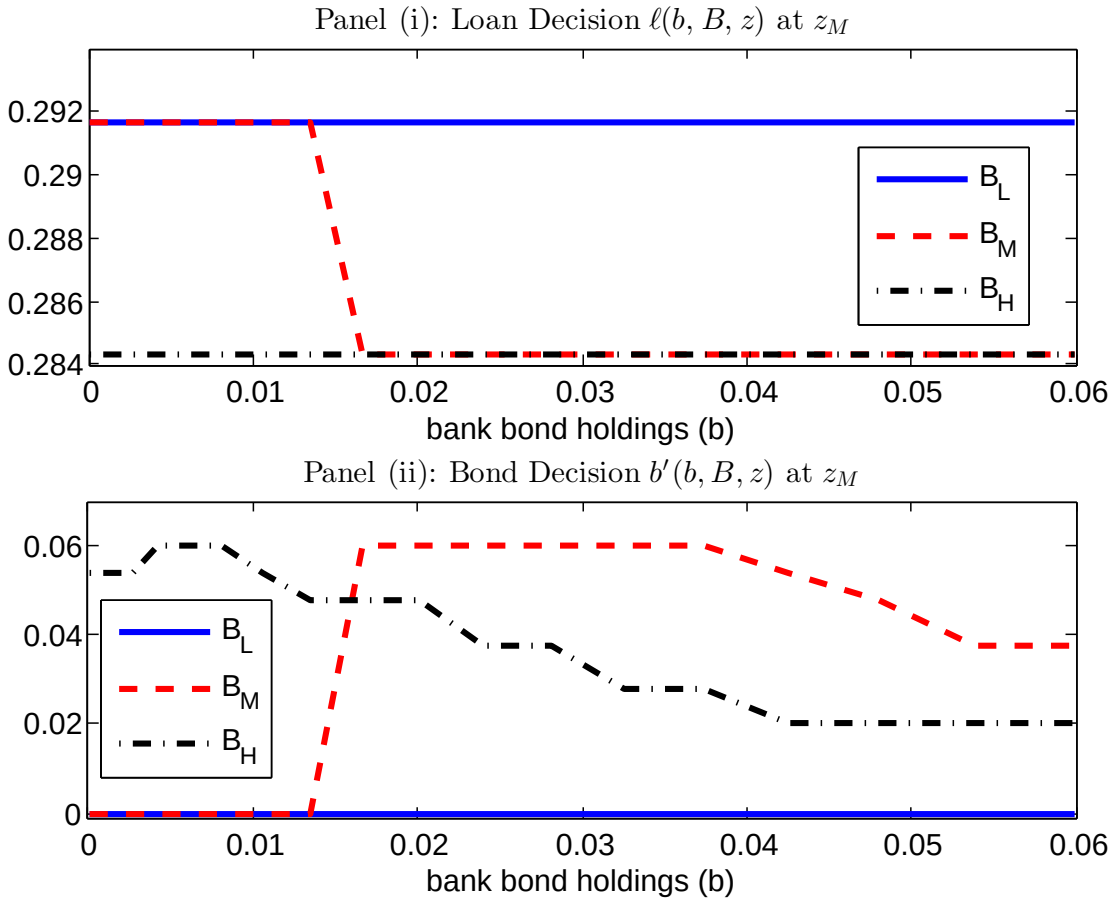
Loan Market: Default - Non-Default





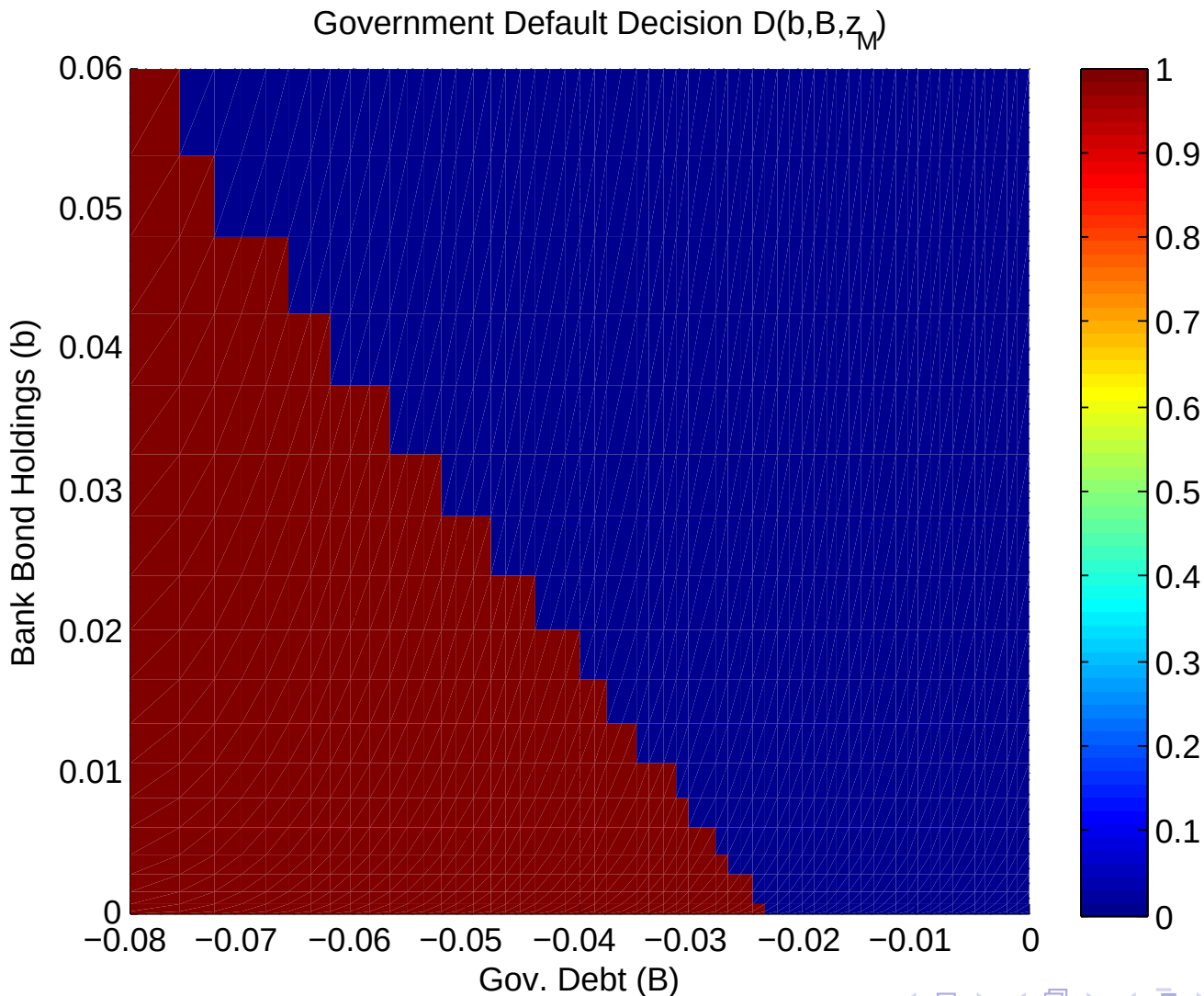
- Sovereign risk affects the risk/return trade-off and balance sheet composition

Balance Sheet Composition and Default Risk

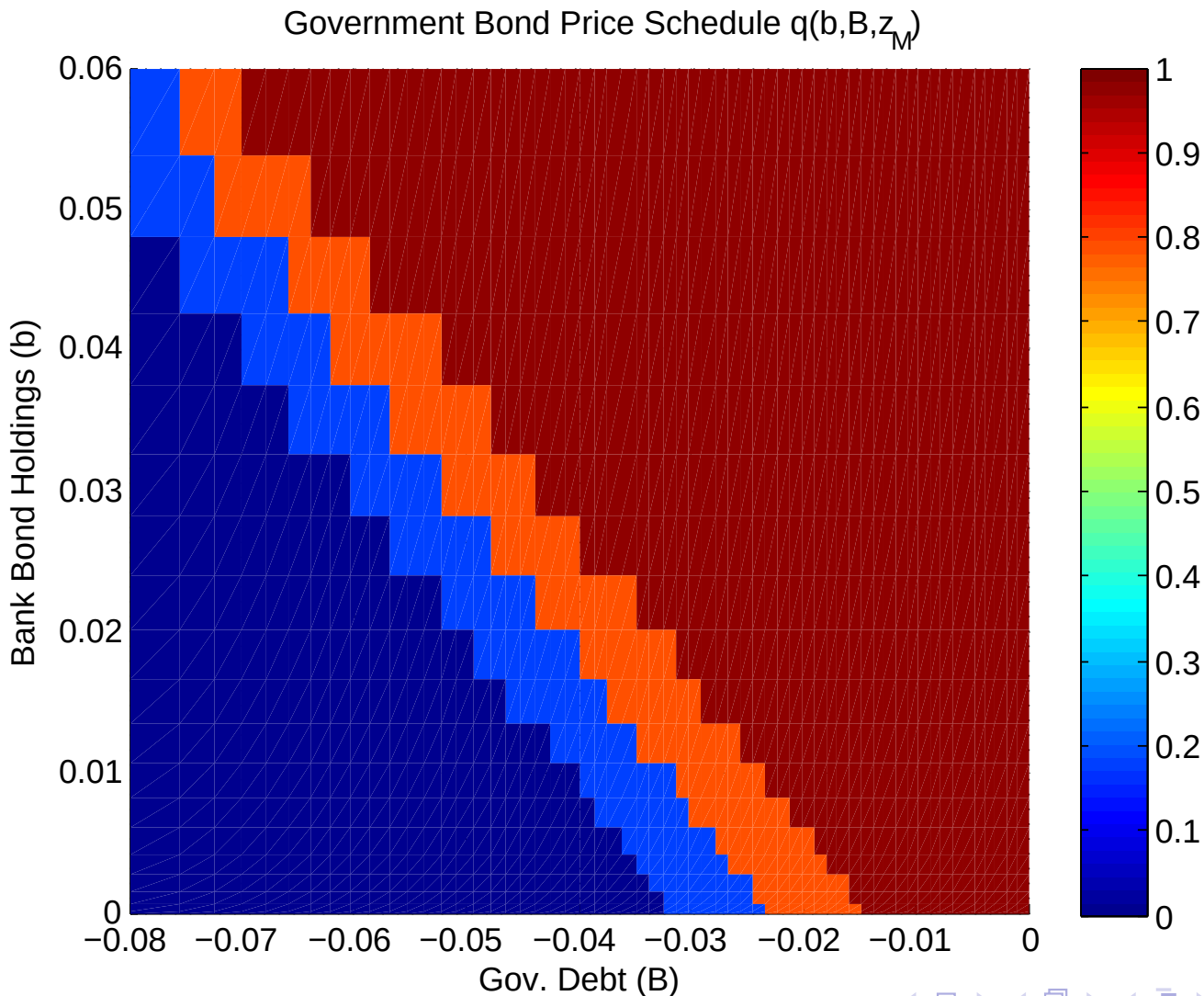


- Low equity issuance costs translate reinforces the role of sovereign risk in shaping the balance sheet composition

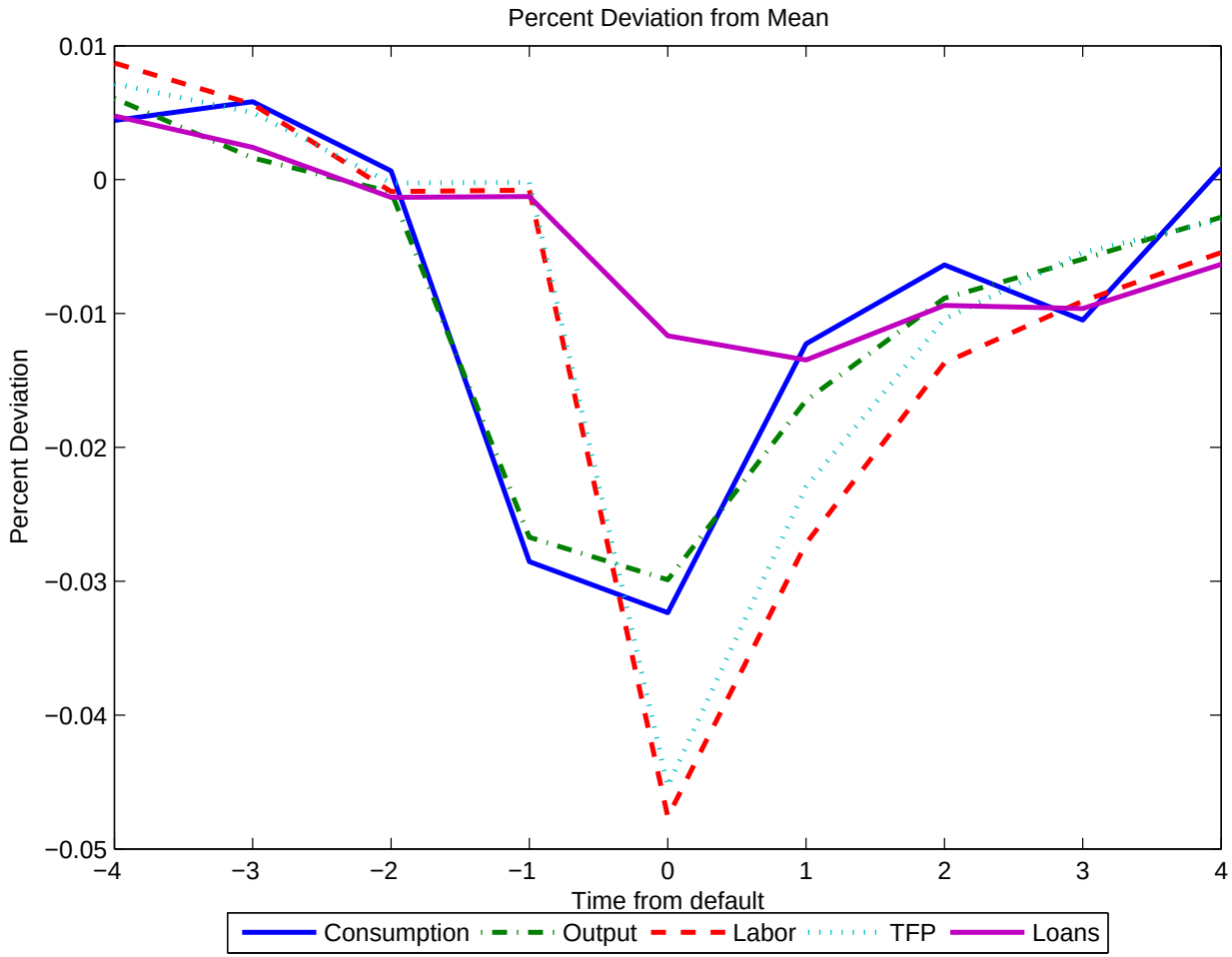
Government Default Set



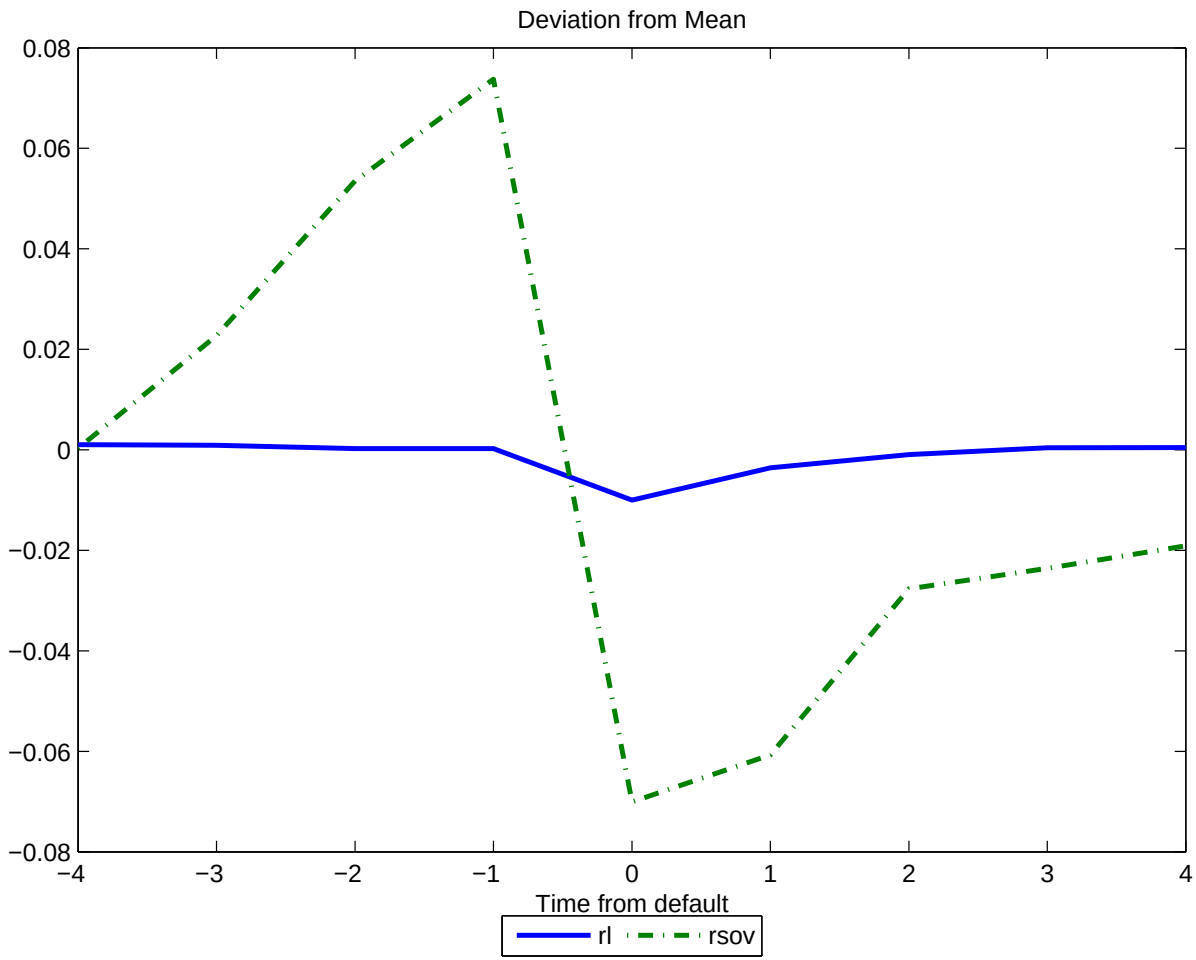
Equilibrium Price Schedule



Dynamics around Default: Macro Aggregates



Dynamics around Default: Interest Rates



Counterfactuals

Counterfactual Experiments

Moment	Benchmark	Higher CR	Basel III
	$\varphi = 0.04$ $\omega = 0$	$\varphi = 0.06$ $\omega = 0$	$\varphi = 0.06$ $\omega = 0$ $\varphi^{lev} = 0.04$
Bank cap. Ratio %	19.59	19.71	19.72
Bank Loans / Assets %	84.23	84.20	84.20
r^{ℓ} %	23.74	23.72	23.72
b/B %	82.47	90.39	90.39
B/y %	12.84	11.96	11.96
Sov. Spread %	1.05	1.33	1.33
$\sigma(c)$ %	1.76	1.62	1.62
$\alpha(b, B, z)$ %		0.0342	0.0341

- Reduction in level of government debt but a larger fraction in domestic hands
- Spread increase, restricting leverage reduces costs of default
- Welfare increases in both cases: consumption volatility diminishes

Relaxing Preferential Treatment

Moment	Benchmark	Basel III	Higher weights	
		$\varphi = 0.06$ $\omega = 0$ $\varphi^{lev} = 0.04$	$\varphi = 0.06$ $\omega = 0.20$ $\varphi^{lev} = 0.04$	$\varphi = 0.06$ $\omega = 1$ $\varphi^{lev} = 0.04$
Cap. Ratio %	19.59	19.72	19.72	19.74
Loans / Assets %	84.23	84.20	84.20	84.17
b/B %	82.47	90.39	90.39	89.58
B/y %	12.84	11.96	11.96	11.99
Sov. Spread %	1.050	1.333	1.333	1.196
$\sigma(c)$ %	1.76	1.62	1.62	1.63
$\alpha(b, B, z)$ %		0.0341	0.0342	0.0346

- Welfare increases with risk weight: significant reduction in consumption volatility
- Non linear response of spreads and debt levels

Conclusion

- The model captures salient features of the behavior of bank loans and banks holdings of sovereign debt.
- Increasing risk-weighted capital requirements as well as introducing leverage ratios in addition to capital requirements improve welfare.
- A lot of work to do:
  - Improve calibration and perform further tests
  - More counterfactuals: counter-cyclical buffers