Assessing Macroprudential Policies in a Macroeconomic Model with Three Layers of Defaults

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Background

- Improving the models that can be used for macro-prudential analysis is an important priority at the ECB (and other central banks)
- The research work is carried out under the Macro-prudential Research Network of EU central banks (MaRs)
- Focus on:
  - developing macrofinancial models with financial instability
  - developing early warning indicators
  - analysing contagion in Europe using the Target2 data

Some examples of the work carried out in the MaRs Network

- Boissay, Collard and Smets (2012)
  - RBC model with heterogeneous banks
  - Inter-bank market fragile due to asymmetric information
  - Systemic crisis: inter-bank shutdown which results in widespread illiquidity
- Aoki and Nikolov (2012) and (2013)
  - Model of systemic crisis caused by the collapse of asset price bubbles
  - Crisis large when bank exposures are large
  - Bank exposures are large due to moral hazard (AN 2012) and shadow banking activities (AN 2013)

This project

- Collaborative effort of several EU central banks
- Authors: Laurent Clerc (BdeF), Alexis Derviz (CNB), Caterina Mendicino (BdeP), Stephane Moyen (DB), Kalin Nikolov (ECB), Javier Suarez (CEMFI), Livio Stracca (ECB), Alex Vardoulakis (FRB)
- Objective: Produce a micro-founded model for macro-prudential analysis
- Main purpose is to have a welfare-justification for the use of regulatory tools
  - explicit modelling of financial intermediaries which can default
  - clear channels through which financial instability imposes costs on the real economy
  - amplification of shocks

Where does financial system risk come from?

- In our model bank risk arises from:
  - idiosyncratic borrower default risk due to imperfect diversification
  - aggregate borrower default risk due to aggregate (real and financial) shocks
- Why are lending and defaults excessive?
  - banks have insured liabilities $\Longrightarrow$ lend cheaply and leverage and borrower default are excessive
  - costly because defaults have deadweight costs
  - when leverage is high, amplification in response to shocks is greater
- Welfare effects of bank capital
  - capital requirements align banks' incentives and prevent excessive risk taking (+ve effect)
  - capital requirements tighten credit supply (-ve effect)
  - at low capital requirements, the +ve effect dominates, otherwise the -ve effect dominates

Related Literature

- Occasionally binding constraints
  - Korinek (2008), Korinek and Jeanne (2011)
  - Bianchi and Mendoza (2011), Bianchi (2012)
  - He and Krishnamurthy (2011), (2012), (2013)
  - Brunnermeier and Sannikov (2013)
- Choice of bad projects under high leverage
  - Martinez-Miera and Suarez (2012)
  - Collard, Dellas, Diba and Loisel (2012)
  - Gallo and Thomas (2012)
  - Christiano and Ikeda (2013)

Related Literature (cont'd)

- Collapse of asset price bubbles
  - Martin and Ventura (2012), Farhi and Tirole (2012)
  - Aoki and Nikolov (2012, 2013), Miao and Wang (2012, 2013)
- Asymmetric information
  - Martin (2008), Martin (2012)
  - Boissay, Collard and Smets (2012)
  - Bigio (2012)

The Model Structure

- Standard debt contracts for all borrowers
  - no state contingency
- Households
  - borrow to buy houses
  - default when the value of the house is less than the mortgage
- Firms
  - 2-period OLG with bequests
  - default when value of the firm less than debt
- Banks
  - 2-period OLG with bequests
  - default when value of loans falls below deposits
  - insured deposits
  - regulatory capital requirement

Patient Households

- The dynasty of patient households are the savers in the economy.
- They maximise the following objective function

$$E_t \left[\sum_{i=0}^{\infty} (\beta^s)^{t+i} \left[\log\left(c_{t+i}^s\right) + v_{t+i}^s \log\left(h_{t+i}^s\right) - \frac{\varrho_{t+i}^s}{1+\eta} \left(l_{t+i}^s\right)^{1+\eta} \right] \right] \quad (1)$$

subject to the intertemporal budget constraint as follows

$$c_t^s + q_t^H h_t^s + d_t \leq w_t l_t^s + q_t^H h_{t-1}^s + R_{t-1}^D d_{t-1} - T_t^s + \Pi_t \quad (2)$$

Impatient Households

- The dynasty of impatient households are the borrowing households in the economy
- They maximise the following objective function

$$E_0 \sum_{t=0}^{\infty} (\beta^m)^t \left[\log(c_t^m) + v_t^m \log(h_t^m) - \frac{\varrho_{t+i}^m}{1+\eta} (l_{t+i}^m)^{1+\eta} \right] \quad (3)$$

subject to the intertemporal budget constraint as follows

$$\begin{aligned} & c_t^m + q_t^H h_t^m - b_t^m && (4) \\ \leq \; & w_t l_t^m + \int_0^{\infty} \max \left\{ \omega_t^m q_t^H h_{t-1}^m - R_{t-1}^m b_{t-1}^m, 0 \right\} dF^m(\omega^m) - T_t^m \\ \equiv \; & n_t^m, \end{aligned}$$

Household default

- Conventional (uncontingent) debt
- Households experience idiosyncratic (mean $= 1$) shocks ω_t^m to their housing value: default whenever house value is less than required repayment

$$\omega_t^m q_t^H h_{t-1}^m < R_{t-1}^m b_{t-1}^m$$

- Defines a critical value of ω_t^m

$$\omega_t^m \leq \overline{\omega}_t^m = x_{t-1}^m / R_t^H,$$

where

$$R_t^H \equiv q_t^H / q_{t-1}^H$$

is the ex post aggregate realized gross return on housing, and

$$x_t^m \equiv \frac{R_t^m b_t^m}{q_t^H h_t^m}$$

is household leverage.

Credit Supply to Households

- Banks supply loans to households as long as the profits from these loans deliver the bank's desired rate of return on equity:

$$E_t \max \left[\omega^H_{t+1} \widetilde{R}^H_{t+1} b^m_t - R^D_t d_t, 0 \right] \geq \rho_t \phi^H b^m_t. \qquad (5)$$

where ω^H_{t+1} is a mortgage-bank-specific loan quality shock and $\widetilde{R}^H_{t+1}$ is the loan return. Using the usual BGG notation we have:

$$(1 - \Gamma^H(\overline{\omega}^H_{t+1}))\widetilde{R}^H_{t+1} b^m_t \geq \rho_t \phi^H_t b^m_t. \qquad (6)$$

where

$$\Gamma^m \left(\overline{\omega}^m_t\right) = \overline{\omega}^m_t \int_{\overline{\omega}^m_t}^{\infty} f\left(\omega^m\right) d\omega^m + \int_0^{\overline{\omega}^m_t} \omega^m f\left(\omega^m\right) d\omega^m$$

- Intuition: mortgage loan profits must deliver the bank's required expected rate of return on equity ρ_t
- Limited liability distortions allow banks to meet rate of return benchmark with lower lending rates

The Impatient Household Problem

- Borrowers choose consumption (c_t^m), housing (h_t^m), labour supply (l_t^m), leverage ($x_t^m = \left(R_t^m b_t^m\right) / \left(q_t^H h_t^m\right)$) and debt ($b_t^m$) to maximise

$$\max E_t \left[\sum_{i=0}^{\infty} \left(\beta^m\right)^{t+i} \left[\log\left(c_{t+i}^m\right) + v_{t+i}^m \log\left(h_{t+i}^m\right) - \frac{\varrho_{t+i}^m}{1+\eta} \left(l_{t+i}^m\right)^{1+\eta} \right] \right] \tag{7}$$

subject to the budget constraint of the dynasty,

$$c_t^m + q_t^H h_t^m - b_t^m \leq w_t l_t^m + \left(1 - \Gamma^m\left(\overline{\omega}_t^m\right)\right) q_t^H h_{t-1}^m - T_t^m, \tag{8}$$

and the participation constraint of the bank,

$$E_t (1 - \Gamma^H(\overline{\omega}_{t+1}^H)) \widetilde{R}_{t+1}^H b_t^m \geq \rho_t \phi_t^H b_t^m. \tag{9}$$

which describes bank loan supply to the household sector and:

$$\widetilde{R}_{t+1}^H b_t^m \equiv \left[\left(\Gamma^m\left(\overline{\omega}_{t+1}^m\right) - \mu^m G^m\left(\overline{\omega}_{t+1}^m\right)\right) q_{t+1}^H \right] h_t^m$$

$$\overline{\omega}_{t+1}^m = \frac{x_t^m}{q_t^H / q_{t+1}^H}$$

Entrepreneurs

- Simplified version of BGG: Entrepreneurs live for two periods
- In second period of life, maximise

$$\max_{c^e_{t+1}, n^e_{t+1}} \left(c^e_{t+1}\right)^{\chi^e} \left(n^e_{t+1}\right)^{1-\chi^e} \tag{10}$$

subject to:

$$c^e_{t+1} + n^e_{t+1} \leq W^e_{t+1} - T^e_t$$

Optimizing behavior yields

$$c^e_{t+1} = \chi^e W^e_{t+1} \tag{11}$$

$$n^e_{t+1} = (1 - \chi^e) W^e_{t+1}. \tag{12}$$

Entrepreneurs (cont'd)

- Hence in first period of life maximise:

$$\max_{k_t, b_t^e, R_t^F} E_t(W_{t+1}^e) \tag{13}$$

subject to the period t resource constraint

$$q_t^K k_t - b_t^e = n_t^e, \tag{14}$$

the definition

$$W_{t+1}^e = \max\left[\omega_{t+1}^e \left(r_{t+1}^k + (1-\delta)\, q_{t+1}^K\right) k_t - R_t^F b_t^e, 0\right], \tag{15}$$

and the bank's participation constraint

$$E_t(1 - \Gamma^F(\overline{\omega}_{t+1}^F))\widetilde{R}_{t+1}^F = \rho_t \phi_t^F, \tag{16}$$

The corporate contracting problem

- Again we use the BGG notation $\Gamma^e\left(\overline{\omega}^e_{t+1}\right)$
- The corporate contracting problem chooses capital (k_t) and leverage $\left(x^e_t = \left(R^e_t b^e_t\right) / \left(q^K_t k_t\right)\right)$ to maximise:

$$\max_{x^e_t, k_t} E_t\left[\left(1 - \Gamma^e\left(\overline{\omega}^e_{t+1}\right)\right) R^K_{t+1} q^K_t k_t\right]$$

subject to the participation constraint of the bank:

$$E_t\left(1 - \Gamma^F\left(\overline{\omega}^F_{t+1}\right)\right)\widetilde{R}^F_{t+1} = \rho_t \phi^F_t, \tag{17}$$

where

$$\widetilde{R}^F_{t+1} = \left(\Gamma^e\left(\overline{\omega}^e_{t+1}\right) - \mu^e G^e\left(\overline{\omega}^e_{t+1}\right)\right) R^K_{t+1} q^K_t k_t$$

$$\overline{\omega}^e_{t+1} = \frac{x^e_t}{R^K_{t+1}}$$

Bankers

- Bankers live for two periods. In second period of life, maximise

$$\max_{c^b_{t+1}, n^b_{t+1}} \left(c^b_{t+1}\right)^{\chi^b} \left(n^b_{t+1}\right)^{1-\chi^b} \tag{18}$$

subject to:

$$c^b_{t+1} + n^b_{t+1} \leq W^b_{t+1}.$$

Optimizing behavior yields

$$c^b_{t+1} = \chi^b W^b_{t+1} \tag{19}$$

$$n^b_{t+1} = (1 - \chi^b) W^b_{t+1}. \tag{20}$$

Bankers (cont'd)

- Hence in first period of life, maximise:

$$\max_{e_t^F} E_t(W_{t+1}^b) = E_t(\widetilde{\rho}_{t+1}^F e_t^F + \widetilde{\rho}_{t+1}^M \left(n_t^b - e_t^F\right)). \quad (21)$$

First order condition wrt e_t^F:

$$E_t \widetilde{\rho}_{t+1}^F = E_t \widetilde{\rho}_{t+1}^M = \rho_t, \quad (22)$$

Aggregate evolution of banker net worth:

$$N_{t+1}^b = \left(1 - \chi^b\right) \left(\widetilde{\rho}_{t+1}^F E_t^F + \widetilde{\rho}_{t+1}^M \left(N_t^b - E_t^F\right)\right). \quad (23)$$

Banks

- Banks are one-period lived firms which raise equity from bankers and deposits from patient households
- Banks specialise in either mortgage or corporate loans. Corporate banks' profits are given by:

$$\pi^F_{t+1} = \max\left[\omega_{t+1}\tilde{R}^F_{t+1} b^e_t - R^D_t d^F_t, 0\right],$$

- Regulatory capital constraint:

$$e^F_t \geq \phi^F_t b^e_t, \tag{24}$$

- Bank default

$$\overline{\omega}^F_{t+1} = (1 - \phi^F_t)\frac{R^D_t}{\tilde{R}^F_{t+1}}, \tag{25}$$

- Ex post rate of return on equity:

$$\tilde{\rho}^F_{t+1} = \frac{\left(1 - \Gamma^F(\overline{\omega}^F_{t+1})\right)\tilde{R}^F_{t+1}}{\phi^F_t}. \tag{26}$$

Capital production firms

- Investment

$$I_t = k_t - (1-\delta)\, k_{t-1}$$

requires resources

$$\left[1 + g\left(\frac{I_t}{I_{t-1}}\right)\right] I_t$$

where $g\left(\frac{I_t}{I_{t-1}}\right)$ is the investment adjustment cost function.

- Firm is owned by the patient households $\Longrightarrow$ choose investment I_t in order to maximize

$$E_t \sum_{t=\tau}^{\infty} \frac{\lambda_\tau^s}{\lambda_t^s} \left\{ q_\tau^K I_\tau - \left[1 + g\left(\frac{I_\tau}{I_{\tau-1}}\right)\right] I_\tau \right\},$$

- FOC:

$$q_t^K = 1 + g\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} g'\left(\frac{I_t}{I_{t-1}}\right) - E_t \varphi_{t,t+1}^P \left(\frac{I_{t+1}}{I_t}\right)^2 g'\left(\frac{I_{t+1}}{I_t}\right).$$

Market clearing conditions

- Aggregate bank capital constraint

$$(1-\chi^b)W_t^b = \phi_t^F \left[q_t^K k_t - (1-\chi^e)W_t^e\right] + \phi_t^M \left(\frac{q_t^H h_t^m x_t^m}{R_t^m}\right).$$

- Deposit market

$$d_t = (1-\phi_t^F) \left[q_t^K k_t - (1-\chi^e)W_t^e\right] + (1-\phi_t^M) \left(\frac{q_t^H h_t^m x_t^m}{R_t^m}\right).$$

- Labour market

$$(1-\alpha)\frac{y_t}{w_t} = l_t^s + l_t^m.$$

- Goods market: long and ugly expression
- Capital market: entrepreneur demand equals capital firm supply

$$q_t^K k_t = n_t^e + b_t^e$$

Baseline Calibration

Household Preference parameters

Description	Parameter	Value
Household Preferences		
Patient Household discount factor	β^s	0.995
Impatient Household discount factor	β^m	0.96
Patient Household utility weight on housing	v^s	0.25
Impatient Household utility weight on housing	v^m	0.25
Patient Household marginal disutility of labour	ϱ^s	1.0
Impatient Household marginal disutility of labour	ϱ^m	1.0
Habit persistence parameter	ψ	0.0
Variance of household idiosyncratic shocks	σ_m^2	0.2
Household bankruptcy cost	μ^m	0.3

Baseline Calibration

Entrepreneurial sector parameters

Description	Parameter	Value
Entrepreneurs		
Dividend payout ratio of entrepreneurs	χ^e	0.1
Variance of entrepreneurial idiosyncratic shocks	σ_e^2	0.2
Entrepreneur bankruptcy cost	μ^e	0.3

Baseline Calibration

Banking sector parameters

Description	Parameter	Value
Bankers		
Dividend payout ratio of bankers	χ^e	0.1
Variance of corporate bank idiosyncratic shocks	σ_F^2	0.05
Variance of mortgage bank idiosyncratic shocks	σ_F^2	0.05
Capital requirement for corporate loans	ϕ^F	0.11
Capital requirement for mortgages	ϕ^M	0.11
Corporate bank bankruptcy cost	μ^F	0.3
Mortgage bank bankruptcy cost	μ^H	0.3

Baseline Calibration

Production parameters and shock processes

Description	Parameter	Value
Production parameters		
Capital share	α	0.3
Capital depreciation rate	δ	0.025
Capital adjustment cost parameter	ξ	5.0
Shock processes		
TFP shock persistence	ρ^A	0.85
Risk shock persistence	ρ^σ	0.85
Housing demand persistence	ρ^D	0.85

The importance of bank capital: steady state

- The bank's required rate of return on equity is given by the following expression:

$$E_t \widetilde{\rho}^F_{t+1} = \frac{E_t \left[1 - \Gamma^F(\omega^F_t)\right] \tilde{R}^F_{t+1}}{\phi^F_t}.$$

- Leverage does two things
  - amplifies the rate of return on equity for given loan spreads (standard effect)
  - increases the probability of bankruptcy - amplifies profits through higher limited liability subsidy

The limited liability subsidy and the rate of return on equity

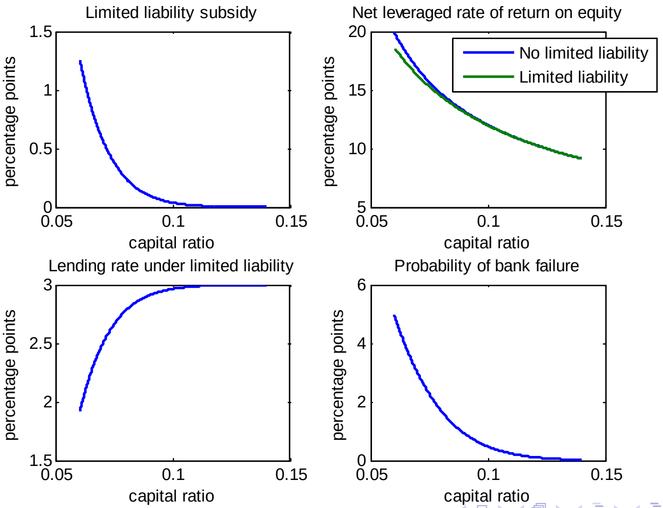
- How much does the limited liability boost the rate of return on equity everything else equal?
- Without bankruptcy, the rate of return on equity is given by:

$$E_t \widetilde{\rho}^F_{t+1} = E_t \frac{\tilde{R}^F_{t+1} - (1 - \phi^F_t) R^D_t}{\phi^F_t}$$

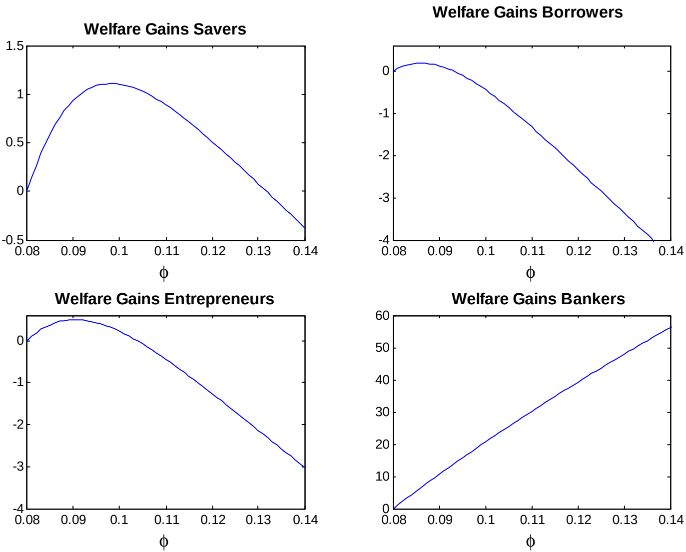
- Hence the limited liability subsidy is given by:

$$\frac{(1 - \phi^F_t) R^D_t - E_t \left(\Gamma^F(\omega^F_t) \tilde{R}^F_{t+1} \right)}{\phi^F_t}$$

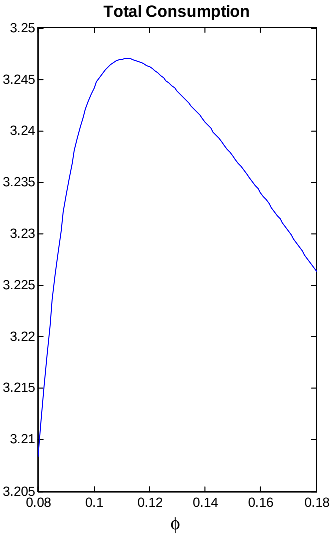
The limited liability subsidy and the rate of return on equity (cont'd)



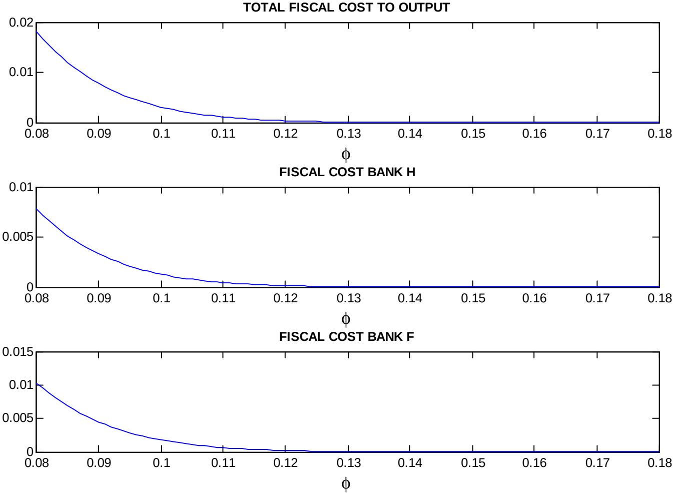
Higher generalised capital ratios in the SS



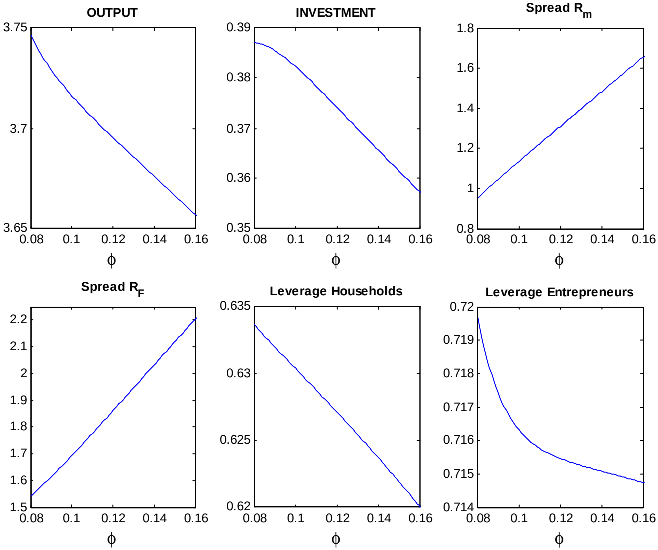
Higher generalised capital ratios in the SS (cont'd)



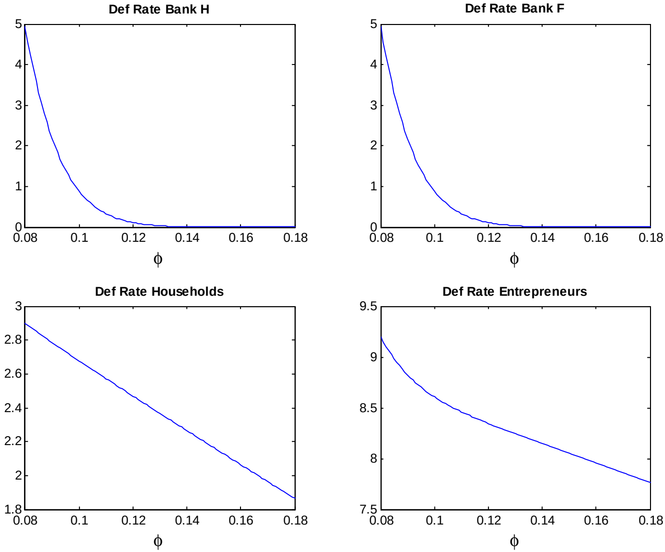
Higher generalised capital ratios in the SS (cont'd)



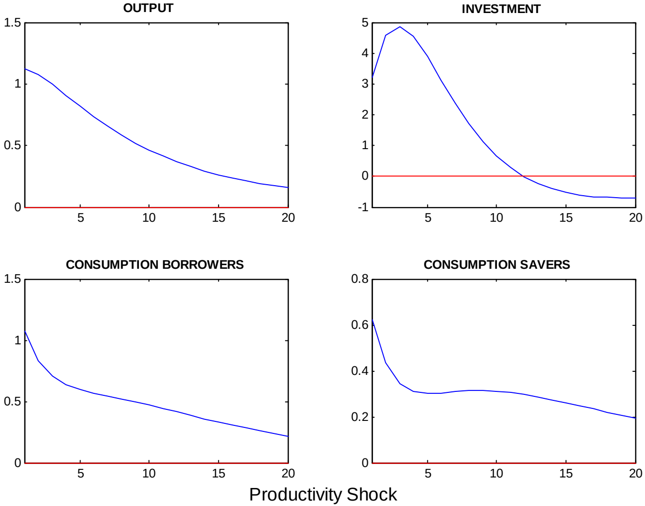
Higher generalised capital ratios in the SS (cont'd)



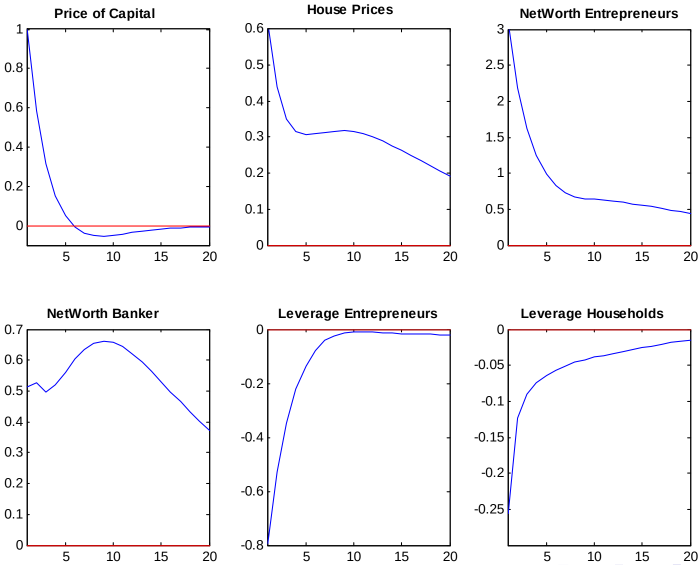
Higher generalised capital ratios in the SS (cont'd)



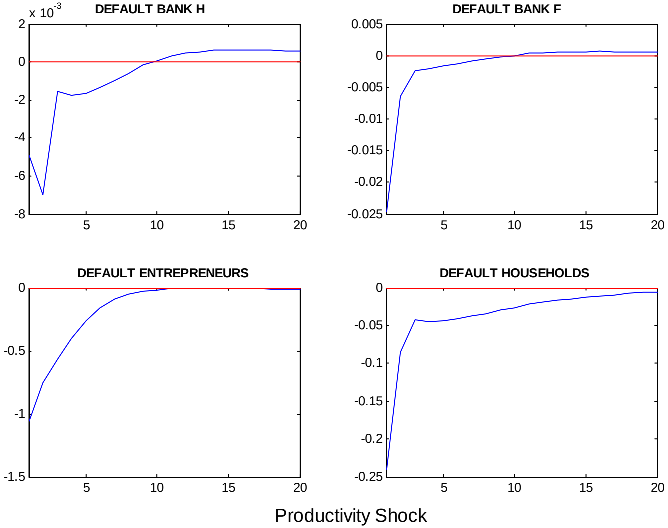
IRF to a TFP shock



IRF to a TFP shock (cont'd)



IRF to a TFP shock (cont'd)



Summary

- We build a model for macroprudential policy
  - key objective is to have a clear channel through which financial instability places costs on the real economy
- In our model
  - banks take excessive risk due to limited liability/deposit insurance