Managing Financial Bubbles

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A rational-bubbles approach to modeling aggregate roll-over crises or systemic runs

- The 2007 financial crisis was caused by the bursting of a rational macroeconomic bubble or pyramid scheme, i.e. large shock to investor sentiment (Martin-Ventura 2011, 2012)

- We develop a prototype model with financial frictions with:
  - savers $\leftrightarrow$ bankers $\leftrightarrow$ entrepreneurs
  - lending must be collateralized, and collateral may be scarce (weak enforcement institutions)

- In this context:
  - investor optimism leads to financial bubbles:
    - intermediation backed by future output ("fundamental" collateral) and by expectation of future financing ("bubbly" collateral)
  - when investor sentiment changes, financial bubbles burst and collateral falls

- Role for a lender of last resort (LOLR) that guarantees private debts
  - the effects of guarantees:
    - ex-ante: they create bubbly collateral and raise bank intermediation
    - ex-post: they are sustained through taxation, lowering bank intermediation
  - analogy with bank runs: LOLR can play a crucial role to coordinate agents in financial markets
  - in bubbly economy, the LOLR always has enough resources to implement the desired policy

Plan

1. A model of how collateral affects credit and investment
2. The bubbly economy
3. A lender of last resort
4. Additional issues

A model of collateral, credit and investment

- OLG: young and old
- Each generation: composed of $i \in \{S, B, E\}$, savers, bankers and entrepreneurs
- *Preferences*: all members of all generations maximize expected consumption when old (i.e. they are patient and risk neutral!)

$$U_t^i = E_t \left\{ C_{t+1}^i \right\}$$

- Savers (measure one) supply one unit of labor when young, $N_t = 1$; and receive wage W_t.
- Portfolio problem: deposits or inventories?
  - Credit (D_t): gross return (possibly contingent) of R_{t+1}^D per unit invested
  - Inventories ($W_t - D_t$): storage, gross return of $\rho < 1$ per unit invested
  - Optimal deposits: $D_t \begin{cases} = W_t & \text{if } E_t R_{t+1}^D > \rho \\ \in [0, W_t] & \text{if } E_t R_{t+1}^D = \rho \\ = 0 & \text{if } E_t R_{t+1}^D < \rho \end{cases}$

Bankers

- Bankers serve as intermediaries between savers and entrepreneurs.
- They maximize expected consumption subject to:
  - Budget constraint:
$$C^B_{t+1} = R^L_{t+1} \cdot L_t - R^D_{t+1} \cdot D_t \quad \text{and} \quad D_t = L_t$$
  - Credit constraint:
$$R^D_{t+1} \cdot D_t \leq \phi_{t+1} \cdot R^L_{t+1} \cdot L_t$$
- This implies:
$$R^D_{t+1} = \phi_{t+1} \cdot R^L_{t+1}$$

Entrepreneurs

- Entrepreneurs own the economy's capital stock and the production technology
  - Borrow from bankers in order to invest
- They maximize expected consumption subject to:
  - Budget constraint:

$$C_{t+1}^{E} = F\left(K_{t+1}, N_{t+1}, \pi_{t+1}\right) - W_{t+1} \cdot N_{t+1} - R_{t+1}^{L} \cdot L_t \quad \text{and} \quad K_{t+1} = L_t$$

  - Technology:

$$F\left(K_t, N_t, \pi_t\right) = \pi_t \cdot K_t^{\alpha} \cdot \left(\gamma^t \cdot N_t\right)^{1-\alpha}$$

- This implies:

$$W_t = (1-\alpha) \cdot \pi_t \cdot \gamma_t^{1-\alpha} \cdot K_t^{\alpha}$$

$$R_t^{L} = \alpha \cdot \pi_t \cdot \gamma_t^{1-\alpha} \cdot K_t^{\alpha-1} + 1 - \delta$$

Dynamics and welfare

- Let lowercase letters refer to variables in units of efficient workers. For instance, $k_t \equiv K_t \cdot \gamma^{-t}$.

- The law of motion:

$$k_{t+1} \begin{cases} = \dfrac{1-\alpha}{\gamma} \cdot \pi_t \cdot k_t^{\alpha} & \text{if } E_t R_{t+1}^D > \rho \\ \in \left[0, \dfrac{1-\alpha}{\gamma} \cdot \pi_t \cdot k_t^{\alpha}\right] & \text{if } E_t R_{t+1}^D = \rho \end{cases} \qquad \text{(Supply of funds)}$$

$$E_t R_{t+1}^D = E_t \left\{ \phi_{t+1} \cdot \left(\alpha \cdot \pi_{t+1} \cdot k_{t+1}^{\alpha-1} + 1 - \delta \right) \right\} \qquad \text{(Demand for funds)}$$

  - If k_t small: investment determined by supply of funds, i.e. savings
    - law of motion increasing and concave
  - If k_t large: investment determined by demand of funds, i.e. collateral
    - law of motion flat

- Effects of productivity/financial shocks.

- Dynamics: monotone convergence to a steady state interval $[k_L^*, k_H^*]$

- Welfare: measured as utility (or expected consumption) of each generation

- Throughout we assume that the frictionless economy ($\phi = 1$) is dynamically efficient.

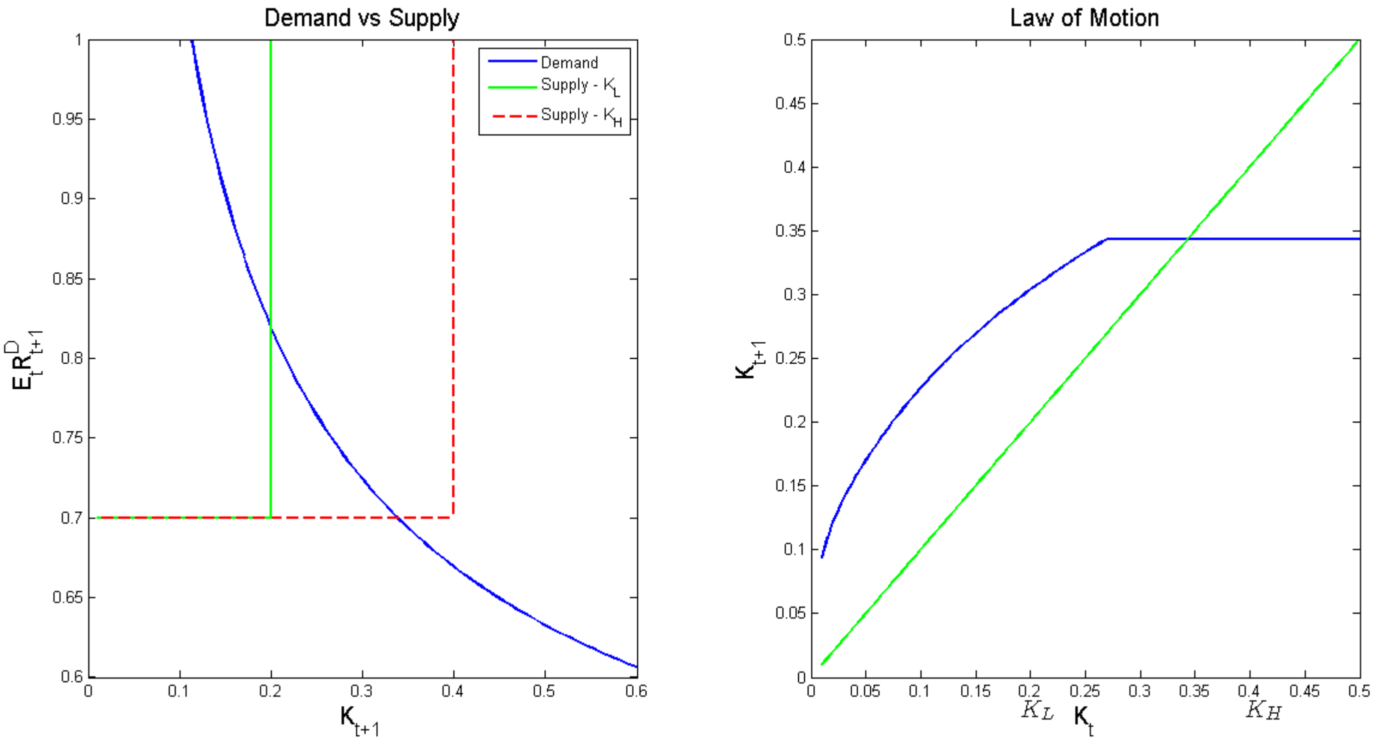

Figure 2: Illustrative Demand and Supply Curves

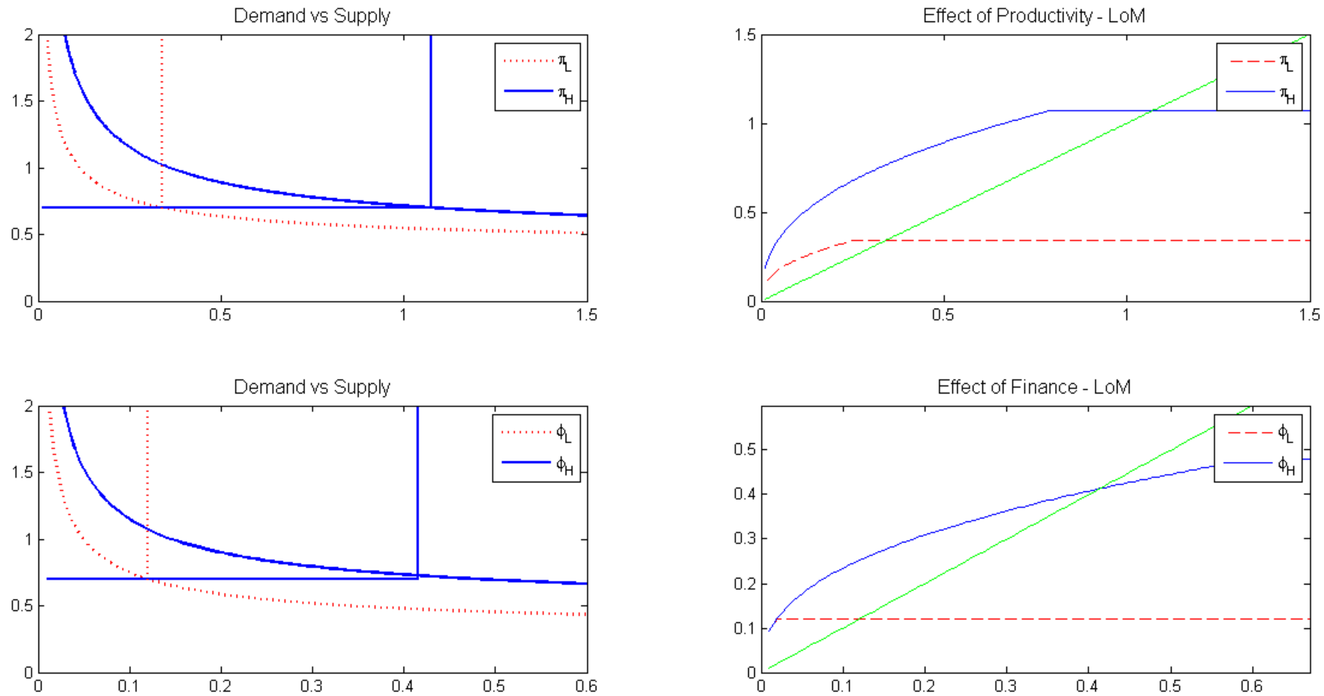

Figure 3: Demand and Supply Curves with Productivity and Financial Shocks

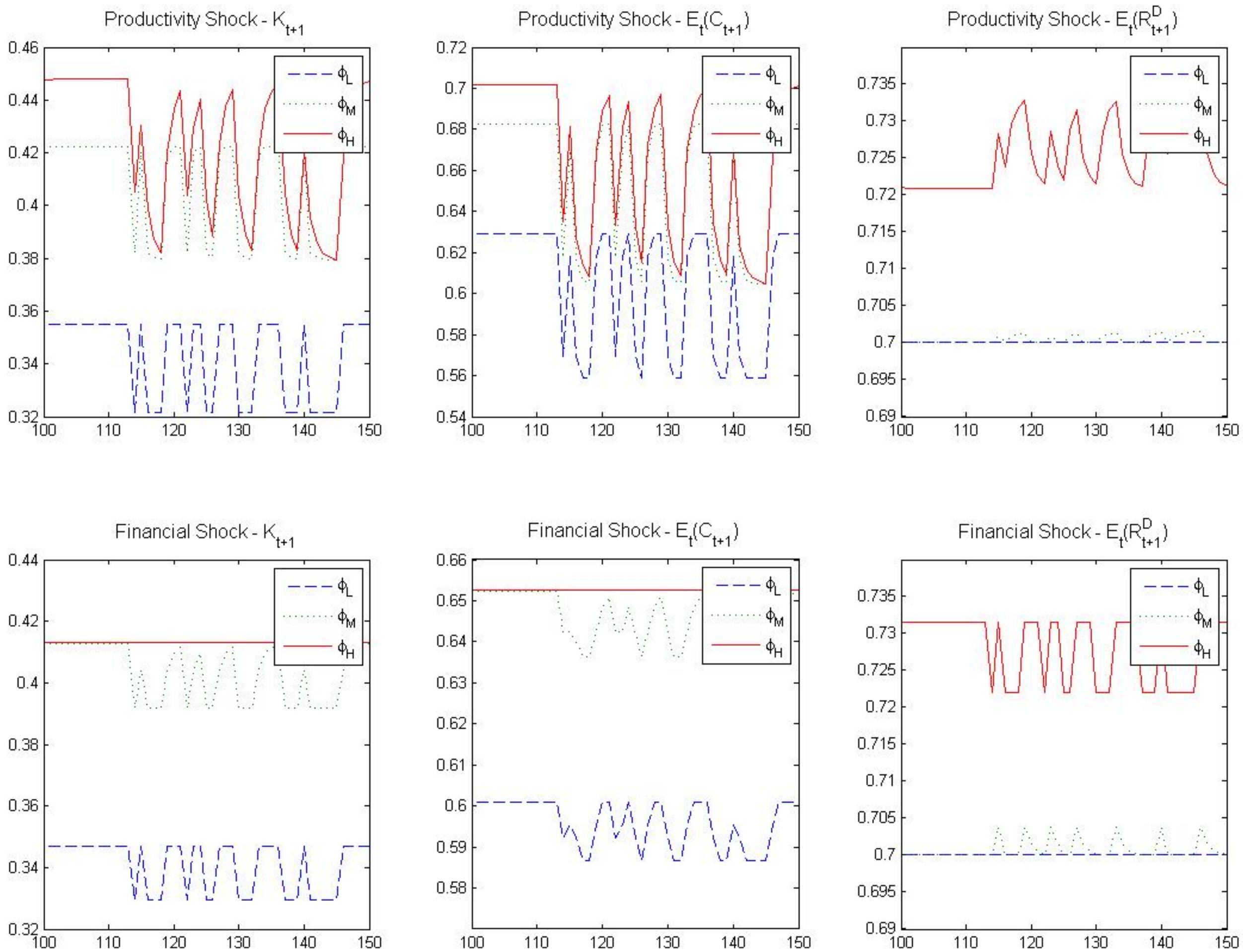

Figure 4: Productivity and Financial Shocks

Key features

- Financial frictions lower the capital stock and welfare
- The economy with productivity shocks:
  - With full intermediation, increases in productivity raise investment through the supply of funds
  - With partial intermediation, increases in productivity raise investment through the demand for funds
  - The interest rate and relative abundance of collateral are countercyclical (spreads are acyclical)
- The economy with financial shocks:
  - With full intermediation, positive financial shocks have no effect on investment or welfare
  - With partial intermediation, positive financial shocks raise investment through the demand for funds
  - The interest rate and relative abundance of collateral are procyclical (spreads are countercyclical)

The bubbly economy

- Until now: fundamental collateral, deposits and intermediation backed by output
- Introduce bubbly collateral: savers lend to bankers because they expect future savers to do so as well
- Bankers maximize expected consumption subject to:
  - Budget constraint:
$$C_{t+1}^{B} = R_{t+1}^{L} \cdot L_t + B_{t+1} - R_{t+1}^{D} \cdot D_t \quad \text{and} \quad D_t = L_t + B_t$$
  - Credit constraint:
$$R_{t+1}^{D} \cdot D_t \leq \phi_{t+1} \cdot R_{t+1}^{L} \cdot L_t + B_{t+1}$$
- This implies:
$$R_{t+1}^{D} = \min\left\{R_{t+1}^{L}, \frac{\phi_{t+1} \cdot R_{t+1}^{L} \cdot L_t + B_{t+1}}{D_t}\right\}.$$
$$B_t \begin{cases} = 0 & \text{if } E_t B_{t+1} < E_t R_{t+1}^{D} \cdot B_t + \gamma^{t+1} \cdot E_t \beta_{t+1}^{C} \\ \in [0, \infty) & \text{if } E_t B_{t+1} = E_t R_{t+1}^{D} \cdot B_t + \gamma^{t+1} \cdot E_t \beta_{t+1}^{C} \\ = \infty & \text{if } E_t B_{t+1} > E_t R_{t+1}^{D} \cdot B_t + \gamma^{t+1} \cdot E_t \beta_{t+1}^{C} \end{cases}$$
- Thee bubble evolves as follows:
$$B_{t+1} = E_t R_{t+1}^{D} \cdot B_t + \gamma^{t+1} \cdot \left(\beta_{t+1}^{V} + \beta_{t+1}^{C}\right)$$

Dynamics and welfare

- The law of motion:

$$k_{t+1} = \begin{cases} = \dfrac{1-\alpha}{\gamma} \cdot \pi_t \cdot k_t^{\alpha} - \dfrac{b_t}{\gamma} & \text{if } \; E_t R_{t+1}^D > \rho \\ \in \left[0, \dfrac{1-\alpha}{\gamma} \cdot \pi_t \cdot k_t^{\alpha} - \dfrac{b_t}{\gamma}\right] & \text{if } \; E_t R_{t+1}^D = \rho \end{cases} \qquad \text{(Supply of funds)}$$

$$E_t R_{t+1}^D = E_t \left\{ \phi_{t+1} \cdot \left(\alpha \cdot \pi_{t+1} \cdot k_{t+1}^{\alpha-1} + 1 - \delta\right) + \frac{\beta_{t+1}^C}{k_{t+1}} \right\} \qquad \text{(Demand for funds)}$$

$$b_{t+1} = \frac{E_t R_{t+1}^D}{\gamma} \cdot b_t + \beta_{t+1}^V + \beta_{t+1}^C \qquad \text{(Bubble dynamics)}$$

- Key dynamic effects of financial bubbles:
  - Crowding out: bubbles reduce supply of funds for investment, some deposits are used to fund unbacked debts
  - Crowding in: bubbles raise demand of funds for investment, bankers can raise more deposits today if they are expected to leave unbacked debts tomorrow

- Restrictions on admissible bubbles:
  - Bubbles must be non-negative, i.e. $b_t \geq 0$ (free disposal)
  - Bubbles cannot exceed savings, i.e. $b_t \leq (1-\alpha) \cdot A_t \cdot k_t^{\alpha}$ (feasibility)
  - Bubbles shocks: $E_t \beta_{t+1}^V = 0$ and $\beta_t^C \geq 0$ (arbitrage and free disposal)

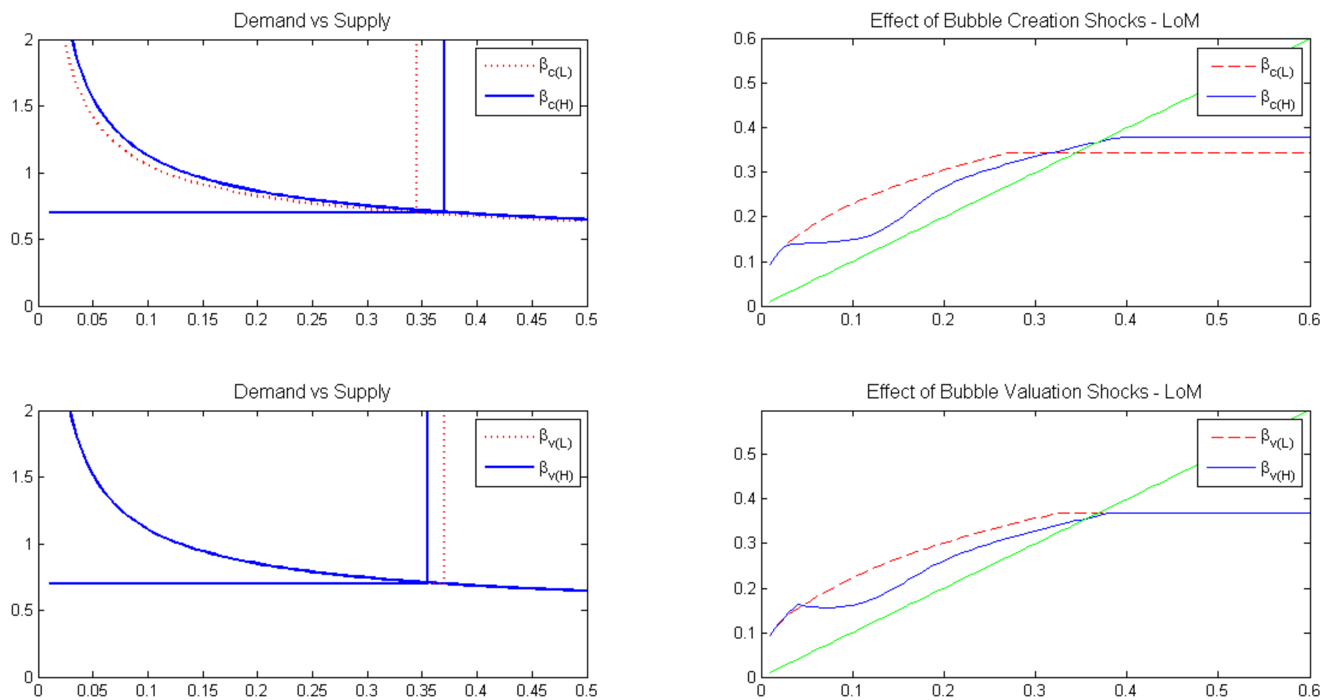

Figure 5: Demand and Supply Curves with Bubble Creation and Valuation Shocks

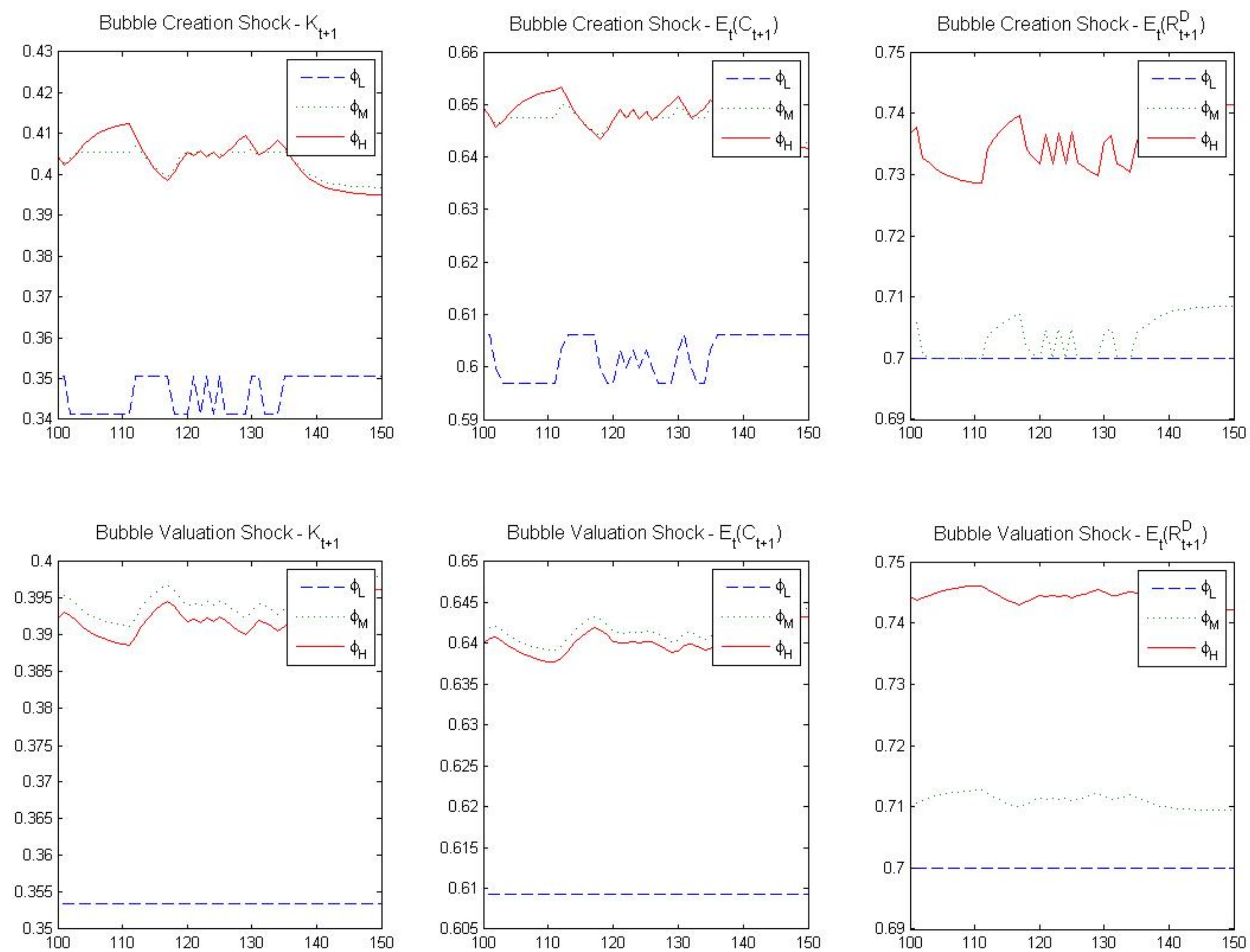

Figure 6: Effect of bubbles

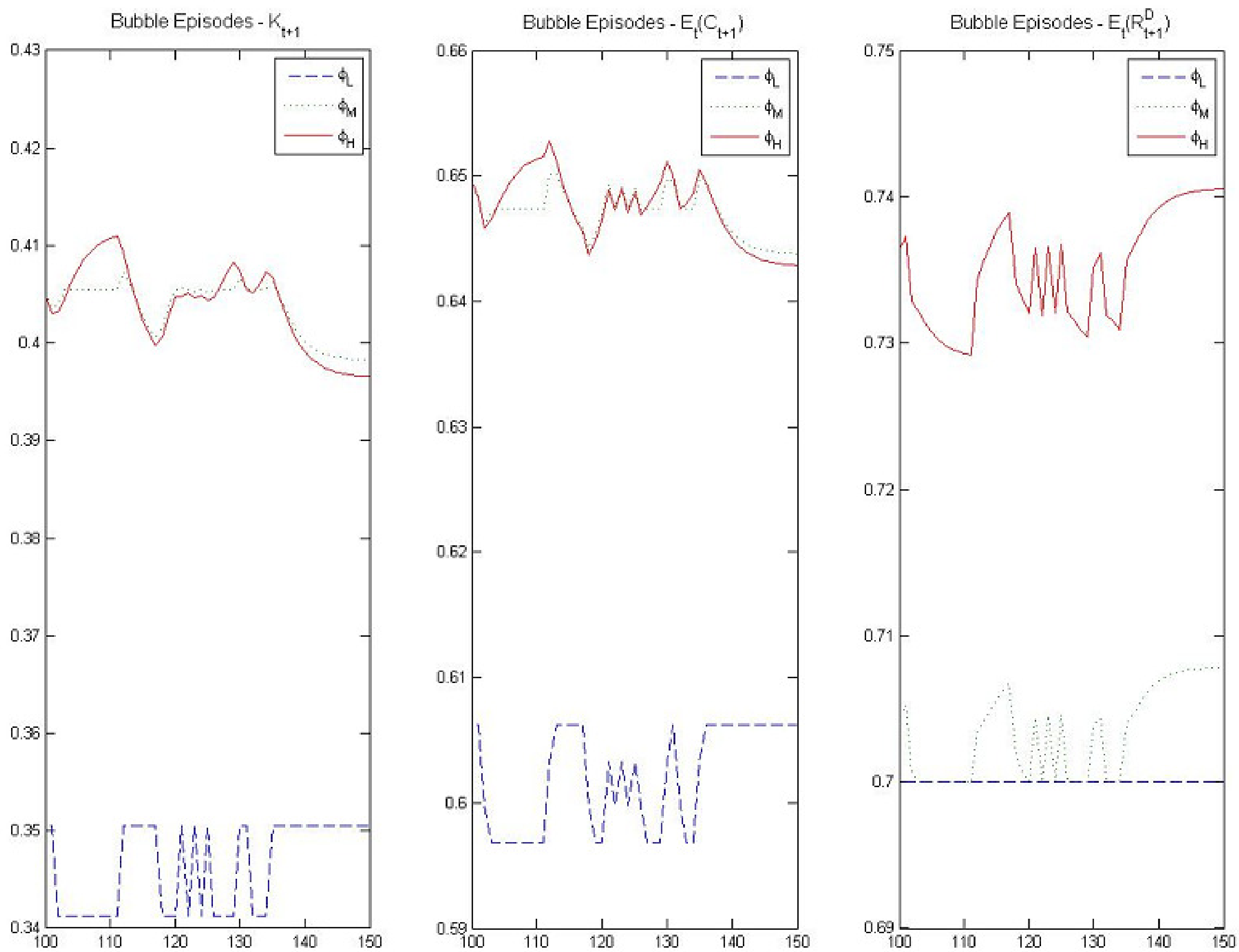

Figure 6(b): Under Bubbly Episodes

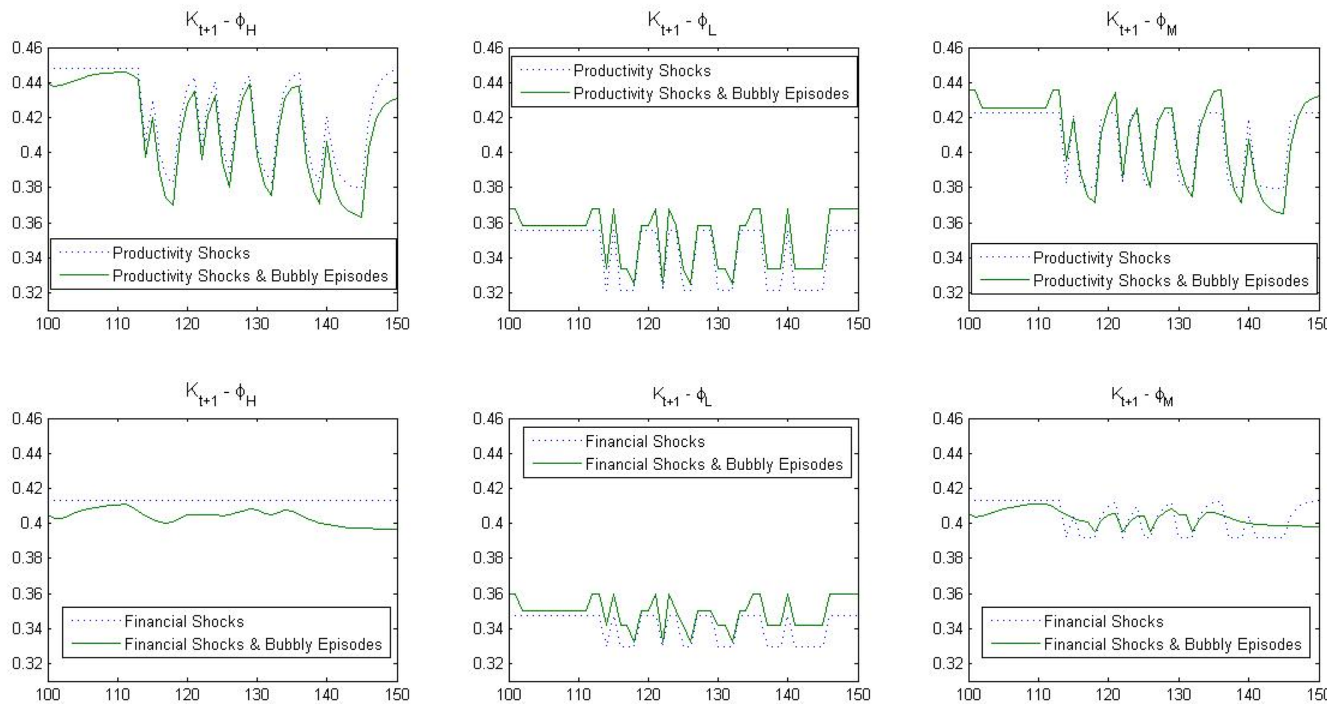

Figure 7: Productivity and Financial Shocks with Bubbly Episodes

Main insights

- The bubble can be expansionary or contractionary
- With full intermediation, there is enough fundamental collateral and the crowding-out effect dominates
  - Bubbly collateral substitutes fundamental collateral
- With partial intermediation, there is not enough fundamental collateral and the crowding-in effect dominates
  - Bubbly collateral complements fundamental collateral
- If the business cycle is driven by productivity shocks, the bubble *destabilizes* the capital stock and welfare
- If the business cycle is driven by financial shocks the bubble *stabilizes* the capital stock and welfare in the case of partial intermediation.

A lender of last resort

- Bubbly economy may experience scarcity of collateral: is there a role for policy?
  - Raise fundamental collateral: institutional reforms to increase ϕ
  - Manage bubbly collateral
    - Bubbly collateral rests on expectations that unbacked debts will be rolled over
    - Role for lender of last resort (LOLR)
- Introduce LOLR that can
  - tax young bankers
  - guarantee unbacked promises left by old bankers
  - public management of collateral
- Disclaimer: no objective function for the LOLR
  - explore theoretical effects of different policies
  - pay special attention to policies that maximize utility (or expected consumption)

Bubbly economy with LOLR

- Let S_t denote transfers to old bankers, financed by taxes T_t on young bankers:
  - S_t possibly contingent, i.e. guarantees
  - no bailouts, i.e. no net transfers to bankers from other agents
  - balanced budget: $S_t = T_t$
  - evolution of transfers: $S_{t+1} = E_t R^D_{t+1} \cdot S_t + \gamma^{t+1} \cdot \left(\sigma^V_{t+1} + \sigma^C_{t+1}\right)$ with $E_t \sigma^V_{t+1} = 0$.
- Bankers maximize expected consumption subject to:
  - Budget constraint:

$$C^B_{t+1} = R^L_{t+1} \cdot L_t + B_{t+1} + S_{t+1} - R^D_{t+1} \cdot D_t \quad \text{and} \quad D_t = L_t + B_t + T_t$$

  - Credit constraint:

$$R^D_{t+1} \cdot D_t \leq \phi_{t+1} \cdot R^L_{t+1} \cdot L_t + B_{t+1} + S_{t+1}$$

  - This implies:

$$R^D_{t+1} = \min\left\{R^L_{t+1}, \frac{\phi_{t+1} \cdot R^L_{t+1} \cdot L_t + B_{t+1} + S_{t+1}}{D_t}\right\}$$

Dynamics and welfare

- The law of motion:

$$k_{t+1} = \begin{cases} = \dfrac{1-\alpha}{\gamma} \cdot \pi_t \cdot k_t^{\alpha} - \dfrac{b_t + s_t}{\gamma} & \text{if } \; E_t R^D_{t+1} > \rho \\ \in \left[0, \dfrac{1-\alpha}{\gamma} \cdot \pi_t \cdot k_t^{\alpha} - \dfrac{b_t + s_t}{\gamma}\right] & \text{if } \; E_t R^D_{t+1} = \rho \end{cases} \qquad \text{(Supply of funds)}$$

$$E_t R^D_{t+1} = E_t \left\{\phi_{t+1} \cdot \left(\alpha \cdot \pi_{t+1} \cdot k_{t+1}^{\alpha-1} + 1 - \delta\right)\right\} + \frac{E_t \left\{\beta^C_{t+1} + \sigma^C_{t+1}\right\}}{k_{t+1}} \qquad \text{(Demand for funds)}$$

$$b_{t+1} = \frac{E_t R^D_{t+1}}{\gamma} \cdot b_t + \beta^V_{t+1} + \beta^C_{t+1} \qquad \text{(Bubble dynamics)}$$

$$s_{t+1} = \frac{E_t R^D_{t+1}}{\gamma} \cdot s_t + \sigma^V_{t+1} + \sigma^C_{t+1} \qquad \text{(Policy dynamics)}$$

- Dynamic effects of LOLR policy mimic those of financial bubble:
  - Crowding out: transfers reduce supply of funds for investment, some deposits used to fund taxes
  - Crowding in: expected transfers raise demand of funds for investment, bankers can raise more deposits today if they are backed by LOLR

A policy rule

- Consider a LOLR that manages the demand for deposits so that it always equals the supply of funds:
  - if collateral is scarce and $E_t R^D_{t+1} = \rho$, the LOLR complements bubbly collateral and sets $E_t \sigma^C_{t+1} > 0$ until all of the economy's funds are intermediated
  - if collateral is abundant and $E_t R^D_{t+1} > \rho$, the LOLR sets $E_t \sigma^C_{t+1} \leq 0$ to reduce the demand for funds until the interest rate on deposits is exactly equal to ρ.
- This policy 'complements' the financial bubble when collateral is scarce and 'counteracts' it when collateral is abundant:
  - generates high output, although it might raise its volatility
  - it leads to low interest rates

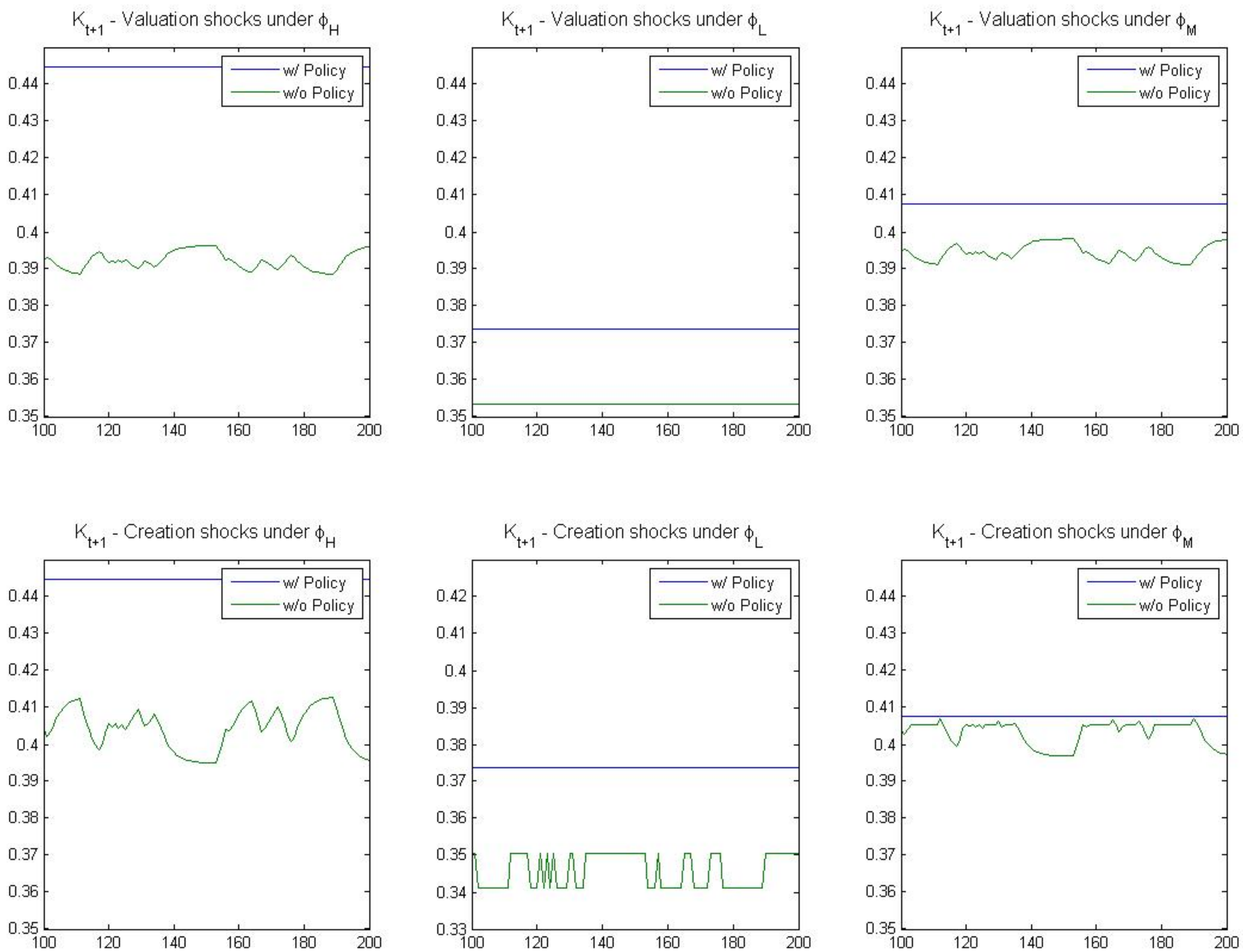

Figure 10: Effect of Government Policy - No Fundamental Shocks

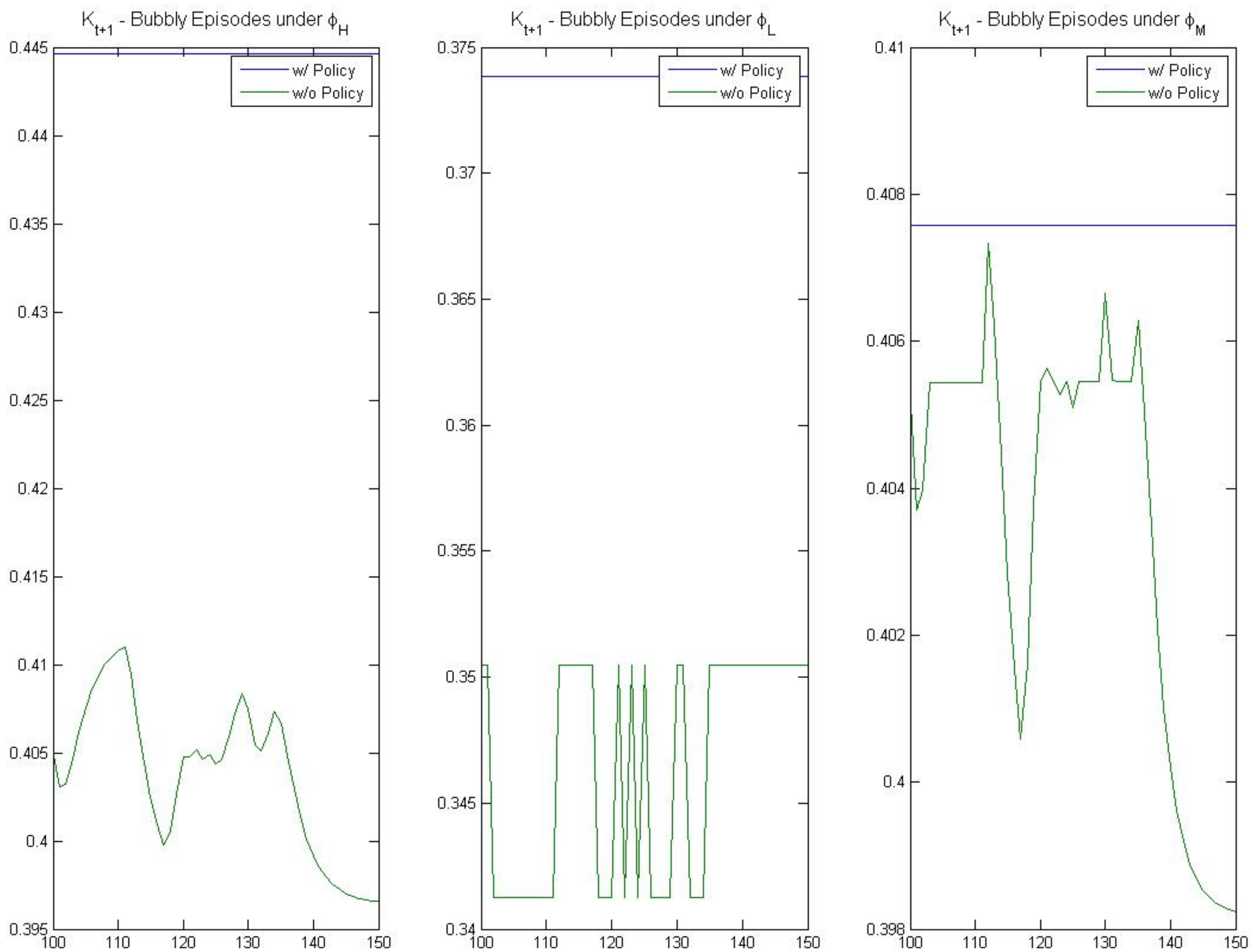

Figure 11: Effect of Government Policy - No Fundamental Shocks

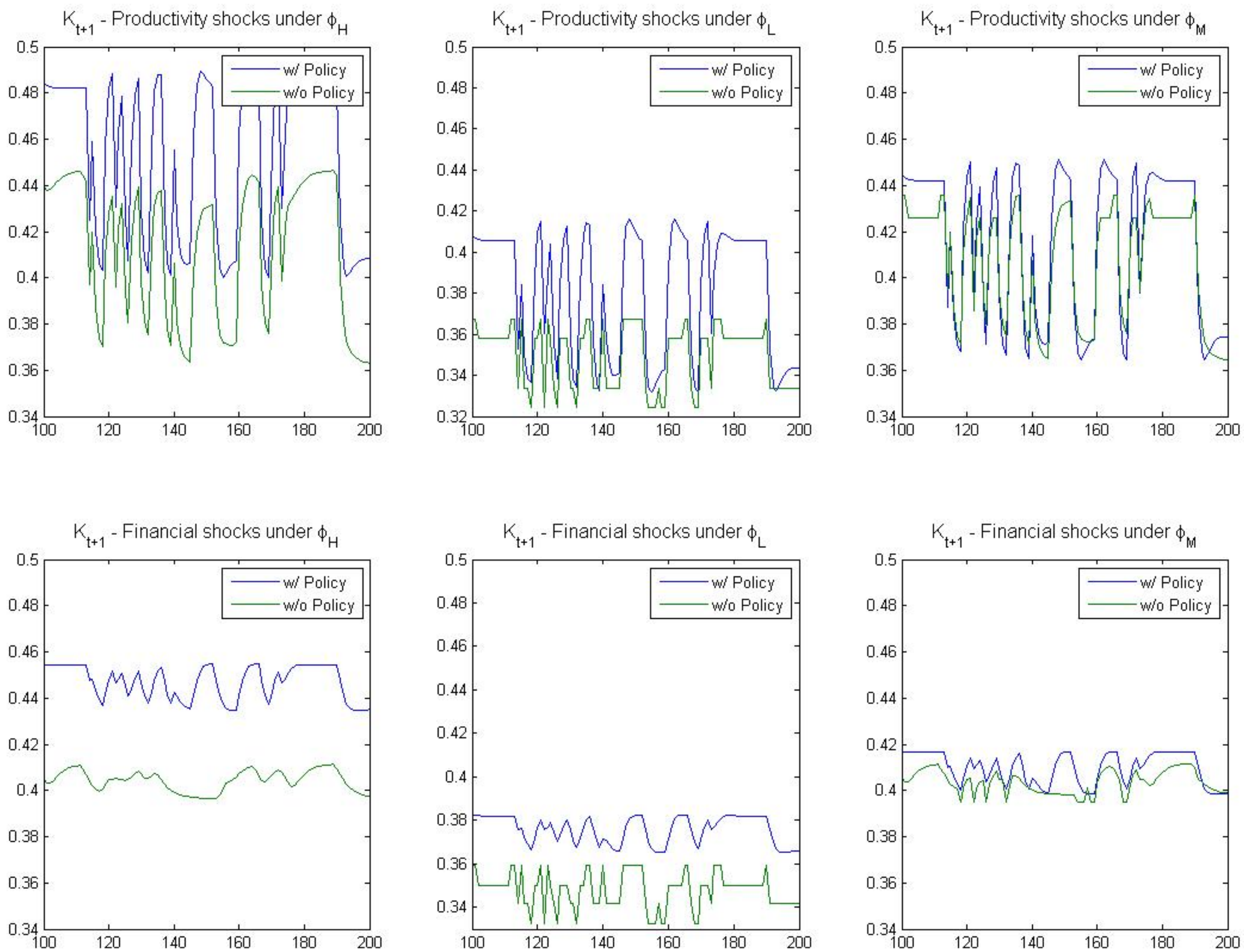

Figure 8: Effect of Government Policy (bubbly episodes)

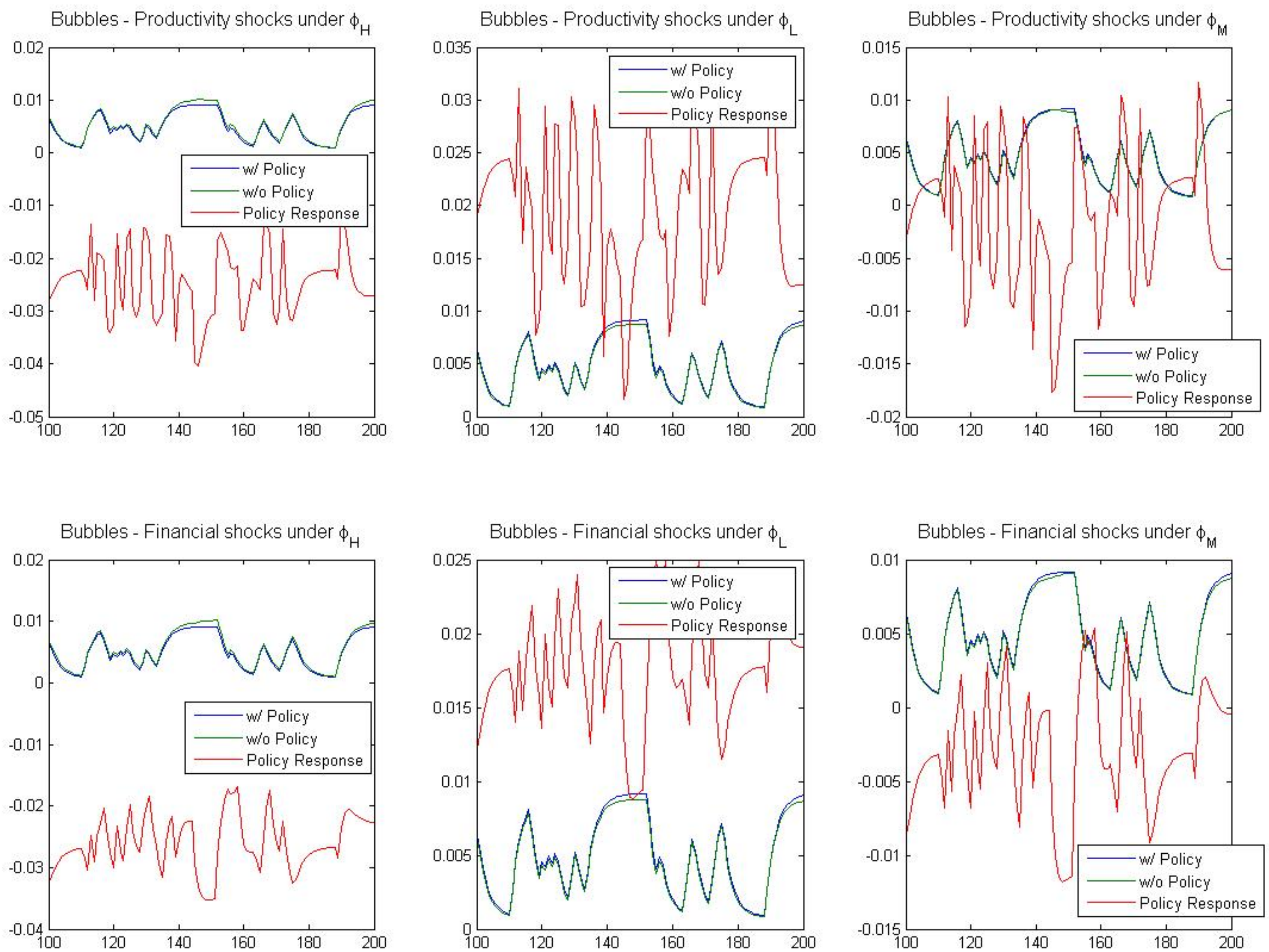

Figure 9: Size of bubbles with and without policy intervention

Additional issues

- The fiscal backstop
- Financial vs. corporate bubbles
- Financial bubbles and capital flows

A rational-bubbles approach to modeling aggregate roll-over crises or systemic runs

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- We develop a prototype model with financial frictions with:
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  - in bubbly economy, the LOLR always has enough resources to implement the desired policy

Additional slides:

Related literature

- Rational bubbles
  - Samuelson (1958), Tirole (1985)
  - Samuelson (1958), Kiyotaki and Moore (2008): fiat money as a bubble
- Bubbles and economic growth
  - Saint-Paul (1992), Grossman and Yanagawa (1993), King and Ferguson (1993), Olivier (2000)
- Bubbles and financial frictions: macroeconomic implications
  - Azariadis and Smith (1993): existence
  - Caballero and Krishnamurthy (2006), Farhi and Tirole (2010), Miao and Wang (2011), Aoki and Nikolov (2011): liquidity
  - Kocherlakota (2010), Martin and Ventura (2011): collateral
  - Ventura (2011): cost of capital
- Financial accelerator
  - Bernanke and Gertler (1989), Kiyotaki and Moore (1997)
- Bailouts and crises
  - Tornell and Schneider (2004), Ranciere, Tornell and Westermann (2008), Bianchi (2012)

Type of Shocks	α	δ	ρ	γ	π	$\{\pi_H,\pi_L\}$	ϕ	$\{\phi_H,\phi_L\}$	$\{\beta^c_H,\beta^c_L\}$	$\{\beta^v_{HH},\beta^v_{HL},\beta^v_{LH},\beta^v_{LL}\}$
Sim. 1 - Productivity Shocks	0.4	0.1	0.7	1.02	1	{-0.05,+0.05}	{0.42,0.44,0.46}	{0,0}	{0,0}	{0,0,0,0}
Sim. 2 - Financial Shocks	0.4	0.1	0.7	1.02	1	{0,0}	{0.42,0.44,0.46}	{-0.05,0.05}	{0,0}	{0,0,0,0}
Sim. 3 - Bubble Creation	0.4	0.1	0.7	1.02	1	{0,0}	{0.42,0.44,0.46}	{0,0}	{0.003,0.001}	{0,0,0,0}
Sim. 4 - Bubble Valuation	0.4	0.1	0.7	1.02	1	{0,0}	{0.42,0.44,0.46}	{0,0}	{0.003,0.003}	{-0.00025,0.001,-0.001,0.00025}
Sim. 5 - Bubbly Episodes	0.4	0.1	0.7	1.02	1	{0,0}	{0.42,0.44,0.46}	{0,0}	{0.003,0.001}	{-0.00025,0.001,-0.001,0.00025}
Sim. 6 - Production Shocks & Bubbly Episodes	0.4	0.1	0.7	1.02	1	{-0.05,+0.05}	{0.42,0.44,0.46}	{0,0}	{0.003,0.001}	{-0.00025,0.001,-0.001,0.00025}
Sim 7 - Financial Shocks & Bubbly Episodes	0.4	0.1	0.7	1.02	1	{0,0}	{0.42,0.44,0.46}	{-0.05,0.05}	{0.003,0.001}	{-0.00025,0.001,-0.001,0.00025}

Table 1: Table of Parameters

Type of Shocks	Statistic	ϕ_L		ϕ_M		ϕ_H	
Policy		w/o	w/	w/o	w/	w/o	w/
Sim. 1 - Productivity Shocks	μ_K	0.338		0.401		0.413	
	$s.d._K$	(0.017)		(0.021)		(0.029)	
Sim. 2 - Financial Shocks	μ_K	0.338		0.401		0.413	
	$s.d._K$	(0.009)		(0.010)		(0.004)	
Sim. 3 - Bubble Creation	μ_K	0.346		0.403		0.404	
	$s.d._K$	(0.006)		(0.005)		(0.007)	
Sim. 4 - Bubble Valuation	μ_K	0.348	0.374	0.402	0.407	0.401	0.445
	$s.d._K$	(0.005)	(0.004)	(0.006)	(0.004)	(0.007)	(0.004)
Sim. 5 - Bubbly Episodes	μ_K	0.346	0.374	0.403	0.408	0.404	0.445
	$s.d._K$	(0.006)	(0.004)	(0.005)	(0.004)	(0.006)	(0.004)
Sim. 6 - Production Shocks & Bubbly Episodes	μ_K	0.346	0.374	0.401	0.408	0.404	0.445
	$s.d._K$	(0.018)	(0.032)	(0.027)	(0.034)	(0.030)	(0.036)
Sim 7 - Financial Shocks & Bubbly Episodes	μ_K	0.346	0.374	0.401	0.408	0.404	0.445
	$s.d._K$	(0.011)	(0.008)	(0.006)	(0.008)	(0.006)	(0.009)

Table 2: Simulation Statistics