Managing Financial Bubbles

Alberto Martin Jaume Ventura

CREI, Universitat Pompeu Fabra and Barcelona GSE

September 2013

Introduction

- Financial turmoil that began in 2007-08 led to the largest crisis since the great depression
- Focus on two features
  - Began with widespread financial 'panic'
    - Credit markets stopped functioning in August 2007
    - Roll-over crisis in short-term commercial paper spread to other markets (e.g. interbank market)
    - Increase in spreads, higher premia, liquidation of collateral and fall in asset prices (Gorton, Brunnermeier)
  - Governments have transferred trillions of dollars to financial institutions
- These two aspects of the crisis have given rise to vigorous debate
  - Can we think of the crisis the bursting of a financial bubble?
    - what are bubbles? How do they affect the macroeconomy? Why does their bursting lead to a recession?
  - What is the rationale for these public interventions, even by governments that are under financial stress?
    - do they correct underlying market failure?
    - do they boost activity in the short run at the expense of long run incentives?

Our view of financial bubbles

- Crisis characterized by an aggregate roll-over crisis or 'systemic' run
- Can be modeled as bursting of bubble, i.e. large shock to investor sentiment (Martin-Ventura 2011)
- In real-world financial markets: because of financial frictions, intermediation backed by output but also by expectation of future financing ("investor sentiment")
- To model this insight
  - macroeconomic model with financial frictions
  - key role of financial markets: savers $\leftrightarrow$ bankers $\leftrightarrow$ entrepreneurs
  - but 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)
    - part of intermediation is a financial bubble: expected to be rolled over indefinitely
    - financial bubbles provide collateral
  - when investor sentiment changes, financial bubbles burst and collateral falls

Main insights

- Macroeconomic effects of financial bubbles:
  - When fundamental collateral is scarce, financial bubbles
    - complement fundamental collateral, crowding in intermediation, investment and output
  - When fundamental collateral is abundant, financial bubbles
    - substitute fundamental collateral, crowding out intermediation, investment and output
  - Financial bubbles may raise or reduce the level and volatility of economic activity, depending on the properties of fundamental collateral
- Role for a lender of last resort (LOLR)
  - in principle, useful to manage the financial bubble to maximize consumption
  - to reduce a financial bubble: policies that tax roll over of private debts
  - to sustain a financial bubble: policies that guarantee roll over of private debts
    - ex-ante: these policies create bubbly collateral and raise bank intermediation
    - ex-post: these policies are sustained through taxation, lowering bank intermediation
  - analogy with bank runs: LOLR can play a crucial role to coordinate agents in financial markets
  - what if LOLR does not have enough resources to implement desired policy?
    - in bubbly economy, it always does!

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)

Roadmap

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:

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

  - Technology:

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

- This implies:

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

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

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:

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

$$E_t R_{t+1}^D = E_t \phi_{t+1} \cdot \left(\alpha \cdot E_t A_{t+1} \cdot k_{t+1}^{\alpha-1} + 1 - \delta\right)$$

  - 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 expected consumption of the generation

$$E_t c_{t+1} = \rho \cdot \left(\frac{1-\alpha}{\gamma} \cdot A_t \cdot k_t^{\alpha} - k_{t+1}\right) + \alpha \cdot E_t A_{t+1} \cdot k_{t+1}^{\alpha} + (1-\delta) \cdot k_{t+1}$$

An economy with productivity shocks

- Simulate economy in three scenarios: abundant collateral (ϕ high), scarce collateral (ϕ low) and intermediate collateral (ϕ intermediate)
  - Persistent productivity shocks with two values, $A_t \in \{A_L, A_H\}$, $\Pr(A_{t+1} \neq A_t) = 0.2$
  - Generate a series for A_t and $E_t A_{t+1}$ of length 10,000 periods: used in all scenarios.
  - Compute the steady state interval for each scenario and start the economy in interval midpoint.

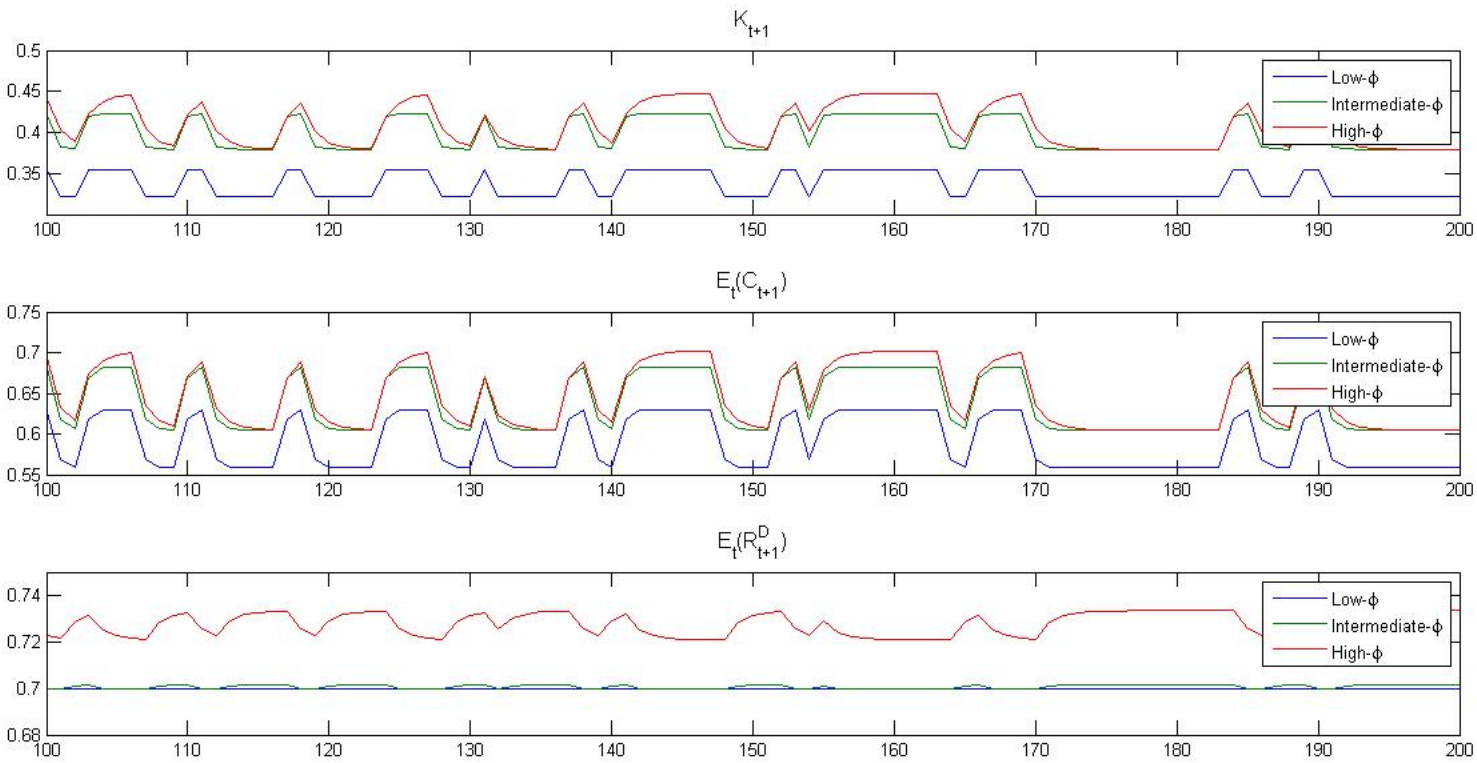

Figure 1: Productivity Shocks

An economy with productivity shocks

- Simulate economy in three scenarios: abundant collateral (ϕ high), scarce collateral (ϕ low) and intermediate collateral (ϕ intermediate)
  - Persistent productivity shocks with two values, $A_t \in \{A_L, A_H\}$, $\Pr(A_{t+1} \neq A_t) = 0.2$
  - Generate a series for A_t and $E_t A_{t+1}$ of length 10,000 periods: used in all scenarios.
  - Compute the steady state interval for each scenario and start the economy in interval midpoint.
- Main insights:
  - Financial frictions lower the capital stock and welfare
  - With full intermediation, increases in productivity raise investment through the supply of funds
  - With partial intermediation, increases in productivity raise investment through the demand of funds
  - The interest rate and relative abundance of collateral are countercyclical (spreads are acyclical)

An economy with financial shocks

- Simulate economy in three scenarios: abundant collateral (ϕ high), scarce collateral (ϕ low) and intermediate collateral (ϕ intermediate)
  - Persistent financial shocks with two values, $\phi_t \in \{\phi_L, \phi_H\}$, $\Pr(\phi_{t+1} \neq \phi_t) = 0.2$
  - Generate a series for $E_t\phi_{t+1}$ of length 10,000 periods: used in all scenarios.
  - Compute the steady state interval for each scenario and start the economy in interval midpoint.

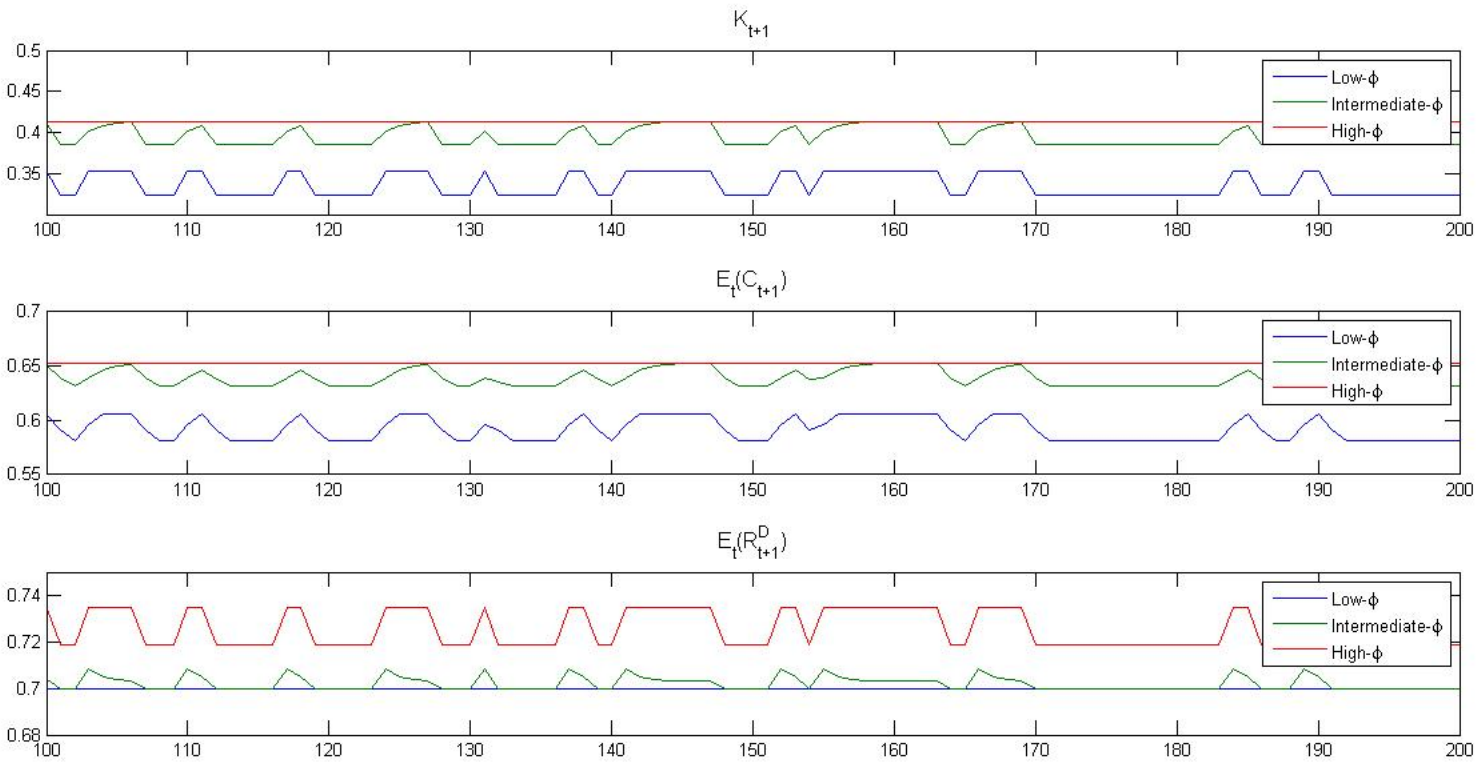

Figure 2: Financial Shocks

An economy with financial shocks

- Simulate economy in three scenarios: abundant collateral (ϕ high), scarce collateral (ϕ low) and intermediate collateral (ϕ intermediate)
  - Persistent financial shocks with two values, $\phi_t \in \{\phi_L, \phi_H\}$, $\Pr(\phi_{t+1} \neq \phi_t) = 0.2$
  - Generate a series for $E_t\phi_{t+1}$ of length 10,000 periods: used in all scenarios.
  - Compute the steady state interval for each scenario and start the economy in interval midpoint.
- Main insights:
  - Financial frictions lower the capital stock and welfare
  - With full intermediation, positive financial shocks have no effect on investment or welfare
  - With partial intermediation, positive financial shocks raise investment through the demand of 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 are willing to lend to bankers because they expect others to so in the future as well
- Formally:
  - Bankers collect deposits, lend, and finance outstanding unbacked debts left behind by previous generation of bankers
  - Let $B_t + B_t^N$ denote total outstanding debt left by generation $t-1$
    - B_t: debt that has been rolled over from previous periods
    - B_t^N: debt that accrues fro the first time in period t
  - Denote B_t and B_t^N as old and new bubble, respectively
- Why do bankers take on these unbacked debts?
  - They expect to roll them over as well
    - Taking over these debts is akin to purchasing bubbles for $B_t + B_t^N$ and selling them for a value of $E_t B_{t+1}$
  - Moreover, each generation is able to enlarge the stock of outstanding debts
    - This is a akin to initiating new bubbles for a value of B_{t+1}^N

The bubbly economy (II)

- Savers and entrepreneurs unaffected
- Bankers now maximize expected consumption subject to:
  - Budget constraint:

$$C_{t+1}^B = R_{t+1}^L \cdot L_t + B_{t+1} + B_{t+1}^N - R_{t+1}^D \cdot D_t \quad \text{and} \quad D_t = L_t + B_t + B_t^N$$

  - Credit constraint:

$$R_{t+1}^D \cdot D_t \leq \phi_{t+1} \cdot R_{t+1}^L \cdot L_t + B_{t+1} + B_{t+1}^N$$

- Note: outstanding debts are pledged as collateral
- This implies:

$$B_t + B_t^N \begin{cases} = 0 & \text{if} \quad \left(B_t + B_t^N\right) \cdot E_t R_{t+1}^D > E_t B_{t+1} \\ \in [0, \infty) & \text{if} \quad \left(B_t + B_t^N\right) \cdot E_t R_{t+1}^D = E_t B_{t+1} \\ = \infty & \text{if} \quad \left(B_t + B_t^N\right) \cdot E_t R_{t+1}^D < E_t B_{t+1} \end{cases},$$

$$R_{t+1}^D = \min \left\{ R_{t+1}^L, \frac{\phi_{t+1} \cdot R_{t+1}^L \cdot L_t + B_{t+1} + B_{t+1}^N}{D_t} \right\}.$$

Dynamics and welfare

- The law of motion:

$$k_{t+1} = \begin{cases} = \dfrac{1-\alpha}{\gamma} \cdot A_t \cdot k_t^{\alpha} - \dfrac{b_t + b_t^N}{\gamma} & \text{if } E_t R_{t+1}^D > \rho \\ \in \left[0, \dfrac{1-\alpha}{\gamma} \cdot A_t \cdot k_t^{\alpha} - \dfrac{b_t + b_t^N}{\gamma}\right] & \text{if } E_t R_{t+1}^D = \rho \end{cases}$$

$$E_t R_{t+1}^D = E_t \phi_{t+1} \cdot \left(\alpha \cdot E_t A_{t+1} \cdot k_{t+1}^{\alpha-1} + 1 - \delta\right) + \frac{E_t b_{t+1}^N}{k_{t+1}}$$

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

- Restrictions on admissible bubbles:
  - Bubbles must be non-negative, i.e. $b_t \geq 0$ and $b_t^N \geq 0$
  - Bubbles cannot exceed savings, i.e. $b_t + b_t^N \leq (1-\alpha) \cdot A_t \cdot k_t^{\alpha}$
  - Bubbles must satisfy:

$$E_t b_{t+1} = \frac{E_t R_{t+1}^D}{\gamma} \cdot \left(b_t + b_t^N\right)$$

Dynamics and welfare (II)

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

- Welfare: measured as expected consumption of the generation

$$E_t c_{t+1} = \rho \cdot \left(\frac{1-\alpha}{\gamma} \cdot A_t \cdot k_t^{\alpha} - k_{t+1} - \frac{b_t + b_t^N}{\gamma} \right) + \alpha \cdot E_t A_{t+1} \cdot k_{t+1}^{\alpha} + (1-\delta) \cdot k_{t+1} + E_t \left\{ b_{t+1} + b_{t+1}^N \right\}$$

An economy with productivity and bubble shocks

- Simulate economy in three scenarios: abundant collateral (ϕ high), scarce collateral (ϕ low) and intermediate collateral (ϕ intermediate)
  - Productivity shocks exactly as before
  - Bubble shocks given by $b_t^N \in \left\{b_L^N, b_H^N\right\}$, with $b_L^N = 0$ and transition β. Given that

$$b_{t+1} = \frac{E_t R_{t+1}^D}{\gamma} \cdot \left(b_t + b_t^N\right),$$

bubble converges to $b = \dfrac{E_t R_{t+1}^D}{\gamma - E_t R_{t+1}^D} \cdot b_t^N$

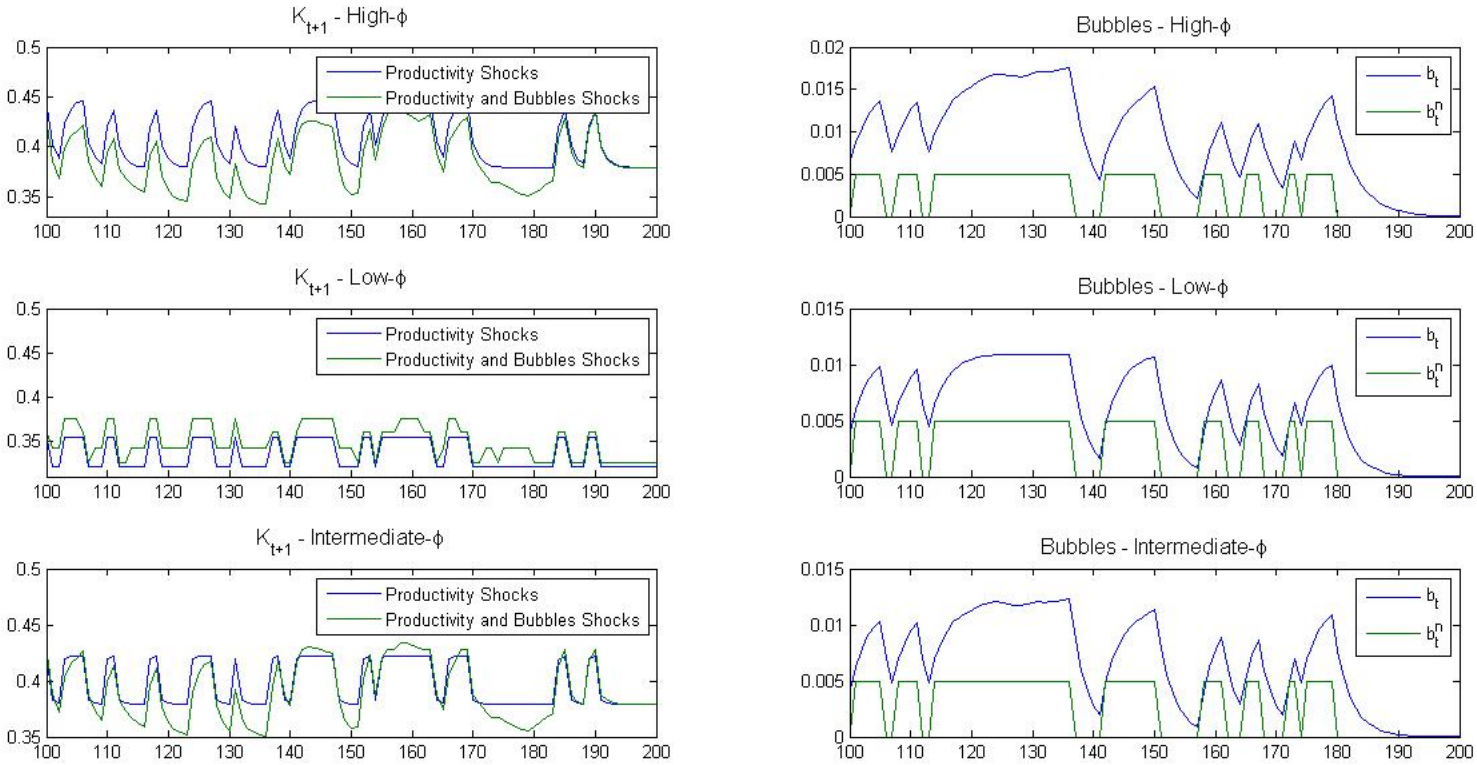

Figure 3: Productivity and Bubble Shocks

An economy with productivity and bubble shocks

- Simulate economy in three scenarios: abundant collateral (ϕ high), scarce collateral (ϕ low) and intermediate collateral (ϕ intermediate)
  - Productivity shocks exactly as before
  - Bubble shocks given by $b_t^N \in \left\{b_L^N, b_H^N\right\}$, with $b_L^N = 0$ and transition β. Given that

$$b_{t+1} = \frac{E_t R_{t+1}^D}{\gamma} \cdot \left(b_t + b_t^N\right),$$

    bubble converges to $b = \dfrac{E_t R_{t+1}^D}{\gamma - E_t R_{t+1}^D} \cdot b_t^N$

- 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
  - The bubble *destabilizes* the capital stock and welfare

An economy with financial and bubble shocks

- Simulate economy in three scenarios: abundant collateral (ϕ high), scarce collateral (ϕ low) and intermediate collateral (ϕ intermediate)
  - Financial shocks exactly as before
  - Bubble shocks given by $b_t^N \in \left\{b_L^N, b_H^N\right\}$, with $b_L^N = 0$ and transition β. Given that

$$b_{t+1} = \frac{E_t R_{t+1}^D}{\gamma} \cdot \left(b_t + b_t^N\right),$$

bubble converges to $b = \dfrac{E_t R_{t+1}^D}{\gamma - E_t R_{t+1}^D} \cdot b_t^N$

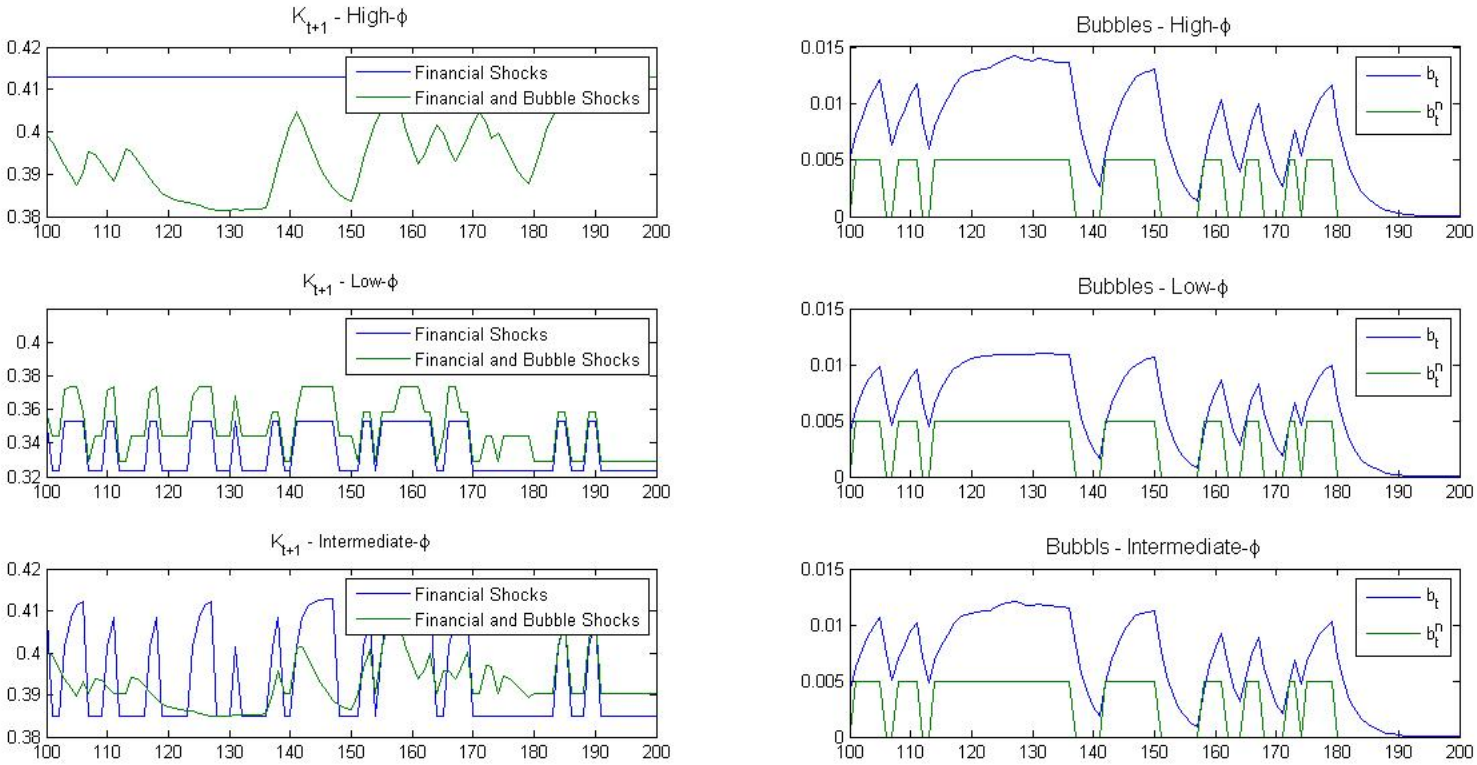

Figure 4: Financial and Bubble Shocks

An economy with financial and bubble shocks

- Simulate economy in three scenarios: abundant collateral (ϕ high), scarce collateral (ϕ low) and intermediate collateral (ϕ intermediate)
  - Financial shocks exactly as before
  - Bubble shocks given by $b_t^N \in \left\{b_L^N, b_H^N\right\}$, with $b_L^N = 0$ and transition β. Given that

$$b_{t+1} = \frac{E_t R_{t+1}^D}{\gamma} \cdot \left(b_t + b_t^N\right),$$

    bubble converges to $b = \dfrac{E_t R_{t+1}^D}{\gamma - E_t R_{t+1}^D} \cdot b_t^N$

- 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
  - 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 agency that can
  - tax young bankers
  - back 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 expected consumption

Bubbly economy with LOLR

- Introduce LOLR that intervenes in financial markets
  - agency that can taxed unbacked debt, but also subsidize it when bankers are unable to roll it over
  - intervention could be contingent
- Let S_t denote transfers to old bankers, financed by taxes on young bankers
  - no bailouts, i.e. no net transfers to bankers from other agents
- Savers and entrepreneurs unaffected
- Bankers maximize expected consumption subject to:
  - Budget constraint:

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

  - Credit constraint:

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

- Note: LOLR transfers can be pledged as collateral

Dynamics and welfare

- The law of motion:

$$k_{t+1} = \begin{cases} = \dfrac{1-\alpha}{\gamma} \cdot A_t \cdot k_t^{\alpha} - \dfrac{b_t + b_t^N + s_t}{\gamma} & \text{if } E_t R_{t+1}^D > \rho \\ \in \left[0, \dfrac{1-\alpha}{\gamma} \cdot A_t \cdot k_t^{\alpha} - \dfrac{b_t + b_t^N + s_t}{\gamma}\right] & \text{if } E_t R_{t+1}^D = \rho \end{cases}$$

$$E_t R_{t+1}^D = E_t \phi_{t+1} \cdot \left(\alpha \cdot E_t A_{t+1} \cdot k_{t+1}^{\alpha-1} + 1 - \delta\right) + \frac{E_t b_{t+1}^N}{k_{t+1}} + \frac{E_t s_{t+1}}{k_{t+1}} - \frac{E_t R_{t+1}^D}{\gamma} \cdot \frac{s_t}{k_{t+1}}$$

- 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 expected to be backed by LOLR
  - Ultimately, collateral provision of LOLR to banking system

$$\frac{E_t s_{t+1}}{E_t R_{t+1}^D} - \frac{s_t}{\gamma}$$

- Restrictions on admissible bubbles as before, but
  - Bubbles cannot exceed savings net of taxes, i.e. $b_t + b_t^N + s_t \leq (1-\alpha) \cdot A_t \cdot k_t^{\alpha}$

Dynamics and welfare (II)

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

- Welfare: measured as expected consumption of the generation:

$$\begin{aligned} E_t c_{t+1} \;=\; & \rho \cdot \left(\frac{1-\alpha}{\gamma} \cdot A_t \cdot k_t^{\alpha} - k_{t+1} - \frac{b_t + b_t^N + s_t}{\gamma} \right) + \alpha \cdot E_t A_{t+1} \cdot k_{t+1}^{\alpha} \\ & + (1-\delta) \cdot k_{t+1} + E_t \left\{ b_{t+1} + b_{t+1}^N + s_{t+1} \right\} \end{aligned}$$

An economy with abundant collateral and a LOLR

- If collateral is abundant, financial bubble crowds out capital accumulation and reduces consumption
- Simulate policy that neutralizes the effect of bubbles
  - Productivity, financial and bubble shocks as before
  - Policy consists in setting $s_0 = -\left(b_0 + b_0^N\right)$ and

$$s_{t+1} = \frac{E_t R_{t+1}^D}{\gamma} \cdot s_t - b_{t+1}^N$$

    from there onwards
  - Tax unbacked debt and transfer the proceeds to young bankers
- Main insights:
  - With full intermediation, bubble is contractionary
  - There is enough fundamental collateral and the crowding out effect of bubbles dominates
  - Policy raises capital stock and consumption, and may stabilize or destabilize the economy

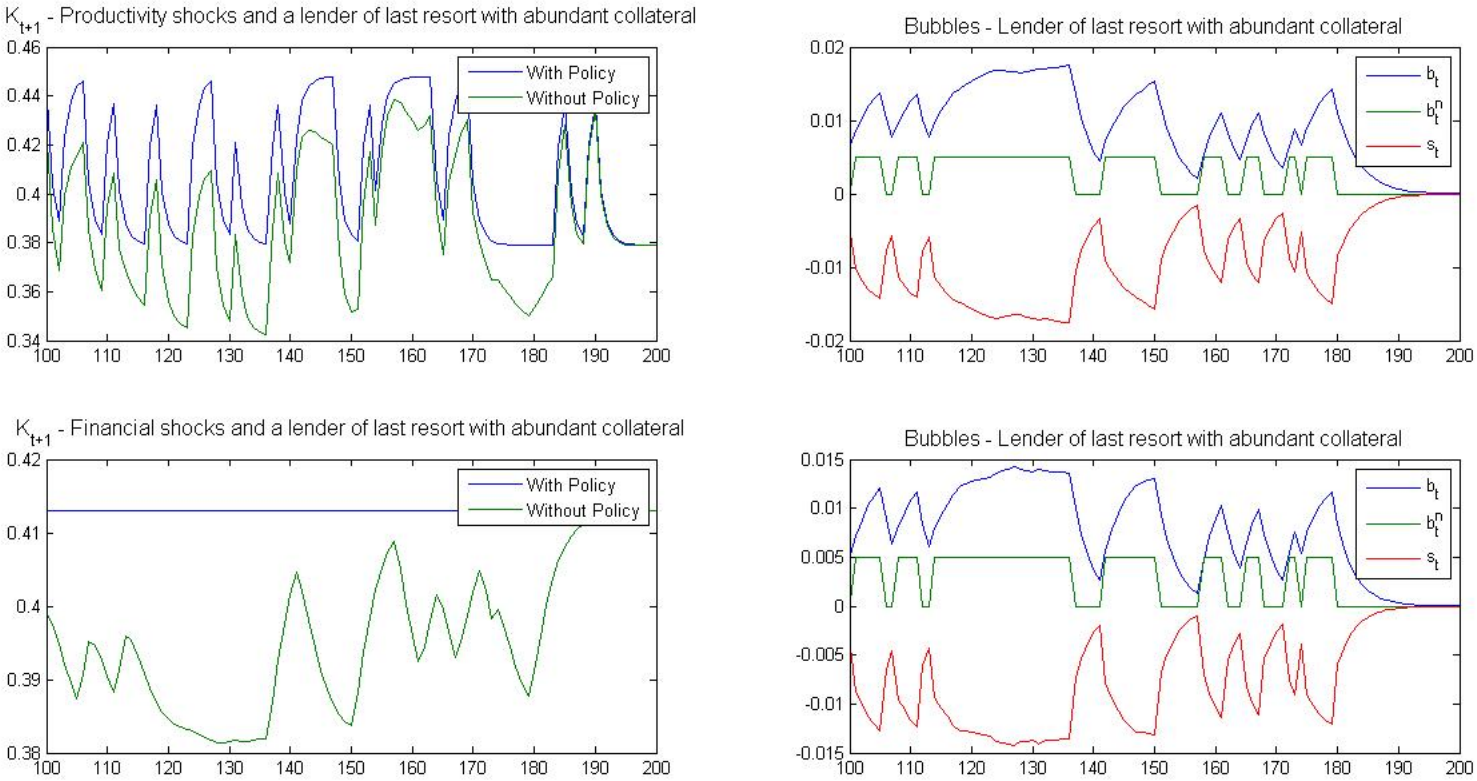

Figure 5: Lender of Last Resort With Abundant Collateral

An economy with scarce collateral a LOLR

- If fundamental collateral is scarce, financial bubble can provide additional collateral and raise capital accumulation and consumption

- Simulate policy that sustains bubbles

  – Productivity, financial and bubble shocks as before

  – Policy consists in setting $s_0 = 0$ and

$$s_{t+1} = \frac{\rho}{\gamma} \cdot s_t - b_{t+1}^N + [\rho - \phi_{t+1} \cdot (1 - \delta)] \cdot k_{t+1} - \phi_{t+1} \cdot \alpha \cdot A_{t+1} \cdot k_{t+1}^{\alpha - 1}$$

    from there onwards

  – This policy taxes young bankers and uses the proceeds to subsidize unbacked debt

- Main insights:

  – With partial intermediation, there is not enough fundamental collateral and the bubble can crowd in investment

  – LOLR policy can 'sustain' bubble by subsidizing old bankers in the event that unbacked debts cannot be rolled over

  – Policy tailored to provide collateral up to the point where inventories eliminated, but no more

  – Policy raises capital stock and consumption, and may stabilize or destabilize the economy

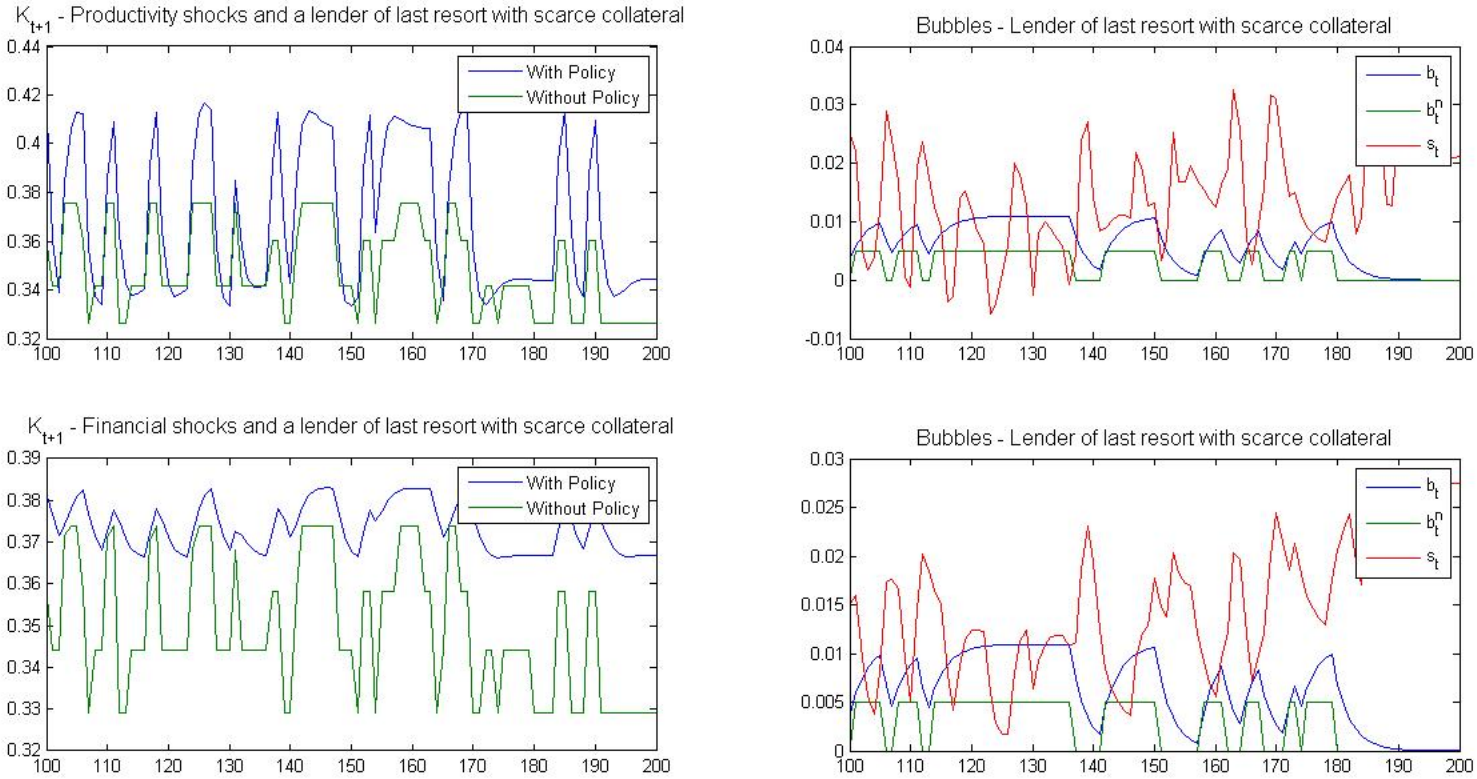

Figure 6: Lender of Last Resort With Scarce Collateral

The fiscal backstop

- When collateral is limited: LOLR can raise the capital stock and consumption by sustaining unbacked debts
  - In a sense, LOLR avoids aggregate panics or roll over-crises by pledging resources to old bankers
  - But does it have resources to honor this pledge? What is the fiscal backstop?
- Let τ denote the LOLR's taxation 'capacity', i.e. the max. that it can tax per effective worker
  - If $\tau \geq s_t$ in all periods along desired path, no problem: LOLR can always pay transfers with taxes
  - If $\tau < s_t$ in some periods along desired path, taxation not sufficient: in this case, LOLR can resort to debt
  - LOLR budget constraint becomes

$$\tau_t + \frac{E_t d_{t+1}}{E_t R^D_{t+1}} = s_t + d_t,$$

    where d_t denotes debt due at time t
- There seems to be no problem, except...
  - Current debt issues backed by future taxes and future debt issues
  - LOLR can issue debt today partly because it is expected to also issue debt in the future
  - Just like unbacked debt, LOLR debt is prone to changes in investor sentiment and roll over crises
  - Or is it?

The fiscal backstop (II)

- Suppose LOLR eliminates inventories and sets $E_t R^D_{t+1} = \rho$ for all t
  - Policy partly financed by raising debt
  - Debt issued at time t cannot exceed tax capacity and debt issued at $t+1$;

$$E_t d_{t+1} \leq \tau + \gamma \cdot E_t \left[\frac{E_{t+1} d_{t+2}}{\rho} \right]$$

  - But debt issued at time $t+1$ will also be limited by tax capacity and debt issued at $t+2$;

$$E_t d_{t+1} \leq \tau + \frac{\gamma}{\rho} \cdot E_t \left[\tau + \gamma \cdot E_{t+1} \left[\frac{E_{t+2} d_{t+3}}{\rho} \right] \right]$$

  - Iterating this process forward;

$$E_t d_{t+1} \leq \tau \cdot \sum_{n=0}^{\infty} \left(\frac{\gamma}{\rho} \right)^n = \infty$$

    where this last equality follows from $\frac{\gamma}{\rho} > 1$

- Interpretation
  - regardless of how small τ is, the LOLR has an unlimited fiscal backstop!
  - always true in the bubbly economy because growth rate exceeds the interest rate
  - discounted value of taxes is infinite
  - LOLR can provide unlimited collateral: desired policy can always be implemented

Additional issues

- Financial vs. corporate bubbles
  - Main insight: dynamics affected not only by amount of collateral, but also by its distribution
- What are inventories?
- Risk aversion and volatility
- Contract incompleteness and bankruptcy costs

Discussion and final thoughts

- Crisis began as widespread panic or run on financial system
  - simple theoretical model of financial bubbles
- Financial markets need collateral: how is it created?
  - Fundamental collateral (i.e. output) sustained by enforcement institutions
  - Bubbly collateral (i.e. debt that is expected to be rolled over) sustained by investor sentiment
- Bubbly episodes: fluctuations in credit and productive investment
  - financial bubbles provide collateral: may stabilize or destabilize the economy
  - when investor sentiment changes, bubbles burst and collateral falls
- Role for LOLR to manage collateral and raise output and consumption
  - in economy with limited intermediation, LOLR can 'sustain' bubbly collateral
    - ex-ante: policy creates collateral, boosts intermediation, investment and growth
    - ex-post: policy requires taxation, lowers intermediation, investment and growth
  - in the bubbly economy, fiscal backstop unlimited!
- At the end of the day revisit old and fascinating question
  - should the authority try to manage bubbles? (Bernanke and Gertler (1999))
  - but do so in a theoretically consistent model where the bubble is an equilibrium phenomenon

Where do we go from here?

- Can these mechanisms really be quantitatively important?
  - let's see
  - embed investor sentiment shock into quantitative model
    - sophisticated model with rich demographics / preferences
  - can we distinguish between TFP and investor sentiment shocks in recent past?
  - Carvalho et al. (2011)