Bubble-Driven Business Cycles

Seminar, University of Bonn

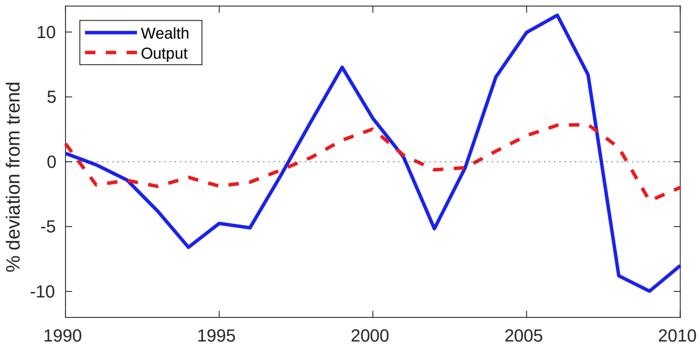
Benjamin Larin

January 29, 2020

University of St.Gallen; Swiss Institute for Empirical Economic Research; Globalization of Real Estate Network, University of Zurich

Introduction

Recent US boom-bust episodes



Notes: Both series are from US NIPA (FRED), expressed in logarithms, deflated with the CPI, and detrended with the HP filter. The smoothing parameter of the HP filter is set to 100 (see, e.g., Backus and Kehoe, 1992, AER or Ríos-Rull, 1996, REStud). Real net wealth in levels: 2001:Q1–2002:Q3: -10.06%, 2007:Q1–2009:Q3: -21.08%

HP-filter

This paper

- Boom-bust episodes have become more prevalent in recent history Carvalho, Martín, and Ventura (2012 *AER:P&P*)

This paper

- Boom-bust episodes have become more prevalent in recent history Carvalho, Martín, and Ventura (2012 *AER:P&P*)
- Bust: decline in real wealth by 10% and 21%

This paper

- Boom-bust episodes have become more prevalent in recent history Carvalho, Martín, and Ventura (2012 *AER:P&P*)
- Bust: decline in real wealth by 10% and 21%
    - Driven by asset price movements

This paper

- Boom-bust episodes have become more prevalent in recent history Carvalho, Martín, and Ventura (2012 *AER:P&P*)
- Bust: decline in real wealth by 10% and 21%
  - Driven by asset price movements
  - Adverse macroeconomic effects in terms of, e.g., welfare (Glover et al., forth. *JPE*) and confidence-driven output volatility (Heathcote and Perri, 2018 *REstud*; Hintermaier and Koeniger, 2018 *QE*)

This paper

- Boom-bust episodes have become more prevalent in recent history Carvalho, Martín, and Ventura (2012 *AER:P&P*)
- Bust: decline in real wealth by 10% and 21%
  - Driven by asset price movements
  - Adverse macroeconomic effects in terms of, e.g., welfare (Glover et al., forth. *JPE*) and confidence-driven output volatility (Heathcote and Perri, 2018 *REstud*; Hintermaier and Koeniger, 2018 *QE*)

$\rightarrow$ Fundamentals vs. bubble?

This paper

- Boom-bust episodes have become more prevalent in recent history Carvalho, Martín, and Ventura (2012 *AER:P&P*)
- Bust: decline in real wealth by 10% and 21%
    - Driven by asset price movements
    - Adverse macroeconomic effects in terms of, e.g., welfare (Glover et al., forth. *JPE*) and confidence-driven output volatility (Heathcote and Perri, 2018 *REstud*; Hintermaier and Koeniger, 2018 *QE*)

  → Fundamentals vs. bubble?
- Empirical evidence on the effect of (ir/rational) bubbles on the macroeconomy Brunnermeier and Schnabel (2016 *CEPR*); Jorda, Schularick, and Taylor (2015 *JME*)

This paper

- Boom-bust episodes have become more prevalent in recent history — Carvalho, Martín, and Ventura (2012 *AER:P&P*)
- Bust: decline in real wealth by 10% and 21%
  - Driven by asset price movements
  - Adverse macroeconomic effects in terms of, e.g., welfare (Glover et al., forth. *JPE*) and confidence-driven output volatility (Heathcote and Perri, 2018 *REstud*; Hintermaier and Koeniger, 2018 *QE*)

  → Fundamentals vs. bubble?
- Empirical evidence on the effect of (ir/rational) bubbles on the macroeconomy — Brunnermeier and Schnabel (2016 *CEPR*); Jorda, Schularick, and Taylor (2015 *JME*)

→ This paper: explain boom-bust episodes through the lens of a quantitative macro model with **rational bubbles**

Research questions

Research questions

- How to explain boom-bust episodes as a result of aggregate asset price bubbles?

Research questions

Research questions

- How to explain boom-bust episodes as a result of aggregate asset price bubbles?
- How does an OLG model with rational bubbles and financial frictions perform in a more generalized, quantitative setup?

What I do

- Extend overlapping-generations RBC model (Ríos-Rull, 1996, *REStud*) by i) rational and stochastic bubbles, ii) entrepreneurs and savers, and iii) credit market imperfections

What I do

- Extend overlapping-generations RBC model (Ríos-Rull, 1996, *REStud*) by i) rational and stochastic bubbles, ii) entrepreneurs and savers, and iii) credit market imperfections
- Model nests following stylized models

What I do

- Extend overlapping-generations RBC model (Ríos-Rull, 1996, *REStud*) by i) rational and stochastic bubbles, ii) entrepreneurs and savers, and iii) credit market imperfections
- Model nests following stylized models
- Model nests following stylized models

What I do

- Extend overlapping-generations RBC model (Ríos-Rull, 1996, *REStud*) by i) rational and stochastic bubbles, ii) entrepreneurs and savers, and iii) credit market imperfections
- Model nests following stylized models
- Model nests following stylized models
    - Tirole (1985 *Ectra*)
      $\rightarrow$ crowding-out channel

What I do

- Extend overlapping-generations RBC model (Ríos-Rull, 1996, *REStud*) by i) rational and stochastic bubbles, ii) entrepreneurs and savers, and iii) credit market imperfections
- Model nests following stylized models
- Model nests following stylized models
    - Tirole (1985 *Ectra*)
      $\rightarrow$ crowding-out channel
    - Farhi and Tirole (2012 *REStud*)
      $\rightarrow$ liquidity channel

What I do

- Extend overlapping-generations RBC model (Ríos-Rull, 1996, *REStud*) by i) rational and stochastic bubbles, ii) entrepreneurs and savers, and iii) credit market imperfections
- Model nests following stylized models
- Model nests following stylized models
    - Tirole (1985 *Ectra*)
      $\rightarrow$ crowding-out channel
    - Farhi and Tirole (2012 *REStud*)
      $\rightarrow$ liquidity channel
    - Martin and Ventura (2012 *AER*, 2016 *JEEA*)
      $\rightarrow$ bubble-creation channel

What I do

- Extend overlapping-generations RBC model (Ríos-Rull, 1996, *REStud*) by i) rational and stochastic bubbles, ii) entrepreneurs and savers, and iii) credit market imperfections
- Model nests following stylized models
- Model nests following stylized models
    - Tirole (1985 *Ectra*)
      → crowding-out channel
    - Farhi and Tirole (2012 *REStud*)
      → liquidity channel
    - Martin and Ventura (2012 *AER*, 2016 *JEEA*)
      → bubble-creation channel
- Numerical solution; analyze relevance of different transmission channels; compare model-generated results with observed data

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced

▸ literature

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced
- Bubbles affect the macroeconomy through different channels

▸ literature

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced
- Bubbles affect the macroeconomy through different channels
  - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)

▸ literature

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced
- Bubbles affect the macroeconomy through different channels
    - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
    - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *REStud*)

▸ literature

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced
- Bubbles affect the macroeconomy through different channels
  - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
  - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *REStud*)
  - New: stochastic channel of bubbles

▸ literature

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced
- Bubbles affect the macroeconomy through different channels
  - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
  - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *REStud*)
  - New: stochastic channel of bubbles
- Match US wealth and GDP from 1990 to 2010 with TFP and sentiment shocks

▸ literature

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced
- Bubbles affect the macroeconomy through different channels
  - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
  - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *REStud*)
  - New: stochastic channel of bubbles
- Match US wealth and GDP from 1990 to 2010 with TFP and sentiment shocks
  - Back out model-based measure of aggregate bubble

▸ literature

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced
- Bubbles affect the macroeconomy through different channels
  - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
  - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *REStud*)
  - New: stochastic channel of bubbles
- Match US wealth and GDP from 1990 to 2010 with TFP and sentiment shocks
  - Back out model-based measure of aggregate bubble
  - Bubble explains most of the fluctuations in wealth

▸ literature

What I find

- Calibrated model (US) admits equilibria with bubbles and they are expansionary if financial friction is sufficiently pronounced
- Bubbles affect the macroeconomy through different channels
  - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
  - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *REStud*)
  - New: stochastic channel of bubbles
- Match US wealth and GDP from 1990 to 2010 with TFP and sentiment shocks
  - Back out model-based measure of aggregate bubble
  - Bubble explains most of the fluctuations in wealth
  - Robust to including investment adjustment cost

▸ literature

The model

Households

- Overlapping generations with age denoted by $j \in \{1, 2, ..., J\}$

Households

- Overlapping generations with age denoted by $j \in \{1, 2, ..., J\}$
- Constant population growth: n

Households

- Overlapping generations with age denoted by $j \in \{1, 2, ..., J\}$
- Constant population growth: n
- GHH preferences:

Greenwood, Hercowitz, and Huffmann (1988, *AER*)

$$\mathbb{E} \sum_{j=1}^{J} \beta^{j-1} \zeta_j u(c_j, l_j), \qquad u(c_j, l_j) = \frac{\left[c_j - g^t \theta \frac{l_j^{1+\chi}}{1+\chi} \right]^{1-\sigma} - 1}{1 - \sigma}$$

Households

- Overlapping generations with age denoted by $j \in \{1, 2, ..., J\}$
- Constant population growth: n
- GHH preferences:

Greenwood, Hercowitz, and Huffmann (1988, *AER*)

$$\mathbb{E} \sum_{j=1}^{J} \beta^{j-1} \zeta_j u(c_j, l_j), \qquad u(c_j, l_j) = \frac{\left[c_j - g^t \theta \frac{l_j^{1+\chi}}{1+\chi}\right]^{1-\sigma} - 1}{1-\sigma}$$

- Earnings and pensions
  - $j \leq J^w$: supply labor and earn $(1-\tau) w e_j l_j$
  - $j > J^w$: retire and receive *pen*

Entrepreneurs

- A saver becomes an entrepreneur with probability p^E at age J^E

▸ Profit maximization wrt h_j

Entrepreneurs

- A saver becomes an entrepreneur with probability p^E at age J^E
- Entrepreneur has access to production technology

$$y_{t,j} = Z_t^Y k_{t,j}^{\alpha} \left(g^t h_{t,j}\right)^{1-\alpha}$$

▸ Profit maximization wrt h_j

Entrepreneurs

- A saver becomes an entrepreneur with probability p^E at age J^E
- Entrepreneur has access to production technology

$$y_{t,j} = Z_t^Y k_{t,j}^{\alpha} \left(g^t h_{t,j}\right)^{1-\alpha}$$

- Entrepreneurs choose the same capital-labor ratios $\Rightarrow$ aggregation:

$$Y_t = Z_t^Y K_t^{\alpha} \left(g^t L_t\right)^{1-\alpha}$$

$$w_t = (1-\alpha)\frac{Y_t}{L_t} \tag{1}$$

$$R_t = 1 + \alpha\frac{Y_t}{K_t} - \delta \tag{2}$$

▸ Profit maximization wrt h_j

Entrepreneurs

- A saver becomes an entrepreneur with probability p^E at age J^E
- Entrepreneur has access to production technology

$$y_{t,j} = Z_t^Y k_{t,j}^{\alpha} \left(g^t h_{t,j}\right)^{1-\alpha}$$

- Entrepreneurs choose the same capital-labor ratios $\Rightarrow$ aggregation:

$$Y_t = Z_t^Y K_t^{\alpha} \left(g^t L_t\right)^{1-\alpha}$$

$$w_t = (1-\alpha)\frac{Y_t}{L_t} \tag{1}$$

$$R_t = 1 + \alpha\frac{Y_t}{K_t} - \delta \tag{2}$$

- Entrepreneurs face linear profit function $\Pi_t(k_{t,j}) = (R_t - 1)k_{t,j}$

▸ Profit maximization wrt h_j

Savers

- Savers have access to an “inferior” production technology

$$y_{t,j,S} = (\gamma - 1 + \delta)k_{t,j,S}$$

Savers

- Savers have access to an “inferior” production technology

$$y_{t,j,S} = (\gamma - 1 + \delta)k_{t,j,S}$$

- (Gross) rate of return to inferior capital: $\gamma \geq 0$

Savers

- Savers have access to an “inferior” production technology

$$y_{t,j,S} = (\gamma - 1 + \delta)k_{t,j,S}$$

- (Gross) rate of return to inferior capital: $\gamma \geq 0$
- Only used if γ sufficiently large

Savers

- Savers have access to an “inferior” production technology

$$y_{t,j,S} = (\gamma - 1 + \delta)k_{t,j,S}$$

- (Gross) rate of return to inferior capital: $\gamma \geq 0$
- Only used if γ sufficiently large
- Alternative interpretation: storage technology that transfers 1 unit of income in t into γ units in $t+1$

$\Rightarrow$ Kinked credit supply curve

Credit markets

- Non-contingent one-period credit contracts with gross rate of return R^D_{t+1}

Credit markets

- Non-contingent one-period credit contracts with gross rate of return R_{t+1}^{D}
- Frictionless economy: savers lend to entrepreneurs such that marginal products are equalized

Credit markets

- Non-contingent one-period credit contracts with gross rate of return R^D_{t+1}
- Frictionless economy: savers lend to entrepreneurs such that marginal products are equalized
- Entrepreneurs face borrowing constraint Kiyotaki and Moore (1997, *JPE*)

$$R^D_{t+1} d_{t+1,j+1} \leq \mathbb{E}_t W_{t+1,j+1}$$

Firm value

- Collateral: firm value

$$W_{t+1,j+1} = \underbrace{(1-\delta)k_{t+1,j+1}}_{\text{fundamental}}$$

Firm value

- Collateral: firm value

$$W_{t+1,j+1} = \underbrace{(1-\delta)k_{t+1,j+1}}_{\text{fundamental}} + \underbrace{R^B_{t+1}\left[b_{t+1,j+1} + b^N_{t+1,j+1}\right]}_{\text{bubble}}$$

Firm value

- Collateral: firm value

$$W_{t+1,j+1} = \underbrace{(1-\delta)k_{t+1,j+1}}_{\text{fundamental}} + \underbrace{R^B_{t+1}\left[b_{t+1,j+1} + b^N_{t+1,j+1}\right]}_{\text{bubble}}$$

- R^B_{t+1}: Gross rate of return on bubbles

Firm value

- Collateral: firm value

$$W_{t+1,j+1} = \underbrace{(1-\delta)k_{t+1,j+1}}_{\text{fundamental}} + \underbrace{R^B_{t+1}\left[b_{t+1,j+1} + b^N_{t+1,j+1}\right]}_{\text{bubble}}$$

- R^B_{t+1}: Gross rate of return on bubbles
- New entrepreneurs create bubbles

Diba and Grossman (1988 *EJ*)

$$b^N_{t+1} = g^{t+1} \times \nu$$

Firm value

- Collateral: firm value

$$W_{t+1,j+1} = \underbrace{(1-\delta)k_{t+1,j+1}}_{\text{fundamental}} + \underbrace{R^B_{t+1}\left[b_{t+1,j+1} + b^N_{t+1,j+1}\right]}_{\text{bubble}}$$

- R^B_{t+1}: Gross rate of return on bubbles
- New entrepreneurs create bubbles

Diba and Grossman (1988 *EJ*)

$$b^N_{t+1} = g^{t+1} \times \nu$$

- Aggregate bubble evolves according to

$$B_{t+1} = R^B_t(B_t + B^N_t)$$

Savers' problem

$$V^S(j, m; \Omega) = \max_{c,l,a'} u(c, l) + \beta \varrho_{j+1} \mathbb{E} V^S(j+1, m'; \Omega') \tag{3}$$

subject to

$$c + d' = (1 - \tau) w e_j l + m + I_j^r pen + beq$$
$$m' = R^{D'} d', \quad d' \geq 0$$

Notes:

- Inferior production vs lending
  - If $R^D = \gamma$ savers are indifferent
  - If $R^D > \gamma$ savers do not use inferior production technology
- Different problem for $j = J^E - 1$ ...

Savers' problem for $j = J^E - 1$

$$V^S(J^E - 1, m; \Omega) = \max_{c,l,a'} u(c, l) + p^E \beta \varrho_{j+1} \mathbb{E} V^E(J^E, m'; \Omega') \qquad (4)$$
$$+ (1 - p^E) \beta \varrho_{j+1} \mathbb{E} V^S(J^E, m'; \Omega')$$

subject to

$$c + a' = (1 - \tau) w e_j l + m + I_j^r pen + beq$$
$$m' = R^{D'} a', \quad a' \geq 0$$

Entrepreneurs' problem

$$V^E(j, m; \Omega) = \max_{c,l,k',b',d'} u(c, l) + \beta \varrho_{j+1} \mathbb{E} V^E(j+1, m'; \Omega') \qquad (5)$$

subject to

$$c + k' + b' - d' = (1-\tau) w e_j l + m + I_j^r pen + beq$$

$$R^{D'} d' \leq (1-\delta) k' + R^{B'} \left(b' + b^{N'} \right)$$

$$m' = R' k' - R^{D'} d' + R^{B'} \left(b' + b^{N'} \right)$$

Note: for $j = J^E$ net worth is given by $m = R^D a$

Equilibrium (I of III)

A *sequential equilibrium* consists of sequences of individual consumption and labor supply $\left\{c_{t,j}, l_{t,j}\right\}_{j=1}^{J}$ for both savers and entrepreneurs as well as of sequences of bubbles, bonds, capital, and debt $\{b_{t,j}, a_{t,j}, k_{t,j}, d_{t,j}, \}_{j=1}^{J}$ for all $t \geq 0$ maximizing the household problems eqs. (3) to (5), a sequence of prices $\{w_t, R_t, R_t^D, R_t^B\}_{t=0}^{\infty}$ satisfying eqs. (1) and (2), a sequence of shocks $\left\{Z_t^Y\right\}_{t=1}^{\infty}$ drawn from its respective distribution and initial values $\left\{b_{0,j}, a_{0,j}, k_{0,j}, d_{0,j}\right\}_{j=1}^{J}, Z_0^Y, R_0^d$ such that

- the labor market clears

$$\underbrace{\sum_{j=1}^{J} N_{t,j} e_j l_{j,t}}_{\text{labor supply}} = \underbrace{\sum_{j=J^w}^{J} \frac{p^E N_{t,j}}{\varrho_j} h_{j,t}}_{\text{labor demand}} = L_t,$$

Equilibrium (II of III)

- the capital market clears

$$K_t = \sum_{j=J^E+1}^{J} \frac{p^E N_{t,j}}{\varrho_j} k_{t,j},$$

- the market for bubbles clears

$$\underbrace{B_t}_{\text{supply of bubbles}} = \underbrace{\sum_{j=J^E}^{J} \frac{p^E N_{t,j}}{\varrho_j} b_{t,j}}_{\text{demand for bubbles}},$$

- the credit market clears

$$A_t \equiv \sum_{j=1}^{J^E} \frac{N_{t,j}}{\varrho_j} a_{t,j} + \sum_{s=J^E+1}^{J} \frac{(1-p^E) N_{t,j}}{\varrho_j} a_{t,j} \geq \sum_{j=J^E+1}^{J} \frac{p^E N_{t,j}}{\varrho_j} d_{t,j} \equiv D_t,$$

Equilibrium (III of III)

- the government budget is balanced

$$\tau w_t L_t = \sum_{j=J^w+1}^{J} N_{t,j} pen_t,$$

- the goods market clears

$$Y_t + \gamma(A_t - D_t) = C_t + K_{t+1} - (1-\delta)K_t + (A_{t+1} - D_{t+1}),$$

- bubbles are freely disposable and the capital stock is positive

$$B_t \geq 0, K_t \geq 0.$$

Steady state results

Existence of bubbles in equilibrium (I) (non-stochastic steady state; $\gamma = 0$)

- In equilibrium bubbles have to satisfy
  - Micro-consistency: strictly positive and bounded demand by agents

Existence of bubbles in equilibrium (I) (non-stochastic steady state; $\gamma = 0$)

- In equilibrium bubbles have to satisfy
  - Micro-consistency: strictly positive and bounded demand by agents
  - Macro-consistency:

$$B_t \geq 0, K_t \geq 0$$

Existence of bubbles in equilibrium (I) (non-stochastic steady state; $\gamma = 0$)

- In equilibrium bubbles have to satisfy
  - Micro-consistency: strictly positive and bounded demand by agents
  - Macro-consistency:

$$B_t \geq 0, K_t \geq 0$$

- Necessary conditions

	Fundamental	
Binding	$R^D < R$	
Slack	$R^D = R$	

Existence of bubbles in equilibrium (I) (non-stochastic steady state; $\gamma = 0$)

- In equilibrium bubbles have to satisfy
  - Micro-consistency: strictly positive and bounded demand by agents
  - Macro-consistency:

$$B_t \geq 0, K_t \geq 0$$

- Necessary conditions

	Fundamental	Bubbly
		no bubble creation
Binding	$R^D < R$	$R^B = R^D = gn < R$
Slack	$R^D = R$	

Existence of bubbles in equilibrium (I) (non-stochastic steady state; $\gamma = 0$)

- In equilibrium bubbles have to satisfy
  - Micro-consistency: strictly positive and bounded demand by agents
  - Macro-consistency:

$$B_t \geq 0, K_t \geq 0$$

- Necessary conditions

	Fundamental	Bubbly
		no bubble creation
Binding	$R^D < R$	$R^B = R^D = gn < R$
Slack	$R^D = R$	$R^B = R^D = gn = R$

Existence of bubbles in equilibrium (I) (non-stochastic steady state; $\gamma = 0$)

- In equilibrium bubbles have to satisfy
  - Micro-consistency: strictly positive and bounded demand by agents
  - Macro-consistency:

$$B_t \geq 0, K_t \geq 0$$

- Necessary conditions

	Fundamental	Bubbly	
		no bubble creation	bubble creation
Binding	$R^D < R$	$R^B = R^D = gn < R$	$R^B = R^D < \{gn, R\}$
Slack	$R^D = R$	$R^B = R^D = gn = R$	

Existence of bubbles in equilibrium (I) (non-stochastic steady state; $\gamma = 0$)

- In equilibrium bubbles have to satisfy
  - Micro-consistency: strictly positive and bounded demand by agents
  - Macro-consistency:

$$B_t \geq 0, K_t \geq 0$$

- Necessary conditions

	Fundamental	Bubbly	
		no bubble creation	bubble creation
Binding	$R^D < R$	$R^B = R^D = gn < R$	$R^B = R^D < \{gn, R\}$
Slack	$R^D = R$	$R^B = R^D = gn = R$	$R^B = R^D = R < gn$

Existence of bubbles in equilibrium (II) (non-stochastic steady state; $\gamma = 0$)

- Testable implications for gn, R^D, R in postwar US   Jorda et al. (2019, *QJE*)

Existence of bubbles in equilibrium (II) (non-stochastic steady state; $\gamma = 0$)

- Testable implications for gn, R^D, R in postwar US Jorda et al. (2019, *QJE*)
    - Average real GDP growth: $gn = 1.032$

Existence of bubbles in equilibrium (II) (non-stochastic steady state; $\gamma = 0$)

- Testable implications for gn, R^D, R in postwar US Jorda et al. (2019, *QJE*)
  - Average real GDP growth: $gn = 1.032$
  - Return on bonds: $R^D = 1.017$

Existence of bubbles in equilibrium (II) (non-stochastic steady state; $\gamma = 0$)

- Testable implications for gn, R^D, R in postwar US   Jorda et al. (2019, *QJE*)
    - Average real GDP growth: $gn = 1.032$
    - Return on bonds: $R^D = 1.017$
    - Return on capital: $R = 1.067$

Existence of bubbles in equilibrium (II) (non-stochastic steady state; $\gamma = 0$)

- Testable implications for gn, R^D, R in postwar US Jorda et al. (2019, *QJE*)
  - Average real GDP growth: $gn = 1.032$
  - Return on bonds: $R^D = 1.017$
  - Return on capital: $R = 1.067$

$\Rightarrow$ $R^D < gn < R$:

  - Rational bubbles might have existed in the US
  - Borrowing constraint has to be binding
  - Bubble creation has to exist

Existence of bubbles in equilibrium (II) (non-stochastic steady state; $\gamma = 0$)

- Testable implications for gn, R^D, R in postwar US   Jorda et al. (2019, *QJE*)
  - Average real GDP growth: $gn = 1.032$
  - Return on bonds: $R^D = 1.017$
  - Return on capital: $R = 1.067$

  $\Rightarrow R^D < gn < R$:
    - Rational bubbles might have existed in the US
    - Borrowing constraint has to be binding
    - Bubble creation has to exist
- With $\gamma > 0$: similar conclusions, except that $R^D \geq \gamma$
  - If $R^D > \gamma$: Savers do not use inferior technology
  - If $R^D = \gamma$: Savers use inferior technology and R^D constant

Calibration strategy postwar US; annual; $\gamma = 0$

- Cross-section: $\{e_j\}_{j=1}^{J}$ to match 1995 earnings distribution (SCF)

▸ details ▸ cross-sectional fit

Calibration strategy postwar US; annual; $\gamma = 0$

- Cross-section: $\{e_j\}_{j=1}^{J}$ to match 1995 earnings distribution (SCF)
- Agnostic calibration of bubble creation: set ν to match entrepreneurial wealth share of bubbles of 1% (steady state)

▸ details ▸ cross-sectional fit

Calibration strategy postwar US; annual; $\gamma = 0$

- Cross-section: $\{e_j\}_{j=1}^{J}$ to match 1995 earnings distribution (SCF)
- Agnostic calibration of bubble creation: set ν to match entrepreneurial wealth share of bubbles of 1% (steady state)
- Match empirical values for R^D, gn and R by

▸ details ▸ cross-sectional fit

Calibration strategy postwar US; annual; $\gamma = 0$

- Cross-section: $\{e_j\}_{j=1}^{J}$ to match 1995 earnings distribution (SCF)
- Agnostic calibration of bubble creation: set ν to match entrepreneurial wealth share of bubbles of 1% (steady state)
- Match empirical values for R^D, gn and R by
  - setting $g = 1.02$ and $n = 1.011$ as observed in the data

▸ details ▸ cross-sectional fit

Calibration strategy postwar US; annual; $\gamma = 0$

- Cross-section: $\{e_j\}_{j=1}^{J}$ to match 1995 earnings distribution (SCF)
- Agnostic calibration of bubble creation: set ν to match entrepreneurial wealth share of bubbles of 1% (steady state)
- Match empirical values for R^D, gn and R by
  - setting $g = 1.02$ and $n = 1.011$ as observed in the data
  - match $R = 1.067$ by setting $\delta = 0.052$ ($\frac{K}{Y}$ will be matched with β)

$$\delta = 1 + \alpha \left(K/Y\right)^{-1} - R.$$

$\Rightarrow$ implied investment-output ratio of 0.23 (0.174 in the data)

▸ details ▸ cross-sectional fit

Calibration strategy postwar US; annual; $\gamma = 0$

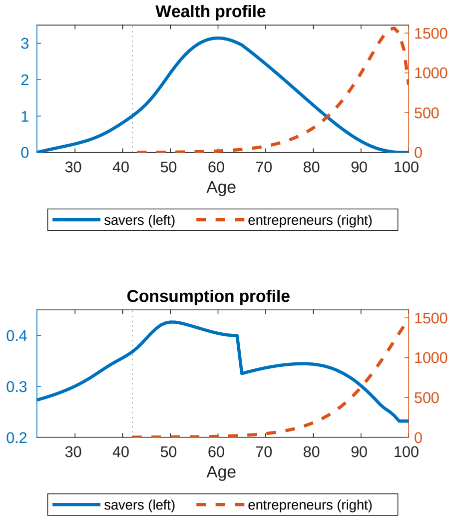
- Cross-section: $\{e_j\}_{j=1}^{J}$ to match 1995 earnings distribution (SCF)
- Agnostic calibration of bubble creation: set ν to match entrepreneurial wealth share of bubbles of 1% (steady state)
- Match empirical values for R^D, gn and R by
  - setting $g = 1.02$ and $n = 1.011$ as observed in the data
  - match $R = 1.067$ by setting $\delta = 0.052$ ($\frac{K}{Y}$ will be matched with β)

    $$\delta = 1 + \alpha \left(K/Y\right)^{-1} - R.$$

    $\Rightarrow$ implied investment-output ratio of 0.23 (0.174 in the data)
  - match $R - R^D = 0.05$ by setting $\eta = 0.001$ ($p^E = 0.002$)

▸ details ▸ cross-sectional fit

Entrepreneurs and savers experience very different lives



→ CEV of entrepreneur's vs saver's life: 232 %

The macroeconomic effect of bubbles: decomposition

	General equil. fundamental	Partial equil.	General equil. bubbly
Output Y	0		**0.9**
Capital K	0		**2.2**
Labor L	0		**0.2**
Credit demand D	0		**2.2**
Savers' wealth A	0		**2.2**
Entrep.' wealth A^E	0		**3.2**
Bubble B	0		**1**

All in %, bubble relative to wealth, other relative to previous column. Prices: $b^N\uparrow$, $w\uparrow$, $pen\uparrow$, $beq\uparrow$, $R\downarrow$, $R^D\uparrow$

$\rightarrow$ Total effect of bubbles: expansionary

The macroeconomic effect of bubbles: decomposition

	General equil. fundamental	Partial equil.	General equil. bubbly
		b^N	
Output Y	0	7.6	
Capital K	0	24.4	
Labor L	0	0	
Credit demand D	0	24.4	
Savers' wealth A	0	-0.0	
Entrep.' wealth A^E	0	24.4	
Bubble B	0	0	

All in %, bubble relative to wealth, other relative to previous column. Prices: $b^N \uparrow$, $w \uparrow$, $pen \uparrow$, $beq \uparrow$, $R \downarrow$, $R^D \uparrow$

→ Bubble-creation channel: expansionary (if borrowing constraint binding)

Martin and Ventura (2012 *AER*, 2016 *JEEA*)

$$R^D d \leq (1-\delta)k + R^B(b + b^N)$$

The macroeconomic effect of bubbles: decomposition

	General equil. fundamental	Partial equil.			General equil. bubbly
		b^N	$w + pen + beq$		
Output Y	0	7.6	1.8		
Capital K	0	24.4	0.8		
Labor L	0	0	2.3		
Credit demand D	0	24.4	0.8		
Savers' wealth A	0	-0.0	0.8		
Entrep.' wealth A^E	0	24.4	0.8		
Bubble B	0	0	0		

All in %, bubble relative to wealth, other relative to previous column. Prices: $b^N \uparrow$, $w \uparrow$, $pen \uparrow$, $beq \uparrow$, $R \downarrow$, $R^D \uparrow$

$\rightarrow$ Amplified by higher wages and pensions

The macroeconomic effect of bubbles: decomposition

	General equil. fundamental	Partial equil.			General equil. bubbly
		b^N	$w + pen + beq$	R	
Output Y	0	7.6	1.8	-4.9	
Capital K	0	24.4	0.8	-13.5	
Labor L	0	0	2.3	-1.2	
Credit demand D	0	24.4	0.8	-13.5	
Savers' wealth A	0	-0.0	0.8	0	
Entrep.' wealth A^E	0	24.4	0.8	-13.5	
Bubble B	0	0	0	0	

All in %, bubble relative to wealth, other relative to previous column. Prices: $b^N \uparrow$, $w \uparrow$, $pen \uparrow$, $beq \uparrow$, $R \downarrow$, $R^D \uparrow$

$\rightarrow$ Dampened by lower return on capital

The macroeconomic effect of bubbles: decomposition

	General equil. fundamental	Partial equil.				General equil. bubbly
		b^N	$w + pen + beq$	R	savers' R^D	
Output Y	0	7.6	1.8	-4.9	0.3	
Capital K	0	24.4	0.8	-13.5	0.7	
Labor L	0	0	2.3	-1.2	0.1	
Credit demand D	0	24.4	0.8	-13.5	0.7	
Savers' wealth A	0	-0.0	0.8	0	1.4	
Entrep.' wealth A^E	0	24.4	0.8	-13.5	0.7	
Bubble B	0	0	0	0	0	

All in %, bubble relative to wealth, other relative to previous column. Prices: $b^N \uparrow$, $w \uparrow$, $pen \uparrow$, $beq \uparrow$, $R \downarrow$, $R^D \uparrow$

$\rightarrow$ Liquidity channel: expansionary (if borrowing constraint binding)

Farhi and Tirole (2012 *REStud*)

Higher $R^D \Rightarrow$ savers save more $\Rightarrow$ new entrepreneurs start with higher net worth $\Rightarrow$ more investment

The macroeconomic effect of bubbles: decomposition

	General equil. fundamental	Partial equil.					General equil. bubbly
		b^N	$w + pen + beq$	R	savers' R^D	entrep.' R^D	
Output Y	0	7.6	1.8	-4.9	0.3	-3.9	
Capital K	0	24.4	0.8	-13.5	0.7	-10.2	
Labor L	0	0	2.3	-1.2	0.1	-1	
Credit demand D	0	24.4	0.8	-13.5	0.7	-10.2	
Savers' wealth A	0	-0.0	0.8	0	1.4	0	
Entrep.' wealth A^E	0	24.4	0.8	-13.5	0.7	-9.2	
Bubble B	0	0	0	0	0	1	

All in %, bubble relative to wealth, other relative to previous column. Prices: $b^N \uparrow$, $w \uparrow$, $pen \uparrow$, $beq \uparrow$, $R \downarrow$, $R^D \uparrow$

→ crowding-out channel: always contractionary

Tirole (1985 *Ectra*)

$$R^D d \leq (1-\delta)k + R^B(b + b^N)$$

Higher $R^D \Rightarrow$ Lower leverage: bubbles crowd-out capital

The macroeconomic effect of bubbles: decomposition

	General equil. fundamental	Partial equil.					General equil. bubbly
		b^N	$w + pen + beq$	R	savers' R^D	entrep.' R^D	
Output Y	0	7.6	1.8	-4.9	0.3	-3.9	**0.9**
Capital K	0	24.4	0.8	-13.5	0.7	-10.2	**2.2**
Labor L	0	0	2.3	-1.2	0.1	-1	**0.2**
Credit demand D	0	24.4	0.8	-13.5	0.7	-10.2	**2.2**
Savers' wealth A	0	-0.0	0.8	0	1.4	0	**2.2**
Entrep.' wealth A^E	0	24.4	0.8	-13.5	0.7	-9.2	**3.2**
Bubble B	0	0	0	0	0	1	**1**

All in %, bubble relative to wealth, other relative to previous column. Prices: $b^N \uparrow$, $w \uparrow$, $pen \uparrow$, $beq \uparrow$, $R \downarrow$, $R^D \uparrow$

- Bubbles have an expansionary effect in the calibrated model
- Mainly through the bubble-creation channel
- Liquidity channel almost irrelevant

▸ different ordering ▸ $\gamma = R^D$ ▸ different ν ▸ different $\eta, J^E, \delta, \sigma$

Bubble-driven business cycles

Computation

- Stochastic bubbles: ex-post return on bubbles

$$R_t^B = \underbrace{Z_t^B}_{\text{exogenous}} \times \underbrace{\widetilde{R}_t^B}_{\text{endogenous}}$$

- **Market sentiment:** $\ln Z_t^B$ is a Gaussian white noise with variance σ^B

Computation

- Stochastic bubbles: ex-post return on bubbles

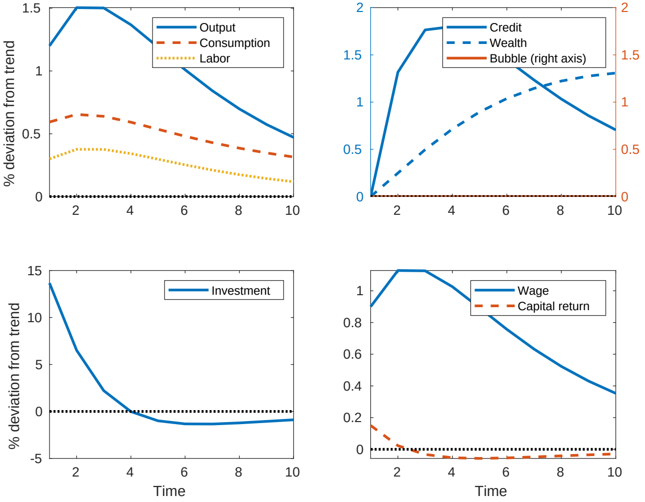
$$R_t^B = \underbrace{Z_t^B}_{\text{exogenous}} \times \underbrace{\widetilde{R}_t^B}_{\text{endogenous}}$$

- **Market sentiment:** $\ln Z_t^B$ is a Gaussian white noise with variance σ^B
- EGM for solving household problem and IRF as a numerical derivative obtained from MIT shocks Boppart, Krusell and Mitman (2018, *JEDC*)
- Focus on $\gamma = \bar{R}^D + \epsilon$, with small ϵ

▸ $\gamma = 0$

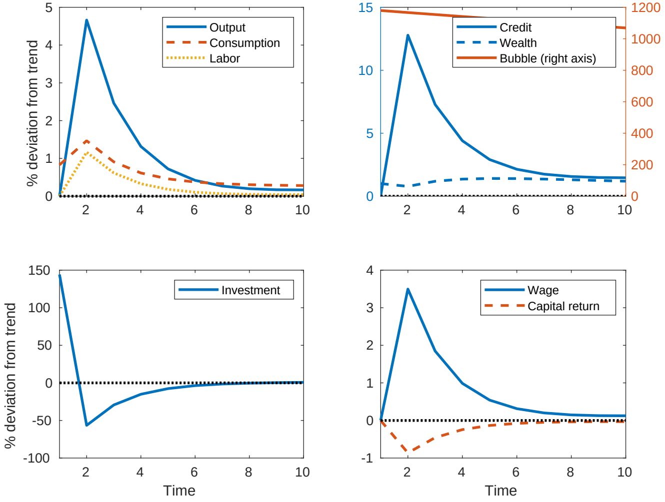
▸ linearity in Z^Y ▸ linearity in Z^B

A *real* business cycle (1% TFP shock)



▸ differences to Ríos-Rull, 1996, *REStud*

A *bubble-driven* business cycle (bubble shock → wealth increases by 1% on impact)



Two recent US boom-bust episodes

Computation of model-implied bubble

- 1990–2010: match $\{Y_t, \mathcal{W}_t\}_{t=1990}^{2010}$ by solving linear IRFs for innovations $\{\epsilon_t^Y, \epsilon_t^B\}_{t=1990}^{2010}$

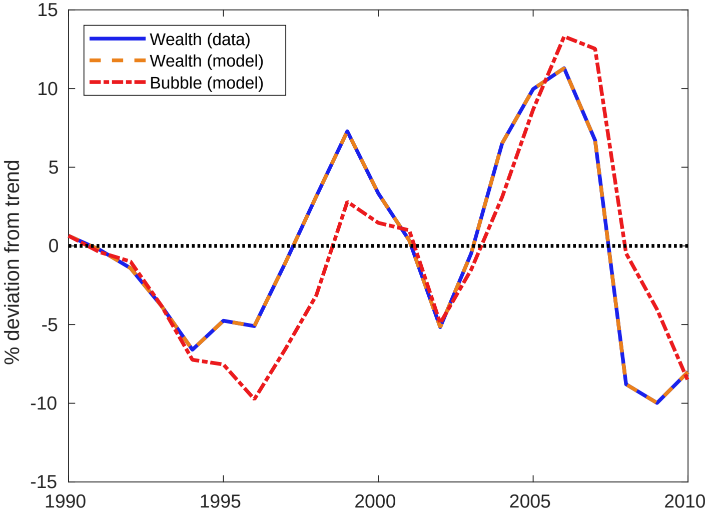
Computation of model-implied bubble

- 1990–2010: match $\{Y_t, \mathcal{W}_t\}_{t=1990}^{2010}$ by solving linear IRFs for innovations $\{\epsilon_t^Y, \epsilon_t^B\}_{t=1990}^{2010}$
- Decomposition

$$\underbrace{\frac{\mathcal{W}_t - \overline{\mathcal{W}}}{\overline{\mathcal{W}}}}_{\text{total wealth}} = \underbrace{\frac{(K_t - \overline{K}) - (D_t - \overline{D}) + (A_t - \overline{A})}{\overline{\mathcal{W}}}}_{\text{fundamental wealth}} + \underbrace{\frac{B_t - \overline{B}}{\overline{\mathcal{W}}}}_{\text{bubbly wealth}}$$

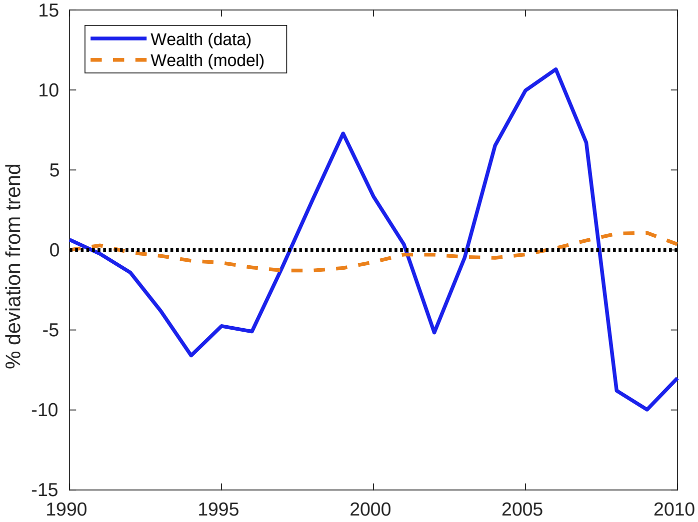
where $\mathcal{W}_t \equiv K_t - D_t + A_t + B_t$.

Recent US boom-bust episodes were driven by a bubble ...



▸ shock series

… and cannot be explained by TFP shocks alone



investment adjustment cost

Summary

Summary

- Explain boom-bust episodes trough the lens of a quantitative overlapping-generations RBC model (Rios-Rull, 1996 *REStud*) with rational, stochastic bubbles and financial frictions

Summary

- Explain boom-bust episodes trough the lens of a quantitative overlapping-generations RBC model (Rios-Rull, 1996 *REStud*) with rational, stochastic bubbles and financial frictions
- Calibrated model can generate expansionary bubbles

Summary

- Explain boom-bust episodes trough the lens of a quantitative overlapping-generations RBC model (Rios-Rull, 1996 *REStud*) with rational, stochastic bubbles and financial frictions
- Calibrated model can generate expansionary bubbles
- Bubbles affect macroeconomy through different channels

Summary

- Explain boom-bust episodes trough the lens of a quantitative overlapping-generations RBC model (Rios-Rull, 1996 *REStud*) with rational, stochastic bubbles and financial frictions
- Calibrated model can generate expansionary bubbles
- Bubbles affect macroeconomy through different channels
  - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)

Summary

- Explain boom-bust episodes trough the lens of a quantitative overlapping-generations RBC model (Rios-Rull, 1996 *REStud*) with rational, stochastic bubbles and financial frictions
- Calibrated model can generate expansionary bubbles
- Bubbles affect macroeconomy through different channels
    - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
    - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *ECTA*)

Summary

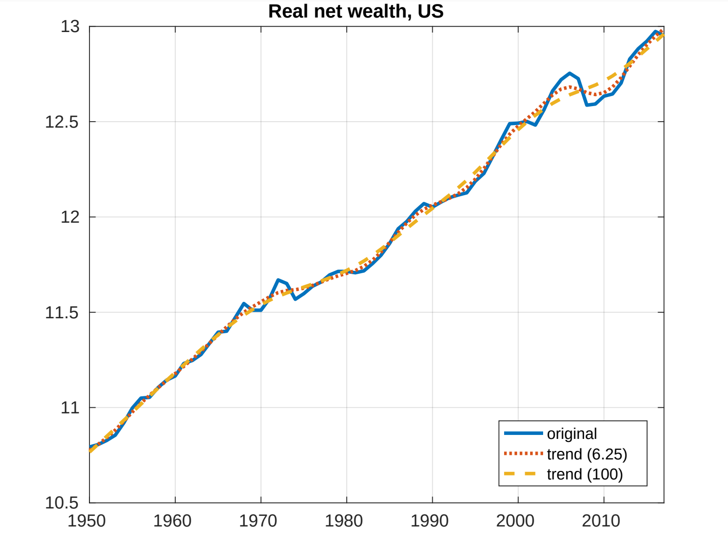
- Explain boom-bust episodes trough the lens of a quantitative overlapping-generations RBC model (Rios-Rull, 1996 *REStud*) with rational, stochastic bubbles and financial frictions
- Calibrated model can generate expansionary bubbles
- Bubbles affect macroeconomy through different channels
    - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
    - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *ECTA*)
    - New channel in multi-period setting: stochastic channel of bubbles

Summary

- Explain boom-bust episodes trough the lens of a quantitative overlapping-generations RBC model (Rios-Rull, 1996 *REStud*) with rational, stochastic bubbles and financial frictions
- Calibrated model can generate expansionary bubbles
- Bubbles affect macroeconomy through different channels
  - Bubble-creation channel necessary for expansionary bubbles to exist — Martin and Ventura (2012 *AER*, 2016 *JEEA*)
  - Liquidity channel quantitatively negligible — Farhi and Tirole (2012 *ECTA*)
  - New channel in multi-period setting: stochastic channel of bubbles
- Recent US boom-bust episodes can be explained by *bubble-driven* business cycle

Appendix

HP-filtered US wealth



back

Literature: quant DSGE literature on boom-bust episodes

- Amplification of fundamental shocks through financial sector

  Bernanke and Gertler (1989 *AER*); Kiyotaki and Moore (1997 *JPE*); Christiano et al. (2015 *AEJ:M*); ...

- Shocks emanating in financial sector, e.g. "valuation shocks" and "liquidity shocks"

  Gertler and Karadi (2011 *JME*); Kiyotaki and Moore (2012 *NBER*); ...

- Shocks to utility function parameters

  Iacoviello (2005 *AER*); Iacoviello and Neri (2010 *AEJ:M*); Kaplan at al. (forth. *JPE*); ...

- Exogenous or near-rational bubbles

  Bernanke and Gertler (1999, 2001), Luik and Wesselbaum (2014 *JM*); Adam et al. (2017 *AER*); ...

$\rightarrow$ Explain boom-bust episodes with **rational bubbles**

Literature: rational bubbles in GE models

- Early models: contractionary bubbles — Samuelson (1958 *JPE*); Tirole (1985 *Ectra*)
- Recent models: expansionary bubbles by adding (financial) frictions

  Farhi and Tirole (2012 *Ectra*); Martin and Ventura (2012 *AER*, 2016 *JEEA*, 2018 *ARE*); Galí (2014 *AER*); ...

  → large-scale OLG, concave utility, TFP shocks, endogenous labor supply, ...

  → confront theory with the data
- More quantitative — Miao, Wang and Xu (2015, *QE*); Galí (2018); Domeij and Ellingson (2018, *JME*)

  → Different mechanisms, very small effects

→ First to consider **rational bubbles** within a **DSGE model** with **overlapping generations** and **financial frictions**

▸ back

Entrepreneurs: static labor choice (I)

- Static problem ($k_{t,j}$ and Z_t^Y are given in t)

$$\max_{h_{t,j}} \Pi_{t,j} = Z_t^Y k_{t,j}^{\alpha} \left(g^t h_{t,j}\right)^{1-\alpha} - w_t h_{t,j} - \delta k_{t,j},$$

Entrepreneurs: static labor choice (I)

- Static problem ($k_{t,j}$ and Z_t^Y are given in t)

$$\max_{h_{t,j}} \Pi_{t,j} = Z_t^Y k_{t,j}^{\alpha} \left(g^t h_{t,j}\right)^{1-\alpha} - w_t h_{t,j} - \delta k_{t,j},$$

Entrepreneurs: static labor choice (I)

- Static problem ($k_{t,j}$ and Z_t^Y are given in t)

$$\max_{h_{t,j}} \Pi_{t,j} = Z_t^Y k_{t,j}^{\alpha} \left(g^t h_{t,j}\right)^{1-\alpha} - w_t h_{t,j} - \delta k_{t,j},$$

- FOC

$$(1-\alpha) Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{k_{t,j}}{h_{t,j}}\right)^{\alpha} = w_t$$

Entrepreneurs: static labor choice (I)

- Static problem ($k_{t,j}$ and Z_t^Y are given in t)

$$\max_{h_{t,j}} \Pi_{t,j} = Z_t^Y k_{t,j}^{\alpha} \left(g^t h_{t,j}\right)^{1-\alpha} - w_t h_{t,j} - \delta k_{t,j},$$

- FOC

$$(1-\alpha) Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{k_{t,j}}{h_{t,j}}\right)^{\alpha} = w_t$$

- Same capital-labor ratios $\Rightarrow$ aggregation:

$$w_t = (1-\alpha) Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{K_t}{L_t}\right)^{\alpha}$$

Entrepreneurs: static labor choice (I)

- Static problem ($k_{t,j}$ and Z_t^Y are given in t)

$$\max_{h_{t,j}} \Pi_{t,j} = Z_t^Y k_{t,j}^{\alpha} \left(g^t h_{t,j}\right)^{1-\alpha} - w_t h_{t,j} - \delta k_{t,j},$$

- FOC

$$(1-\alpha) Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{k_{t,j}}{h_{t,j}}\right)^{\alpha} = w_t$$

- Same capital-labor ratios $\Rightarrow$ aggregation:

$$w_t = (1-\alpha) Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{K_t}{L_t}\right)^{\alpha}$$

- Aggregate output

$$y_{t,j} = Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{k_{t,j}}{h_{t,j}}\right)^{\alpha-1} k_{t,j} = Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{K}{L}\right)^{\alpha-1} k_{t,j}$$

$$\Rightarrow Y_t = Z_t^Y K_t^{\alpha} \left(g^t L_t\right)^{1-\alpha}$$

Entrepreneurs: static labor choice (II)

- From FOC

$$w_t = (1-\alpha) Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{K_t}{L_t}\right)^{\alpha}$$

$$h_{t,j} = \frac{L_t}{K_t} k_{t,j}$$

$$\Rightarrow w_t h_{t,j} = (1-\alpha) Z_t^Y \left(\frac{K_t}{g^t L_t}\right) k_{t,j}$$

back

Entrepreneurs: static labor choice (II)

- From FOC

$$w_t = (1-\alpha) Z_t^Y \left(g^t\right)^{1-\alpha} \left(\frac{K_t}{L_t}\right)^{\alpha}$$

$$h_{t,j} = \frac{L_t}{K_t} k_{t,j}$$

$$\Rightarrow w_t h_{t,j} = (1-\alpha) Z_t^Y \left(\frac{K_t}{g^t L_t}\right) k_{t,j}$$

- Profit function

$$\begin{aligned}
\Pi_t(k_{t,s}) &= Z_t^Y \left(\frac{k_{t,j}}{g^t h_{t,j}}\right)^{\alpha-1} k_{t,j} - w_t h_{t,j} - \delta k_{t,j} \\
&= Z_t^Y \left(\frac{K_t}{g^t L_t}\right)^{\alpha-1} k_{t,j} - (1-\alpha) Z_t^Y \left(\frac{K}{g^t L}\right) k_{t,j} - \delta k_{t,j} \\
&= \left[\alpha Z_t^Y \left(\frac{g^t L_t}{K_t}\right)^{1-\alpha} - \delta\right] k_{t,j} = (R_t - 1) k_{t,j}
\end{aligned}$$

back

Externally calibrated parameters

Parameter		Value	Explanation/Target
Life span	J	79	life spane of 85 years
Period of entrepr. shock	J^E	21	mean age of founding entrepr.: 42 (Azoulay et al., 2018)
Retirement	J^w	43	retirement at 65
Population growth	n	1.011	UN (2017)
Replacement ratio	ξ	0.5	Imrohoroglu et al. (1995 *ET*)
Inverse of IES	σ	4	Havranek (2015 *JEEA*)
Inverse of Frisch elasticity	χ	3	standard value
Productivity profile	$\{e_j\}_{j=1}^J$	see text	Earnings profile in 1995 (SCF)
Survival probabilities	$\{\zeta_j\}_{j=1}^J$	see text	Anderson (1999)
Capital income share	α	1/3	standard value
Technological growth	g	1.02	per-capita GDP growth
Depreciation	δ	0.052	Return on capital 6.7%
TFP shock autocorr.	ρ^Y	0.814	Prescott (1986)
TFP shock volatility	σ^Y	0.014	Prescott (1986)
Bubble shock volatility	σ^B	σ^Y	baseline

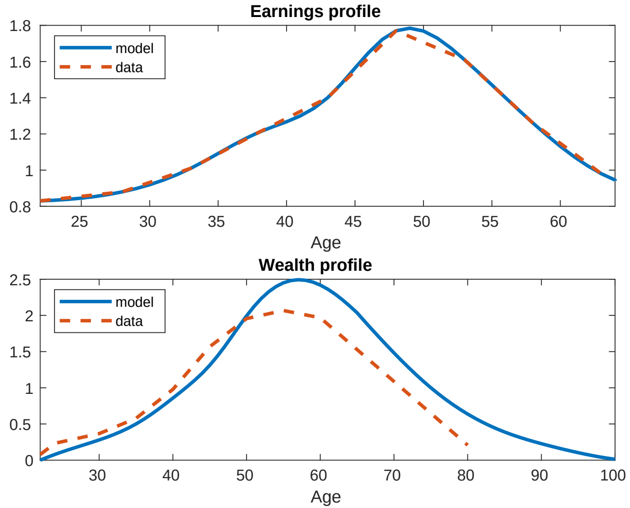
back

Internally calibrated parameters

Parameter		Value	Target	Value
Disutility from labor	θ	31.105	time spent working	$\frac{1}{3}$
Discount factor	β	1.116	capital output ratio (BEA)	2.8
Share entrepreneurs	η	0.001	return differential (Jorda et al., 2018)	0.05
Bubble creation	ν	0.449	entrepreneurial wealth share of bubble	0.01

▸ back

Cross-sectional fit



back

Decomposition with different order

	General equil. fundamental	Partial equil.					General equil. bubbly
		b^N	$w + pen + beq$	R	savers' R^d	entrep.' R^d	
Output Y	0	7.6 (7.6)	0.3 (1.8)	-4.4 (-4.9)	0.3 (0.3)	-3.7 (-3.9)	**0.9**
Capital K	0	24.4 (24.4)	0.8 (0.8)	-10.7 (-13.5)	0.8 (0.7)	-9 (-10.2)	**2.2**
Labor L	0	0 (0)	0.1 (2.3)	-1.1 (-1.2)	0.1 (0.1)	-0.9 (-1)	**0.2**
Credit demand D	0	24.4 (24.4)	0.8 (0.8)	-10.7 (-13.5)	0.8 (0.7)	-9 (-10.2)	**2.2**
Savers' wealth A	0	-0.0 (-0.0)	0.8 (0.8)	0 (0)	1.4 (1.4)	0 (0)	**2.2**
Entrep.' wealth A^E	0	24.4 (24.4)	0.8 (0.8)	-10.7 (-13.5)	0.8 (0.7)	-8.1 (-9.2)	**3.2**
Bubble B	0	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	**1**

All in %, bubble relative to wealth, other relative to fundamental state. Prices: $b^N \uparrow$, $w \uparrow$, $pen \uparrow$, $beq \uparrow$, $R \downarrow$, $R^d \uparrow$

- Different ordering: not cumulative, but isolated comparison to fundamental equilibrium
- Very similar results

back

Decomposition with $\gamma = R^d$

	General equil. fundamental	Partial equil.					General equil. bubbly
		b^N	$w + pen + beq$	R	savers' R^d	entrep.' R^d	
Output Y	0	7.4 (7.6)	2 (1.8)	-8 (-4.9)	0 (0.3)	0 (-3.9)	**1.4 (0.9)**
Capital K	0	24 (24.4)	1.2 (0.8)	-21.6 (-13.5)	0 (0.7)	0 (-10.2)	**3.6 (2.2)**
Labor L	0	0 (0)	2.3 (2.3)	-1.9 (-1.2)	0 (0.1)	0 (-1)	**0.4 (0.2)**
Credit demand D	0	24 (24.4)	1.2 (0.8)	-17 (-13.5)	0 (0.7)	0.1 (-10.2)	**3.7 (2.2)**
Savers' wealth A	0	-0.0 (-0.0)	1.3 (0.8)	0 (0)	0 (1.4)	0 (0)	**1.3 (2.2)**
Entrep.' wealth A^E	0	24 (24.4)	1.2 (0.8)	-17 (-13.5)	0 (0.7)	0 (-9.2)	**3.6 (3.2)**
Bubble B	0	0 (0)	0 (0)	0 (0)	0 (0)	1.3 (1)	**1.3**

All in %, bubble relative to wealth, other relative to previous column. Prices: $b^N \uparrow$, $w \uparrow$, $pen \uparrow$, $beq \uparrow$, $R \downarrow$

- No liquidity channel
- No crowding-out channel
- Only expansionary bubble-creation channel

back

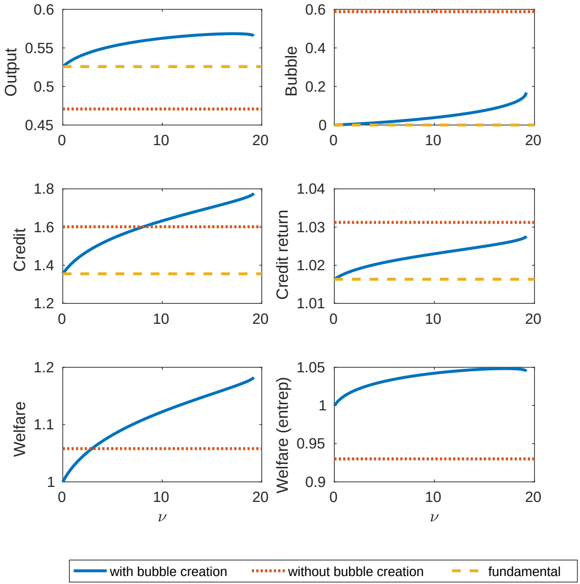
Decomposition with $\gamma = R^d$

	General equilibrium without bubbles	Partial equilibrium				General equilibrium with bubbles
	(1)	(2) $+b^N$	(3) $+w + pen + beq$	(4) $+R$	(5) $+$savers' R^d	(6) $+$entrepreneurs' R^d
Output Y	0.0	7.5	9.5	1.4	1.4	1.4
Capital K	0.0	24.1	25.4	3.7	3.7	3.7
Labor L	0.0	0.0	2.3	0.4	0.4	0.4
Credit D	0.0	24.1	25.4	3.7	3.7	3.7
Savers' wealth A	0.0	-0.001	1.3	1.3	1.3	1.3
Entrep' wealth A^E	0.0	24.1	25.4	3.7	3.7	3.7
Bubble B	0.0	0.0	0.0	0.0	0.0	1.3

- No liquidity channel
- No crowding-out channel
- Only expansionary bubble-creation channel

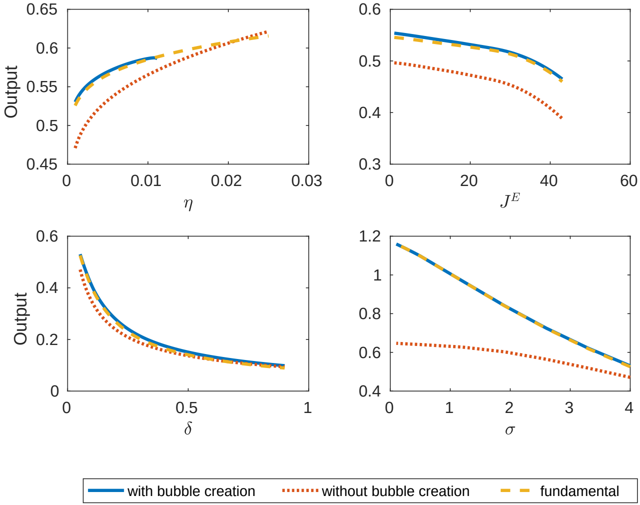
back

Robustness: ν



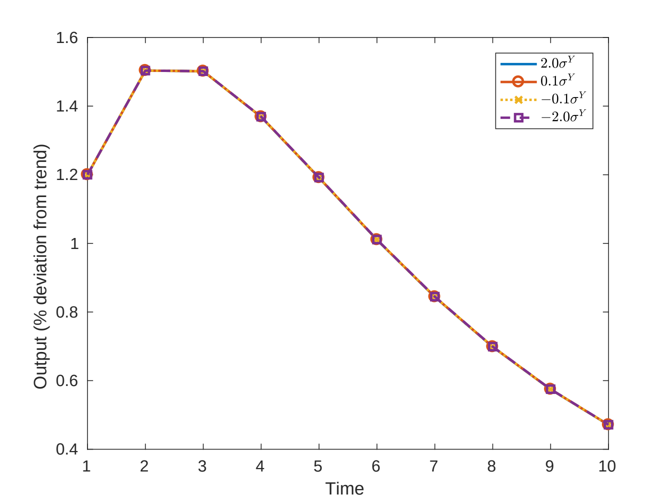
back

Robustness: $\eta, J^E, \delta, \sigma$



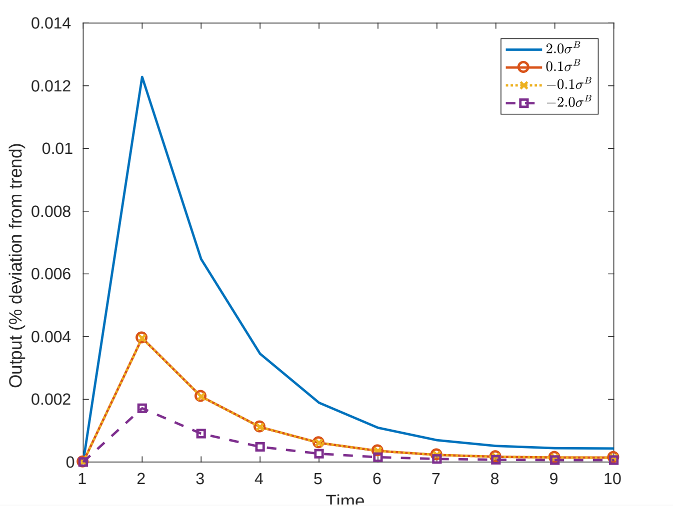
back

Is the IRF of GDP linear in TFP-shocks?



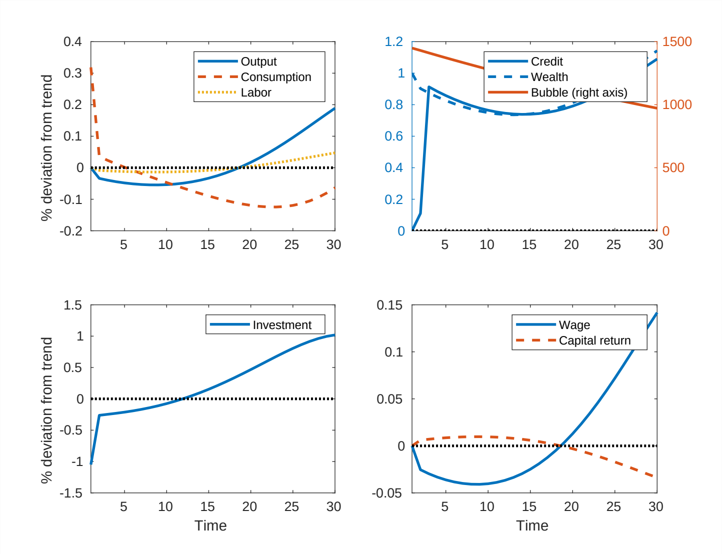
back

Is the IRF of GDP linear in bubble-shocks?

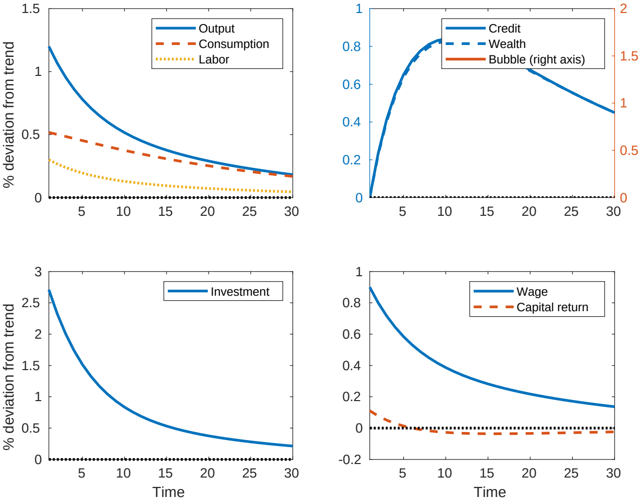


back

A *bubble-driven* business cycle under $\gamma = 0$

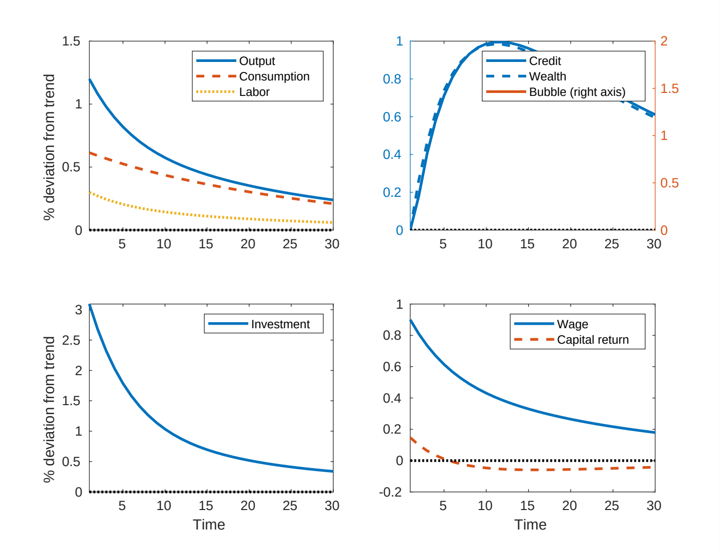


Real business cycle with $\gamma = 0$, no fin. frict., no bubble



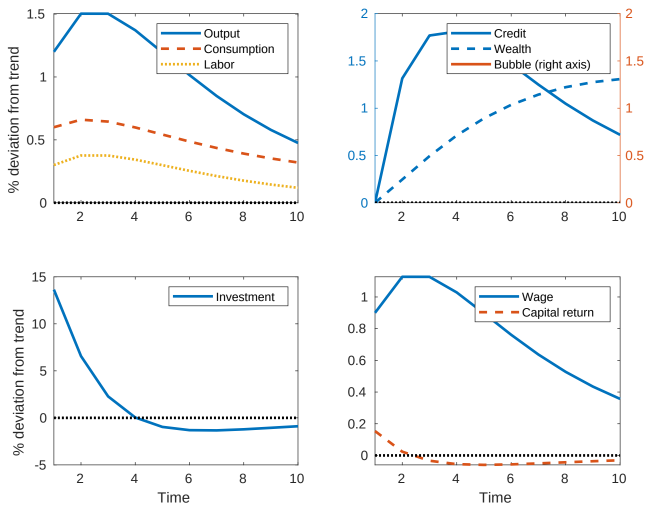
back

Real business cycle: + financial frictions



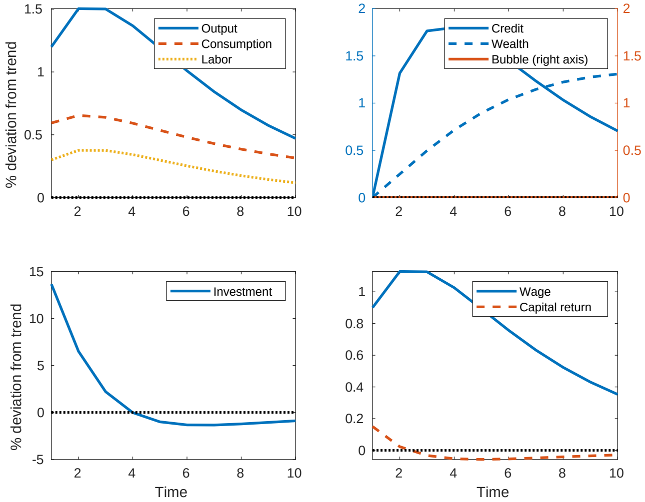
back

Real business cycle: + $\gamma >> 0$



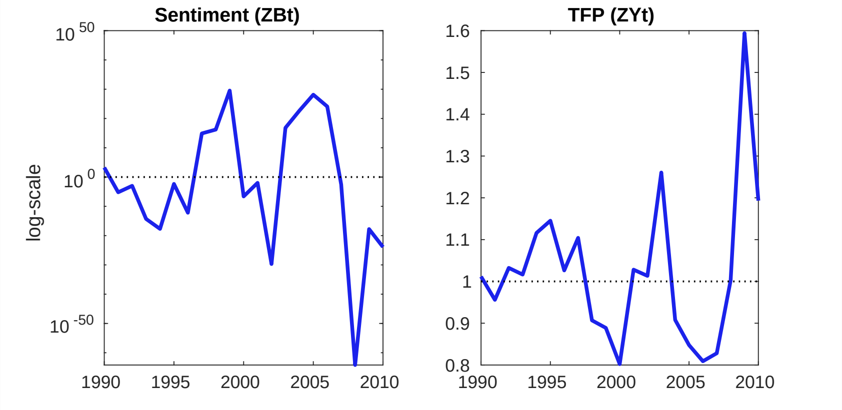
back

Real business cycle: + bubbles



back

Shock series



back

Investment adjustment cost [PRELIMINARY]

- Infinitely-lived, mass-zero, risk-neutral firm sector produces capital under perfect competition

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ q_t I_t \left[1 - \frac{\psi}{2} \left(\frac{I_t}{I_{t-1}} - gn \right)^2 \right] - I_t \right\}.$$

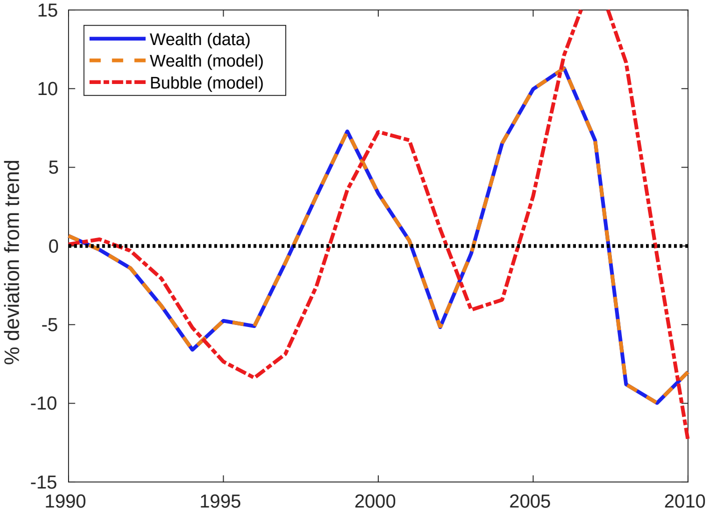
- FOC yields

$$\left[1 - \frac{\psi}{2} \left(\frac{I_t}{I_{t-1}} - gn \right) \left(3 \frac{I_t}{I_{t-1}} - gn \right) \right] q_t = 1 + \beta \mathbb{E}_t \phi \left(\frac{I_{t+1}}{I_t} - gn \right) \left(\frac{I_{t+1}}{I_t} \right)^2 q_{t+1}.$$

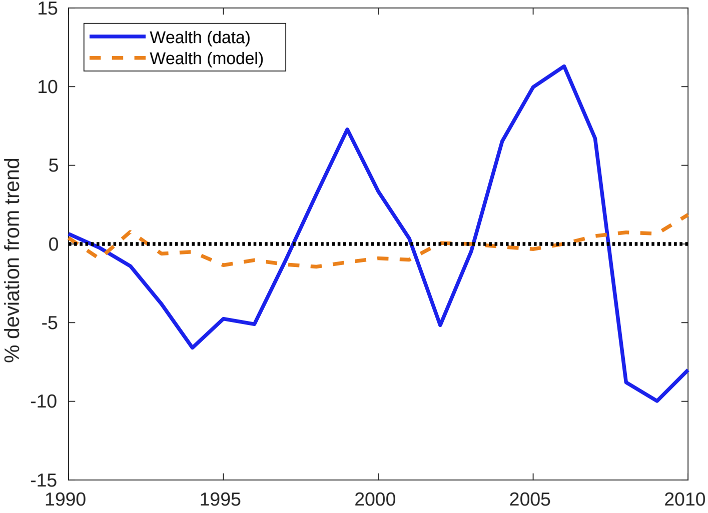
- Law of motion of capital

$$K_{t+1} = (1 - \delta) K_t + I_t \left[1 - \frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - gn \right)^2 \right]$$

Investment adjustment cost: US bubble [PRELIMINARY]



Investment adjustment cost: without bubbles [PRELIMINARY]



back