The International Transmission of Credit Bubbles: Theory and Policy

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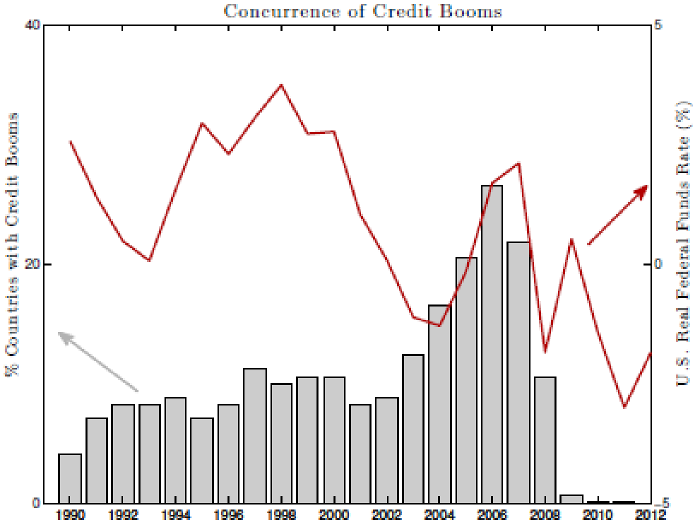
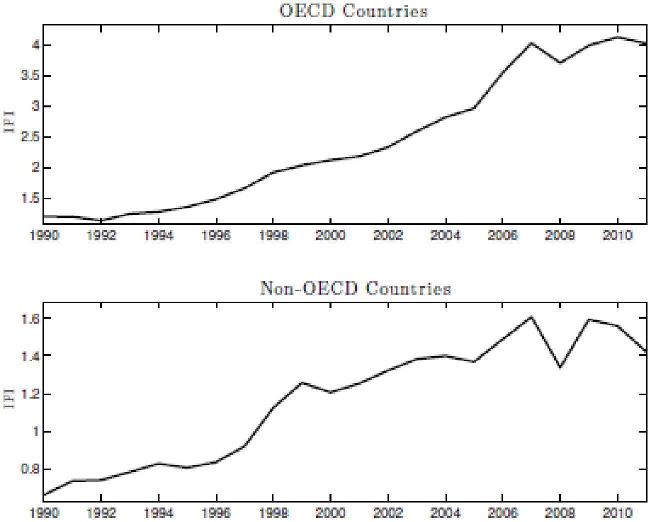
Credit booms and real interest rates, 1990-2012



Financial assets and liabilities as a share of GDP, 1990-2012



Introduction

- Key features of the world economy:
  - low interest rates
  - deep financial integration
  - proliferation of credit booms and busts

- Credit booms closely related to macroeconomic developments (Claessens et al., 2011; Dell'Ariccia et al., 2012; Mendoza and Terrones, 2012)
  - asset prices higher during booms
  - real GDP, consumption and investment growth higher during credit booms
  - real appreciation, widening external deficits (1% of GDP per year of boom)

- Source of concern:
  - credit booms end in crises and low growth (Schularick and Taylor, 2012)
  - current account reversals and large depreciations

This paper

- Builds on Martin and Ventura (2015) model of credit bubbles where ...
  - ... we took from the "financial-accelerator" literature the notion that:
    - ★ credit must be backed by collateral or pledgeable income of borrowers
    - ★ fluctuations in collateral are key to understanding fluctuations in credit
  - ... and we distinguished between:
    - ★ fundamental collateral: credit backed by future output
    - ★ bubbly collateral: credit backed by expectations of future credit
- Develops multi-country model that captures the new environment of low interest rates and deep financial integration and asks:
  - How are credit booms transmitted across countries? What are the key international spillovers? What determines their size and sign?
  - How should policy be conducted in this new environment? What are the key policy externalities? How should they be handled?

Related literature

- Rational bubbles
  - Samuelson (1958), Blanchard and Watson (1982), Scheinkman (1980), Tirole (1985), Weil (1987)
- Bubbles and financial frictions
  - Woodford (1990), Azariadis and Smith (1993), Woodford and Santos (1997), Caballero and Krishnamurthy (2006), Farhi and Tirole (2010), Hirano and Yanagawa (2013), Miao and Wang (2011), Aoki and Nikolov (2011), Kraay and Ventura (2007), Kocherlakota (2010), Martin and Ventura (2011, 2012, 2014), Ventura (2011)
- Financial accelerator
  - Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Bernanke Gertler and Gilchrist (1996) and many others
- Credit booms
  - Gourinchas et al. (2001), Claessens et al. (2011), Dell'Ariccia et al. (2012), Mendoza and Terrones (2012), Ranciere et al. (2008), Schularick and Taylor, 2012

The model: preferences and technology

- Two period OLG model
- Countries $j \in J$ of equal size: savers and entrepreneurs, $i \in \{S, E\}$
- All individuals maximize (Epstein-Zin-Weil)

$$U\left(c^i_{j1t}, c^i_{j2t+1}\right) = \frac{\left(c^i_{j1t}\right)^{1-1/\theta} - 1}{1 - 1/\theta} + \beta \cdot \frac{E_t\left\{\left(c^i_{j2t+1}\right)^{1-\sigma}\right\}^{\frac{1-1/\theta}{1-\sigma}} - 1}{1 - 1/\theta}$$

with $\theta > 1$

- Technology:
  - Production: $F\left(l_{jt}, k_{jt}\right) = A_j \cdot l_{jt}^{1-\alpha} \cdot k_{jt}^{\alpha}$, where $\alpha \in (0,1)$
  - Young endowed with one unit of labor, supplied inelastically: $l_{jt} = 1$
  - Investment as usual: for today, full depreciation
  - Competitive factor markets: $w_{jt} = (1-\alpha) \cdot A_j \cdot k_{jt}^{\alpha}$ and $r_{jt} = \alpha \cdot A_j \cdot k_{jt}^{\alpha-1}$

Bubbles

- Bubbles:
  - Intrinsically useless assets only held for resale
  - Initiated and traded by entrepreneurs
  - Bubbles left by generation t in country j:

$$b_{jt+1} = g_{jt+1} \cdot b_{jt} + n_{jt+1}$$

    - ★ $g_{jt+1} \geq 0$ denotes growth in value of old bubbles
      $\Rightarrow$ bubble-return shocks
    - ★ $n_{jt+1} \geq 0$ denotes value of new bubbles
      $\Rightarrow$ random
      $\Rightarrow$ bubble-creation shocks
  - Bubble summarized in stochastic process $\left\{g_{jt}, n_{jt}\right\}_{j \in J}$ for all t

Savers

- Representative saver:
  - supplies $1-\varepsilon$ units of labor during youth
  - saves fraction z_{jt} of labor income
  - lends $x_{jt}^{j'} \cdot z_{jt}$ to representative entrepreneur in $j' \in J$

- Credit contracts promise contingent return R_{t+1}^{j} for all $j \in J$

- Let $R_{jt+1} = \sum_{j'} R_{t+1}^{j'} \cdot x_{jt}^{j'}$. Then

$$z_{jt} = \frac{\beta^{\theta}}{\beta^{\theta} + E_t \left\{ R_{jt+1}^{1-\sigma} \right\}^{\frac{1-\theta}{1-\sigma}}}$$

$$E_t \left\{ \frac{R_{jt+1}^{-\sigma}}{E_t R_{jt+1}^{1-\sigma}} \cdot R_{t+1}^{j'} \right\} = 1 \ \text{ if } \ x_{jt}^{j'} > 0$$

- Note: $z_{jt} = z_t$ and $x_{jt}^{j'} = x_t^{j'}$ for all j; hence $R_{jt+1} = R_{t+1}$ for all j.

Entrepreneurs

- Representative entrepreneur:
  - supplies ε units of labor during youth
  - saves and sells credit contracts
  - invests in capital and purchases bubbles

- Two restrictions on credit contracts of entrepreneur in $j \in J$
  - credit contracts must offer market return

$$E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot R_{t+1}^{j} \right\} = 1$$

  - letting f_{jt} denote total financing or credit

$$R_{t+1}^{j} \cdot f_{jt} \leq b_{jt+1},$$

i.e., collateral is scarce and bubbly

Entrepreneurs (II)

- Entrepreneurial funds given by:

$$\varepsilon \cdot w_{jt} + \left(E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot g_{jt+1} \right\} - 1 \right) \cdot b_{jt} + E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot n_{jt+1} \right\},$$

wages, bubble purchases, bubble creation

- Bubble market clearing requires

$$E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot g_{jt+1} \right\} = 1 \quad \text{for all } j \text{ and } t$$

- **Assumption:** collateral constraints always bind

$$r_{jt+1} > R_{t+1}^{\sigma} \cdot E_t R_{t+1}^{1-\sigma}$$

- Maximization implies:

$$k_{jt+1} = \frac{\beta^{\theta}}{\beta^{\theta} + r_{jt+1}^{1-\theta}} \cdot \left[\varepsilon \cdot w_{jt} + E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot n_{jt+1} \right\} \right]$$

Global credit market

- Let f_t and b_t denote world credit and bubble, i.e. $f_t = \sum_j f_{jt}$ and $b_t = \sum_j b_{jt}$
- Binding collateral constraints imply

$$R_{t+1} = \frac{b_{t+1}}{f_t}$$

- World credit is determined and distributed as follows:

$$\frac{\beta^\theta}{\beta^\theta + f_t^{\theta-1} \cdot E_t \left\{ b_{t+1}^{1-\sigma} \right\}^{\frac{1-\theta}{1-\sigma}}} \cdot \sum_j (1-\varepsilon) \cdot w_{jt} = f_t$$

$$\frac{f_{jt}}{f_t} = E_t \left\{ \frac{b_{t+1}^{-\sigma}}{E_t b_{t+1}^{1-\sigma}} \cdot b_{jt+1} \right\}$$

- Note: world credit is
  - increasing in (risk-adjusted) expected value of world bubble, i.e. $E_t \left\{ b_{t+1}^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}$
  - allocated according to distribution of world bubble

Equilibrium dynamics

- Competitive equilibrium: bubble $\{g_{jt}, n_{jt}\}_{j\in J}$ and associated sequence $\{k_{jt}, b_{jt}\}_{j\in J}$, for all t, consistent with optimization and market clearing.

- To construct equilibria: propose bubble $\{g_{jt}, n_{jt}\}_{j\in J}$ such that market for bubbles clear and $n_{jt+1} \geq 0$ for all j and t, and determine all possible sequences $\{k_{jt}, b_{jt}\}_{j\in J}$ using:

$$b_{jt+1} = g_{jt+1} \cdot b_{jt} + n_{jt+1},$$

$$f_t = \frac{\beta^\theta}{\beta^\theta + f_t^{\theta-1} \cdot E_t \left\{ b_{t+1}^{1-\sigma} \right\}^{\frac{1-\theta}{1-\sigma}}} \cdot (1-\varepsilon) \cdot (1-\alpha) \cdot \sum_j A_j \cdot k_{jt}^\alpha,$$

$$k_{jt+1} = \frac{\beta^\theta}{\beta^\theta + \left(\alpha \cdot A_j \cdot k_{jt+1}^{\alpha-1}\right)^{1-\theta}} \cdot \left[\varepsilon \cdot (1-\alpha) \cdot A_j \cdot k_{jt}^\alpha + E_t \left\{ \frac{b_{t+1}^{-\sigma}}{E_t b_{t+1}^{1-\sigma}} \cdot n_{jt+1} \right\} \cdot f_t \right].$$

If $k_{jt} \geq 0$ and $b_{jt} \geq 0$ for all j and t, equilibrium!

Equilibrium I: bubleless economy

- Bubbleless equilibrium, with $b_{jt} = 0$ for all j and t
- No collateral, and no credit!
- Capital accumulation given by:

$$k_{jt+1} = \frac{\beta^{\theta}}{\beta^{\theta} + \left(\alpha \cdot A_j \cdot k_{jt+1}^{\alpha-1}\right)^{1-\theta}} \cdot \varepsilon \cdot (1-\alpha) \cdot A_j \cdot k_{jt}^{\alpha}$$

- Two inefficiencies:
  - inefficiently low savings: no collateral
    - capital permanently depressed
  - misallocation of world savings
    - capital temporarily misallocated

Equilibrium II: symmetric global bubble

- Let $\left\{g_{jt+1}, n_{jt+1}\right\}_{j \in J}$ be s.t. bubbles proportional to output in all countries:

$$\frac{b_{jt+1}}{g} = \frac{\beta^{\theta}}{\beta^{\theta} + g^{1-\theta}} \cdot (1-\varepsilon) \cdot (1-\alpha) \cdot A_j \cdot k_{jt}^{\alpha},$$

- Credit in country j equals:

$$E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot n_{jt+1} \right\} = \frac{\beta^{\theta} \cdot (1-\varepsilon) \cdot (1-\alpha)}{\beta^{\theta} + g^{1-\theta}} \cdot A_j \cdot k_{jt}^{\alpha} - b_{jt}$$

- **Main insight:** two effects of global bubble
  - raises $R_{t+1} = g$ (crowding-in effect), but also b_{jt} (crowding-out effect)
  - steady state capital stock maximized at interior interest rate $g^* \in (0, 1)$

- Relative to bubbleless economy
  - global bubble does not affect distribution of capital
  - but it does affect global credit and investment

Equilibrium III: global bubbly episodes

- World economy fluctuates between fundamental and bubbly states, with transition probability $\pi < 0.5$
- Credit for investment in $j \in J$ equals:

$$E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot n_{jt+1} \right\} = \begin{cases} \dfrac{\beta^{\theta} \cdot (1-\varepsilon) \cdot (1-\alpha)}{\beta^{\theta} + \left((1-\pi)^{\frac{1}{1-\sigma}} \cdot g \right)^{1-\theta}} \cdot A_j \cdot k_{jt}^{\alpha} - b_{jt} & \text{if } B \\ \dfrac{\beta^{\theta} \cdot (1-\varepsilon) \cdot (1-\alpha)}{\beta^{\theta} + \left(\pi^{\frac{1}{1-\sigma}} \cdot g \right)^{1-\theta}} \cdot A_j \cdot k_{jt}^{\alpha} & \text{if } F \end{cases}$$

- **Main insight:** world output fluctuates with bubble
  - crowding-in and crowding-out effects of bubbles strong during episode
  - when bubbly episode begins:
    - growth of savings and investment equalized across countries:no capital flows
    - over time, crowding out effect of bubble strengthens
    - bubble expansionary in short-run but uncertain in long-run

Equilibrium IV: local bubbly episodes

- World divided into Q regions: each bubbly episode in region $q \in Q$
- Credit available for investment equals:

$$\begin{cases} \eta_{jt} \cdot \frac{\beta^{\theta} \cdot (1-\varepsilon) \cdot (1-\alpha)}{\beta^{\theta} + (1-\pi)^{\frac{1-\theta}{1-\sigma}} \cdot g^{1-\theta}} \cdot \sum_j A_j \cdot k_{jt}^{\alpha} - b_{jt} & \text{if } B \text{ and } j \in J_q \\ 0 & \text{if } B \text{ and } j \notin J_q \\ \frac{\beta^{\theta} \cdot (1-\varepsilon) \cdot (1-\alpha)}{\beta^{\theta} + \pi^{\frac{1-\theta}{1-\sigma}} \cdot \left(\frac{g}{Q}\right)^{1-\theta}} \cdot A_j \cdot k_{jt}^{\alpha} & \text{if } F \end{cases},$$

where η_{jt} is country j's share of world output

- **Main insights:**
  - global investment, and its distribution, fluctuates with bubble
  - during bubbly episode:
    - global demand for credit expands
    - savings increase and reallocated to bubbly region: non-bubbly regions contract
    - bubbles drive capital flows and financial integration (sudden stops)
    - bubbles need not reallocate resources productively

Managing the world economy: what can governments do?

- The laissez-faire equilibrium may provide too little or too much bubble
- Consider *expectationally-robust policies*: implement the same allocation regardless of investor sentiment
- Governments:
  - promise to give entrepreneurs of generation t a contingent transfer equal to s_{jt+1} when old
  - if transfer is positive (negative): financed by taxing (subsidizing) young entrepreneurs
  - debt financing is also possible, but not done here

Managing the world economy: what can governments do?

- Define a policy as a stochastic process: $\left\{g_{jt}^{s}, n_{jt}^{s}\right\}_{j \in J}$ for all t such that:

$$s_{jt+1} = g_{jt+1}^{s} \cdot s_{jt} + n_{jt+1}^{s}.$$

- Given policy and bubble process:

$$k_{jt} = \frac{\beta^{\theta}}{\beta^{\theta} + r_{jt+1}^{1-\theta}} \cdot \left(\varepsilon \cdot w_{jt} + E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot \left(n_{jt+1} + n_{jt+1}^{s} \right) \right\} \right)$$

- **Main insight:**
  - like bubble, policy provides collateral: guarantees (crowding-in)
  - like bubble, policy needs to be financed: taxes (crowding-out)

Proposition

Leaning against investor sentiment: any laissez-faire equilibrium with bubble $\left\{\bar{g}_{jt}, \bar{n}_{jt}\right\}_{j \in J}$ for all t can be replicated by a policy $\left\{g_{jt}^{s}, n_{jt}^{s}\right\}_{j \in J}$ such that

$$n_{jt}^{s} = \bar{n}_{jt} - n_{jt} \quad \textit{and} \quad g_{jt}^{s} \cdot s_{jt} = \bar{g}_{jt} \cdot \overline{b}_{jt} - g_{jt} \cdot b_{jt}$$

for all j and t.

Managing the world economy: Pareto optima

- Focus on the set of deterministic bubbles
- In steady state, increase in bubble size has:
  - monotonic effect on interest rate
  - non-monotonic effect on capital stock
- Hence larger bubbles:
  - raise welfare of entrepreneurs (only depends on k_{jt})
  - ambiguous effect on welfare of savers (depends also on R_{t+1})
- In all Pareto optimal allocations, the capital stock is non-increasing in the bubble
  - whether it is decreasing or not depends on weight on savers vs. entrepreneurs

Managing the world economy: equilibrium outcomes

- Let $\gamma_j^E, \gamma_j^S \geq 0$ be the weights of government j on entrepreneurs and savers.

Definition

A cooperative equilibrium of the global economy is characterized by a bubble $\left\{g^c, n_j^c\right\}_{j \in J}$ that satisfies

$$\left\{g^c, n_j^c\right\}_{j \in J} \in \arg\max \sum_j \upsilon_j \cdot \left[\gamma_j^E \cdot U_j^E + \gamma_j^S \cdot U_j^S\right],$$

for some $\upsilon_j \geq 0$, plus equilibrium conditions.

Definition

A non-cooperative equilibrium of the global economy is characterized by a set of bubbles $\left\{g^{nc}, n_j^{nc}\right\}_{j \in J}$ that satisfies

$$\left\{g^{nc}, n_j^{nc}\right\} \in \arg\max \left[\gamma_j^E \cdot U_j^E + \gamma_j^S \cdot U_j^S\right] \text{ for } j \in J$$

Managing the world economy: results

- Cooperative equilibria are Pareto optimal
- Non-cooperative equilibria are generically not Pareto optimal
  - intuition: countries do not internalize effects of their policy on international interest rate
  - negative spillovers on foreign entrepreneurs
  - ambiguous spillovers on foreign savers

  $\Longrightarrow$ global bubble will be inefficiently large or small
- Two benchmark cases in which global bubble is too large:
  - governments place high value on welfare of entrepreneurs (i.e., on domestic output)
  - countries are small
- But non-cooperative equilibrium may still dominate bubleless benchmark!

Managing the world economy: summary

- In all Pareto optimal allocations, the capital stock is non-increasing in the bubble
- Pareto optimal allocations can be replicated through credit guarantee/transfer scheme
- Cooperative equilibria are Pareto optimal
- Non-cooperative equilibria are generically not Pareto optimal
  - intuition: countries do not internalize effects of their policy on international interest rate
- Two benchmark cases in which global bubble will be too large:
  - governments place high value on welfare of entrepreneurs (i.e., on domestic output)
  - countries are small
- But non-cooperative equilibrium may still dominate bubleless benchmark!

What have we learned?

- We live in a world of low interest rates and deep financial integration where credit bubbles are likely to pop up and burst
  - bubbles drive financial integration
    - bubbles fuel capital flows, not the other way around
  - bubbles raise global savings and reallocate them across countries
- Effects of credit bubbles:
  - *host country*: capital inflows, credit and investment boom, high growth and welfare
  - *rest of the world*: capital outflows, reduction in credit and investment, negative effect on growth and unclear welfare
- The laissez-faire economy is generically suboptimal and there is a need for credit market interventions that stabilize economic activity
- A global planner can replicate optimal bubble allocation through credit market interventions
  - policy of "leaning against investor sentiment"
  - externalities may prevent this policy from arising in non-cooperative fashion