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

- Bubbles and financial frictions

- 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)

\[
U\left(c_{j1t}^i, c_{j2t+1}^i\right) = \frac{\left(c_{j1t}^i\right)^{1-1/\theta} - 1}{1 - 1/\theta} + \beta \cdot \frac{E_t \left\{ \left(c_{j2t+1}^i\right)^{1-\sigma} \right\}^{1-1/\theta} - 1}{1 - 1/\theta}
\]

with \( \theta > 1 \)

- Technology:
  - Production: \( F(l_{jt}, k_{jt}) = A_j \cdot l_{jt}^{1-\alpha} \cdot k_{jt}^\alpha \), 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
  - bubble-return shocks
- $n_{jt+1} \geq 0$ denotes value of new bubbles
  - random
  - bubble-creation shocks

- Bubble summarized in stochastic process $\{g_{jt}, n_{jt}\}_{j \in J}$ for all $t$
Savers

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

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

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

$$z_{jt} = \frac{\beta^\theta}{\beta^\theta + E_t \left\{ R_{jt+1}^{1-\sigma} \right\}^{\frac{1-\theta}{1-\sigma}}} \cdot \frac{E_t \left\{ \frac{R_{jt+1}^{1-\sigma}}{E_t R_{jt+1}^{1-\sigma}} \cdot R_{jt+1}' \right\} = 1 \text{ if } x_{jt}' > 0}{E_t R_{jt+1}^{1-\sigma}}$$

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

- Representative entrepreneur:
  - supplies $\varepsilon$ 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
    $$E_t \left\{ \frac{R_{t+1}^{1-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot R_t^j \right\} = 1$$
  - letting $f_{jt}$ denote total financing or credit
    $$R_t^j \cdot f_{jt} \leq b_{jt+1},$$
    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
  \[
  E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot g_{jt+1} \right\} = 1 \text{ for all } j \text{ and } t
  \]

- **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:

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

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

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

If $k_{jt} \geq 0$ and $b_{jt} \geq 0$ for all $j$ and $t$, equilibrium!
Equilibrium I: bubbleless economy

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

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

- Two inefficiencies:
  - inefficiently low savings: no collateral
    - capital permanently depressed
  - misallocation of world savings
    - capital temporarily misallocated
Equilibrium II: symmetric global bubble

- Let \( \{g_{jt+1}, n_{jt+1}\} \}_{j \in J} \) be s.t. bubbles proportional to output in all countries:
  \[
  \frac{b_{jt+1}}{g} = \frac{\beta^\theta}{\beta^\theta + g^{1-\theta}} \cdot (1 - \varepsilon) \cdot (1 - \alpha) \cdot A_j \cdot k_j^\alpha,
  \]

- Credit in country \( j \) equals:
  \[
  E_t \left\{ \frac{R_{t+1}^{-\sigma}}{E_t R_{t+1}^{1-\sigma}} \cdot n_{jt+1} \right\} = \frac{\beta^\theta \cdot (1 - \varepsilon) \cdot (1 - \alpha)}{\beta^\theta + g^{1-\theta}} \cdot A_j \cdot k_j^\alpha - b_{jt}
  \]

- **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:

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

- **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:

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

where $\eta_{jt}$ 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: \( \{ g_{jt}^s, n_{jt}^s \}_{j \in J} \) for all \( t \) such that:

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

- Given policy and bubble process:

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

- 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 \( \{ \bar{g}_{jt}, \bar{n}_{jt} \}_{j \in J} \) for all \( t \) can be replicated by a policy \( \{ g_{jt}^s, n_{jt}^s \}_{j \in J} \) such that

\[
 n_{jt}^s = \bar{n}_{jt} - n_{jt} \quad \text{and} \quad g_{jt}^s \cdot s_{jt} = \bar{g}_{jt} \cdot \bar{b}_{jt} - g_{jt} \cdot b_{jt}
\]

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 $\gamma^E_j, \gamma^S_j \geq 0$ be the weights of government $j$ on entrepreneurs and savers.

**Definition**

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

$$\left\{g^c_j, n^c_j\right\}_{j \in J} \in \arg \max \sum_j v_j \cdot \left[\gamma^E_j \cdot U^E_j + \gamma^S_j \cdot U^S_j\right],$$

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

**Definition**

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

$$\left\{g^{nc}_j, n^{nc}_j\right\}_{j \in J} \in \arg \max \left[\gamma^E_j \cdot U^E_j + \gamma^S_j \cdot U^S_j\right]$$

for $j \in J$. 

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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
  - $\rightarrow$ 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 bubbleless 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 bubbleless 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