Bubbles
Plan

Overview

Varieties of bubbles

Evidence on the effects of bubbles

Bubbles and monetary policy

Annex
Typically two phases in financial crises:

1. The run-up phase: asset prices boom and imbalances build up

   Usually imbalances form gradually and volatility is low, so the risk buildup is initially hard to detect.

   Booming asset prices often rationalized by some type of innovation (“this time is different”) so past standards don’t apply

   Incentive distortions at work

   - over-leveraging
   - over-investing
   - maturity/currency mismatches

   Externalities generating systemic risk – financial stability as a ‘public good’

Kuala Lumpur 2016 - Luis Servén
2. The crisis phase: risk materializes and asset prices collapse

Often following a ‘trigger event’ of modest economic significance (the ‘Minsky moment’) – e.g., the subprime collapse

Amplification mechanisms (spillovers/externalities) get in action

    Creditor runs

    Domino and network effects (interconnectedness)

    Asset fire sales

More severe for credit-fed asset booms – more deleveraging and amplification.

Potentially large (and long-lasting) real effects
What is a bubble?

Loose definition (Kindleberger): “A bubble may be defined as a sharp rise in the price of an asset ..., with the initial rise generating expectations of further rises and attracting new buyers – generally speculators interested in profits from trading in the asset rather than its use or earning capacity.” […]
What is a bubble?

Blunt definition (also attributed to Kindleberger):

“A bubble exists when the investor holds the asset in the hope of selling it to a greater fool”
What is a bubble?

Working definition:

“A bubble is a large and sustained overpricing of an asset”

Not every mispricing is a bubble.

Under a bubble, usually the mispricing (i.e., the difference between observed and fundamental price) grows in an explosive manner
Practical difficulty to establish unambiguously the presence of bubbles.

To spot a bubble we need to be able to assess with some accuracy the (generally unobserved) “fundamental value” of the asset – a difficult, in many cases impossible task.

This explains the traditional reluctance of policy makers to target asset prices

A supposed bubble may be observationally equivalent to a poor model of the fundamentals – so the fundamental value is misstated.

Hence the term ‘bubble’ commonly refers to large / persistent asset price movements that appear unrelated to fundamentals
Minsky’s five stages of a bubble (Kindleberger 1978):

1. Displacement: some financial or technological innovation raises expectations of profitability and growth.

2. Boom: asset prices grow at a rising pace. Low volatility. Expansion of credit and investment

3. Euphoria: asset prices explode. Suspicions that there might be a bubble.


5. Panic: asset prices collapse in a fire sale, weakening balance sheets and triggering amplification and spillover mechanisms.

Models of bubbles try to replicate (some of) these features.
Famous bubble episodes:

- Tulipmania (1634-1638)
- Mississippi bubble (1719-20)
- South Sea bubble (1720)
- Railroad manias (1840s)
- 1929
- Dotcom bubble
- Housing/Subprime
FAMOUS WRONG GUESSES
IN HISTORY

{when all Europe guessed wrong}

The date—October 3rd, 1719.
The scene—Hotel de Nevers, Paris.
A wild mob—fighting to be heard.
"Fifty shares!" "I’ll take two hundred!" "Five hundred!" "A thousand here!" "Ten thousand!"

Shrill cries of women. Hoarse shouts of men. Speculators all exchanging their gold and jewels or a lifetime’s meager savings for magic shares in John Law’s Mississippi Company. Shares that were to make them rich overnight.

Then the bubble burst. Down—down went the shares. Facing utter ruin, the frenzied populace tried to “sell”. Panic-stricken mobs stormed the Banque Royale. No use! The bank’s coffers were empty. John Law had fled. The great Mississippi Company and its promise of wealth had become but a wretched memory.
HISTORY sometimes repeats itself—but not invariably. In 1719 there was practically no way of finding out the facts about the Mississippi venture. How different the position of the investor in 1929!

Today, it is inexcusable to buy a “bubble”—inexcusable because unnecessary. For now every investor—whether his capital consists of a few thousands or mounts into the millions—has at his disposal facilities for obtaining the facts. Facts which—as far as is humanly possible—eliminate the hazards of speculation and substitute in their place sound principles of investment.

Saturday Evening Post, September 14th, 1929
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What favors the formation of bubbles?

¶ Financial innovation – e.g., securitization
¶ Uncertainty about fundamentals – due to, e.g., technological change
¶ Low real interest rates – easy finance and risk-taking
¶ Inefficiencies in market microstructure – e.g., herding
¶ Large numbers of inexperienced investors – e.g., never having witnessed a nationwide housing price decline
¶ ‘Investor sentiment’ is important – holding a bubble only makes sense if we expect someone else to buy it tomorrow
The run-up to the Great Depression featured also a real estate bubble.

The stock market bubble was heavily leveraged – through widespread margin purchases.
Figure 1
Returns on: equaly weighted internet index, S&P 500, NASDAQ
Since firms have negative earnings, use imputation – assume that firms are already as profitable as old-economy equivalents.
# Comparing the South Sea bubble and the dotcom mania

## Table 1: Comparison of stock price increases and decline, 1719-21 and 1998-2001

<table>
<thead>
<tr>
<th>Stock</th>
<th>Price increase*</th>
<th>Peak-to-trough**</th>
<th>St.dev. of daily returns</th>
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<tr>
<td><strong>South Sea bubble</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>South Sea Company</td>
<td>843.0%</td>
<td>-88.0%</td>
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<tr>
<td>East India Company</td>
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<tr>
<td>Microsoft</td>
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</tbody>
</table>

*Note:*  
* from minimum during 12 months prior to peak  
** 12 months subsequent to peak
The « Conservation of the Bubble »

Bubbles (Standardized Dollar Prices)

- Nikkei
- NASDAQ
- GSCI
- Real Estate
- Emerging Markets
Varieties of bubbles

• **Irrational** bubbles: due to investor irrationality or psychological biases (e.g., Greenspan’s “irrational exuberance”, Kindleberger’s “manias”)

• **Rational** bubbles: they can exist will fully rational investors. Different settings to consider:
  
  i. Rational bubbles without frictions
  
  ii. Market incompleteness
  
  iii. Heterogeneous information
  
  iv. Limited arbitrage
(i) Rational bubbles without frictions

Simplest setup (Blanchard-Watson): consider the asset arbitrage equation

\[ p_t = \frac{E_t \left( p_{t+1} + d_{t+1} \right)}{1+r} \]

Where \( d = \) flow return (may be non-pecuniary), and the required rate of return \( r \) is assumed constant.

*All investors have the same information* (hence the same \( E \)). Recursive substitution yields:

\[ p_t = E_t \sum_{i=1}^{T-t} \frac{d_{t+i}}{(1+r)^i} + E_t \frac{p_T}{(1+r)^{T-t}} \]
Recall for later that here we used the *law of iterated expectations* – i.e., \( E_t[E_{t+1} d_{t+i+1}] = E_t d_{t+i+1} \)

For assets with finite maturity \( T \), \( p_T = 0 \), so the unique solution is the fundamental value \( v_t \).

For assets with infinite maturity, the unique solution is the fundamental value only if the transversality condition holds:

\[
\lim_{T \to \infty} E_t \left[ \frac{P_{t+T}}{(1 + r)^T} \right] = 0
\]

However, any other solution adding a term \( B_t \) will do as well, provided:
Absent the transversality condition, any other solution adding a term $B_t$ will do as well, provided:

\[ p_t = v_t + B_t \]

\[ E_t [B_{t+1}] = B_t (1 + r) \]

i.e., the bubble $B$ has to grow (in expectation) at the rate $r$. Hence with a bubble the gap between the actual and the fundamental price is expected to widen over time.
Assume that with probability $p$ the bubble bursts. Let $\tilde{B}_{t+1}$ denote the expected value of the bubble if it does not burst. Then

$$E_t[B_{t+1}] = p \cdot 0 + (1 - p)\tilde{B}_{t+1} = (1 + r)B_t$$

Hence if the bubble is still going on, we must have

$$\frac{\tilde{B}_{t+1}}{B_t} = \frac{(1 + r)}{1 - p}$$

Thus the higher the probability of a bubble collapse $p$, the more quickly the bubble has to grow to yield the required rate of return to bubble holders.

Hence a bubble must grow faster when it is seen as more likely to burst.
This also implies that over time riskier bubbles (i.e., those with a higher probability of bursting) must grow faster than less-risky ones.

So in a multiple-bubble environment, the riskiest bubble must eventually dominate: it will become larger than the less-risky bubbles.

…a sort of ‘Gresham law’ for bubbles
With reproducible assets, bubbles can depress the fundamental value over time

Example: a real estate bubble. The fundamental price of housing equals the present value of housing services (rents).

A real estate bubble raises housing prices and encourages more construction.

The increased supply of housing over time lowers rents and hence the fundamental price of housing. Over time the bubble grows exponentially and the fundamental price keeps falling.

When the bubble bursts, the new price of housing is lower than the initial one owing to the larger stock.
But bubbles typically have wider effects – they raise wealth and lead to booming consumption, investment and growth.
The requirement that the expected rate of growth of the bubble must equal $r$ imposes some constraints:

- Absent frictions, rational bubbles cannot arise with finite horizons and/or for assets with finite maturity – i.e., such that $p_T = 0$ after some $T$.

  The reason is that $p_{T-1} = E_{T-1}[p_T + d_T] = E_{T-1}[d_T] = v_{T-1}$ and by backward induction this applies to all previous periods.
Absent frictions, bubbles can arise only if the economy is *dynamically inefficient* \((r < g)\)

Otherwise, the bubble would have to grow faster than the economy – eventually overtaking it all.

Under dynamic inefficiency, bubbles are stores of value that can replace inefficient over-investment (i.e., investment that requires more income than it generates).

Thus bubbles can be welfare-improving!

But in this case they would be associated with increased consumption but decreased investment, not what we usually observe.
(ii) Market incompleteness

With incomplete markets bubbles can be sustained in more general settings:

- e.g., fiat money in overlapping generations models allows trades not possible without it
- So it has a positive value even though it is intrinsically worthless

A leading example: financial frictions / borrowing constraints (Fahri and Tirole 2010; Martin and Ventura 2011, Miao et al 2016…)

Then bubbles provide collateral allowing investors to finance more good projects
For example, consider a collateral restriction that limits borrowing to a fraction of asset value:

\[ cr_t \leq \phi q_t K_t \]

A bubble creates additional collateral:

\[ cr_t \leq \phi (q_t K_t + B_t) \]

This eases credit restrictions – leads to more credit creation and allows firms to take on additional projects.

Here welfare-improving bubbles can raise investment, rather than displacing it.

They can be sustained even if the private return \( r < g \), because the social return on capital exceeds the market interest rate due to externalities / spillovers.
A particular case: financial frictions that allow efficient and inefficient investments to coexist – their rates of return differ, but financial resources cannot be transferred from bad to good projects.

• Bubbles created by investors with good projects help growth by offering investors with bad projects an alternative asset, so they reduce their inefficient investments (Martin and Ventura 2011).

• In effect, the bubbles channel resources towards efficient projects, hence raising efficient investment and growth.

[This only works if bubbles do not become ‘too big’ – otherwise they crowd out efficient investment as well, as in the standard case]
• When bubbles burst the mechanism transferring resources from inefficient to efficient investors breaks down, and growth falls

This is similar in spirit to what happens in credit markets in the presence of collateral constraints that prevent efficient firms from borrowing enough.

• Stock price bubbles create additional collateral for investors to borrow

• When bubbles burst and asset prices collapse, collateral is destroyed.

• The destruction of collateral leads to a credit crunch and a fall in consumption, investment and output.
(iii) Heterogeneous information

What if investors are rational but face heterogeneous information?

Key insight: in models where all investors share the same information, the law of iterated expectations facilitates “folding back” of future payoffs to the present

The representative investor’s expectation today of her expectation tomorrow of future payoffs is equal to his expectation today of future payoffs.
With differential information across investors, asset prices depend partly on **average expectations** (i.e., average of all market participants) about future payoffs.

The law of iterated expectations does NOT hold for average expectations:

the average expectation today of the average expectation tomorrow of future payoffs is NOT equal to today’s average expectation of future payoffs.

\[ \bar{E}_t[\bar{E}_{t+1}d_{t+i+1}] \neq \bar{E}_t[d_{t+i+1}] \]
This leads to Keynes’ *beauty contest*:

“… professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole; so that each competitor has to pick, not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view. It is not a case of choosing those which, to the best of one’s judgement, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practise the fourth, fifth and higher degrees.” Keynes (1936), page 156.
• How do higher-order expectations work?

Simple example [Allen, Morris and Shin (2006)]: a random fundamental $\theta$ to be inferred --- distributed normally with mean $y$ and variance $1/\alpha$. Each agent $i$ observes a signal $x_i = \theta + \varepsilon_i$ where $\varepsilon_i$ has mean zero and variance $1/\beta$.

Compute iterated average expectations:

$$\bar{E}_t[\bar{E}_{t+1}[\bar{E}_{t+2}...]$$ (usually denoted $\bar{E}_t^k$)

No role for time, so just drop time subscripts.

[To form expectations, agents solve a classic signal-extraction problem and weigh more the signal $x$ the bigger the signal-to-noise ratio $\beta / \alpha$.]
\[ E_i(\theta) = \frac{\alpha y + \beta x_i}{\alpha + \beta} \]
\[ \overline{E}(\theta) = \frac{\alpha y + \beta \theta}{\alpha + \beta} \]
\[ E_i(\overline{E}(\theta)) = \frac{\alpha y + \beta E_i(\theta)}{\alpha + \beta} \]
\[ = \frac{\alpha y + \beta \left( \frac{\alpha y + \beta x_i}{\alpha + \beta} \right)}{\alpha + \beta} \]
\[ = \left( 1 - \left( \frac{\beta}{\alpha + \beta} \right)^2 \right) y + \left( \frac{\beta}{\alpha + \beta} \right)^2 x_i \]
\[ \overline{E}(\overline{E}(\theta)) = \left( 1 - \left( \frac{\beta}{\alpha + \beta} \right)^2 \right) y + \left( \frac{\beta}{\alpha + \beta} \right)^2 \theta \]
\[ \overline{E}^k(\theta) = \left( 1 - \left( \frac{\beta}{\alpha + \beta} \right)^k \right) y + \left( \frac{\beta}{\alpha + \beta} \right)^k \theta. \]
Putting back the time subscripts:

$$
\overline{E}_t(\overline{E}_{t+1}(\theta)) = \left(1 - \left(\frac{\beta}{\alpha + \beta}\right)^2\right)y + \left(\frac{\beta}{\alpha + \beta}\right)^2 \theta \neq \frac{\alpha y + \beta \theta}{\alpha + \beta} = \overline{E}_t(\theta).
$$

$$
\overline{E}_t(\overline{E}_{t+1}(\ldots \overline{E}_{T-2}(\overline{E}_{T-1}(\theta)))) = \left(1 - \left(\frac{\beta}{\alpha + \beta}\right)^{T-t}\right)y + \left(\frac{\beta}{\alpha + \beta}\right)^{T-t} \theta.
$$

As the horizon expands, the higher-order average expectation converges to the public signal $y$ and away from the fundamental – the public signal matters “too much”.

In a more elaborate model, they find that (1) the price deviates systematically from the consensus fundamentals (i.e., there is a bubble), and (2) the price reacts “too little” to changes in the consensus fundamental value.
“In fact, the best explanation for the market’s back-and-forth swings is that each day we are conducting a Keynesian beauty contest, and reassessing what others think that still others are thinking. On days without much news, the market is simply reacting to itself. And because anxiety is running high, investors make quick, sometimes impulsive, responses to relatively minor events.”

September 3 2011
• One way to assess the impact of higher-order expectations is by examining the “higher order wedge”: the difference between the equilibrium price and what it would be if higher-order expectations were replaced by first order expectations (Bacchetta and van Wincoop 2008).

Consider a setting with risk-averse, infinite-horizon investors. The basic pricing equation is analogous to the standard one – but with average expectations:

$$P_t = \frac{1}{R} \bar{E}_t (P_{t+1} + D_{t+1}) - \phi_t.$$  

(This includes a risk premium $\phi$)
• If all agents had the same information, we would get

\[ P_t = \sum_{s=1}^{\infty} \frac{1}{R^s} E_t D_{t+s} - \sum_{s=1}^{\infty} \frac{1}{R^s} E_t \phi_{t+s} - \phi_t \]

Instead, we get higher-order average expectations:

\[ P_t = \sum_{s=1}^{\infty} \frac{1}{R^s} \bar{E}_t^s D_{t+s} - \sum_{s=1}^{\infty} \frac{1}{R^s} \bar{E}_t^s \phi_{t+s} - \phi_t \]

The higher-order wedge is the difference between this and the average-expectation version of the usual formula (\( P_t^* \) say):

\[ \Delta_t = P_t - P_t^* = \sum_{s=1}^{\infty} \frac{1}{R^s} \left[ \bar{E}_t^s D_{t+s} - \bar{E}_t D_{t+s} \right] - \sum_{s=1}^{\infty} \frac{1}{R^s} \left[ \bar{E}_t^s \phi_{t+s} - \bar{E}_t \phi_{t+s} \right] \]
• The wedge can be shown to depend on first and higher-order expectations of future expectational errors:

$$\Delta_t = \sum_{s=1}^{\infty} \frac{1}{R_s} E_t^s (E_{t+s} PV_{t+s} - PV_{t+s})$$

(here $PV$ is just the present value of future dividends).

Investors make decisions not just based on what they expect future dividends to be, but also on what they expect the market’s expectational error next period to be about those future dividends, and what they expect next period’s market expectation of the expectational error in the subsequent period to be…and so forth.
• The expectational errors relevant for the wedge are those based on public signals.

Why? Public signals provide a coordination mechanism through which the average investor may conclude that (on average) other investors will be either overly optimistic or pessimistic about the present value of future payoffs.

For example, a supply shock that raises the asset price leads the average investor to believe that other investors have more favorable private signals than s/he does. The average investor therefore believes that the market will be overly optimistic.

Even if investors themselves do not believe that future dividends will be higher, they will nonetheless buy more of the asset in the belief that the price tomorrow will be high due to overly optimistic beliefs by others.
• The higher-order wedge weakens the correlation between the price of the asset and its fundamental value (the present value of dividends) and hence creates room for bubbles – more so the longer the horizon (as higher-order terms come into play):

Panel A: Correlation between Price and PV

![Diagram showing correlation between price and present value](image)
(iv) Limited arbitrage

Bubbles may arise from the limited ability of rational or well-informed investors to offset the actions of uninformed or behavioral traders – e.g., momentum traders, chartists…

In the efficient markets model, the rational / informed traders would burst the bubble.

But barriers to arbitrage prevent the rational traders from correcting mispricing – they know over (under)-valuation when they see it, but run against short-selling constraints, performance incentives, noise traders or other factors.
Some factors that may cause rational traders to “ride the bubble” (at least for a while) rather than leaning against it:

**fundamental risk**: going against the bubble is risky because fundamentals may change and validate the mispricing.

**liquidation risk**: rational portfolio managers care about short-term price movements because temporary losses encourage fund outflows at the worst time – so they do not act aggressively against the overpricing.

**noise trader risk**: irrational traders may worsen the mispricing and cause large losses to rational traders in the near term (even if fundamentals do drive prices in the long term).
Synchronization risk: bringing down a bubble requires coordination among a sufficient number of rational investors -- to prevent losses from attacking too early or waiting too long. The absence of a synchronization mechanism may discourage attacks – or cause them in response to nearly insignificant news

• Housing bubble

“When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you’ve got to get up and dance. We’re still dancing”

Chuck Prince, Citibank’s former CEO, Financial Times, July 9 2007, on why Citi was riding the mortgage-driven boom
• Internet Bubble (1999 - 2000)

“We thought it was the eighth inning, and it was the ninth.”

Stanley Druckenmiller, manager of Soros’ Quantum Fund, New York Times April, 29 2000, on why he didn’t think that the party would end so quickly

“The moral of this story is that irrational market can kill you ... Julian [Robertson of Tiger Fund] said ‘This is irrational and I won’t play’ and they carried him out feet first. Druckenmiller said ‘This is irrational and I will play’ and they carried him out feet first.”

Quote of a financial analyst
Portfolio restrictions in combination with heterogeneous beliefs can affect asset overpricing.

• Short-sales constraints: prevent pessimistic investors from deflating a bubble fed by optimistic investors

• Financial innovation (e.g., ABS tranching) makes it easier for optimists to take positions in the asset

• But introduction of CDS may also help pessimists to quickly deflate a bubble
**Traders’ behavior and bubbles**

There is a presumption that short-term investment horizons favor bubbles – investors’ return consists mostly of capital gains (not enough time for dividends).

One way to test this idea is through experiments in which individuals carry out security trades in two settings (Hirota and Sunder 2007):

-- long-horizon: investors’ decision horizon extends up to maturity of the security (which pays a terminal dividend at $T = 30$).

-- short-horizon: the horizon ends before maturity. Exiting investors receive an endogenously-determined price.
Fig. 4. Stock prices for Session 6 (Long-Horizon Session).

* One transaction in period 2 occurred at 5,050 because the bidder said he inadvertently added 50 to the intended bids of 50.
** Allocative efficiency of this market is undefined because all investors had identical dividends.
Fig. 10. Stock prices for Session 10 (Short-Horizon Session).

* One transaction in period 9 occurred at 2,260 because the bidder said he inadvertently added 2 to the intended bids of 260.
** Allocative efficiency of this market is undefined because all investors had identical dividends.
The main finding is that security prices tend to form bubbles in short-, but not in long-horizon markets.

With short investor horizons, prices lose their dividend anchors and their levels and paths become indeterminate. Investors are unable to backward-induct from dividend anchors, so they tend to form their expectations of future prices by forward induction using first-order adaptive or trend processes.

In contrast, prices in markets populated by long-horizon investors tend to converge to the fundamentals.

Other experiments also show that bubbles are more likely to occur when the future dividends are more uncertain.
Evidence on the effects of bubbles

Classic models of bubbles consider ‘permanent’ bubbles – they exist (or do not) forever. Welfare effects refer to steady-state comparisons – ignoring the transition between them.

In reality bubbles inflate and burst unpredictably.

This adds to asset price volatility and propagates to real variables, especially through financial amplification mechanisms.
Fragility can make bubbles socially undesirable in spite of their possible role as a store of value, because bubble bursting can have big adverse real effects.

Little is known so far about how bubbles form and burst.

Models resort to exogenous factors, sunspots, ‘investor sentiment’…
Important: not all bubbles are equally troubling

Equity vs credit-based bubbles: the bubbles that matter are those that feed an asset price – credit loop

– e.g., the burst of the dotcom bubble did not have major adverse effects, but the housing bubble did.

Rising asset prices feed into credit expansión (through e.g., collateral constraints), booming investment, further asset price rises etc.

In the data, feedback between housing prices and credit is very tight – more so than that between equity prices and credit.
Synchronization of real and financial cycles within countries

*Sample: 79 countries, 1990q1-2010q4*

<table>
<thead>
<tr>
<th>Concordance</th>
<th>Industrial Countries</th>
<th>Latin America</th>
<th>Non-LAC EMs</th>
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<tr>
<td>(Real output, Credit)</td>
<td>0.747</td>
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<td>(Stock prices, Capital inflows)</td>
<td>0.615</td>
<td>0.571</td>
<td>0.604</td>
</tr>
<tr>
<td>(Housing prices, Capital inflows)</td>
<td>0.584</td>
<td>0.410</td>
<td>0.568</td>
</tr>
<tr>
<td>(Real exchange rate, Capital inflows)</td>
<td>0.530</td>
<td>0.554</td>
<td>0.584</td>
</tr>
</tbody>
</table>

The figures presented in this table represent the concordance statistics for the cycles of the corresponding pair of variables (Harding and Pagan, 2002b). The concordance index takes values between 0 and 1 and measures the fraction of time that the two cycles are in the same cyclical phase. The concordance figures presented in the table are computed over the period 1990q1-2010q4. Concordance measures over the full sample period, 1970q1-2010q4, are computed but not reported and they are available from the authors upon request. Although we do not report the cross-country average, they yield qualitatively similar results.

- Luis Servén
When a leveraged bubble bursts, deleveraging depresses spending and output and increases macro risk in credit markets. The recovery is very slow.

What is the actual evidence on the effects of leveraged bubbles vs other bubbles?

Jordá, Schularik and Taylor (2016): review evidence on asset prices and credit from advanced countries since 1870

Main finding: unleveraged bubbles (pure ‘irrational exuberance’) pose only a limited threat to macro/financial stability. ‘Credit boom bubbles’ are much more dangerous.

Leveraged housing bubbles are the most harmful of all.
For the empirical analysis, a bubble is defined as

- A rise in log asset price beyond 1sd from a country-specific H-P trend
- Followed by a large real price correction > 15% (so only bursting bubbles are included)

Table 2: Average amplitude, rate, and duration of bubbles

<table>
<thead>
<tr>
<th></th>
<th>Full sample</th>
<th>Pre-WW2</th>
<th>Post-WW2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Equity</td>
<td>(2) House</td>
<td>(3) Equity</td>
</tr>
<tr>
<td>Amplitude</td>
<td>28.1 (24.3)</td>
<td>14.9 (13.8)</td>
<td>22.5 (17.9)</td>
</tr>
<tr>
<td>Rate</td>
<td>14.9 (11.0)</td>
<td>5.2 (3.7)</td>
<td>12.1 (10.7)</td>
</tr>
<tr>
<td>Duration</td>
<td>2.1 (1.0)</td>
<td>3.1 (1.3)</td>
<td>2.4 (1.1)</td>
</tr>
<tr>
<td>Observations</td>
<td>98</td>
<td>41</td>
<td>24</td>
</tr>
</tbody>
</table>

Notes: Amplitude refers to the percentage change in the price from the point in time where the asset price breaks the one standard deviation barrier with respect to the Hodrick-Prescott trend, and the collapse of the bubble. Rate refers to the annual rate of change in the price of the asset identified by the amplitude variable. Duration refers to the number of periods that the bubble lasts so that amplitude divided by duration equals rate. Standard errors in parenthesis. See text.
Figure 4: Examples of the bubble indicator for six illustrative episodes

The figures show, for each 10-year window, the log real asset price (rebased to the start year), a band of ±1 standard deviation (for that country’s detrended log real asset price), and the years for which the Bubble Signal is turned on using our algorithm.
<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Pre-WW2</th>
<th>Post-WW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial crisis recessions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No bubble</td>
<td>15</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Equity bubble</td>
<td>13</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Housing bubble</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Both bubbles</td>
<td>13</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Normal recessions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No bubble</td>
<td>70</td>
<td>46</td>
<td>24</td>
</tr>
<tr>
<td>Equity bubble</td>
<td>34</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Housing bubble</td>
<td>7</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Both bubbles</td>
<td>9</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>55</td>
<td>65</td>
</tr>
</tbody>
</table>

Notes: The table entries show the number of events of each type in the relevant sample period. Recessions are the peaks of business cycles identified using Bry and Boschan (1971) algorithm. A recession is labeled financial if there is a financial crisis within a 2 year window of the peak. Otherwise it is labeled normal. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. See text.
Table 4: Logit models for financial recessions. Full and post-WW2 samples

<table>
<thead>
<tr>
<th></th>
<th>Full sample</th>
<th></th>
<th>Post-WW2 sample</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Benchmark</td>
<td>(2) Credit only</td>
<td>(3) Full model</td>
<td>(4) Benchmark</td>
</tr>
<tr>
<td>Credit</td>
<td>0.40***</td>
<td>(0.11)</td>
<td>0.49***</td>
<td>(0.17)</td>
</tr>
<tr>
<td>No bubble</td>
<td>0.22</td>
<td>(0.18)</td>
<td>0.56</td>
<td>(0.35)</td>
</tr>
<tr>
<td>× credit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity bubble</td>
<td>0.18</td>
<td>(0.18)</td>
<td>-0.07</td>
<td>(0.29)</td>
</tr>
<tr>
<td>× credit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing bubble</td>
<td>0.54***</td>
<td>(0.20)</td>
<td>0.55*</td>
<td>(0.30)</td>
</tr>
<tr>
<td>× credit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both bubbles</td>
<td>0.82***</td>
<td>(0.30)</td>
<td>1.20**</td>
<td>(0.50)</td>
</tr>
<tr>
<td>× credit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudo-R²</td>
<td>0.03</td>
<td>0.13</td>
<td>0.08</td>
<td>0.20</td>
</tr>
<tr>
<td>AUC</td>
<td>0.61</td>
<td>0.71</td>
<td>0.69</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Observations</td>
<td>142</td>
<td>142</td>
<td>142</td>
<td>81</td>
</tr>
</tbody>
</table>

Notes: Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01. The dependent variable based on peaks of business cycles identified using Bry and Boschan (1971) algorithm. The dependent variable is one if the recession is associated with a financial crisis within a 2-year window of the peak, 0 otherwise. Bubble episodes are associated with recessions by considering the expansion over which the bubble takes place and using the subsequent peak. See text.

Financial crises + recession are more likely with credit-fed housing and equity bubbles.
Compute local projections (Jordá 2005) to check if output losses are bigger in credit-fed bubbles:

\[ \Delta_{h}y_{i,t(p)} = \sum_{i=1}^{I-1} a_{i,h} D_{i,t(p)} + \mu_{h} + \sum_{j} \gamma_{h}^{j,Hi} d_{i,t(p)}^{j} \times \delta_{i,t(p)} + \sum_{j} \gamma_{h}^{j,Lo} d_{i,t(p)}^{j} \times (1 - \delta_{i,t(p)}) + \epsilon_{i,t(p)} \text{ for } h = 1, \ldots, 5, \]

\( p \) denotes a peak in (detrended) output

\( \Delta_{h}y_{i,t(p)} \) is the output change from the peak

\( d_{i,t(p)}^{j} = 1 \) if the pre-peak expansion has a bubble

\( \delta_{i,t(p)} = 1 \) if credit growth is above its historical mean
Housing bubbles are worse than equity bubbles, and both more damaging when fueled by credit.
Adding controls (GDP growth, investment growth, inflation, interest rates, CA/GDP) does not change much the results.
Bubbles and monetary policy

Halting bubbles in their early stage poses a tough political economy problem – spoiling the party

Hard to tighten macro policy or regulation in the boom – countries could have done it in the run-up to the crisis, but nobody did.

Should monetary policy target asset prices?

Rather than just react to goods inflation and the output gap (the Taylor rule), react to asset price inflation too (“flexible inflation targeting”)
Orthodox view: many problems

- Hard to spot bubbles early on – and time the intervention
- Interest rate ‘too blunt’ an instrument
- Many assets -- which ones to watch? (real estate?)

Pre-crisis consensus

- focus on inflation and output gap
- ignore asset price developments, unless threat to primary objectives
- react only to the consequences of bubbles – ‘mopping up’
Post-crisis challenge to consensus:
• low / stable inflation no guarantee of financial stability
• asset price rise not warranted by fundamentals leads to instability

React to the prices of assets
• raise interest rates in response to a developing asset price bubble (‘lean against the wind’)
• e.g., react to the price of assets held by leveraged institutions (Adrian and Shin 2010)

Some evidence that rate of asset acquisition is affected
Also: lending standards react to money tightening
Back to targeting financial aggregates?
How robust is the case for ‘leaning against the wind’?

Maintained assumption:
\[ \uparrow \text{interest rate} = \downarrow \text{bubble} \]

Based on a "fundamentals" intuition:
\[ \uparrow \text{interest rate} = \downarrow \text{asset price} \]
But two key features of a bubble:

(i) no payoffs to be discounted
(ii) return on the bubble = growth in bubble size

Equilibrium requirement:

↑ interest rate  = ↑ expected bubble growth

So "leaning against the wind" may amplify fluctuations in the size of the bubble

So what is the impact of interest rate changes on asset prices under rational bubbles? (Galí 2014, Galí and Gambetti 2015)
Asset pricing equation (under risk neutrality)

\[ Q_t R_t = E_t \{ D_{t+1} + Q_{t+1} \} \]

Decomposition

\[ Q_t = Q_t^F + Q_t^B \]

\[ Q_t^F = E_t \left\{ \sum_{k=1}^{\infty} \left( \prod_{j=0}^{k-1} \frac{1}{R_{t+j}} \right) D_{t+k} \right\} \]

\[ Q_t^B R_t = E_t \{ Q_{t+1}^B \} \]

Impact of interest rate increase?

\[ \uparrow \text{interest rate} \Rightarrow \downarrow Q_t^F, \uparrow E_t \{ Q_{t+1}^B / Q_t^B \} \]
Equilibrium bubble dynamics (log-linearized):

$$q_t^B = q_{t-1}^B + r_{t-1} + \zeta_t$$

where \(\{\zeta_t\}\) is an arbitrary process, such that \(E_{t-1}\{\zeta_t\} = 0\) for all \(t\)

\(\Rightarrow\) "level indeterminacy"

Note that

$$\zeta_t = \zeta_t^* + \psi(R_t - E_{t-1}\{R_t\})$$

where \(\{\zeta_t^*\}\) is orthogonal to interest rate innovations and \(\psi \leq 0\)
Exogenous process for the interest rate

\[ r_t = \rho_r r_{t-1} + \varepsilon_t \]

Bubble response:

\[ \frac{\partial q^B_{t+k}}{\partial \varepsilon_t} = \psi + \frac{1 - \rho_r^k}{1 - \rho_r} \]

for \( k = 0, 1, 2, \ldots \)

Long run effect

\[ \lim_{k \to \infty} \frac{\partial q^B_{t+k}}{\partial \varepsilon_t} = \psi + \frac{1}{1 - \rho_r} \]

Possible rationale for "leaning against the wind" policies: large, negative \( \psi \)

\[ \Rightarrow \text{fragile foundations} \]
Example (refinement)

\[
\psi \equiv \frac{\partial q_t^F}{\partial \varepsilon_t} = -\frac{R}{R - \rho_r}
\]

Bubble response:

\[
\frac{\partial q_{t+k}^B}{\partial \varepsilon_t} = -\frac{R}{R - \rho_r} + \frac{1 - \rho_r^k}{1 - \rho_r}
\]

for \( k = 0, 1, 2, \ldots \)

Long run effect

\[
\lim_{k \to \infty} \frac{\partial q_{t+k}^B}{\partial \varepsilon_t} = \frac{\rho_r (R - 1)}{(R - \rho_r)(1 - \rho_r)} > 0
\]
- Asset price decomposition

\[ Q_t = Q_t^F + Q_t^B \]

- Dynamic response to an exogenous monetary policy shock

\[ \frac{\partial q_{t+k}}{\partial \varepsilon_t^m} = (1 - \gamma_t) \frac{\partial q_{t+k}^F}{\partial \varepsilon_t^m} + \gamma_t \frac{\partial q_{t+k}^B}{\partial \varepsilon_t^m} \]

for \( k = 0, 1, 2, 3, \ldots \) where \( \gamma_t \equiv Q_t^B / Q_t \)
• Model predictions:

\[ \frac{\partial q_{t+k}^F}{\partial \epsilon_t^m} < 0 \]

For small \( \psi \) and sufficiently large \( k \):

\[ \frac{\partial q_{t+k}^B}{\partial \epsilon_t^m} > 0 \]

In the latter case, and if \( \gamma_t \equiv Q_t^B / Q_t \) is sufficiently large:

\[ \frac{\partial q_{t+k}}{\partial \epsilon_t^m} > 0 \]
Figure 6. Monetary Policy and the 1928-29 Stock Market Bubble

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Figure 8. Monetary Policy and the Housing Bubble
Figure 7. Monetary Policy and the Dotcom Bubble

Kuala Lumpur 2016 - Luis Servén
• Under reasonable scenarios, raising the interest rate only has a short-lived negative effect on the bubble – then it gets bigger

• Unless the bubble is small, the interest rate increase may feed further the increase in asset prices

• The result holds also in a full-blown NK model of monetary policy (but without financial frictions)
• Result consistent with evidence from past episodes

• Attempting to deflate bubbles with monetary tightening may be a risky strategy

• Weak theoretical foundations for a policy of ‘leaning against the wind’
Another policy view: two targets demand two objectives.

For price stability, monetary policy.

For financial stability, ‘macro-prudential’ policy.

Financial regulation aimed to systemic risk – rather than just the risk of the individual institution

Measures to weaken amplification mechanisms – time / currency mismatches – and strengthen capital /liquidity buffers…

But so far not much evidence on the effectiveness of macro-prudential tools at stopping / preventing bubbles.
Annex

Some macro models with bubbles
Martin and Ventura AER 2011: bubbles and growth

Two key ingredients:
• Financial frictions
• Shocks to ‘investor sentiment’
• Financial frictions allow efficient and inefficient investments to coexist – their rates of return differ.

• Bubbles help growth by reducing inefficient investments and raise efficient ones.

• Sentiment shocks generate bubbly dynamics – bubbles come and go.

• They lead to consumption booms – and may lead to investment and output booms too.
Model setup:

2-period lived individuals, consume only when old. 2 assets: productive capital and intrinsically worthless bubbles.

2 types of investors (in proportions $\varepsilon$ and $1 - \varepsilon$)
  Efficient: output cost of acquiring capital = 1
  Inefficient: cost $1/\delta > 1$
  Average cost then is $A = \varepsilon + (1 - \varepsilon)\delta$

Cobb-Douglas setting: $y_t = k_t^{\alpha} l_t^{1-\alpha}$; let $l_t = 1$
Young save all their labor income:

$$S_t = (1 - \alpha) k_t^{\alpha}; \quad \text{the saving rate} \quad s_t \equiv \frac{S_t}{y_t} = 1 - \alpha$$
Financial frictions prevent efficient investor borrowing from inefficient investors (otherwise only the efficient would invest).

At any time the ‘supply’ of bubbles may include:
• ‘old’ bubbles, to be sold by today’s old $b$
• New bubbles created by today’s productive investors $b^{NP}$
• New bubbles created by today’s non-productive investors $b^{NU}$

The demand for bubbles comes only from today’s young
Bubbles must satisfy 2 conditions:
(1) Yield the same expected rate of return as the alternative asset (risk neutrality)
(2) Not become ‘too big’ – exceeding the young’s saving

This leads to two possible configurations with bubbles:
A. ‘small’ bubble: its total market value is less than the resources of the non-productive investors
   Then they hold some capital too
   The expected return on the bubble must equal the return on capital to non-productive investors: \( \alpha k_t^{\alpha-1} / (1/\delta) \)
B. ‘large bubble’: its total market value exceeds the resources of the non-productive investors
   Then productive investors must hold the bubble too
   The expected return on the bubble must equal the (higher) return on capital to productive investors: \( \alpha k_t^{\alpha-1} \)
Formally:

\[
E_t \left\{ \frac{b_{t+1}}{b_t + b_{t}^{NP} + b_{t}^{NU}} \right\} \begin{cases}
\delta \cdot \alpha \cdot k_{t+1}^{\alpha-1} \\
\in [\delta \cdot \alpha \cdot k_{t+1}^{\alpha-1}, \alpha \cdot k_{t+1}^{\alpha-1}] \\
= \alpha \cdot k_{t+1}^{\alpha-1}
\end{cases}
\]

if \( \frac{b_t + b_{t}^{NP}}{(1 - \varepsilon) \cdot s \cdot k_t^{\alpha}} < 1 \)

if \( \frac{b_t + b_{t}^{NP}}{(1 - \varepsilon) \cdot s \cdot k_t^{\alpha}} = 1 \)

if \( \frac{b_t + b_{t}^{NP}}{(1 - \varepsilon) \cdot s \cdot k_t^{\alpha}} > 1 \)

\( 0 \leq b_t \leq s \cdot k_t^{\alpha} \).

(There is also an intermediate ‘borderline’ case with the return on the bubble somewhere in between the returns on capital of the two types of investors).

Note: total resources of non-productive investors are \((1 - \varepsilon)sk_t^{\alpha} + b_t^{NU}\)

So the test is \( \left(b_t^{NP} + b_t^{NU} + b_t\right) \) vs \((1 - \varepsilon)sk_t^{\alpha} + b_t^{NU}\)
What happens to capital accumulation?

• If the bubble is small, the marginal holder is a non-productive investor. Capital accumulation is:

\[
\varepsilon sk_t^\alpha + b_t^{NP} + \delta \left( (1-\varepsilon)sk_t^\alpha + b_t^{NU} - (b_t^{NU} + b_t^{NP} + b_t) \right)
\]

resources of the productive

• If the bubble is large, the marginal holder is a productive investor. Non-productive do not invest. Capital accumulation is:

\[
\varepsilon sk_t^\alpha + b_t^{NP} - \left( b_t^{NU} + b_t^{NP} + b_t \right) - \left( (1-\varepsilon)sk_t^\alpha + b_t^{NU} \right)
\]

resources of the productive
Hence ‘old bubbles’ crowd out investment (inefficient first, efficient afterwards), while new bubbles *may* crowd it in by shifting resources to efficient investors:

\[
k_{t+1} = \begin{cases} 
A \cdot s \cdot k_t^\alpha + (1 - \delta) \cdot b_t^{NP} - \delta \cdot b_t & \text{if } \frac{b_t + b_t^{NP}}{(1 - \varepsilon) \cdot s \cdot k_t^\alpha} < 1 \\
 s \cdot k_t^\alpha - b_t & \text{if } \frac{b_t + b_t^{NP}}{(1 - \varepsilon) \cdot s \cdot k_t^\alpha} \geq 1
\end{cases}
\]

So there is a ‘reallocation effect’ additional to crowding-out.

But the reallocation effect disappears if:
• No new bubbles are possible \((b^{NP} = 0)\)
• Borrowing and lending are allowed (or all investors are equally efficient) so \(\square = 1\).

Then we only get the classical crowding-out effect.

Reallocation dominates (there is crowding in) if \((1 - \delta)b_t^{NP} > \delta b_t\)
So emergence of new bubbles may raise investment and growth.

When can bubbles arise? To see it, look at bubbles relative to saving: \( x_t = b_t / s k_t^\alpha \); and analogously for \( x_t^{NP}, x_t^{NU} \).

Then the laws of motion of the bubble can be restated

\[
E_t x_{t+1} \begin{cases}
= \frac{\alpha}{s} \cdot \frac{\delta \cdot (x_t + x_t^{NP} + x_t^{NU})}{A + (1 - \delta) \cdot x_t^{NP} - \delta \cdot x_t} \\
\in \left[ \frac{\alpha}{s} \cdot \frac{\delta \cdot (x_t + x_t^{NP} + x_t^{NU})}{A + (1 - \delta) \cdot x_t^{NP} - \delta \cdot x_t}, \frac{\alpha}{s} \cdot \frac{x_t + x_t^{NU} + x_t^{NP}}{1 - x_t} \right] \\
= \frac{\alpha}{s} \cdot \frac{x_t + x_t^{NP} + x_t^{NU}}{1 - x_t}
\end{cases}
\]

if \( \frac{x_t + x_t^{NP}}{1 - \varepsilon} < 1 \)

if \( \frac{x_t + x_t^{NP}}{1 - \varepsilon} = 1 \)

if \( \frac{x_t + x_t^{NP}}{1 - \varepsilon} > 1 \)

\[0 \leq x_t \leq 1.\]
The important thing here is the anticipated rate of growth of the bubble. For a small bubble,

\[
\frac{\partial E_t x_{t+1}}{\partial x_t} \bigg|_{x=0} = \frac{\alpha \delta}{sA}
\]

The bubble will become ‘too large’ with certainty unless

\[
\alpha < \frac{sA}{\delta} = s \left( \frac{\varepsilon}{\delta} + 1 - \varepsilon \right) \equiv \alpha_c
\]

If this holds, contractionary (crowding-out) bubbles are possible. [Note with homogeneous investors this is just the classic condition for dynamic inefficiency \( \alpha < s \)].

In addition, expansionary bubbles are possible if \( \alpha < \alpha_E \) (another parameter combination)
In summary:

Region I: no bubbles are possible
Region II: only contractionary
Region IV: only expansionary
Region III: both
• Here $c_t = \alpha k_t^\alpha + b_t$
• Contractionary bubbles raise consumption (and welfare!) but lower investment and output.
• Expansionary bubbles raise consumption and investment.

These aggregate fluctuations are unrelated to fundamentals.

The appearance and disappearance of bubbles and their evolution depend on ‘investor sentiment’—stochastic sequences $x, x^{NP}, x^{NU}$ consistent with the laws of motion.
Example in the paper with two types of shocks to sentiment:

- Large socks: shift the economy between bubbleless and bubbly equilibrium
- Small shocks: govern bubble dynamics
The ‘market for bubbles’ in the model can be reinterpreted in terms of the credit market.

And the financial friction can be reinterpreted as the presence of collateral constraints preventing efficient firms from borrowing enough.

The bubbles then affect the stock prices of efficient and inefficient firms. In particular, they create more collateral for efficient investors to borrow – and this raises investment efficiency and growth.

When bubbles burst (stock prices crash), there is a loss of collateral, a credit crunch and a fall in consumption and output.
Model simulation with a collateral constraint
Bubbles and capital flows

In an open economy, rational bubbles can act as a substitute for capital flows. Their effects are then similar to those of financial integration (Ventura 2011).

Limited stores of value make emerging markets fertile ground for the emergence of bubbles. These economies often show bubble-like dynamics with asset booms and crashes (e.g., Caballero et al 2006).
Ventura’s 2011 model

Open-economy relative of previous model.

- Different countries characterized by different rates of return on investment
- Financial friction: international trade in assets is restricted (extreme version: no asset trade)
- Unrestricted goods trade so growth rates are equalized

Bubbles arise in low-efficiency countries (but they are not traded internationally)

And they play the same role as international financial integration – shift capital to more efficient countries
Sketch of model:

- $J$ countries
- No asset trade (K-controls? Expropriation risk?) so rates of return differ across countries.
- 2 factors (K and L) used to produce L- and K-intermediates
- 2 final goods: consumption (uses K and L intermediates) and investment (K intermediate only)
- No trade in final goods, free trade in intermediates.
- perfect competition and equal technologies everywhere
- Overlapping generations (of size 1). Young work and save; old consume.
- Productivity of investment in country $j$ indexed by $\pi^j$
- Capital depreciates fully; i.e., $K_{t+1}^j = \pi_{t+1}^j L_t^j$
Here the growth rate of world consumption (equal in all countries in the long run via ToT) is
\[ g_t = \alpha R_t \]
Here \( \alpha = \) share of L in production of the C-good
\( R_t = \) average rate of return on countries’ portfolios

**In the absence of bubbles**, all national saving (= the wage) goes to capital: \( q_tI_t^j = w_t \). \( (q = \) price of I good)

The return on country j’s portfolio is
\[ R_t^j = g_t^{-\alpha/(1-\alpha)} \pi_t^j \]
(\( \pi = \) productivity. Higher world consumption growth means higher wages and hence a lower rate of return on capital)

and world growth just depends on average productivity:
\[ g_t = (\alpha \pi_t)^{1-\alpha} \]
**Bubbly equilibrium**

If $R_t^j > g_t$ for all $j$ and $t$, the non-bubble equilibrium is unique. But if $R_t^j < g_t$ for some $j$ and $t$, there may be other equilibria with rational bubbles. The young buy the bubbles from the old and use them as a store of value. Without international asset trade, these bubbles are just domestic.

If there is a bubble, it grows at the rate

$$B_{t+1}^j = m_{t+1}^j B_t^j$$

($m_{t+1}$ may be unknown at time $t$).

Now the country portfolio includes $B$ too: $B_t^j + q_t I_t^j = w_t$. 
The portfolio share of the bubble depends on $E_t m_{t+1}^j$ compared with the return on capital, $E_t[r_{t+1} \pi_{t+1}^j/q_t]$. If the former is greater, all saving goes to the bubble; if the latter is bigger, all goes to capital.

The return on the country portfolio now is

$$R_t^j = (1-b_{t-1}^j) g_t^{-\alpha/(1-\alpha)} \pi_t^j + b_{t-1}^j m_t^j$$

(b is the bubble’s portfolio share).

Here bubbles may arise in low-productivity countries. Assume there are 2 equal sets of countries: high productivity $\pi^H$ and low productivity $\pi^L$. Absent bubbles, world consumption growth is just

$$g_t = (\pi^H + \pi^L)^{1-\alpha} (\alpha / 2)^{1-\alpha}$$
In this setup, a low-productivity country $j$ may coordinate on a bubbly equilibrium. For this to be possible, the growth rate cannot be less than the rate of return on capital (otherwise there will not be enough demand for the bubble):

$$g_t > g_t^{-\alpha/(1-\alpha)} \pi_t^j.$$ Equivalently, $g_t^{1/(1-\alpha)} > \pi_t^j$

This can only hold for the low-productivity countries.

Assume that a fraction $\phi$ of the low-productivity countries coordinate on the bubbly equilibrium. In those countries, $b = 1$, so that the bubble **fully** crowds out investment.
World consumption growth now is:
\[ g_t = \alpha \left( R_t^H + R_t^L \right) / 2 = (\alpha / 2) \left[ g_t^{\alpha/(1-\alpha)} \pi_t^H + (1-\varphi) g_t^{\alpha/(1-\alpha)} \pi_t^L \right. \]
\[ \left. + \varphi \ g_t \right] \]

Solving, we get:
\[ g_t = \left[ \alpha/(2-\alpha \varphi) \right]^{(1-\alpha)} \left[ \pi^H + (1-\varphi) \pi^L \right]^{1-\alpha} \]

The key implication is that the world growth rate is higher the bigger \( \varphi \) – i.e., the more low-productivity countries coordinate on the bubble.

Why? Without capital flows, the bubble provides the mechanism to improve the world allocation of investment – it crowds out investment in low-efficiency countries and raises investment in high-efficiency countries.
• Investment rises in high-productivity countries through the general-equilibrium effects: (a) lower demand for K-goods in low-productivity countries lowers the price of capital q – thus raising their capital accumulation for given levels of saving and investment; (b) higher consumption demand raises the wage and hence saving across the world.
• Hence a larger proportion of bubble countries raises investment, the world capital stock and growth.
• Low-productivity bubble countries enjoy a higher rate of return on their portfolio relative to the rest of the world – hence international rate of return differentials decline, and so does the dispersion of consumption levels across countries.
• Here bubbles are a second-best mechanism to improve the world allocation of investment – they are a substitute for capital flows.
Other applications of the model:

(1) *Cyclical fluctuations*: assume each country can transit between low and high productivity states with fixed probability. Now all (or none) of the countries can have the bubble. Transitions to low-productivity states lead to expansions of the bubble; transitions to high productivity contract it.

As before, the bubble raises world growth but now it also makes investment more volatile: when productivity is high the bubble contracts and investment expands; conversely when it is low. Hence the bubble allows saving-investment separation – just like capital flows would.
Financial fragility: assume exogenous expectational shocks – shifts between optimism (belief that future generations will buy the bubble) and pessimism (belief that they will not). These trigger shifts from the bubbly to the bubbleless equilibrium (i.e., bursts of the bubble).

Now shocks to expectations can affect real variables. All countries go through bubbly and bubbleless periods. Bubble bursts cause wealth and consumption falls – consumption declines in low-productivity countries and rises in the others (and conversely when the bubble starts).

Here “financial fragility” results from the absence of asset trade – with asset trade, all investment would go to efficient countries, with no role for expectational shocks.
(3) **External shocks**: assume two countries, North and South. In North, productivity fluctuates between high and low. In South it is constant and low. What happens here depends on the North-South productivity gap.

- If the gap is small, South is better off investing.
- If the gap is large, South is better off holding a bubble. World growth is more sensitive to North’s fluctuations because bubble growth itself depends on world growth.
- In the intermediate case, South invests when North’s productivity is low and holds a bubble when it is high. South (and world) growth falls more in the onset of a North recession (because the bubble bursts) and rises more in the onset of a boom (because the bubble gets under way).
Here small shocks in North may have strong effects on asset prices in South, with major effects on consumption and wealth.

This offers a perspective on the effects of reforms in South -- that narrow the productivity gap against North -- on its vulnerability to external shocks:

• At first, reforms raise consumption in South but make it more vulnerable to shocks from North – drops in North productivity lead to financial crises.
• Further reductions in the productivity gap eventually rule out bubbles, make investment more attractive, and allow South to achieve consumption stability.
• But bubble holders lose out from the implementation of these reforms – and this may undermine support for the reforms.
Caballero and Krishnamurty (2006)

- Like Ventura, the basic ingredient is the shortage of stores of value in emerging markets: poor investor protection prevents firms from capitalizing future earnings and using them as stores of value (or collateral) for investors.
- Investors seek external stores of value (through capital outflows). But these offer low rates of return relative to the high growth potential of emerging markets (similarly to dynamic inefficiency).
- This creates room for rational bubbles on unproductive local assets (e.g., real estate).
- Bubbles would be beneficial because they relax collateral constraints – except that they can (exogenously) crash.
• When the bubble crashes, there can be a “credit crunch” due to lack of lending collateral: bankers / investors’ holdings of foreign goods are the only collateral available. Its volume constrains lending and investment.

• Private bankers / investors do not provide sufficiently for the crash state. In the private optimum, they hold too much of the bubble and too little of foreign goods:
  • In a “large crash” state, the social return on foreign goods is the marginal product of capital $R$. The private return (to lenders) equals the private return on loans $p_C < R$ – and $p_C$ is lower the tighter the collateral requirements (i.e., the less financially-developed the economy). [Note $p_C > R$ is never feasible – nobody would borrow]
  • Bankers show “lack of prudence” in their ex-ante portfolio decisions: they chase high returns by investing excessively in the bubble, rather than retaining international liquidity for lending
Private (P) vs socially (S) optimal portfolio share of the bubble ($\alpha$).
• The bubble creates “financial fragility” – makes the economy vulnerable to credit crunches in the event of a large bubble crash (a crash when $\alpha > \alpha^S$).

• How can we retain the beneficial effects of the bubble (as store of value) but prevent credit crunches? Risk management policies.
  • Liquidity requirements: force agents to hold $(1 - \alpha^S)$ of their portfolios in foreign reserves (e.g., reserve requirements on the banking system). But agents have clear incentive to deviate: at $p_C = 1$, their optimal choice (in the graph) is $\alpha = 1$ and hold only the bubble. So this is hard to enforce.
  • Public debt (a la Diamond) – to replace the bubble as store of value. But debt itself is a bubble, subject to crashes if future generations refuse to hold it. To make it crash-proof, the government must have enough tax capacity to collateralize the debt with future tax revenues (but it will never need to actually raise the taxes, a la Diamond-Dybvig). This serves as the intergenerational coordination mechanism.
Technological innovation and bubbles


Arrival of new, unfamiliar investment opportunities – e.g., Internet stocks; emerging markets – may result in large asset price movements detached from fundamentals, and booming real activity.

This happens due to ‘information spillovers’ – nobody knows how profitable investment is, so agents try to infer information from what others do and from public (noisy) signals.

This turns out to make asset prices to react too much to noise and too little to fundamentals – it leads to ‘rational exuberance’.
Stylized model with two types of agents:
-- entrepreneurs / investors who invest in a new technology.
-- traders who purchase the capital assets from investors.

Initially, the profitability of the technology is unknown. At $t=1$, investors receive a noisy profitability signal (possibly correlated across investors), and decide their investment.

At $t=2$, some entrepreneurs find out they can’t wait and sell their capital to the traders.

Traders observe aggregate investment (and/or other public signal) and try to guess the profitability of capital (the fundamental) before deciding their asset demand.

At $t=3$, profitability is revealed and production takes place.
This setup generates a sort of ‘beauty contest’:

-- entrepreneurs base their investment decisions on their expectation of what traders will pay for the assets

-- traders look at investment decisions to infer how profitable the new technology really is (just like financial markets follow carefully the release of macro data).

Hence entrepreneurs (traders) must form beliefs about traders’ (entrepreneurs) beliefs about entrepreneurs’ (traders’) beliefs…a beauty contest.

Investment and asset prices depend on higher-order beliefs.
In equilibrium of this model, asset prices and investment respond too much to the noisy signal (like in Allen et al).

Here it is optimal for entrepreneurs to invest more in response to the belief that traders will incur positive forecast errors (because they will pay more for the assets).

This in turn contributes to inflate asset prices (as traders see higher investment and overestimate the fundamental).

Hence there is too much volatility in asset prices and investment.

A policy of asset price stabilization is Pareto-improving: pro-cyclical taxation of asset transactions (or some other similar device).
The bursting subprime bubble

Housing was a prime source of borrowing collateral in the runup to the crisis. Collateralized borrowing plays a critical role in the economy. Its collapse can be seen as a critical ingredient in the real costs of the subprime crisis.

Kocherlakota 2009: stylized model (closed-economy analogous to Caballero and Krishnamurty) in which collateral scarcity can generate a bubble in the price of collateral.

An intrinsically worthless asset (land) may have value because it serves to relax (directly or indirectly) borrowing constraints faced by productive investors. Collateral helps reallocate resources towards entrepreneurs with good projects.
Basic ingredients:

- Some entrepreneurs randomly get good projects, others do not.
- Each entrepreneur has one unit of land, which is the only collateral and yields no return. Lending will be made only against (and up to the value of) this collateral.

Two equilibria arise:

(1) No bubble: land is worthless, and there is no borrowing. Entrepreneurs without good projects (‘savers’) just hold depreciating capital (there is no one to lend to).

(2) Bubble: land has a positive constant price. Only entrepreneurs with good projects (‘investors’) hold capital. They borrow as much as possible. The others hold land and bonds (loans).
The bubbly equilibrium is better in terms of output, wages, and welfare. The basic reason is there is more wealth.

The bubbly equilibrium may feature lower capital than the bubbleless equilibrium. The reason is that with the bubble productive efficiency rises: resources can be channeled from savers to investors through lending. Savers do not have to hold (useless) capital.

From these two equilibria, go to an expanded model that starts with a stochastic bubble that can burst forever in any given period with exogenous probability.
In the expanded model, savers’ problem is a bit more involved because the bubble can burst at any time. So they hold some capital to hedge this risk. Otherwise, the initial equilibrium is very similar to the simple bubbly equilibrium.

Assume the bubble bursts. Investors are not much affected -- their liabilities are wiped out along with the value of their land. But savers lose much of their wealth (land and loans). This leads to a drop in consumption.

After the collapse, borrowing disappears. All projects must be self-financed (i.e., financial markets shut down). The capital stock declines permanently.

Note the problem is not that intermediaries (if present) are in trouble – it is that investors have no collateral.
Figure 1: Output Before and After A Bubble Burst
What policies would help ex post?

There are two problems after the burst:
(1) Investors lack collateral
(2) Savers lack high-return saving vehicles

To remedy (1), the government could provide another source of collateral – public debt, like in Caballero-Krishnamurty.
To remedy (2), the government could issue high-return debt to savers [so the government effectively acts as financial intermediary]

Standard policies do not always do this. For example, giving debt to intermediaries to recapitalize them will not fix (1).