Bubbles

Macroeconomics IV

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Spring 2011

References

- Allen, F. and D. Gale, "Bubbles and Crises," *Economic Journal*, 110:236-255, 2000.
- Tirole, J., "Asset Bubbles and Overlapping Generations," *Econometrica,* 53,(6), 1499-1528, November 1985.
- Abreu D. and M. Brunnermeier, "Bubbles and Crashes," *Econometrica,* 71:173-204, 2003.

Introduction

- Historical: Dutch Tulipmania, South Sea... Great Crash of 1929
- South Sea Bubble (1710-1720)
  - Isaac Newton: 04/20/1720 sold shares at £7,000, profiting £3,500. Re-entered the market later – ended up losing £20,000
  - "I can calculate the motions of the heavenly bodies, but not the madness of people"
- Japan boom-bust (a lost decade); EMEs, Nasdaq, real estate (all around the developed world), commodities
- Where do they come from? What to do about them?

Main points

- Two broad (and polar) views:
  - There is a shortage of store of value – bubbles help fixing this problem
  - Agents misbehave (either an agency problem or a behavioral problem)
- My view: These views are more intertwined than it may seem
  - The former is about macro environments where there is shortage of assets
  - The latter is about the location of bubbles
- Other: "irrational exuberance" and more formal behavioral stories
  - My view: More likely to arise when the above conditions are present

Risk shifting

- Allen-Gale (2000) – Bubbles and crises
- There is a pattern:
  - Phase 1: financial liberalization or some expansionary policy fuels a bubble
  - Phase 2: the bubble bursts and asset prices collapse
  - Phase 3: widespread defaults by leveraged asset buyers, leading to a banking and/or exchange rate crisis, and a persistent recession
- Main ingredient (this is all we'll discuss here): Uncertainty about payoffs (real or financial sector) can lead to bubbles in an intermediated financial system (risk shifting/asset substitution)

Model

- Two dates, $t = 1, 2$ and a single consumption good
- Two assets:
  - Safe and in variable supply at a rate r
  - Risky and in fixed supply. Stochastic return is R per unit, with density $h(R)$ and support $[0, R_{MAX}]$
- The return on the safe asset is determined by marginal product of capital: $r = f'(x)$ where x are units of the consumption good (standard assumptions on f)
- Non-pecuniary convex cost of investing in risky assets $c(x)$ (to restrict portfolio sizes and to ensure equilibrium profit for borrowers)

Model

- There is a continuum of small, risk neutral *investors*; idem for *banks*.
- Investors have no wealth while banks have a fixed amount B (which they supply inelastically). Only investors know how to invest, so banks' only choice is to lend to investors
- Banks and investors are restricted to used simple debt contracts (in particular, they don't depend on size)
- Since investors can borrow as much as they want at the going rate, in equilibrium the contracted rate on loans must be equal to the riskless interest rate
- Symmetric eq. All investors are identical ex-post. X_s and X_R are the representative investor's holdings of the safe and risky assets

Risk shifting

- Because banks use debt contracts and cannot observe investment decisions by borrowers, the latter does not bear the full cost of investment if the outcome is bad, while it gets the benefit if the outcome is good
- If representative investor buys X_s and X_R, it borrows $X_s + PX_R$ (where P is rel. price of risky asset) and the repayment (if not bankrupt) is $r(X_s + PX_R)$
- The liquidation value of the portfolio is $rX_s + RX_R$, so the payoff for the investor is:

$$\max\{(R - rP)X_R, 0\}$$

- and the decision problem is:

$$\max_{X_R \geq 0} \; X_R \int_{R^*=rP}^{R_{MAX}} (R - rP)h(R)dR - c(X_R)$$

Equilibrium

- Market clearing conditions:

$$\begin{aligned} X_R &= 1 \\ X_S + P &= B \\ r &= f'(X_S), \end{aligned}$$

- the focs evaluated at the equilibrium are:

$$\int_{R^*=rP}^{R_{MAX}} (R - rP)h(R)dR = c'(1)$$

$$r = f'(B - P)$$

from which we can solve for (r, P)

P

- We can re-write the foc wrt to P to get:

$$P = \frac{1}{r}\frac{\int_{R^*=rP}^{R_{MAX}} Rh(R)dR - c'(1)}{\Pr[R \geq R^*]}$$
$$= \frac{1}{r}\left(E[R|R \geq R^*] - \frac{c'(1)}{\Pr[R \geq R^*]}\right)$$

- Define the *fundamental* as the price an agent would be willing to pay in the absence of risk shifting, then:

$$P^f = \frac{1}{r}\left(E[R] - c'(1)\right)$$

- It is easy to show that, as long as $\Pr[R \leq R^*] > 0$,

$$P > P^f$$

Proof

$$
\begin{aligned}
rP\,\Pr[R &\geq R^*] = \int_{R^*=rP}^{R_{MAX}} Rh(R)dR - c'(1) \\
&= rP^f - \int_0^{R^*} Rh(R)dR \\
&> rP^f - (rP)(1 - \Pr[R \geq R^*])
\end{aligned}
$$

$$\Rightarrow$$

$$rP > rP^f$$

Final remarks

- Hence, due to risk shifting, P is higher than fundamental (bubble)
- The counterpart of the bubble is the bank losses, and hence the rest of the story...
- In a sense it is not a GE bubble, as the price of banks should go down... but it may well be that households are stuck... this takes us to the standard model of RE bubbles in macro, which highlights the shortage of assets..

Asset shortages

- Let's remove uncertainty to highlight the fact that the nature of these bubbles is very different from the risk-shifting argument
- Read Tirole's 1982 "On the possibility of speculation under RE" (EMA).... so you realize that *rational* bubbles are not easy to get...
- But we know from Samuelson's (1958) consumption-loan model that "bubbles" (i.e. assets with positive price but no intrinsic value) can exist in OLG structures (infinite new traders in the horizon) and that they can be *good*
  - "Money" in Samuelson's model, but not for its transaction service but to store value. Pareto gain from solving dynamic inefficiency (no capital wasted to store value).

A barebones version of Samuelson's model

- OLG. Individuals live for two periods, they are born with an endowment w_t
- Which they save in its entirety and only consume when old (hence we can index the generations welfare by $c_{t,t+1}$) .
- There is no population growth, but the endowment grows at a rate γ.

$$\begin{aligned} w_{t+1} &= (1+\gamma)w_t \\ c_{t,t+1} &= (1+r_t)w_t \end{aligned}$$

- What is the interest rate in this economy?

Mother nature...

- The answer depends on which assets are available to store value.
- Samuelson first observed that the young could not save by lending to the old since the latter will not be around to repay them later (financial market incompleteness). The only option of the young is to trade with "mother nature," i.e. to invest in physical capital.
- Let's simplify the technology side and assume that it has constant returns: π. That is, one unit of savings at t produce $1+\pi$ at $t+1$ (we could have a more standard $f(k)$... but main insights would be unchanged). It follows that the interest rate in this economy must be:

$$r_t = \pi$$

and utility is:

$$U_t^{MN} = (1+\pi)w_t$$

Social contract

- Is there any other solution to this model? Consider a social contract by which the young give the entire endowment to their parents who then consume it. Under this social contract the welfare of generation t is:

$$U_t^{SC} = (1+\gamma)w_t$$

- If $\gamma > \pi$, the social contract provides a higher utility than the market!
- How is this possible? In each period, the resources that the market economy devotes to investment, w_t, exceed the resources that it obtains from such activity, $(1+\pi)w_{t-1}$, wasting:

$$(\gamma - \pi)w_{t-1}$$

- The social contract stops this waste, and raises welfare for all

Bubbles

- More broadly: the market economy is overaccumulating capital to facilitate store of value
- Does this mean that the market economy is suboptimal? Not necessarily. Naturally, if $\gamma < \pi$ the market outperforms the social contract. But even if $\gamma > \pi$, the market can reach the same allocation as the social contract, provided we enlarge the saving options of the young to include one irreproducible and useless object with price B_t such that:

$$B_{t+1} = (1 + r_t)B_t$$

Welfare

- Let $x \equiv B/w$. Then

$$x_{t+1} = \frac{B_{t+1}}{w_{t+1}} = \frac{(1+r_t)B_t}{(1+\gamma)w_t} = \frac{1+r_t}{1+\gamma}x_t$$

- If $x < 1$, then $r_t = \pi$ and the bubble vanishes asymptotically.
- However, if $x = 1$, then $r_t = \gamma$ and we reproduce the social contract! That is, not only a bubble can exist, but it is also welfare enhancing.

Final remarks

- There are two Pareto-rankable stationary equilibria (bubble better than fundamental); and a continuum of non-stationary equilibria that converge to the fundamental equilibrium that provide intermediate welfare (note: all these equilibria contain bubbles, but these become small relative to the economy)
- Bubbles arise as a result of coordination across different generations. But this is just one of the possible equilibria, and hence the possibility of a crash is latent

Appendix: Abreu and Brunnermeier

- Behavioral biases lead to bubbles (they take this as given)
- Assuming that rational arbitrageurs understand that the market will eventually collapse, will they still ride the bubble?
- *Delayed arbitrage model* (riding the bubble for a while may be optimal) [connection with earlier discussion on limited arbitrage]
- A model of *market timing*
  - Dispersion in exit strategies makes the bubble possible
  - At some random time t_0 price surpasses the fundamental value. Thereafter, rational arbitrageurs become sequentially aware that the price has departed from fundamentals. They don't know whether they are early or late relative to others
  - Bubble bursts when a sufficient mass of arbitrageurs have sold out (coordination)

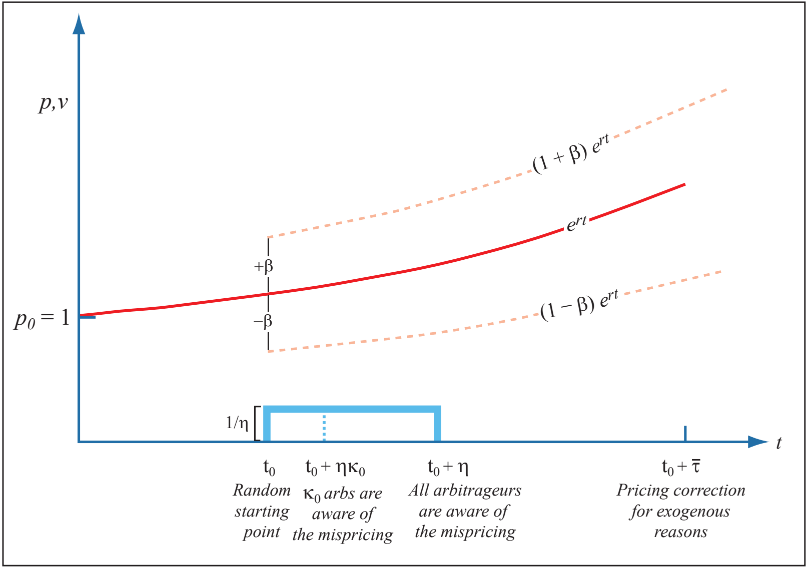
The Setup

- In "Bubbles and Crashes," they discuss an "irrational exuberance" episode where after same random date t_0 the price continues to rise at some rate $g > r$, while the fundamental only rises at r
- The main economic forces in their EMA paper are also found in their simpler, JFE, paper: "Synchronization Risk and Delayed Arbitrage" (we will develop this one, although the connection with a bubble is less direct)
- There is a single risky asset with price p_t and fundamental v_t. Prior to the arrival of a shock at a random time t_0, the fundamental value is e^{rt} and after that $(1 + \tilde{\beta})e^{rt}$, with $\tilde{\beta}$ taking values β and $-\beta$ with equal prob., and $F(t_0) = 1 - e^{-\lambda t_0}$
- Prior to the shock at t_0, $p_t = v_t$. After t_0 the price deviates from fundamentals until full arbitrage takes place (the crash if $-\beta$, which we assume henceforth)

The Setup

- There are two types of agents: rational arbitrageurs and behavioral traders
- The only role of the latter agents is to support the mispricing and maintain the price at $p_t = e^{rt}$ as long as the selling pressure by rational arbitrageurs lies below a threshold $\kappa(.)$
- The focus of the paper is on the former agents. Arbitrageurs are ex-ante identical but receive information about the deviation sequentially (uniformly) between t_0 and $t_0 + \eta$
- An individual arbitrageur who learns about the change in fundamental at t_i (denoted by $\hat{t}_i$) thinks that t_0 is distributed between t_i and $t_i - \eta$

The Setup



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The Setup

- Arbitrageurs are risk neutral but the maximum short position is $x_i = -1$. The "normal/neutral" position is $x_i = 0$. Departing from this benchmark generates ("large") holding costs of $cp_t|x_i|$
- The price correction occurs as soon as the aggregate order imbalance of all arbitrageurs exceeds $\kappa(t - t_0)$, with (reduced form from behavioral agents)

$$\kappa(t - t_0) = \kappa_0 \left[1 - (1/\bar{\tau})(t - t_0)\right]$$

- [If the trading order exceeds κ, there is a randomization of the price at which orders are executed]
- Motivation: The longer the mispricing persists, the smaller is the mass of behavioral traders that remain confident that the "price is right"
- Since there are no price changes, arbitrageurs cannot infer t_0 from them while pressure is below $\kappa(.)$

Market Timing and Delayed Arbitrage

- Arbitrageur $\hat{t}_i$ specifies a trading strategy as function of $\tau_i = t - t_i$. A-B focus on trigger strategies such that the arbitrageur sets $x_i = 0$ until a date $t_i + \tau_i^*$ and $x_i = -1$ after that (until the correction takes place)
- An arbitrageur that trades just before the correction achieves the highest payoff. By postponing the trade he reduces holding costs but risks missing the arbitrage opportunity (Keynes: "beat the gun" terminology)
- Let $h(t|\ \hat{t}_i)$ be arbitrageur $\hat{t}_i$'s perceived hazard rate that the price correction occurs in the next instant t. Thus, his estimate of a correction in the next (small) time interval Δ is $h(t|\ \hat{t}_i)\Delta$, while the holding cost is $cp_t\Delta$
- Thus the arbitrageur will only trade if the expected benefit $\beta p_t h(t|\ \hat{t}_i)\Delta$ exceeds the expected cost of holding a nondiversified portfolio $(1 - h(t|\ \hat{t}_i)\Delta)cp_t\Delta$
- Of course the hazard rate depends on other arbitrageurs' trading strategies. A-B restrict attention to symmetric trigger strategy equilibria (based on EMA article)

Abreu-Brunnermeier: Market Timing and Delayed Arbitrage

- If all arbitrageurs trade with a delay τ', then the price correction occurs at $t_0 + \varphi(\tau')$, where the latter is defined implicitly from

$$\varphi(\tau') = \tau' + \eta\kappa(\varphi(\tau'))$$

- Using the linear expression for $\kappa(.)$, we have

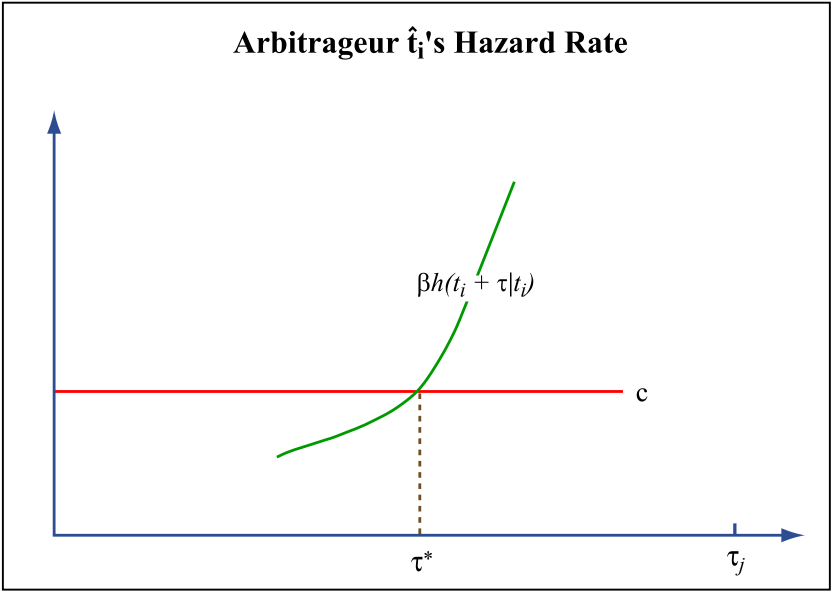
$$\varphi(\tau') = \bar{\tau}\frac{\tau' + \eta\kappa_0}{\bar{\tau} + \eta\kappa_0}$$

Market Timing and Delayed Arbitrage

- Arbitrageur $\hat{t}_i$ knows that, in equilibrium, the price correction will occur no later than $t_i + \varphi(\tau')$ but after $t_i + \varphi(\tau') - \eta$
- Given the prior distribution on t_0, the latter observation yields a simple posterior:

$$h(t|\hat{t}_i) = \begin{cases} 0 & \text{for} \quad t < t_i + \varphi(\tau') - \eta \\ \frac{\lambda}{1-\exp\{-\lambda(t_i+\varphi(\tau')-t))\}} & \text{for} \quad t \geq t_i + \varphi(\tau') - \eta \end{cases}$$

Market Timing and Delayed Arbitrage



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Final Remarks

- Arbitrage is delayed. This is possible because mispricing is never common knowledge, which preserves the disagreement about the timing of price corrections
  - The arbitrageur who becomes immediately aware of the mispricing at t_0 knows that at $t_0 + \eta$ everybody knows about the mispricing. However, the trader who only becomes aware at $t_0 + \eta$ thinks that he might be the first to hear of it and he does not know that all traders already know it. Hence, even if everybody knows of the mispricing at $t_0 + \eta$, only the first trader knows that everybody knows
  - At $t_0 + 2\eta$, even the last trader knows that everybody knows, but he does not know that everybody knows that everybody knows of the mispricing, and so on
- The main distinction with noise-traders is that most of the action comes from the rational traders. It is the uncertainty about the behavior of other rational traders that leads to delayed arbitrage