Monetary Policy for a Bubbly World

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Facts and Questions

- Key facts characterizing the US business cycle during the last two decades:
  - Fact 1: large fluctuations in net worth

Households and Nonprofit Organizations; Net Worth, Level/Gross Domestic Product*100

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  - Fact 1: large fluctuations in net worth
  - Fact 2: positive correlation between net worth and investment
  - Fact 3: positive correlation between net worth and interest rates
  - Fact 4: increase in central bank’s and government’s liabilities during liquidity trap

- Key questions:
  - How can we rationalize large fluctuations in net worth?
  - What are their effects on output, investment, interest rates and monetary aggregates?
  - What are the implications for (conventional and unconventional) monetary policy?
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Fed funds and 3m T-Bill rates: US, 1990-2015

Effective Federal Funds Rate
3-Month Treasury Bill: Secondary Market Rate
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This Paper

A model of credit, bubbles, and money:

1. Credit frictions linking collateral and investment

2. Rational bubbles:
   - Collateral effect → investment ↑
   - Overhang effect → investment ↓

3. Monetary economy
   - Money used for transactions but may compete with credit as a store of value
   - Bubbles can be real and nominal

Model consistent with facts 1-4

Useful to understand monetary policy in a bubbly world
**Agents**

- Two-period OLG structure
- Risk-neutral Epstein-Zin preferences:
  \[
  U\left(c_{1t}^i, c_{2t+1}^i\right) = \left(\frac{c_{1t}^i}{1-1/\theta} - 1\right) + \beta^i \cdot \frac{E_t\{c_{2t+1}^i\}^{1-1/\theta} - 1}{1-1/\theta}
  \]

- Savers: fraction $1 - \varepsilon$
  - Supply one unit of labor when young and receive wage $(1 - \tau)w_t$
  - Save by lending to entrepreneurs $F_t$ and by holding money $M_t$

- Entrepreneurs: fraction $\varepsilon$
  - Supply one unit of labor when young and receive wage $(1 - \tau)w_t$
  - Construct portfolios of capital and bubbles, $K_t$ and $B_t$
  - Finance their activities by selling credit contracts, $F_t$

- Only critical assumption is that savers cannot invest in capital
**Capital and Bubbles**

- **Capital:**
  - Production: \( Y_t = \left( \gamma^t L_t \right)^{1-\alpha} K_t^\alpha \)
  - Entrepreneurs invest in capital when young, and use it in production when old
  - Capital depreciates at rate \( \delta \)

- **Bubbles:**
  - Intrinsically useless assets that young entrepreneurs buy to resale them when old
  - Law of motion of bubbles of type \( j \): \( B_{t+1}^j = R_{t+1}^j \cdot B_t^j + N_{t+1}^j \)
    - \( R_{t+1}^j \) is the growth rate of old bubbles
    - \( N_{t+1}^j \) is the value of newly created bubbles
Entrepreneurs sell credit contracts to savers

- Promise a contingent gross return $R^i_{t+1}$
- $R_{t+1}$ is the real interest rate, so $R_{t+1} = E_t R^i_{t+1}$

Credit friction:

$$R^i_{t+1} \cdot F^i_t \leq \sum_j B^{i,j}_{t+1}$$

No restriction on the state-contingency of contracts
Money

- Monetary authorities set inflation $\pi_{t+1} \equiv p_{t+1}/p_t$ by setting money supply.

- Government spending absorbs fluctuations in seignorage:

$$G_t = \tau w_t + \frac{M_t - M_{t-1}}{p_t}$$

- Why hold money?
  - Small transaction needs:
    $$\frac{M_t^i}{p_t} \geq \nu \cdot \gamma^t, \quad \nu \to 0$$
  - Store of value: return $\pi_{t+1}^{-1}$
Entrepreneurs’ optimality conditions

Assumptions:

- Entrepreneurs do not consume when young: $\beta^E \to \infty$
- Entrepreneurs are credit constrained: $F_t = \frac{\sum_j B^i_{t+1}}{R_{t+1}}$

As a result, total investment in capital is:

$$K_{t+1} = \varepsilon(1 - \tau)w_t + \frac{\sum_j B^i_{t+1}}{R_{t+1}} - \sum_j B^i_t$$
Savers’ optimality conditions

- Total savings of young savers are given by:

\[ S_t = (1 - \varepsilon) \frac{\beta^\theta}{\beta^\theta + R_{t+1}^{1-\theta}} (1 - \tau) w_t \]

- Focus on \( \theta > 1 \rightarrow \) saving rate increasing in the interest rate

- Savers allocate \( S_t - \frac{M_t}{p_t} \) to credit, where:

\[
\frac{M_t}{p_t} \begin{cases} 
= 0 & \text{if } R_{t+1} > E_t \pi_{t+1}^{-1} \\
\in [0, S_t] & \text{if } R_{t+1} = E_t \pi_{t+1}^{-1} \\
= S_t & \text{if } R_{t+1} < E_t \pi_{t+1}^{-1}
\end{cases}
\]
Market clearing

- Factor markets: $w_t = \gamma^t (1 - \alpha) K_t^\alpha$ and $r_t = \gamma^t \alpha K_t^{\alpha-1}$
- Market for bubbles: $E_t R_{t+1}^j = R_{t+1}$ and $N_j^t \geq 0$ for each $j$
- Credit market:
  \[
  (1 - \varepsilon) \frac{\beta^\theta}{\beta^\theta + R_{t+1}^{1-\theta}} (1 - \tau) w_t - \frac{M_t}{p_t} = F_t = \frac{E_t \sum_j B^j}{R_{t+1}}
  \]
- Money market:
  \[
  M_t \left( R_{t+1} - E_t \pi_{t+1}^{-1} \right) = 0
  \]
Equilibrium bubbles

- Existence of bubbles requires low interest rates: possible sources
  - Dynamic inefficiency (traditional approach); bubbles are contractionary
  - Financial frictions (our approach); bubbles are expansionary

- Finding equilibria:
  - Propose process \( \{ R^j_t, N^j_t, \pi_t \} \) s.t. \( N^j_t \geq 0 \) and \( \pi_t > 0 \)
  - Determine all possible sequences for state variables \( \{ K_t, B^j_t \} \) such that agents optimize and markets clear
  - Check that \( K_t \geq 0, B^j_t \geq 0 \) in all histories.
Equilibrium dynamics

Let $x_t \equiv \gamma^{-t} X_t$ denote variable $X_t$ in efficiency units. Given an admissible stochastic process $\{R_t^j, n_t^j, \pi_t\}$, equilibrium dynamics are given by:

- The law of motion of each bubble $j$:

$$b_{t+1}^j = \frac{R_{t+1}^j}{\gamma} b_t^j + n_{t+1}^j$$

- The law of motion for the capital stock:

$$k_{t+1} = \frac{\epsilon}{\gamma} (1 - \tau)(1 - \alpha) k_t^\alpha + \frac{E_t \sum_j b_{t+1}^j}{R_{t+1}} - \frac{1}{\gamma} \sum_j b_t^j$$

- Credit market clearing interest rate:

$$R_{t+1} = \max \left\{ \frac{\gamma E_t \sum_j b_{t+1}^j}{(1 - \varepsilon)\frac{\beta^\theta}{\theta + R_{t+1}^1 - \sigma} (1 - \tau)(1 - \alpha) k_t^\alpha}, E_t \pi_{t+1}^{-1} \right\}$$
Bubbles are pyramid schemes

- Ex. 1: Stock price $>$ NPV of dividends
- Ex. 2: Firm credit $>$ NPV of cash flows

Bubbles are implicit contracts whose terms can be specified in real or nominal terms:

- **Real**: terms are specified in goods $\rightarrow$ inflation does not affect the real value of these bubbles
- **Nominal**: terms are specified in money $\rightarrow$ inflation affects the real value of these bubbles

Credit contracts inherit the properties of bubbles backing them

Inflation has real effects even when contracts can be indexed to inflation at zero cost and there is no money illusion
A USEFUL BUBBLE SPECIFICATION

- Two aggregate states, bubbly and fundamental, $z_t \in \{F, B\}$ with transition probability $\lambda$

- New bubbly credit is created in the bubbly state:

$$n_t = \begin{cases} 
0 & \text{if } z_t = F \\
n & \text{if } z_t = B 
\end{cases}$$

- A fraction $\omega$ of existing bubbly credit defaults in the fundamental state
Examples

- Real bubble as short-term contract indexed to inflation:

\[ R^{1R}_{t+1} = \begin{cases} 
\frac{R_{t+1}}{1-\lambda \omega} & \text{if } z_t = B \\
\frac{(1-\omega)R_{t+1}}{1-\lambda \omega} & \text{if } z_t = F
\end{cases} \]

- Nominal bubble as short-term contract unindexed to inflation:

\[ R^{1N}_{t+1} = \frac{\pi^{-1}_{t+1}}{E_t \pi^{-1}_{t+1}} R^{1R}_{t+1} \]

- Key: inflation does not affect real bubbles, but it does affect nominal bubbles

- We can also have bubbles as long term contracts → inflation expectations will matter as well
Consider an economy that experiences a bubbly episode where bubbles are real:

\[ b_{t+1} = R_{t+1} R_t \cdot b_t + n_{t+1} \]

This economy transitions to the fundamental state at some \( t \) and returns to the bubbly state later on.

Suppose that throughout the inflation rate is fixed at \( \pi \) that is large enough to avoid liquidity traps.
BOOMS, BUSTS AND THE BUBBLE OVERHANG

Bubble

Output

Interest rate
Nominal bubbles and monetary shocks

Consider an economy that is in the bubbly state but where bubbles are nominal

\[ b_{t+1} = R_{t+1}^{1N} \cdot b_t + n_{t+1} \]

If inflation were fixed, then nominal bubbles behave just like real bubbles.

How does this economy react to monetary shocks?
RESPONSE TO A MONETARY SHOCK

### Bubble

![Graph of Bubble Response](image)

### Output

![Graph of Output Response](image)

### Interest rate

![Graph of Interest Rate Response](image)

### Inflation

![Graph of Inflation Response](image)
Bubbly Phillips curve
Bubble-targeting monetary policy

- What if monetary authorities attempt to stabilize the bubbly episode by setting $\pi_t(B) < \pi_t(F)$?

- The idea is to inflate bubbles away in bad times at the cost of more rapid bubble expansion in good times
Bubble-targeting monetary policy

Bubble

Interest rate

Output

Inflation
Falling into a liquidity trap

Consider again an economy that experiences a bubbly episode.

But now, the inflation target is low enough so that the economy falls into a liquidity trap in the fundamental state.

Low inflation would be chosen if monetary authorities put sufficient weight on the welfare of the current savers.
Inflation targets
Counter-cyclical policy
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Understanding these facts through the lens of our model

- Low interest rate and low inflation environment has created a fertile ground for bubbles and liquidity traps
- Bubbly fluctuations have led to boom-bust cycles in credit, investment, and output. More recently, the crash of the real estate bubble has put many economies into a liquidity trap with an unprecedented expansion in government liabilities
- Our framework provides a blueprint for monetary policy in such a bubbly world
Conclusions

- We proposed a framework to understand monetary policy in a bubbly world.

- Bubbles (real or nominal) affect economic activity through collateral and overhang effects.

- Monetary policy affects economic activity through two channels:
  - Expectations of inflation affect interest rates when the economy is in a liquidity trap.
  - Monetary shocks affect bubbles when bubbly credit is anchored in nominal terms.

- Bubble induced nominal rigidities without resorting sticky prices or money illusion.

- We used the model to give a broad interpretation of salient macroeconomic facts of the last two decades.