Monetary Policy and Asset Price Fluctuations

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based on work with
Cosmin Ilut, Roberto Motto, Massimo Rostagno
Background

• General consensus among policy makers (particularly in Washington).
  – Sharp, inefficient increases in asset prices are possible (especially those not based on fundamentals, e.g., ‘bubbles’).
  – But, not advisable for real-time policymakers to try to identify and ‘pop’ bubbles.

• In any case, markets are stabilized by inflation targeting strategy implemented with the following rule:

\[ R_t = \text{const} + \alpha \pi \pi^e_{t+1}, \quad \alpha \pi > 1 \]

• Idea:
  – Bubble-based booms associated with high demand for goods.
  – Such booms stimulate inflation.
  – Interest rate inflation targeting rule automatically tightens monetary policy at that time.
Empirical Findings

• Asset price booms are almost always associated with:
  – *low* inflation

• Suggests that if anything,
  – Interest rate inflation targeting rule *destabilizes* asset prices

• Credit growth is almost always high during asset price booms.
  – Consistent with ‘BIS’ recommendation that monetary policy should respond to credit growth.

• (See Adalid-Detken, Bordo-Wheelock)
Model Findings

• New Keynesian models:

  – Offer a coherent interpretation of the apparently anomalous inflation/stock market boom observations.

  – Under that interpretation, inflation targeting adds fuel to an asset market boom.

  – A monetary policy that tightens in response to high credit growth or strong stock market helps.
Evidence from US data

- 19th and early 20th century
- Great Depression and later
• Now, let’s turn to the more recent US data....
## Quantifying the Previous Results

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<th>1919Q1-2010Q1</th>
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### Stock Market Booms

#### A. Non-boom, non-civil war, 1803-1914

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#### B. Boom episodes

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Summary

- Stock market booms are periods of low inflation.

- Strong credit growth.
Simple Sticky Price Model Analysis

- Households:
  \[ E_t \sum_{l=0}^{\infty} \beta^l \left[ \log(C_{t+l}) - \frac{L_{t+l}^{1+\sigma_L}}{1 + \sigma_L} \right]. \]
  \[ P_tC_t + B_{t+1} \leq W_tL_t + R_{t-1}B_t + T_t, \]

- Firms:
  - usual Dixit-Stiglitz environment
    \[ Y_t = \left[ \int_0^1 Y_{lt} \frac{1}{\lambda_f} dl \right]^{\lambda_f}. \]
    \[ Y_{it} = \exp(a_t)L_{it}. \]
  - Calvo sticky prices
    \[ P_{i,t} = \begin{cases} 
    P_{i,t-1} & \text{with probability } \xi_p \\
    \tilde{P}_t & \text{with probability } 1 - \xi_p 
    \end{cases} \]
Closing the Model

• Policy rule:

\[ \log \left( \frac{R_t}{R} \right) = a_\pi E_t \log(\pi_{t+1}), \]

• Resource constraint:

\[ C_t \leq Y_t \]

• Technology:

\[ a_t = \rho a_{t-1} + u_t, \quad u_t \equiv \xi_t^0 + \xi_{t-1}^1, \quad u_t, \xi_t^0, \xi_t^1 \text{ iid} \]
Efficient (Ramsey) Equilibrium

• No price-setting frictions, no monopoly power.

• Consumption and employment determined by equating marginal cost and marginal benefit of working:

\[ \psi_L L_t^{\sigma_L} C_t = \exp(a_t) \]

\[ \to \psi_L L_t^{\sigma_{L+1}} = 1, \quad L_t \text{ constant} = \left( \frac{1}{\psi_L} \right)^{\frac{1}{\sigma_{L+1}}} \]

\[ \to C_t = \exp(a_t) \left( \frac{1}{\psi_L} \right)^{\frac{1}{\sigma_{L+1}}} \]

‘natural rate of interest’ : 
\[ 1 + R_t^* = \frac{1}{\beta E_t(C_t/C_{t+1})} = \frac{1}{\beta E_t \exp(a_t - a_{t+1})} \]
Log-linearized Equilibrium in Deviation from Efficient

- Phillips curve:  
  \[ \hat{\pi}_t = \gamma \hat{x}_t + \beta E_t \hat{\pi}_{t+1}. \]

  \[ \gamma = \frac{(1 - \xi_p)(1 - \beta \xi_p)}{\xi_p}(1 + \sigma_L), \]

- Policy:  
  \[ \hat{R}_t = a_\pi E_t \hat{\pi}_{t+1}. \]

- IS curve:  
  \[ \hat{x}_t = -E_t \left[ \hat{R}_t - \hat{\pi}_{t+1} - R_t^* \right] + E_t \hat{x}_{t+1} \]

  \[ \text{persistence, } \rho, \text{ typically estimated to be high, so} \]

  \[ \text{‘normal shocks’, } \xi_t^0, \text{ have little impact on natural rate.} \]

- Natural rate:  
  \[ R_t^* = E_t a_{t+1} - a_t = (\rho - 1) a_t + \xi_t^1. \]
• Solution:

\[ \hat{\pi}_t = \eta_\pi a_t + \phi_\pi \xi_t^1 \]
\[ \hat{x}_t = \eta_x a_t + \phi_x \xi_t^1, \]

• Easy to show: \( \eta_x, \eta_\pi < 0 \)
  – With stationary shock, output under-reacts technology shock, and inflation drops.
Pure Sticky Wages

• Drop price-setting frictions.
  – Intermediate good firms set price to marginal cost.
  – Price Phillips curve is dropped.

• We assume EHL-style wage frictions.
  – Labor hired by firms

\[ L_t = \left[ \int_0^1 (h_{t,j}) \frac{1}{\lambda_w} dj \right]^{\lambda_w}, 1 \leq \lambda_w. \]

  – Demand for j-type labor:

\[ h_{t,j} = \left( \frac{W_t}{W_{t,j}} \right)^{\frac{\lambda_w}{1-\lambda_w}} L_t. \]
Pure Sticky Wages, cnt’d...

- Labor is supplied by households
- Assume representative household has each type, $j$, of labor.
- Adopt ‘indivisible labor’ assumption as in Gali (and Rogerson, Hansen, Mulligan and Krusell, et al)
- Individual worker draws work aversion, $l \in [0, 1]$ and

  $$
  \text{utility} = \begin{cases} 
  \log(C_t) - l^{\sigma_L} & \text{if employed} \\
  \log(C_t) & \text{if not employed} 
  \end{cases}
  $$
Pure Sticky Wages, cnt’d....

• Demand for labor, $h_{t,j}$, is determined by the wage rate, $W_{t,j}$, and this is set outside the household by a monopoly union.

• The household sends workers with the least work aversion into the market, and keeps the rest at home

\[
\begin{align*}
\text{workers}: & 0 \leq l \leq h_{t,j} \\
\text{non-workers}: & l > h_{t,j}
\end{align*}
\]

• All workers receive the same level of consumption (insurance in household).
Pure Sticky Wages, cnt’d....

• Integral of utility of type $j$ workers

\[
\int_0^{h_{t,j}} [\log(C_t) - l^{\sigma_L}] f(l) \, dl + \int_{h_{t,j}}^1 \log(C_t) f(l) \, dl
\]

\[
= \log(C_t) - \frac{h_{t,j}^{1+\sigma_L}}{1 + \sigma_L}
\]

• Integrating over all types, $j$, to get household utility:

\[
\log(C_t) - \int_0^1 \frac{h_{t,j}^{1+\sigma_L}}{1 + \sigma_L} \, dj.
\]
Pure Sticky Wages, cnt’d....

• Problem of the representative household

\[
\log(C_t) - \int_0^1 \frac{h_{t,j}^{1+\sigma_L}}{1 + \sigma_L} dj.
\]

\[
P_tC_t + B_{t+1} \leq B_tR_{t-1} + \int_0^1 W_{t,j} h_{t,j} dj + \text{Transfers and profits}_t.
\]

• Since wages are given, the only problem is a consumption/saving problem.
Slight Detour on Frisch...

• When $h_{t,j}$ is quantity of labor supplied by a representative worker of type $j$, then $1/\sigma_L$ is that worker’s Frisch (i.e., holding income effects constant) labor supply elasticity.

• We suppose that $h_{t,j}$ is a quantity of workers, and that people can either work, or not.

• The object, $1/\sigma_L$, now has nothing to do with Frisch elasticity.
  – It summarizes the degree of heterogeneity in the population in terms of ‘aversion’ to work.
Pure Sticky Wages, cnt’d....

- Type $j$-type monopoly union.

- Calvo-type wage setting friction:

$$W_{t,j} = \begin{cases} W_{t-1,j} & \text{with probability } \xi_w \\ \tilde{W}_t & \text{with probability } 1 - \xi_w \end{cases}$$

- Problem at $t$:

$$E_t \sum_{i=0}^{\infty} (\beta \xi_w)^i \nu_{t+i} \left[ \tilde{W}_t h_{t+i}^t - \frac{(h_{t+i}^t)^{1+\sigma_L}}{(1 + \sigma_L)\nu_{t+i}} \right].$$

Employment in $t+i$ of type $j$ labor whose wage was most recently set in $t$.
Pure Sticky Wages, cnt’d....

• Wage setting gives rise to the following wage-Phillips curve:

\[ \widehat{\pi}_{w,t} = \gamma_w \left[ (1 + \sigma_L)\widehat{x}_t - \widehat{W}_t \right] + \beta \widehat{\pi}_{w,t+1} \]

\[ \gamma_w = \frac{(1 - \xi_w)(1 - \beta \xi_w)}{\xi_w \left( 1 + \sigma_L \frac{\lambda_w}{\lambda_{w-1}} \right)} \]

Household MRS, cost of supplying an extra worker.

• Wage inflation high when cost of working is high, compared with wage. Makes sense!
Pure Sticky Wages, cnt’d....

• The object, $\bar{w}_t$, is

$$\bar{w}_t = \frac{W_t}{P_t \exp(a_t)}$$

= marginal cost divided by price=a constant when there are no price frictions

$\rightarrow \hat{\bar{w}}_t = 0$

• Also

$$\frac{\bar{w}_t}{\bar{w}_{t-1}} = \frac{W_t}{P_t \exp(a_t)} \frac{P_{t-1} \exp(a_{t-1})}{W_{t-1}} = \frac{\pi_{w,t}}{\pi_t} \exp[-(a_t - a_{t-1})] = 1$$

$\rightarrow \hat{\pi}_{w,t} = \hat{\pi}_t + a_t - a_{t-1}$
Pure Sticky Wages, cnt’d….

• Pure sticky wage Phillips curve:

\[
\hat{\pi}_{w,t} = \gamma_w (1 + \sigma_L)\hat{x}_t + \beta\hat{\pi}_{w,t+1}, \quad \gamma_w = \frac{(1 - \xi_w)(1 - \beta\xi_w)}{\xi_w \left(1 + \sigma_L \frac{\lambda_w}{\lambda_w-1}\right)}
\]

• As in firm-specific capital literature, curve is flatter the faster cost rises with quantity supplied (here, labor) and the flatter is demand curve.
Log-linearized Sticky Wage Equilibrium

Phillips curve: \( \hat{\pi}_{w,t} = \gamma_w (1 + \sigma_L) \hat{x}_t + \beta \hat{\pi}_{w,t+1} \)

\[
\text{IS: } \hat{x}_t = - \left[ \hat{R}_t - E_t (\hat{\pi}_{t+1} + R^*_t) \right] + E_t \hat{x}_{t+1}
\]

\[
\text{Policy: } \hat{R}_t = a_{\pi} \overbrace{E_t \hat{\pi}_{t+1}}^{=E_t \pi_{w,t+1}}
\]

Definition/Flexible prices: \( \hat{\pi}_{w,t} = \hat{\pi}_t + a_t - a_{t-1} \)

Natural Rate of Interest: \( R^*_t = E_t a_{t+1} - a_t = (\rho - 1) a_t + \xi^1_t \)

• First three equations: 3 equations in 3 unknowns.
• Solution:

\[
\hat{\pi}_{w,t} = \eta^w_{\pi} a_t + \phi^w_{\pi} \xi_t^{1}, \\
\hat{x}_t = \eta^w_{x} a_t + \phi^w_{x} \xi_t^{1}
\]

• Easy to show (as in sticky price):

\[
\eta^w_{\pi}, \eta^w_{x} < 0
\]

• Also (as in sticky price):

\[
\phi^w_{\pi} < 0, \phi^w_{x} > 0 \text{ possible}
\]
Simulation of Pure Sticky Price and Pure Sticky Wage Model

- Parameter values:

\[ \beta = 1.03^{-1/4}, \quad a_{\pi} = 1.50, \quad \xi_w = \xi_p = 0.75, \quad \rho = 0.9, \quad \sigma_L = 1. \]

| Table 1: Period $t$ Response to News, $\xi^t_1$, that Period $t + 1$ Technology Innovation Will be 1% Higher |
|-------------------------------------------------|------------------|------------------|
| change in inflation (quarterly, basis points)   | pure sticky prices | pure sticky wages |
| change in hours worked (percent deviation from steady state) | 1.1 | 0.98 |
| change in nominal interest rate (quarterly, basis points) | -29 | -175 |
| change in efficient rate of interest (quarterly, basis points) | 100 | 100 |

- Monetary policy goes in exactly the wrong way!
- In the case of sticky price model, inflation forecast targeting rule actually destabilizes inflation!
result, \( \frac{d\pi}{d\xi_t} < 0, \frac{dx}{d\xi_t} > 0 \), more robust under sticky wages
Summary and Outstanding Questions

• Found that optimism about the future can cause a boom today and low inflation.
  – Optimism need not be ex post correct, or even rational ex ante.

• Effects are due to bad monetary policy.
  – Boom in employment and output reflects loose monetary policy
  – Under Ramsey-optimal policy inflation and output do no respond to signals about the future.

• How does this work in empirically estimated models?

• Are there ways to improve things by adding variables to Taylor rule, in particular, credit?

• Need more complicated model, that cannot be solved analytically.
Next

- Estimate a medium-sized DSGE model with signals
  - ‘Normal’ technology shock:
    \[ a_t = \rho_a a_{t-1} + \varepsilon_t \]
  - Shock considered here (J Davis):
    \[
    a_t = \rho_a a_{t-1} + \varepsilon_t + \xi_{t-1} + \xi_{t-2} + \xi_{t-3} + \xi_{t-4} + \xi_{t-5} + \xi_{t-6} + \xi_{t-7} + \xi_{t-8}
    \]
- Evaluate importance of \( \xi_{t-i} \) for business cycles
- Explore implications of \( \xi_{t-i} \) for monetary policy.
Outline

• Estimation
  – Results
  – ‘Excessive optimism’ and 2000 recession

• Implications for monetary policy
  – Monetary policy causes economy to over-react to signals....inadvertently creates ‘boom-bust’

• Explore alternative formulations of monetary policy that have better welfare properties
Model

• Features (version of CEE)
  – Habit persistence in preferences
  – Investment adjustment costs in change of investment
  – Variable capital utilization
  – Calvo sticky (EHL) wages and prices

• Non-optimizers: \( P_{it} = P_{i,t-1}, \ W_{j,t} = \mu_z W_{j,t-1} \)

• Probability of not adjusting prices/wages: \( \xi_p, \xi_w \)
Observables and Shocks

• Six observables:
  – output growth,
  – inflation,
  – hours worked,
  – investment growth,
  – consumption growth,
  – T-bill rate.

• Sample Period: 1984Q1 to 2007Q1
\[ E_t^j \sum_{l=0}^{\infty} \left( \frac{1}{1.03^{1/4}} \right)^l \zeta_{c,t+l} \left\{ \log(C_{t+l} - bC_{t+l-1}) - \psi_L \frac{l^2_{t+l,j}}{2} \right\} \]

\[ K_{t+1} = (1 - 0.02)K_t + (1 - S) \left( \zeta_{I,t} \frac{I_t}{I_{t-1}} \right)I_t \]

\[ Y_t = \left[ \int_0^1 \lambda_{f,t} \, \frac{1}{Y_{jt}} \, dj \right]^{\lambda_{f,t}} Y_{j,t} = \left[ z_t \exp \left( \frac{a_t}{\lambda_{f,t}} \right) L_{j,t} \right]^{1-a} (u_tK_{j,t})^\alpha, z_t = \exp(\mu z t) \]

\[ \log \left( \frac{R_t}{R} \right) = \tilde{\rho} \log \left( \frac{R_{t-1}}{R} \right) + (1 - \tilde{\rho}) \frac{1}{R} \left[ a_\pi \bar{\pi} \log \left( \frac{\bar{\pi}_{t+1}}{\bar{\pi}} \right) + \frac{a_y}{4} \log \left( \frac{y_t}{y} \right) \right] + \varepsilon_t^M \]
Shock representations

markup

\[
\log\left(\frac{\lambda_{f,t}}{\lambda_f}\right) = \rho_{\lambda_f} \log\left(\frac{\lambda_{f,t-1}}{\lambda_f}\right) + \varepsilon_{\lambda_{f,t}}
\]

discount rate

\[
\log(\zeta_{c,t}) = \rho_{\zeta_c} \log(\zeta_{c,t-1}) + \varepsilon_{\zeta_{c,t}}
\]

efficiency of investment

\[
\log(\zeta_{I,t}) = \rho_{\zeta_I} \log(\zeta_{I,t-1}) + \varepsilon_{\zeta_{I,t}}
\]

technology

\[
a_t = \rho_a a_{t-1} + \varepsilon_t + \xi_{t-1}^1 + \xi_{t-2}^2 + \xi_{t-3}^3 + \xi_{t-4}^4 + \xi_{t-5}^5 + \xi_{t-6}^6 + \xi_{t-7}^7 + \xi_{t-8}^8
\]

monetary policy

\[
\varepsilon_t^M = \rho_M \varepsilon_{t-1}^M + \varepsilon_{u,t}.
\]
## Parameters: priors and posteriors

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Variance decompositions

Percent Variance in Indicated Variable Due to Indicated Shock

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<th>Δ log I</th>
<th>Δ log Y</th>
<th>Δ log h</th>
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### Variance Decomposition, Technology Shocks

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<th>variable</th>
<th>$\varepsilon_t + \sum_{i=1}^{8} \xi_{t-i}$</th>
<th>$\varepsilon_t$</th>
<th>$\varepsilon_t + \sum_{i=1}^{4} \xi_{t-i}$</th>
<th>$\sum_{i=5}^{8} \xi_{t-i}$</th>
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</table>
• Estimated technology shock process:

\[
\begin{align*}
\hat{a}_t &= \rho_a a_{t-1} + \varepsilon_t + \xi_{t-1}^1 + \xi_{t-2}^2 + \xi_{t-3}^3 + \xi_{t-4}^4 + \xi_{t-5}^5 + \xi_{t-6}^6 + \xi_{t-7}^7 + \xi_{t-8}^8 \\
\end{align*}
\]
Centered 5-quarter moving average of shocks

NBER trough

Signals 5-8 quarters in past

NBER peak

Current shock plus most recent Four quarters’ signals
• Let’s see how a signal that turns out to be false works in the full, estimated model.
Benchmark: *Ramsey* Response to Signal Shock

- Drop Monetary Policy Rule.

- Now, economic system under-determined. Many equilibria.

- We select the best equilibrium, the Ramsey equilibrium: optimal monetary policy.
Response of Simple Monetary Model to Positive Signal About Technology in Period 8 that is not Realized

Sticky wages exacerbate the problem
Why is the Boom-Bust So Big?

• Most of boom-bust reflects suboptimality of monetary policy.

• What’s the problem?

  – Monetary policy ought to respond to the natural (Ramsey) rate of interest.

  – Relatively sticky wages and inflation targeting exacerbate the problem
Policy solution

• Modify the Taylor rule to include:
  
  – Natural rate of interest (probably not feasible)
  – Credit growth
  – Stock market.

• Explored consequences of adding credit growth and/or stock market by adding Bernanke-Gertler-Gilchrist financial frictions.
Conclusion

• According to the data, stock market booms are accompanied by low inflation.

• New Keynesian models with signals about future technology can account for this pattern.

• Implications for monetary policy:
  – Booms reflect inefficiently loose monetary policy.
  – Optimism about the future requires a high real interest rate.
  – Inflation targeting does produce high rate at this time. By not raising rates, or even lowering them, monetary policy is very loose at the wrong time.
  – Responding to credit growth may improve things.