Monetary Policy and Asset Price Fluctuations

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based on work with

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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:

$$R_t = \text{const} + \alpha_\pi \pi_{t+1}^e, \ \alpha_\pi > 1$$

- 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)

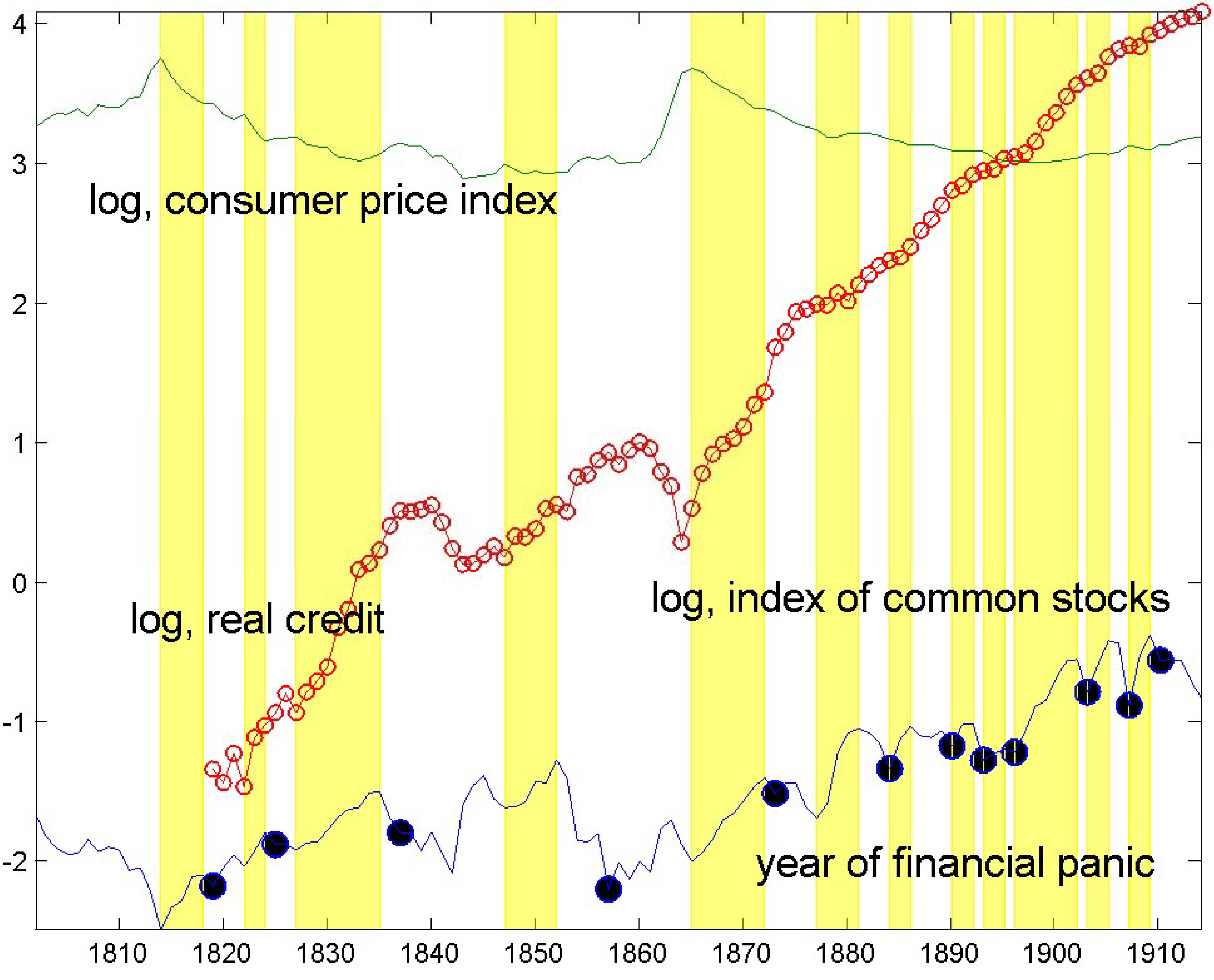
Model Findings

- 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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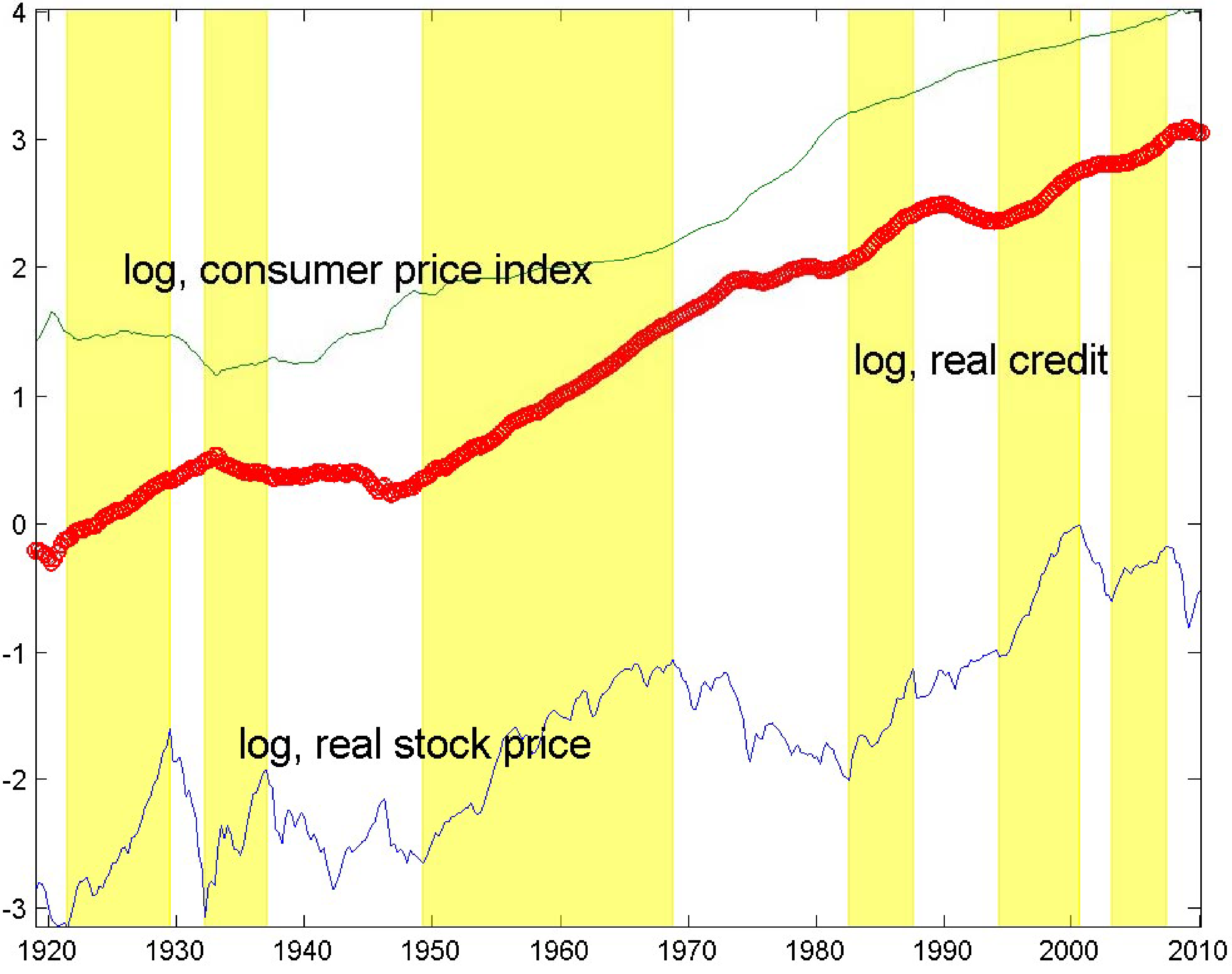
1900
1910
log, consumer price index
log, real credit
log, index of common stocks
year of financial panic

- Now, let’s turn to the more recent US data….


log, consumer price index
log, real credit
log, real stock price
4
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1920
1930
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1980
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2000
2010

Quantifying the Previous Results

1803-1914				
Periods	CPI	Credit	GDP	Stock Price
Boom	-2.5	9.5	4.6	10.2
Other (non-Boom, non-war)	0.7	4.0	3.1	-6.3

1919Q1-2010Q1				
Boom	1.8	5.3	4.6	13.8
Other (non-Boom, non-war)	4.0	2.3	2.7	2.7

Various Sub-periods, 1803-1914				
Periods	CPI	Credit	GDP	Stock Price
Boom	-2.5	9.5	4.6	10.2
Other	0.7	4.0	3.1	-6.3
Non-civil war	-0.7	6.5	3.7	0.8

Various Sub-periods, 1919Q1-2010Q1				
Periods	CPI	Credit	GNP	Stock Price
Boom	1.8	5.3	4.6	13.8
Other	4.0	2.3	0.2	-11.7
Whole period	2.7	4.0	2.7	2.7

Stock Market Booms					
A. Non-boom, non-civil war, 1803-1914					
		CPI	Credit	GDP	Stock Price
		0.7	4.0	3.1	-6.3
B. Boom episodes					
panic	trough-peak	CPI	Credit	GDP	Stock Price
1819	1814-1818	-8.0	na	1.8	9.8
1825	1822-1824	-9.8	21.9	3.7	12.1
1837	1827-1835	-1.5	14.6	4.9	5.2
1857	1847-1852	-1.3	7.6	5.4	6.9
1873	1865-1872	-4.1	11.9	4.8	8.5
1884	1877-1881	-0.6	3.5	7.5	16.0
1890	1884-1886	-2.2	4.9	5.9	15.2
1893	1890-1892	0.0	5.6	4.5	7.9
1896	1893-1895	-3.3	4.2	4.4	3.9
1903	1896-1902	0.3	8.6	5.3	11.1
1907	1903-1905	0.0	7.6	2.3	18.3
1910	1907-1909	-1.8	4.0	0.6	25.1

Stock Market Booms				
A. Non-boom, non-World War II, 1919Q1-2010Q1				
	CPI	Credit	GNP	Stock Price
	4.0	2.3	0.2	-11.7
B. Boom episodes				
trough-peak	CPI	Credit	GNP	Stock Price
1921Q3-1929Q3	-0.2	5.7	5.9	19.3
1932Q2-1937Q2	0.6	-2.1	6.5	24.2
1949Q2-1968Q2	2.0	6.3	4.2	8.1
1982Q3-1987Q3	3.2	7.5	4.3	17.5
1994Q2-2000Q2	2.5	6.1	3.9	16.4
2003Q1-2007Q1	3.0	4.6	3.0	10.1

Summary

- Stock market booms are periods of low inflation.
- Strong credit growth.

Simple Sticky Price Model Analysis

- Households:

$$E_t \sum_{l=0}^{\infty} \beta^l \left[\log(C_{t+l}) - \frac{L_{t+l}^{1+\sigma_L}}{1+\sigma_L} \right].$$

$$P_t C_t + B_{t+1} \leq W_t L_t + R_{t-1} B_t + T_t,$$

- Firms:
  - usual Dixit-Stiglitz environment

$$Y_t = \left[\int_0^1 Y_{lt}^{\frac{1}{\lambda_f}} dl \right]^{\lambda_f}. \qquad Y_{it} = \exp(a_t) L_{it}.$$

  - 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:

$$a_t = \rho a_{t-1} + u_t,\ u_t \equiv \xi_t^0 + \overset{\text{‘Signal’}}{\overset{\downarrow}{\xi_{t-1}^1}},\ u_t, \xi_t^0, \xi_t^1 \text{ iid}$$

Efficient (Ramsey) Equilibrium

- No price-setting frictions, no monopoly power.
- Consumption and employment determined by equating marginal cost and marginal benefit of working:

$$\begin{aligned} \psi_L L_t^{\sigma_L} C_t &= \exp(a_t) \\ &\rightarrow \psi_L L_t^{\sigma_L+1} = 1,\ L_t \text{ constant} = \left(\frac{1}{\psi_L}\right)^{\frac{1}{\sigma_L+1}} \\ &\rightarrow C_t = \exp(a_t)\left(\frac{1}{\psi_L}\right)^{\frac{1}{\sigma_L+1}} \end{aligned}$$

$$\text{`natural rate of interest'} \ : \ 1 + R_t^* = \frac{1}{\beta E_t(C_t/C_{t+1})} = \frac{1}{\beta E_t \exp(a_t - a_{t+1})}$$

Log-linearized Equilibrium in Deviation from Efficient

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

Net inflation

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

Percent deviation between actual and natural equilibrium.

- Policy:

$$\hat{R}_t = a_\pi E_t \hat{\pi}_{t+1}.$$

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

persistence, ρ, typically estimated to be high, so ‘normal shocks’, ξ_t^0, have little impact on natural rate.

Impact of news shock, ξ_t^1, is large.

- 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

$$\text{workers:} 0 \leq l \leq h_{t,j}$$

$$\text{non-workers: } l > h_{t,j}$$

- All workers receive the same level of consumption (insurance in household).

Pure Sticky Wages, cnt’d….

- Integral of utility of type *j* workers

$$\int_0^{h_{t,j}}[\log(C_t)-l^{\sigma_L}]f(l)dl+\int_{h_{t,j}}^{1}\log(C_t)\overset{\text{Density of workers of type } l = 1}{\overset{\downarrow}{f(l)}}dl$$

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

- 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

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

$$P_t C_t + B_{t+1} \leq B_t R_{t-1} + \int_0^1 W_{t,j} h_{t,j} dj + \text{Transfers and profits}_t.$$

- 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*

Employment in *t+i* of type *j* labor
whose wage was most recently set in *t*

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

Pure Sticky Wages, cnt'd….

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

$$\hat{\pi}_{w,t} = \gamma_w \overbrace{\left[(1+\sigma_L)\hat{x}_t - \hat{\bar{w}}_t \right]}^{\text{proportional to } \left(-\frac{u_l}{u_c}\right) - \frac{W}{P}} + \beta\hat{\pi}_{w,t+1}$$

Household MRS, cost of supplying an extra worker.

$$\gamma_w = \frac{(1-\xi_w)(1-\beta\xi_w)}{\xi_w\left(1+\sigma_L\frac{\lambda_w}{\lambda_w - 1}\right)}$$

- 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

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

$$= \text{marginal cost divided by price=a constant when there are no price frictions}$$

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

- Also

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

$$\rightarrow \hat{\pi}_{w,t} = \hat{\pi}_t + a_t - a_{t-1}$$

Pure Sticky Wages, cnt'd….

- Pure sticky wage Phillips curve:

$$\hat{\pi}_{w,t} = \gamma_w(1+\sigma_L)\hat{x}_t + \beta\hat{\pi}_{w,t+1}, \qquad \gamma_w = \overbrace{\frac{(1-\xi_w)(1-\beta\xi_w)}{\xi_w\left(1+\sigma_L\frac{\lambda_w}{\lambda_w-1}\right)}}^{\text{slope of wage Phillips curve flatter than for price Phillips curve}}$$

- 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

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

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

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

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

$$\text{Natural Rate of Interest: } R_t^* = E_t a_{t+1} - a_t = (\rho - 1)a_t + \xi_t^1$$

- First three equations: 3 equations in 3 unknowns.

- Solution:

$$\begin{aligned} \hat{\pi}_{w,t} &= \eta_{\pi}^{w} a_t + \phi_{\pi}^{w} \xi_t^1, \\ \hat{x}_t &= \eta_{x}^{w} a_t + \phi_{x}^{w} \xi_t^1 \end{aligned}$$

- Easy to show (as in sticky price):

$$\eta_{\pi}^{w}, \eta_{x}^{w} < 0$$

- Also (as in sticky price):

$$\phi_{\pi}^{w} < 0,\ \phi_{x}^{w} > 0 \text{ possible}$$

Simulation of Pure Sticky Price and Pure Sticky Wage Model

- Parameter values:

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

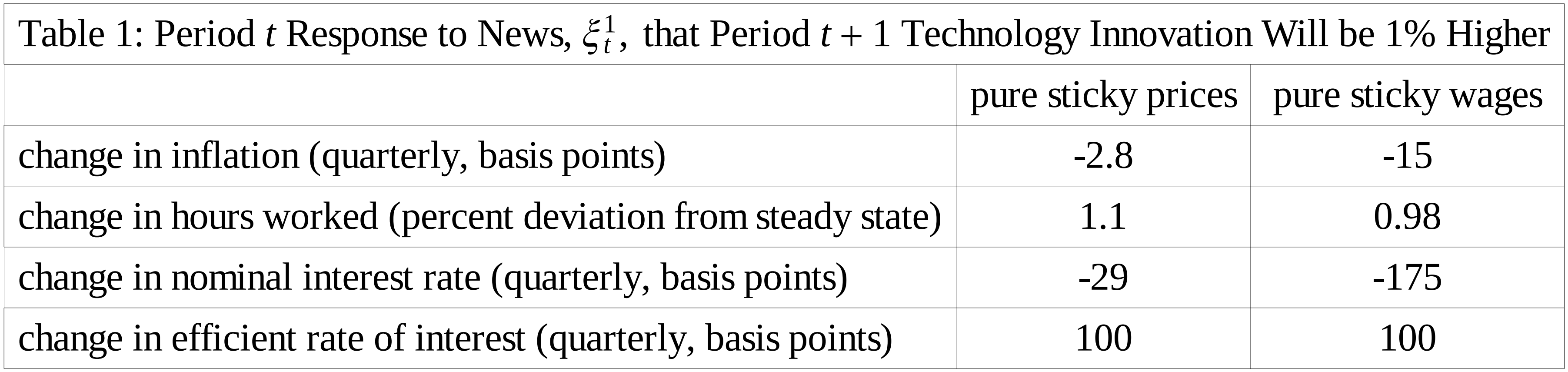
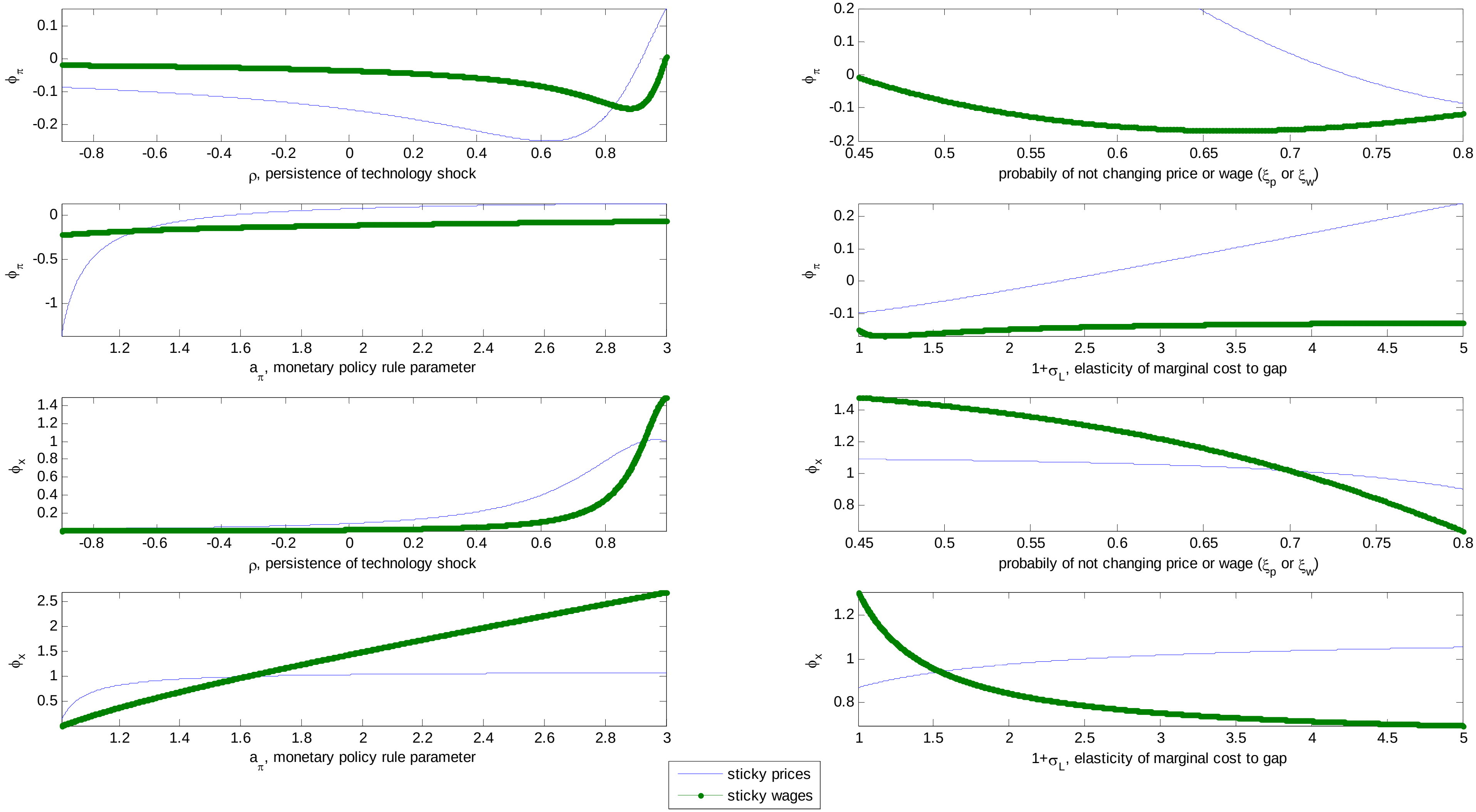


Table 1: Period *t* Response to News, ξ_t^1, that Period $t + 1$ Technology Innovation Will be 1% Higher

	pure sticky prices	pure sticky wages
change in inflation (quarterly, basis points)	-2.8	-15
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, $\frac{d\pi}{d\xi_t^1} < 0, \ \frac{dx}{d\xi_t^1} > 0,$ 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):

$$a_t = \rho_a a_{t-1} + \overbrace{\varepsilon_t + \xi_{t-1}^1 + \xi_{t-2}^2 + \xi_{t-3}^3 + \xi_{t-4}^4}^{\text{'recent information'}} + \overbrace{\xi_{t-5}^5 + \xi_{t-6}^6 + \xi_{t-7}^7 + \xi_{t-8}^8}^{\text{'earlier information'}}$$

- Evaluate importance of ξ_{t-i}^i for business cycles

- Explore implications of ξ_{t-i}^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

$$E_t^j \sum_{l=0}^{\infty} \left(\frac{1}{1.03^{-1/4}} \right)^l \overbrace{\zeta_{c,t+l}}^{\text{preference shock}} \left\{ \log(C_{t+l} - bC_{t+l-1}) - \psi_L \frac{l_{t+l,j}^2}{2} \right\}$$

$$K_{t+1} = (1 - 0.02)K_t + (1 - S\left(\overbrace{\zeta_{I,t}}^{\text{marginal (in-) efficiency of investment}} \frac{I_t}{I_{t-1}} \right))I_t$$

$$Y_t = \left[\int_0^1 Y_{jt}^{\frac{1}{\lambda_{f,t}}} dj \right]^{\overbrace{\lambda_{f,t}}^{\text{markup shock}}} , \qquad Y_{j,t} = \left[z_t \exp\left(\overbrace{a_t}^{\text{technology shock}} \right) L_{j,t} \right]^{1-\alpha} (u_t K_{j,t})^{\alpha},\ z_t = \exp(\mu_z t)$$

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

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

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

monetary policy

$$\varepsilon_t^M = \rho_M \varepsilon_{t-1}^M + \varepsilon_{u,t}.$$

Parameters: priors and posteriors

Parameters	prior mean	mode	s.d.	t-stat	prior distribution	prior standard deviation
Shock Parameters						
ρ_{ξ_i}	0.9	0.88	0.038	23.3	beta	0.05
ρ_{ξ_c}	0.9	0.93	0.018	50.4	beta	0.05
ρ_{λ_f}	0.9	0.45	0.077	5.9	beta	0.05
ρ_{ε^M}	0.1	0.13	0.083	1.6	beta	0.05
ρ_a	0.95	0.96	0.015	64.9	beta	0.02
Economic Parameters						
ξ_w	0.8	0.80	0.016	49.7	beta	0.03
S''	4.0	4.14	0.285	14.5	inverse gamma	0.10
ξ_p	0.5	0.68	0.047	14.6	beta	0.03
a_π	1.5	1.67	0.082	20.3	beta	0.10
$\tilde{\rho}$	0.8	0.76	0.049	15.6	beta	0.04
σ_a	2.0	1.15	0.428	2.7	inverse gamma	2.00
a_y	0.5	0.22	0.054	4.1	beta	0.1

Standard Deviations of Shocks: priors and posteriors

parameter	prior mean	mode	standard deviation	t-statistic	prior	prior standard deviation
σ_{ε}	0.003	0.0014	0.0004	3.8	invg	0.0050
σ_{ξ_c}	0.002	0.0165	0.0027	6.2	invg	0.0050
σ_{ξ_i}	0.002	0.0293	0.0087	3.4	invg	0.0050
σ_{ε^M}	0.001	0.0008	0.0002	3.6	invg	0.0005
σ_{λ_f}	0.050	0.0258	0.0022	11.5	invg	0.0080
σ_{ξ^1}	0.003	0.0010	0.0002	5.0	invg	0.0050
σ_{ξ^2}	0.003	0.0010	0.0002	5.2	invg	0.0050
σ_{ξ^3}	0.003	0.0010	0.0002	5.0	invg	0.0050
σ_{ξ^4}	0.003	0.0010	0.0002	5.3	invg	0.0050
σ_{ξ^5}	0.003	0.0010	0.0002	5.2	invg	0.0050
σ_{ξ^6}	0.003	0.0011	0.0002	4.8	invg	0.0050
σ_{ξ^7}	0.003	0.0010	0.0002	5.0	invg	0.0050
σ_{ξ^8}	0.003	0.0012	0.0003	4.4	invg	0.0050

Variance decompositions

Percent Variance in Indicated Variable Due to Indicated Shock

shock	$\Delta \log c$	$\Delta \log I$	$\Delta \log Y$	$\Delta \log h$	π	R
ε_t	7.0	2.3	6.2	5.5	7.0	7.1
$\lambda_{f,t}$	0.7	0.8	1.8	1.1	9.7	0.8
ε_t^M	2.7	1.5	3.8	0.5	0.1	0.9
ξ_t^1	4.0	1.3	3.8	3.2	3.9	4.1
ξ_t^2	4.0	1.4	4.0	3.3	3.9	4.1
ξ_t^3	4.6	1.6	4.6	3.9	4.5	4.8
ξ_t^4	4.5	1.6	4.5	4.1	4.5	4.8
ξ_t^5	4.7	1.7	4.8	4.7	4.9	5.3
ξ_t^6	5.7	2.0	5.7	6.1	6.2	6.7
ξ_t^7	5.2	1.8	5.1	6.0	5.9	6.4
ξ_t^8	6.9	2.4	6.7	8.5	8.2	8.8
$\zeta_{t,c}$	41.8	22.0	12.6	21.5	24.8	29.5
$\zeta_{t,i}$	8.2	59.7	36.3	31.6	16.1	16.9

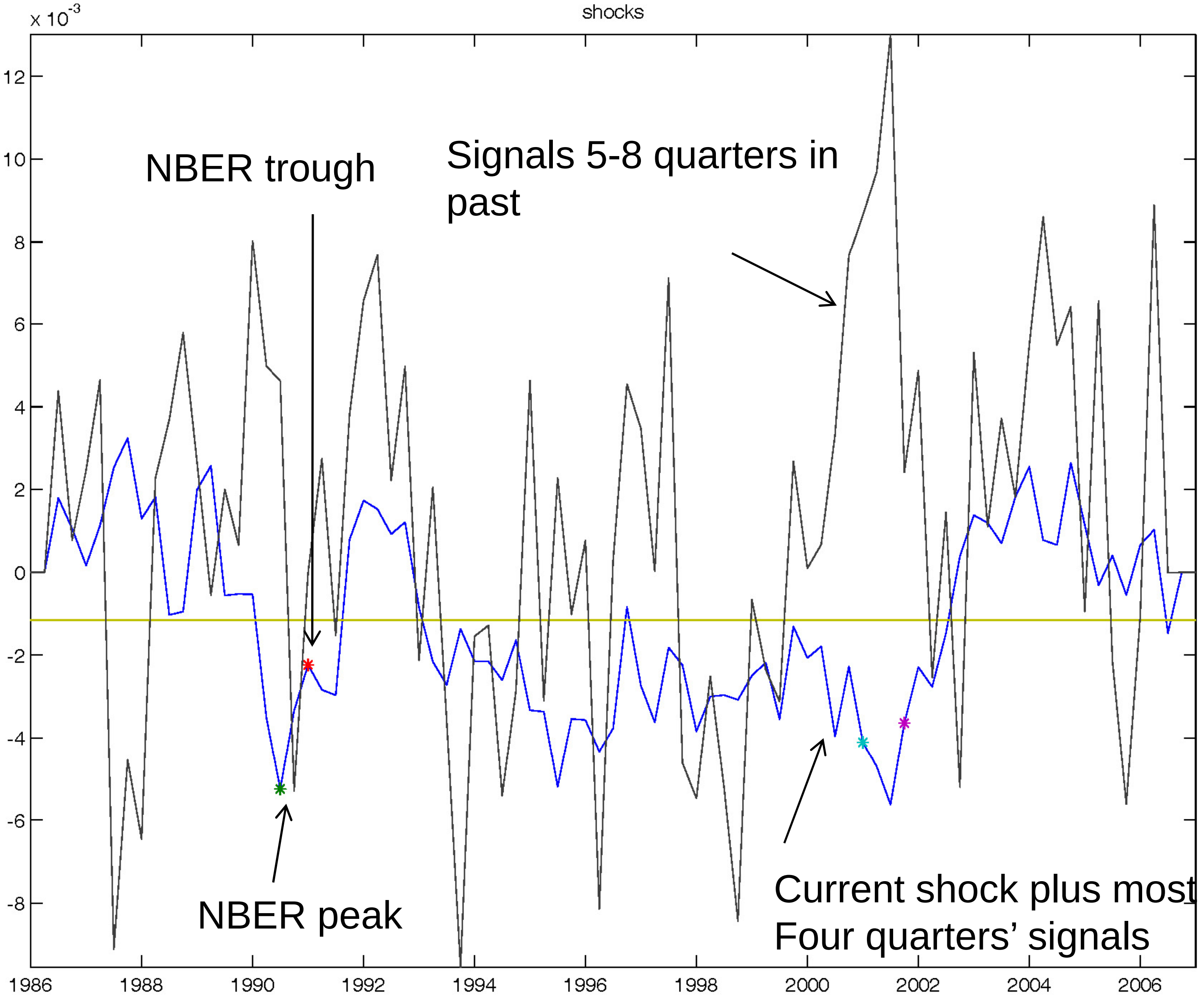
Variance Decomposition, Technology Shocks

variable	$\varepsilon_t + \sum_{i=1}^{8} \xi_{t-i}^{i}$	ε_t	$\varepsilon_t + \sum_{i=1}^{4} \xi_{t-i}^{i}$	$\sum_{i=5}^{8} \xi_{t-i}^{i}$
consumption growth	46.6	7.0	24.1	22.5
investment growth	16.1	2.3	8.2	7.9
output growth	45.4	6.2	23.1	22.3
log hours	45.3	5.5	20.0	25.3
inflation	49.0	7.0	23.8	25.2
interest rate	52.1	7.1	24.9	27.2

- Estimated technology shock process:

$$\overbrace{a_t}^{\text{log, technology shock}} = \rho_a a_{t-1} + \overbrace{\varepsilon_t + \xi^1_{t-1} + \xi^2_{t-2} + \xi^3_{t-3} + \xi^4_{t-4}}^{\text{'recent information'}} + \overbrace{\xi^5_{t-5} + \xi^6_{t-6} + \xi^7_{t-7} + \xi^8_{t-8}}^{\text{'earlier information'}}$$

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.

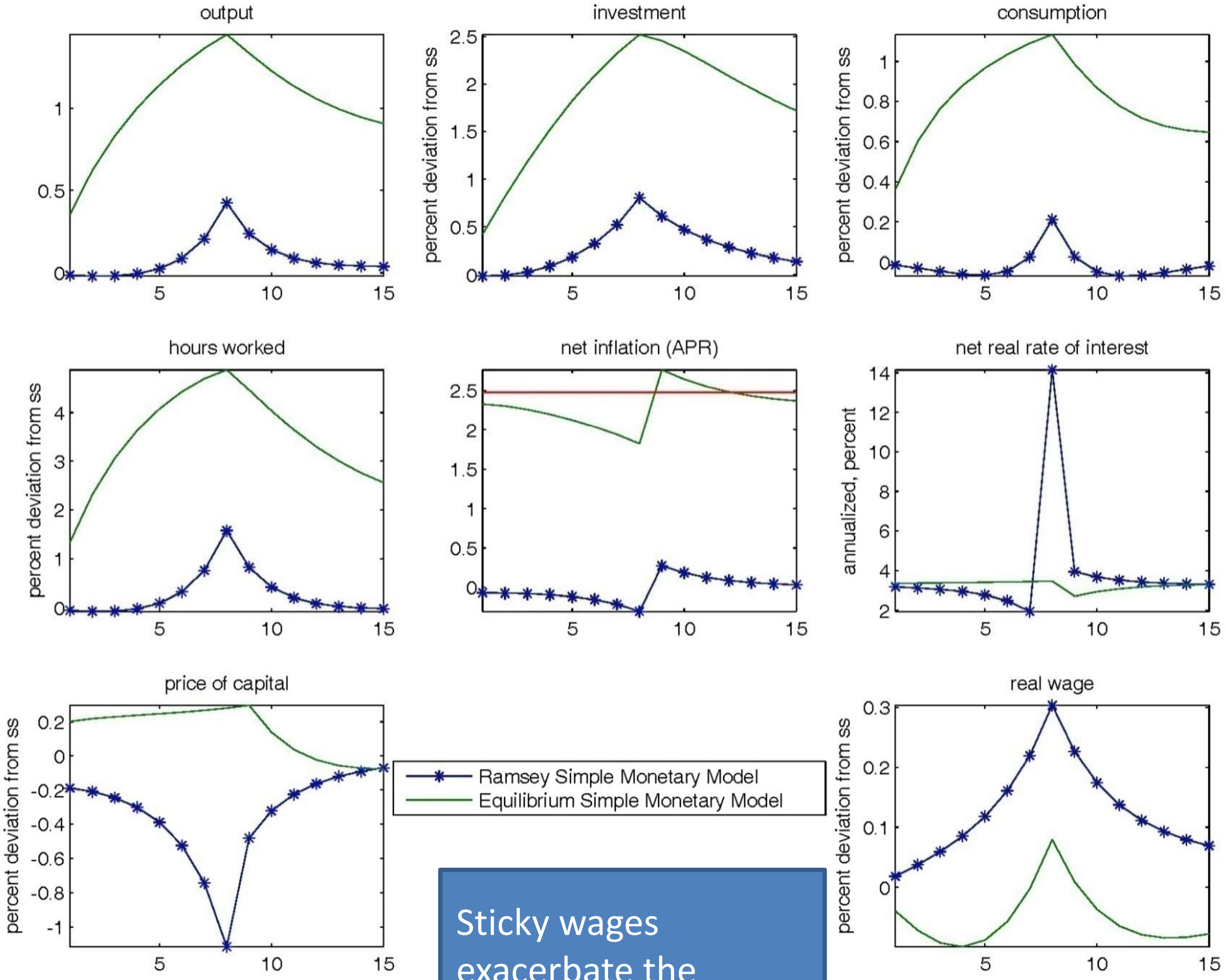
Benchmark: *Ramsey* Response to Signal Shock

- 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.