Hysteresis in Unemployment and Jobless Recoveries

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[1] This presentation should not be reported as representing the views of the IMF. The views expressed in this paper and presentation are those of the author(s) and do not necessarily represent those of the IMF or IMF policy.

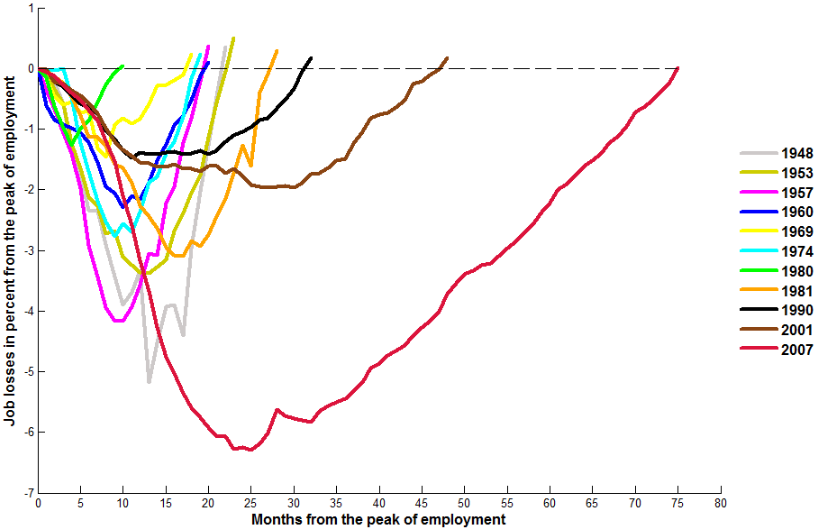
Outline

Outline

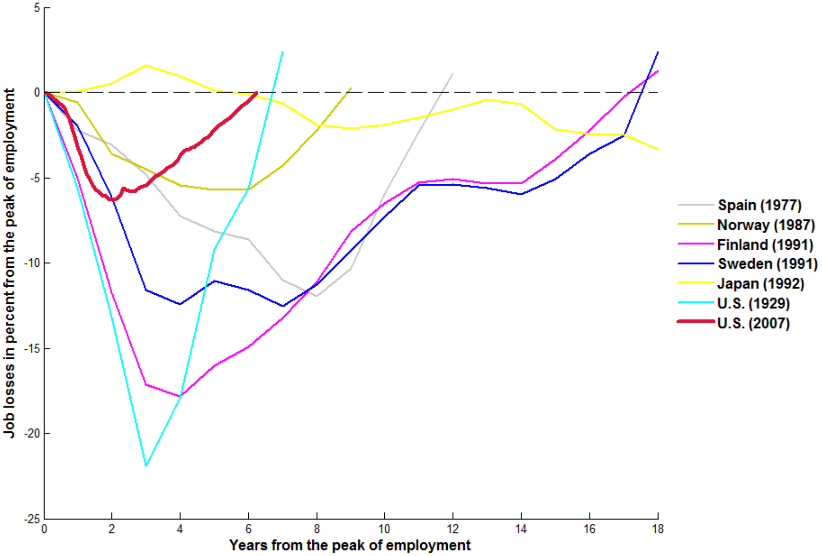
Main questions

- What caused the Great Recession in the U.S.?
- Why did the unemployment rate stay above 8% for more than 18 quarters since the official end of the recession?
- Is there a framework that explains the Great Recession and is consistent with the rest of the postwar period?

Jobless recoveries



Job losses in financial crises



Wealth losses in the U.S.

Recession	Employment recovery (months)	Average wealth change (%)
1953	8	1.20
1957	8	0.75
1960	6	1.12
1969	6	0.65
1974	6	0.71
1980	4	0.51
1981	9	0.75
1990	11	-0.15
2001	16	-0.13
2007	76	-3.04

Table : Wealth losses and joblessness of recoveries. Wealth is calculated as Net Worth of Households and Nonprofit Organizations (quarterly data) divided by CPI. Source: FRED.

Hysteresis in unemployment

- The unemployment rate is highly persistent in the U.S. quarterly data: 0.973 (s.e = 0.016)
  - TFP shocks alone are unlikely to explain this persistence
  - Need movements in the natural rate (supply determined) Graph

My approach

- Construct a general equlibrium model with rational expectations and continuum of steady state equilibria.
  - Does not contain a natural rate of unemployment.
- Two types of shocks:
  - fundamental supply (TFP) shocks as in standard models.
    - act as a cyclical component.
    - have improved propagation.
  - non-fundamental demand (sunspot) shocks to wealth expectations.
    - have permanent effect on the unemployment rate.
- Estimate the model for the entire postwar data.

Preview of results

- Jobless recoveries = a negative wealth shock + a positive TFP shock.
  - Negative wealth shock $\rightarrow$permanent increase in the unemployment rate.
  - Positive TFP shock $\rightarrow$real growth $\rightarrow$the economy converges to the new high unemployment rate.
- Matches stylistic business cycle features in real wages, output, investment, consumption, the unemployment rate.
- Explains large and persistent increases in the unemployment rate as a highly inefficient outcome.

Hysteresis in unemployment

- Blanchard and Summers (1986, 1987)
  - Demand shocks have permanent effect on both output and the unemployment rate
  - Unrealistic mechanism
- Demand shocks have no permanent effect on the unemployment and GDP (Blanchard and Quah (1989))
- Ball (2009)
  - New and old evidence of hysteresis in unemployment
  - Calls for a better mechanism

Outline

Model

Overview

- My model $\approx$ an RBC model with the labor search externality.
  - An important difference: firms take wages as given as in RBC model $\Rightarrow$ no Nash-bargaining equation.
- "Labor search" (congestion) externality $\Rightarrow$ continuum of steady state equilibria.
- Expectations about the future select an equilibrium.
- Assumption: agents form expectations about their wealth (permanent income) $\Rightarrow$ this select an equilibrium

Model

Households

- Utility is logarithmic.
- Each household owns 1 unit of time that they allocate to labor.
  - There is no disutility from working $\Rightarrow$ All variation in employment is due to variation in the unemployment rate.
- Household accumulate capital k_t that they rent to firms for the rental rate of r_t.

Model

Firms

- One CES production technology for producing goods that uses labor and capital as inputs.
  - Firms maximize profit taking the wage w_t and the rental rate r_t as given.

Model

Labor market

- "Search" technology.
- Externality in the recruiting process ($y_t = F(k_t,\ L_t, \Omega(\bar{L_t}))$ and bilateral monopoly problem $\Rightarrow$ Continuum of steady state equilibria (McAfee and Howitt (1987), DMP (1982,1984)).
  - Not resolved using the Nash-bargaining solution (Shimer (2005)).
  - Instead I assume that firms produce output to meet aggregate demand.

Model

Labor market

- Given the wage w_t a firm can attract as many job applicants as it needs on a competitive market.
- Not all workers are suitable for a given firm $\Rightarrow$firm screens applicants using its hiring department.

$$L_t = x_t + v_t$$

- L_t - total number of employees.
- x_t - production department workers.
- v_t - hiring (screening) department workers.

Model

Labor market

- Efficiency of each worker in the hiring department depends on other firms' hiring efforts.
- If labor is rehired every period:

$$L_t = q_t v_t$$

- q_t is the number of employees one worker can screen (determined in equilibrium from the matching function)

$$q_t = \frac{\bar{M}_t}{\bar{v}_t}$$

Model

Firm's problem

$$
\begin{aligned}
\left(ak_t^{\rho} + bx_t^{\rho} s_t^{\rho}\right)^{\frac{1}{\rho}} - r_t k_t - w_t L_t \quad &\rightarrow \quad \max_{k_t, L_t, v_t, x_t} \\
s.t. \\
x_t + v_t \quad &= \quad L_t \\
q_t v_t \quad &= \quad L_t
\end{aligned}
$$

where

- L_t is the total number of people employed
- x_t is the number of workers producing goods
- v_t is the number of workers in the hiring department
- q_t is the number of workers one worker can hire (determined in equilibrium) Details

Model

Production function

- Individual production function

$$y_t = \left(ak_t^\rho + bL_t^\rho s_t^\rho \Omega_t\right)^{\frac{1}{\rho}}$$

- If labor is rehired every period there is a closed form solution for the externality term $\Omega_t = \Omega(\bar{L_t})$:

$$\Omega_t = \left(1 - \frac{\bar{L_t}}{\Gamma}\right)^\rho$$

where Γ is a constant (parameter of the matching function.)

Details

Model
Summary

$$\frac{1}{c_t} = E_t\left[\beta \frac{1}{c_{t+1}}\left((1-\delta) + a\left(\frac{y_{t+1}}{k_{t+1}}\right)^{1-\rho}\right)\right] \quad (1)$$

$$y_t = c_t + I_t \quad (2)$$

$$I_t = k_{t+1} - (1-\delta)k_t \quad (3)$$

$$y_t = \left(ak_t^\rho + bs_t^\rho L_t^\rho \left(1 - \frac{L_t}{\Gamma}\right)^\rho\right)^{\frac{1}{\rho}} \quad (4)$$

$$w_t = b\left(\frac{y_t}{L_t}\right)^{1-\rho} s_t^\rho \left(1 - \frac{L_t}{\Gamma}\right)^\rho \quad (5)$$

$$s_t = s_{t-1}^\lambda exp(\epsilon_t^p) \quad \epsilon_t^p \sim N(0, \sigma_p^2) \quad (6)$$

- 7 unknowns and 6 equations ⇒the model is incomplete
  - Dynamic indeterminacy
  - Steady state indeterminacy

Closing the model

- Rational expectations are not enough to close the model.
- I close the model by specifying a "belief function."
  - Resolves dynamic indeterminancy.
- My belief function is adaptive.
  - Explains how demand and supply shocks feed back into beliefs.
  - Explains future path of the unemployment rate, output, consumption, investment and the real wage.
- I assume that consumption is determined by wealth.
  - Ludvigson and Lettau (2004), Farmer (2012)

Closing the model

Belief function

- Adapt Friedman's (1957) work on permanent income:

$$c_t = \phi y_t^p \tag{7}$$

- As in Friedman's work expectations about permanent income are adaptive.

$$\frac{y_t^p}{w_t} = \left(\frac{y_{t-1}^p}{w_{t-1}}\right)^{\chi} \left(\frac{y_t}{w_t}\right)^{1-\chi} exp(\epsilon_t^b) \;\; \epsilon_t^b \sim N(0, \sigma_b^2) \tag{8}$$

- These two equations constitute the belief function.
- Expectations are relative to wages
  - removes productivity trend from growing real output y_t
  - ensures balanced growth path

Consistency with rational expectations

- In every steady state $y_{ss}^{p} = y_{ss}$. The belief function implies

$$\phi = \frac{c_{ss}}{y_{ss}}$$

- But $\frac{c_{ss}}{y_{ss}}$ is pinned down by the Euler Equation, capital accumulation equation and national accounts identity. Thus

$$\phi \equiv 1 - \delta\left(\frac{a}{\frac{1}{\beta} - (1-\delta)}\right)^{\frac{1}{1-\rho}} = \frac{c_{ss}}{y_{ss}}$$

$\Rightarrow$Consistency with rational expectations

Steady state vs Dynamic indeterminacy

- Steady State Indeterminacy $\Leftrightarrow$The complete model still has a continuum of steady states
  - each associated with a unique employment rate, $L_{ss} \in (0,1]$
  - Only one is socially efficient $L^* = \frac{\Gamma}{2}$ (maximizes output for a fixed k_t)
- No Dynamic Indeterminacy $\Leftrightarrow$ Dynamics are pinned down for each set of initial conditions

$$\begin{aligned} k_0 &= \bar{k}_0 \\ s_0 &= \bar{s}_0 \\ \lim_{T\to\infty} E_t\left(\beta^T \frac{k_T}{c_T}\right) &= 0 \\ y_0^P &= \bar{y}_0^p \end{aligned}$$

- But in every steady state $y_{ss}^P = y_{ss} \Rightarrow$ model exhibits hysteresis

Rational expectations

- For any variable X_t, $\eta_t = X_t - E_{t-1}[X_t]$ is white noise.
- How can agents be rational and form expectations in an adaptive way at the same time?
  - Because a Nash Bargaining equation is missing.
  - Adaptive expectations select the equilibrium.

Summary so far

- Labor search general equilibrium model closed with a belief function.
  - Rational expectations
  - Continuum of steady states
  - Unique dynamic path associated with each steady state
- Two sources of shocks.
  - Supply (productivity)
  - Demand (expectations about wealth)

Outline

Estimation

Solution

- For every set of the parameters
  - Log-linearize a model around a fixed steady state $\bar{L} \in (0,1]$ and then solve to get
  - $$X_t = GX_{t-1} + Q\zeta_t$$
  - where X_t is a vector of state variables and $\zeta_t = [\epsilon_t^b, \epsilon_t^p]$
- One of eigenvalues of G is always one $\Rightarrow$hysteresis $\Rightarrow$model generates non-stationary series.

Estimation

Data

- Estimate the model using Metropolis-Hastings algorithm
- Quarterly data on series in wage units 1948:1 - 2011:4
  - GDP in wage units $\frac{y_t}{w_t}$,
  - Consumption in wage units $\frac{c_t}{w_t}$,
  - Investment in wage units $\frac{I_t}{w_t}$
  - The civilian unemployment rate $u_t = 1 - L_t$

Data details

Priors

Parameter	Description	Distribution	Prior mean	Std. Dev.
a	≈Cap. share	beta	0.33	0.15
$\epsilon_{k,l}$	Elasticity b/w k_t & l_t	beta	0.50	0.25
δ	Capital depreciation	beta	0.03	0.015
β	Discount factor	Fixed	0.99	–
$1-\chi$	Expectations gain	beta	0.10	0.05
λ	Productivity pers.	beta	0.90	0.05
σ^p	St.dev. of ϵ^p	Inv. Gamma	0.02	0.01
σ^b	St.dev. of ϵ^b	Inv. Gamma	0.02	0.01

Posteriors

Parameter	Description	Post. mean	$CI_{90\%}$
a	$\approx$Capital share ($=$ if $\rho = 0$)	0.4585	[0.3929, 0.5212]
$\epsilon_{k,l}$	Elasticity b/w k_t and l_t	0.9209	[0.8804, 0.9611]
δ	Capital depreciation	0.0082	[0.0079, 0.0086]
β	Discount factor	0.99	–
$1 - \chi$	Expectations gain	0.0487	[0.0180,0.0777]
λ	Labor prod. persistence	0.9175	[0.8784, 0.9531]
σ^p	St.dev. of ϵ^p	0.0156	[0.0141, 0.0172]
σ^b	St.dev. of ϵ^b	0.0082	[0.0076, 0.0089]
$log\ L = 2101$	MCMC accept. rate 32.84%	100000 draws	50000 kept

Posterior densities

Outline

Results

- Can the model reproduce the data?
  - Compare moments of simulated series and the data
  - The Great Recession (Benchmark vs an RBC model)
- Quantitative effect of each shock separately
  - Impulse response functions

Monte-Carlo Experiment

- Objective: compare non-stationary series in the data and non-stationary series in the model.
  - Volatility and persistence.
- All variables are in log-deviations from their statistical means.

Standard deviations

Variables in wage units

X_t	Simulations MC Avg. $CI_{90\%}$	Data
I_t	14.468 [10.883,18.017]	12.363
C_t	5.589 [2.319,8.849]	5.648
Y_t	6.007 [2.831, 9.173]	3.730
L_t	5.972 [2.784,9.149]	1.767

- I_t is the most volatile series both in the model and the data
- Model matches standard deviations in the data well
  - Standard deviations of I_t, C_t, Y_t are within 90% CI
  - $std(L_t)$ is within 95% CI

Persistence

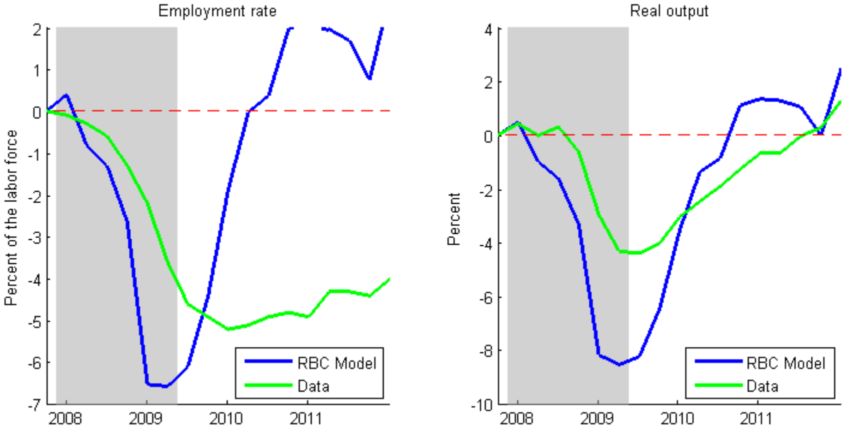
Variables in wage units

X_t	Simulations MC Avg. $CI_{90\%}$	Data
I_t	0.904 [0.858,0.950]	0.904
C_t	0.981 [0.963,0.999]	0.988
Y_t	0.968 [0.942,0.997]	0.966
L_t	0.971 [0.942,0.997]	0.970

- High persistence comes from the model, not from persistence in the shock processes.
- Model matches different persistence of series almost exactly.
- Investment is the least persistent series.
- Persistence of consumption, output and the employment rate is close to random walk. Figures of simulated and actual series

The Great Recession

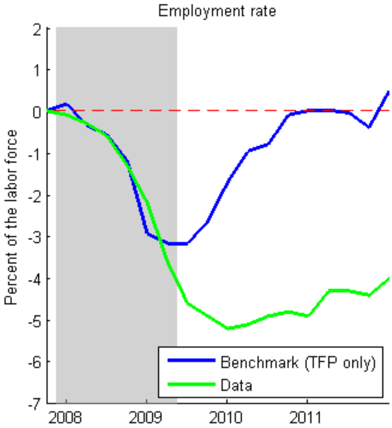
RBC model with linear disutility from labor

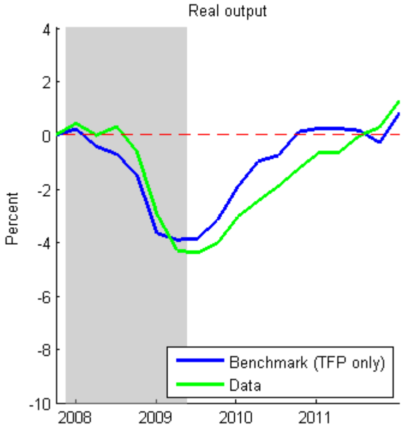


- Quick recovery in both employment and real GDP.

The Great Recession

Benchmark model (TFP shock only)

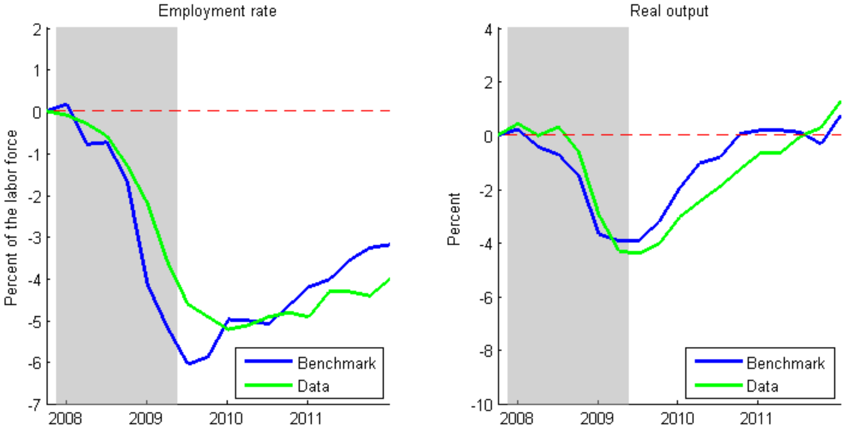




- TFP shocks are much more persistent

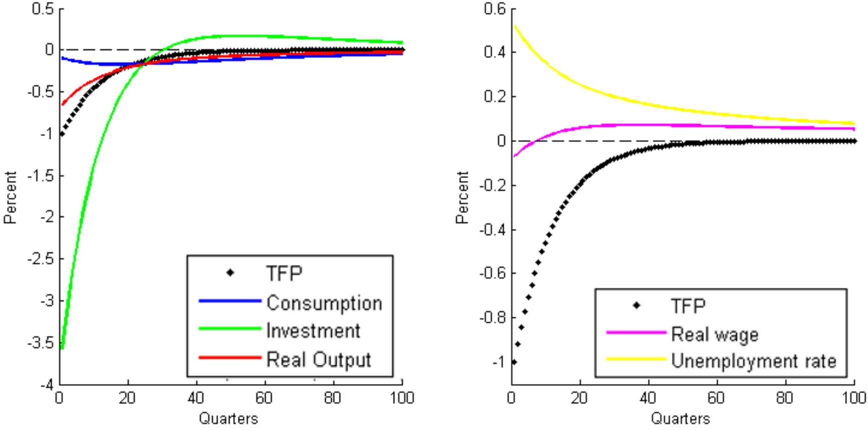
The Great Recession

Benchmark model (both shocks)



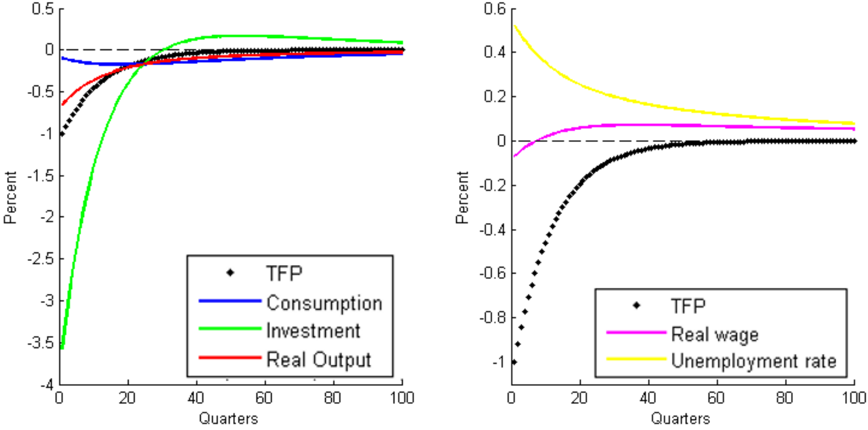
- Sunspot shocks do not affect real output

Impulse response to a 1% negative productivity shock



- Because expectations are adaptive, consumption does not drop as much as in the RBC model, and recovers more slowly.
- Investment decreases more, so capital takes longer to recover. This leads to more persistent drop in output.
- New steady state: same output, slightly lower consumption, slightly higher investment.

Impulse response to a 1% negative productivity shock



- Real wages are rigid with respect to TFP changes
  - Protracted effect of a TFP shock on unemployment.
- Microfoundations for the assumption of the real wage rigidity with respect to TFP (as in Hall (2005), Shimer (2012).)

Response to a 1% negative sunspot shock

- 1% negative sunspot shock generates
  - 1% increase in the unemployment.
  - 1% increase in the real wage.
  - Almost no effect on other real variables.
- Economy jumps to a new steady state so that: $\frac{C_t^{new}}{Y_t^{new}} = \phi$.
- Intuition: similar to the RBC model
  - a drop in demand leads to no change in quantities, and to a drop in price level (inverse of the real wage).
- A rise in wages and drop in employment correspond to what we observe in the data (see, for example Kocherlakota (2012)).

Conclusion

- This paper constructed a general equilibrium rational expectations model with hysteresis in unemployment.
  - Plausible mechanism.
  - Generates both regular and jobless recoveries
- Temporary changes in TFP can lead to an inefficient outcome.
  - In contrast to an RBC model.
- The economy can remain in a highly inefficient equilibrium for a long time.
- Movements typically attributed to changes in the "natural rate" are partially demand caused.
  - Important policy implications

Thank you!

Future work

- Fiscal policy
  - Increase aggregate demand in recessions.
    - Tax cuts vs. Fiscal expansion
- Monetary policy
  - Increase in the interest rate causes a permanent increase in the unemployment rate

Firm's problem

$$
\begin{aligned}
\left(ak_t^\rho + bx_t^\rho s_t^\rho\right)^{\frac{1}{\rho}} - r_t k_t - w_t L_t & \rightarrow \max_{k_t, L_t, v_t, x_t} \\
s.t. & \\
x_t + v_t & = L_t \\
q_t v_t & = L_t
\end{aligned}
$$

where

- L_t is the total number of people employed
- x_t is the number of workers producing goods
- v_t is the number of workers in the hiring department
- q_t is the number of workers one worker can hire (determined in equilibrium)

Firm's problem

- Eliminating v_t gives

$$x_t = L_t - v_t = L_t - \frac{L_t}{q_t} = L_t\left(1 - \frac{1}{q_t}\right)$$

- Leads to the following aggregate production function

$$y_t = \left(ak_t^\rho + bL_t^\rho s_t^\rho\left(1 - \frac{1}{q_t}\right)^\rho\right)^{\frac{1}{\rho}}$$

Firm's problem

How is $q_t$determined?

- Assume standard Cobb-Douglas matching function with elasticity $\theta = 0.5$ (to simplify algebra), number of matches per period m_t

$$m_t = \Gamma \bar{v}_t^{\frac{1}{2}} \cdot 1^{\frac{1}{2}}$$

- Solve for q_t as a function of v_t

$$m_t = q_t \bar{v}_t \Rightarrow q_t = \frac{\Gamma}{\bar{v}_t^{\frac{1}{2}}}$$

- Finally using that $l_t = q_t v_t$, eliminate v_t

$$q_t = \frac{\Gamma}{\bar{v}_t^{\frac{1}{2}}} = \frac{\Gamma}{\bar{L}_t}$$

Go back

Wage Units

Details

- Define nominal wage per full-time employee to be

$$W_t = \frac{(compensation\ of\ employees)_t}{(number\ of\ FTE)_t}$$

- GDP in wage units, Z_t, is defined as

$$Z_t = \frac{Y_t}{W_t} \cdot \frac{1}{N_t}$$

where

- Y_t is nominal U.S. GDP.
- N_t is the labor force.

Wage units

Interpretation

- Let b_t be labor income share in the total output and L_t be the number of FTE
- Then by definition

$$b_t Y_t \equiv W_t L_t$$

- Dividing both sides by the labor force N_t leads to

$$\frac{Y_t}{W_t} \cdot \frac{1}{N_t} \equiv \frac{1}{b_t} \cdot \frac{L_t}{N_t}$$

- GDP measured in wage units Z_t has to be a product of the inverse of the labor share $\frac{1}{b_t}$ and the employment rate $\frac{L_t}{N_t}$

Wage units

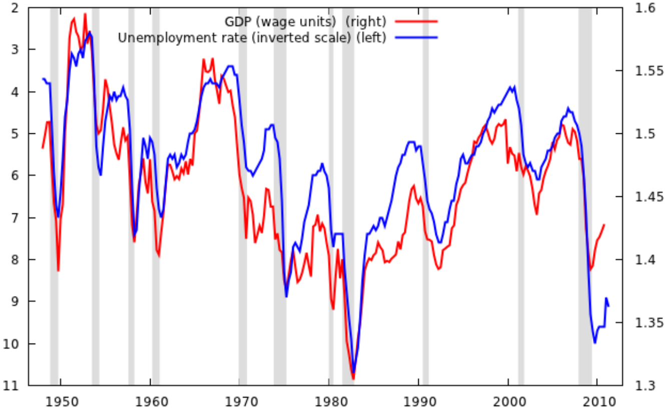


Figure : Civilian unemployment rate (percent, left scale, inverted) and GDP in wage units (right scale). Quarterly data 1948:1 - 2010:4. Shaded areas are NBER recession dates.

Wage units

GDP components

- GDP components are detrended in a similar way:

$$I_t^w = \frac{I_t}{W_t} \cdot \frac{1}{N_t} \qquad C_t^w = \frac{C_t}{W_t} \cdot \frac{1}{N_t}$$

where

- I_t is the sum of nominal private and government investment
- C_t is defined as $C_t = Y_t - I_t$ - nominal private plus government consumption and net exports

Investment in wage units

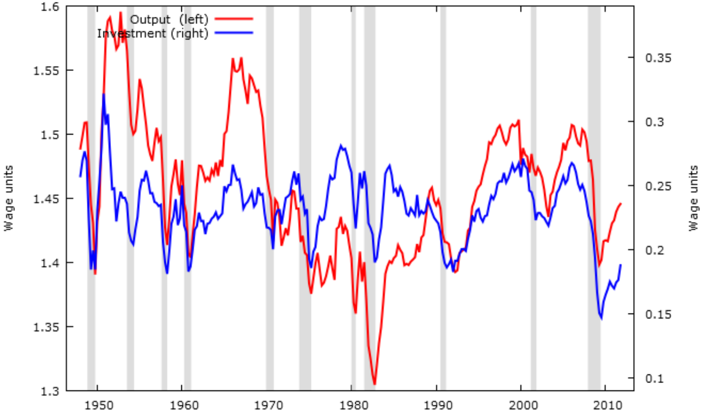
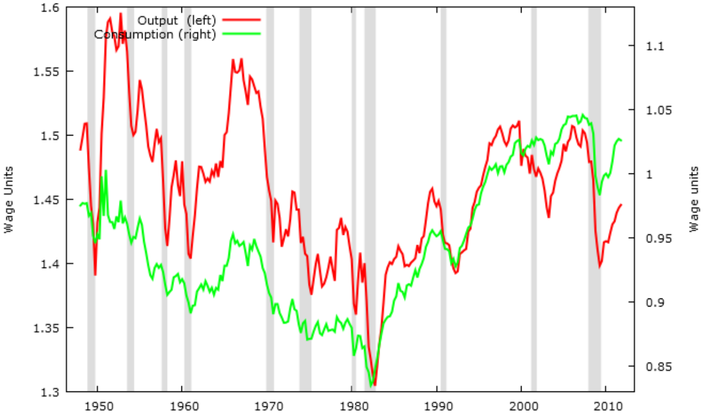


Figure : Investment in wage units

Consumption and GDP in wage units



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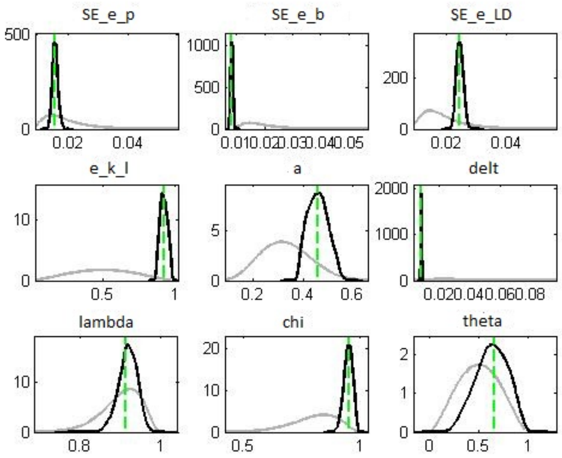
Posterior densities



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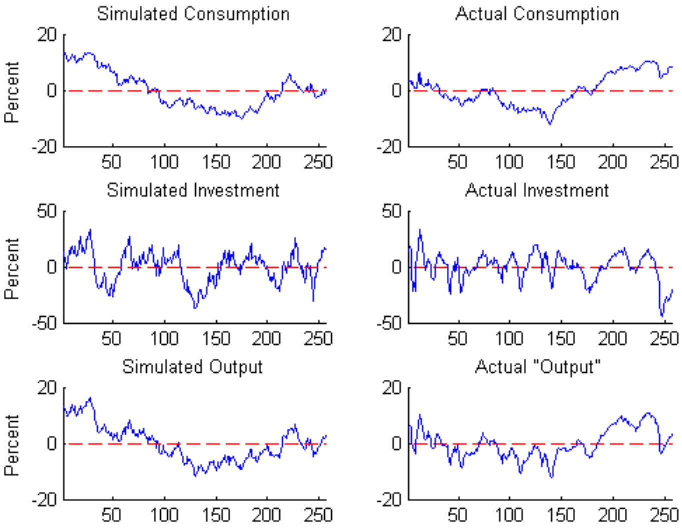
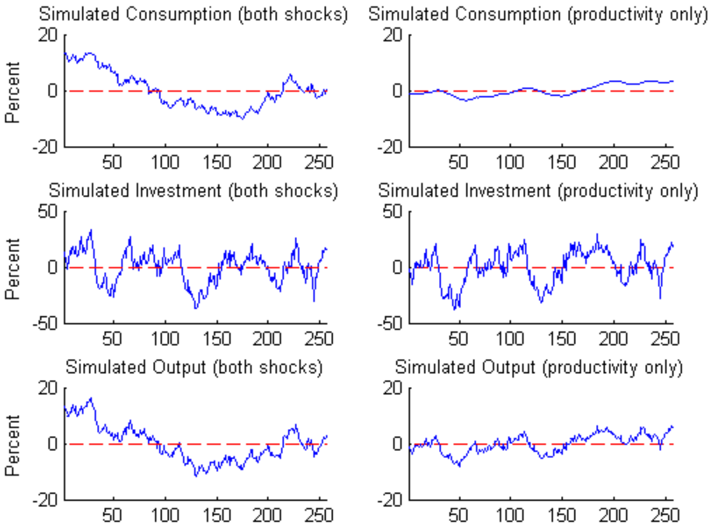
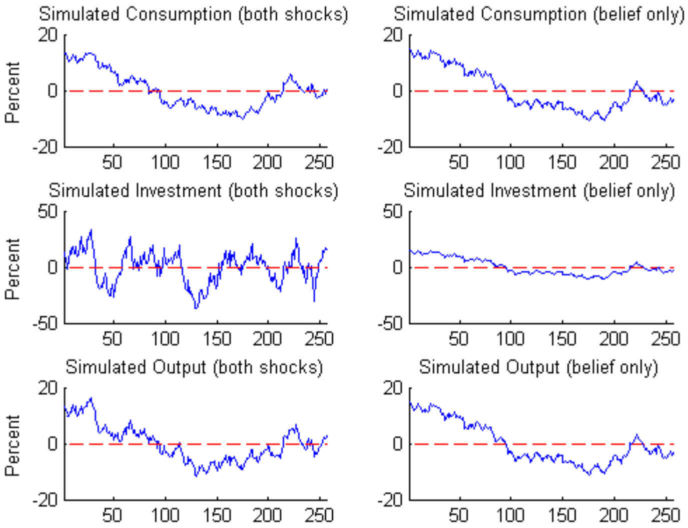
Simulated data vs actual data



Both shocks vs only productivity shocks



Both shocks vs only belief shocks



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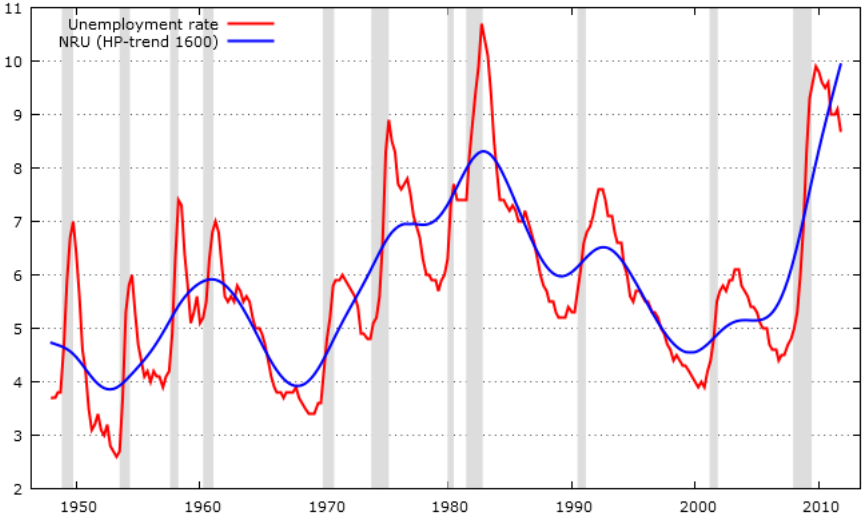
Closing the model

$$C_t = \phi Y_t^p$$
$$Y_t^p = (Y_{t-1}^p)^{\chi}(Y_t)^{1-\chi} exp(\epsilon_t^b)$$

- Normalization $W_t = 1 \Rightarrow$ expectations are formed in variables normalized to nominal wages
  - Ensures parameter stability to both inflation and productivity trend growth

Movements in the natural rate



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