

# AEA CONTINUING EDUCATION PROGRAM



## MONETARY POLICY

GAUTI B. EGGERTSSON, BROWN UNIVERSITY

JANUARY 5-7, 2015

# The liquidity trap: Zero bound on short-term nominal interest rates

Gauti B. Eggertsson

ASSA Meetings

# The liquidity trap

- Keynesian economics has its origin in crisis: The Great Depression.
- The IS-LM model, Hicks illustration of the General Theory was motivated by the zero interest rate during the 1930's.
- Coined the “liquidity trap”.
- Q: What is it?
  - Old answer: No matter how much money you print, it has no effect on output and prices
  - Today's answer: Used as a short hand for the zero bound on the short-term nominal interest rate.
    - I don't lend you 1 dollar unless I get at least 1 dollar back.
    - Monetary policy in a liquidity trap not neutral but expectations play a critical role.

# Outline of talk

## I. The origin of the crisis:

A simple illustrative example.

TWO key elements of crisis

- A drop in the natural level of interest – the real interest rate consistent with full employment (key suspect: tightening in financial conditions.)
- Some frictions that make it hard for real interest rate to fall (key suspect: price rigidities and ZLB).

## II. Policy responses

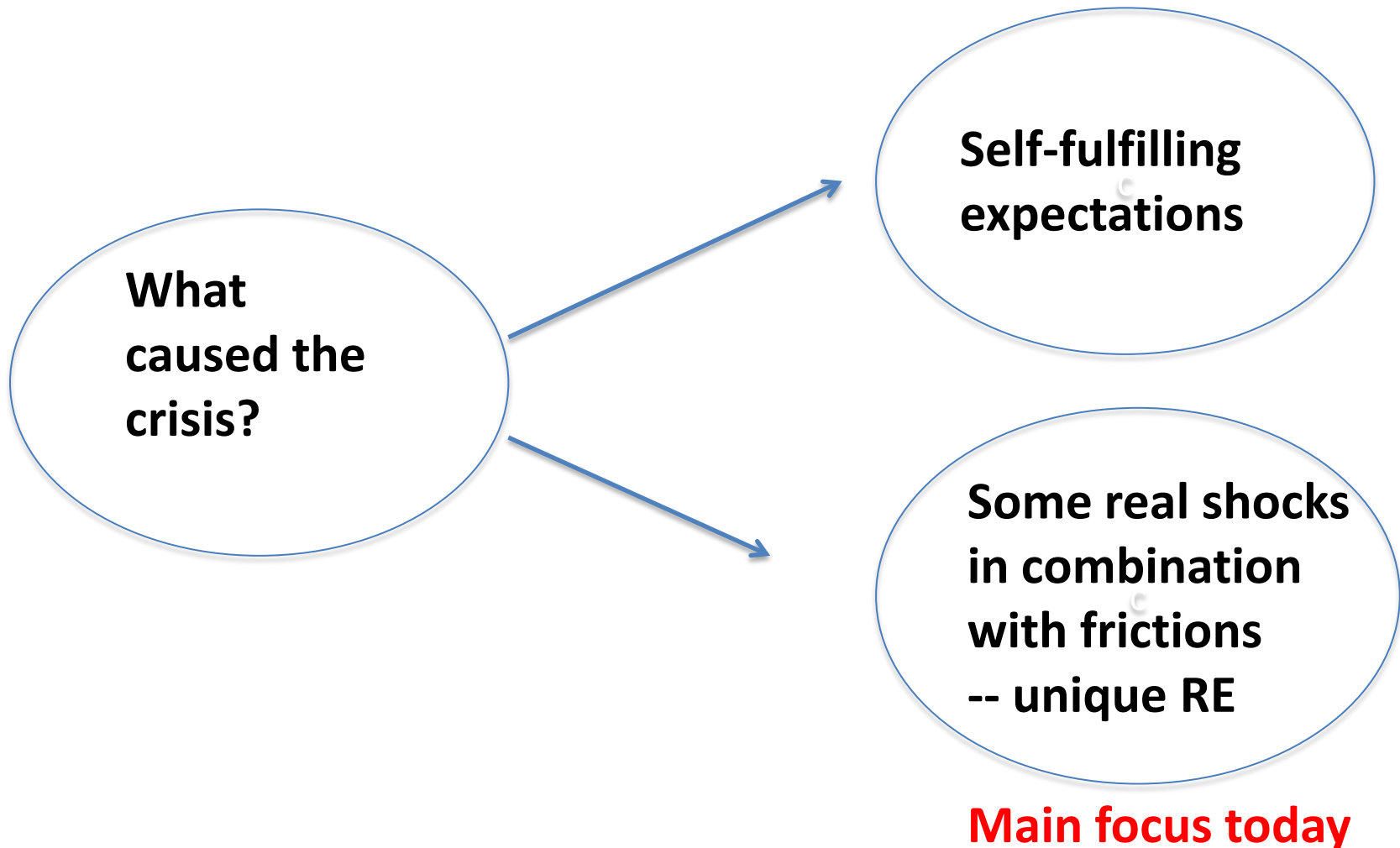
- A Basic New Keynesian Approach
- Short run responses inside a conventional monetary policy regime (fiscal policy, various structural policies)
- Regime changes and the difficult issue of credibility

## III. Historical Analogies

## IV. The Liquidity trap and the Secular Stagnation Hypothesis.



# A particular perspective: Fork in the road I took very early on



# To be clear

- Unique Rational Expectation equilibrium not the only way to go.
- But very convenient because you can talk about comparative statics, e.g. multipliers of government spending etc.
- Stories of multiplicities also interesting.
- But less suitable for a talk – at least by me -- in only 3 hours.

# I. The Origin of the Crisis

*in a stripped down model*

# What causes big contractions?

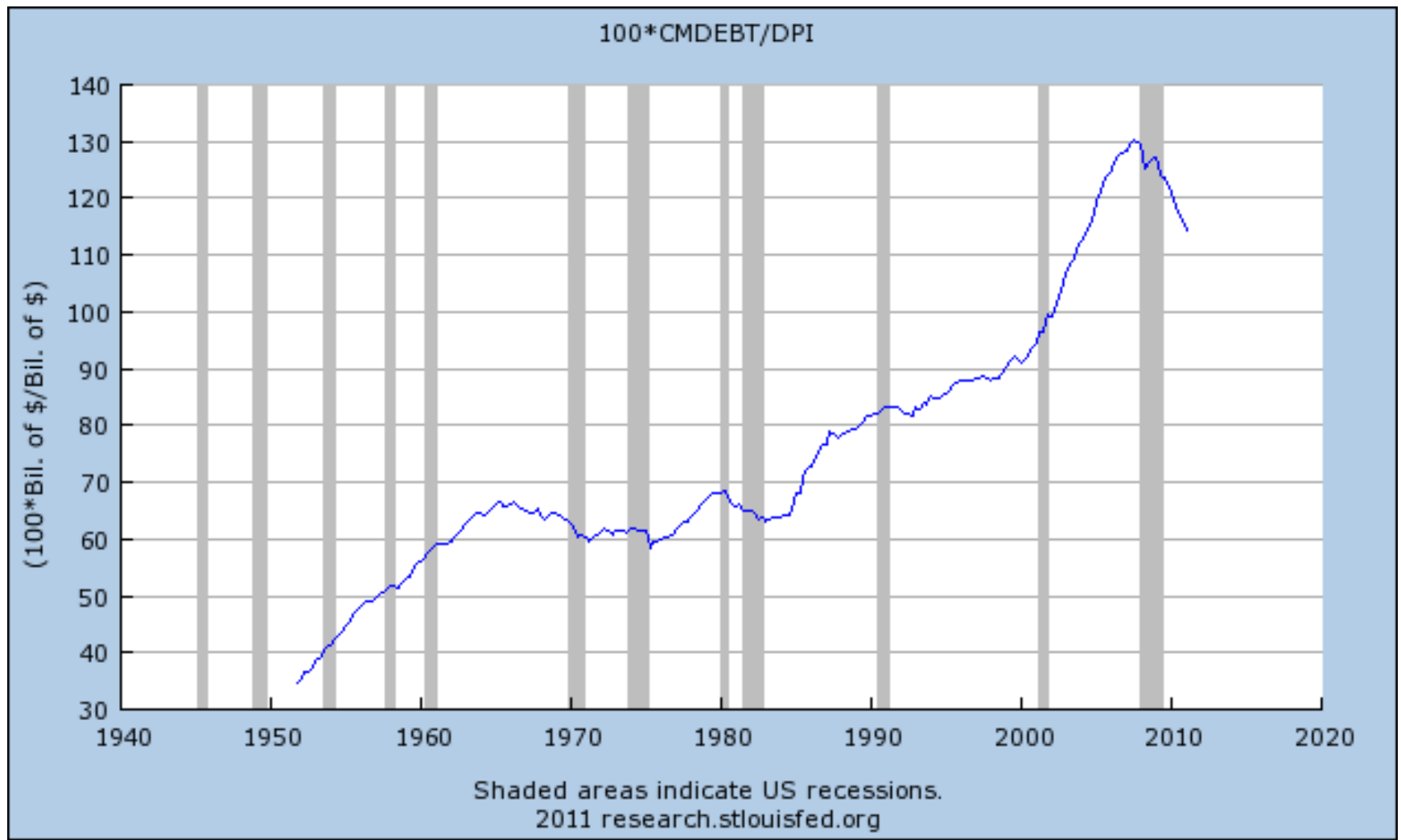
$$Y_t = A_t K_t^{1-\gamma} L_t^\gamma$$

Want a story of incomplete factor utilization.

1. Financial frictions that trigger large change in “intertemporal prices”
2. Zero bound on the short term nominal interest rate + price/wage frictions → make this hard to accommodate.



## Key suspect: Household debt as % of disposable personal income



# 1. Drop in natural rate of interest:

## Simple endowment economy

*variation on Eggertsson-Krugman (2012)*

$$E_0 \sum_{t=0}^{\infty} \beta(i)^t \log C_t(i) \text{ with } i = s \text{ or } b$$

$$D_t(i) = (1 + r_{t-1})D_{t-1}(i) - \frac{1}{2}Y + C_t(i)$$

$$(1 + r_t)D_t(i) \leq D^{high} > 0$$

$$\beta(s) = \beta$$

# Equilibrium in simple model:

## Steady state

Borrower will borrow up to borrowing limit  $\longrightarrow$  
$$C^b = \frac{1}{2}Y - \frac{r}{1+r}D^{high}$$

Saver consumes endowment plus interest income  $\longrightarrow$  
$$C^s = \frac{1}{2}Y + \frac{r}{1+r}D^{high}$$

Saver satisfies Consumption Euler  $\longrightarrow$  
$$\frac{1}{C_t^s} = (1 + r_t)\beta E_t \frac{1}{C_{t+1}^s}$$

Stead state interest will satisfy the savers discount factor  $\longrightarrow$  
$$r = \frac{1 - \beta}{\beta}$$

# Experiment: “Deleveraging” shock

- Debt limit presumably reflect “safe” lending taking into account unintended default by some “moral hazard” consideration
- Minsky Moment → Unexpected reduction in this limit.
- Need to deleverage: Unexpected exogenous drop in the debt limit the borrower must satisfy

$$D^{high} \longrightarrow D^{low}$$



# What happens? Debtor

- Split in “short run” and “long run”.

$$C_L^b = \frac{1}{2}Y - (1 - \beta)D^{low}$$

Number of important issues regarding the “deleveraging” process are swept under the rug.

$$C_S^b = \frac{1}{2}Y + \frac{D^{low}}{1 + r_S} - D^{high}$$

Key robust thing we’re after

→ Leveraged players need to cut down their spending in SR

How does saver react and the real interest rate?

# Saver

$$C_L^s = (1 + r_s) \beta C_S^s$$



$$1 + r_s = \frac{\frac{1}{2}Y + D^{low}}{\beta \frac{1}{2}Y + \beta D^{high}}$$



Can be less than 1  
if  $\beta D^{high} - D^{low}$   
is big enough

Condition for a nasty  
little liquidity trap

# Negative natural rate of interest

- What going on?
- Borrowers spending collapses due to deleveraging
- In order to get the savers to make up for the spending need the real interest rate to decline.
- The decline may be large enough for the real interest rate to be temporarily negative
- Is this a problem?

## 2. Negative natural rate of interest and deflation

- Let us now introduce a nominal price level.
- One period risk-free bond is traded. We imagine that the government controls the nominal interest rate.
- Now two consumption Euler Equations

$$\frac{1}{C_t^s} = (1 + i_t) \beta E_t \frac{1}{C_{t+1}^s} \frac{P_t}{P_{t+1}}$$

$$\frac{1}{C_t^s} = (1 + r_t) \beta E_t \frac{1}{C_{t+1}^s}$$

$$1 + r_s = (1 + i_s) \frac{P_s}{P_L}$$

## 2. Negative natural rate of interest and deflation

Imagine that LR price level is fixed at  $P^*$  (Krugman (1998))

$$1 + r_s = (1 + i_s) \frac{P_s}{P^*}$$

Now imagine  $r(s)$  is negative for the reason we have shown.

What needs to happen?

If  $P_s = P^*$  then  $r_s = i_s < 0$  which violates the zero bound

Set  $i_s = 0$  then  $P_s = (1 + r_s)P^* < P^*$  if  $r(s) < 0$

**Deflation in the short run to create expected inflation**

## 2. Negative natural rate of interest and deflation

- With natural rate of interest negative (real interest rate under flexible prices)

→ **Economy needs expected inflation in the short run.**

- If you fix long run price level then this shows up as deflation in the short run?
- But what if the Central Bank will never tolerate any inflation?

→ **No equilibrium exists consistent with stable prices.**

- If we introduce some pricing frictions, however, and equilibrium exists and the refusal of CB to achieve negative real rate, i.e., **preventing inflation shows up as a decline in output**

### 3. Negative natural rate + nominal frictions + ZLB

- Each household supplies a labor endowment inelastically

$$L_t^b = L_t^s = \bar{L}$$

- Perfectly competitive firms maximize profits:

$$Y_t = L_t^\alpha \quad \frac{W_t}{P_t} = \alpha L_t^{\alpha-1}$$

- If no further frictions exactly the same economy as before.

$$Y_t = \bar{L}^\alpha$$

# Short run sticky wage: Aggregate supply

- Assume that for whatever reason wages in the short run do not adjust

$$W_S = 1 \quad \frac{W_S}{P_S} = \alpha Y_S^{\frac{\alpha-1}{\alpha}} \quad Y_S = L_S^\alpha$$

- Set  $\alpha=0.5$  and then

$$P_S = \frac{1}{\alpha} Y_S^{\frac{1-\alpha}{\alpha}} \quad \text{Aggregate supply}$$

**Key point: Output can be different from labor endowment**  
**What pins down equilibrium? Aggregate demand**



# Aggregate demand

$$C_S^b = \frac{1}{2} Y_S + \frac{D^{low}}{1+i_S} \frac{P_L}{P_S} - D^{high}$$

$$C_S^s = \frac{1}{1+i_S} \frac{P_L}{P_S} \beta^{-1} C_L^s$$

$$Y_S = C_S^s + C_S^b$$

Suppose the central bank now sets

$$P_L = P_S$$

And the shock is large enough so that

$$i_S = 0$$

# Output completely demand determined!

$$Y_S = \beta^{-1} Y_L + 2(\beta^{-1} D^{low} - D^{high})$$

$$P_S = \frac{1}{\alpha} Y_S^{\frac{1-\alpha}{\alpha}}$$

**Output drop depends  
on the size of the  
deleveraging shock**

**Back out prices  
consistent with this  
demand.**

**Consistent with prices  
below steady state or  
constant when alpha=1.**

# Key take-away

- Something triggers the natural rate of interest to be negative
- This is hard to accommodate if wage/prices are not perfectly flexible and/or the central bank will not tolerate enough inflation to accommodate the shock.
- In equilibrium with frictions this shows up as a drop in output due to insufficient demand.

# II. Basic Policy Responses

*in absence of a monetary policy regime changes*

## 2. Basic policy responses: A New Keynesian Approach

Defining the problem:

- Monetary policy regime where the central bank does not accommodate positive inflation.
- Cannot get negative natural rate of interest
- More general model than the we just saw – more dynamics.
- Becomes more interesting to talk about policy.
- Will start by thinking about policy if for whatever reason you can't raise inflation target.
- “Regular policy regime”

# The Model

Households

shock



Utility

$$\max E_t \sum_{T=t}^{\infty} \beta^{T-t} \left[ u(C_T) + \chi \left( \frac{M_t}{P_t} \right) + g(G_T) - \int_0^1 v(L_T(j)) dj \right] \xi_T$$

s.t. budget constraint

Fiscal policy instruments

$$B_t = (1 - \tau_{t-1}^A)(1 + i_{t-1})B_{t-1} + (1 - \tau_t^P) \int_0^1 \Pi_T(i) di \\ + (1 - \tau_t^w) \int_0^1 w_T(j) L_T(j) dj - (1 + \tau_t^s) P_t C_t - T_t$$

Consumption and price indices

Monetary policy instrument

$$C_t \equiv \left[ \int_0^1 c_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, P_t \equiv \left[ \int_0^1 p_t(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}$$

# The Model

## Sticky Prices

Monopolistically competitive firms and linear production function

$$y_t(i) = Y_t \left( \frac{p_t(i)}{P_t} \right)^{-\theta} \quad y_t(i) = L_t(i)$$

Calvo prices. Fraction  $(1-\alpha)$  of firms set new prices in each period (exclusive of sales tax). Commit to produce whatever demanded at the price set.

$$\max_{p_t^*} E_t \left\{ \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} Q_{t,T} (1 - \tau_T^P) \left[ p_t^* \left( \frac{p_t^*}{P_T} \right)^{-\theta} Y_T - W_T(j) \left( \frac{p_t^*}{P_T} \right)^{-\theta} Y_T \right] \right\} = 0$$

Resource constraint

$$Y_t = C_t + G_t$$

Equilibrium

$$\{Y_t, C_t, p_t^*, P_t\} - \{i_t, \tau_t^w, \tau_t^A, \tau_t^s, \tau_t^p, G_t^S, G_t^N\} - \{\xi_t\}$$

# Summarizing the model

**AD**

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r^e(\xi_t)) + E_t(\hat{G}_t - \hat{G}_{t+1}) - \sigma E_t(\hat{\tau}_t^s - \hat{\tau}_{t+1}^s) + \sigma \hat{\tau}_t^A$$

shock

People determine “demand”, i.e. overall spending

**AS**

$$\pi_t = \kappa \hat{Y}_t + \beta E_t \pi_{t+1} + \kappa \psi [\hat{\tau}_t^s + \hat{\tau}_t^w] - \kappa \psi \sigma^{-1} \hat{G}_t^N$$

Firms supply whatever is demanded but demand has effect on their pricing

**ZB**

$$i_t \geq 0$$

$$r_t^e \equiv \log \beta^{-1} + \hat{\xi}_t - E_t \hat{\xi}_{t+1}$$



# Baseline policy

$$i_t = \max(0, r_t^e + \varphi_\pi \pi_t + \varepsilon_t)$$

$$\hat{G}_t = 0 \text{ and } \hat{\tau}_t^s = \hat{\tau}_t^w = \hat{\tau}_t^p = \hat{\tau}_t^A = 0$$

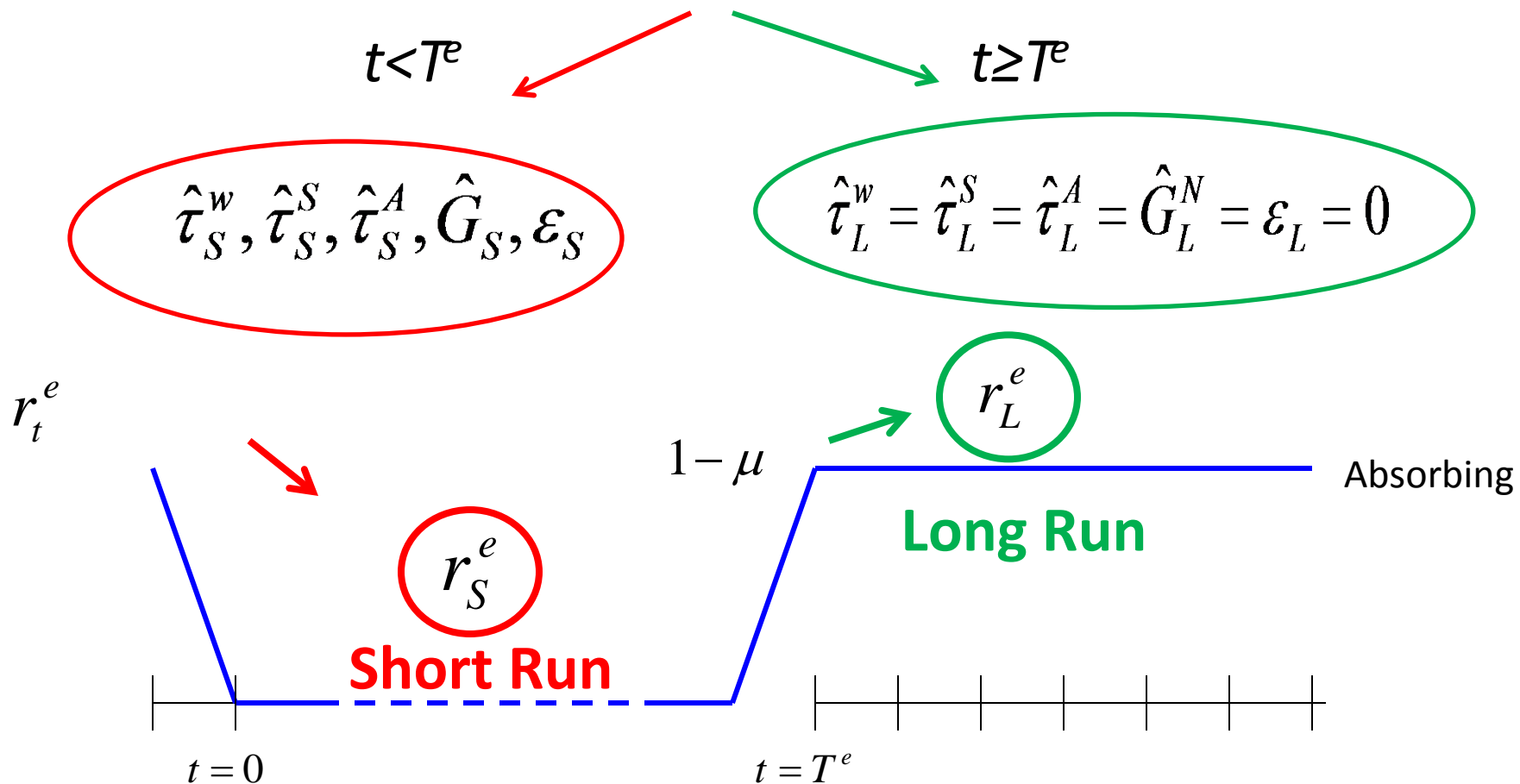
Emphasis here:

Policy on the *margin*, i.e. “multipliers”

*Well defined “benchmark” and study perturbations from this benchmark*

*Will not talk about optimal policy  
e.g. Ramsey or Markov Perfect allocations*

Two states:  
short run and long run  
 transition prob  $1-\mu$ .



# Solution at positive interest rates:

Boils down to only two equations!

In two unknowns!

$$\left. \begin{aligned} \hat{Y}_S &= \mu \hat{Y}_S - \sigma[\varphi_\pi - \mu]\pi_S - \sigma\varepsilon_S + (1 - \mu)[\hat{G}_S - \sigma\hat{\tau}_S^s] \\ \pi_S &= \kappa\hat{Y}_S + \mu\beta\pi_S + \kappa\psi[\hat{\tau}_S^s + \hat{\tau}_S^w] - \kappa\psi\sigma^{-1}\hat{G}_S \end{aligned} \right\} t < T^e$$

Purely forward looking

For  $t \geq T^e$

$$\hat{Y}_L = \pi_L = 0$$

For  $t < T^e$

$$E_t \hat{Y}_{t+1} = (1 - \mu) \cdot 0 + \mu \cdot \hat{Y}_S$$

$$E_t \pi_{t+1} = (1 - \mu) \cdot 0 + \mu \cdot \pi_S$$

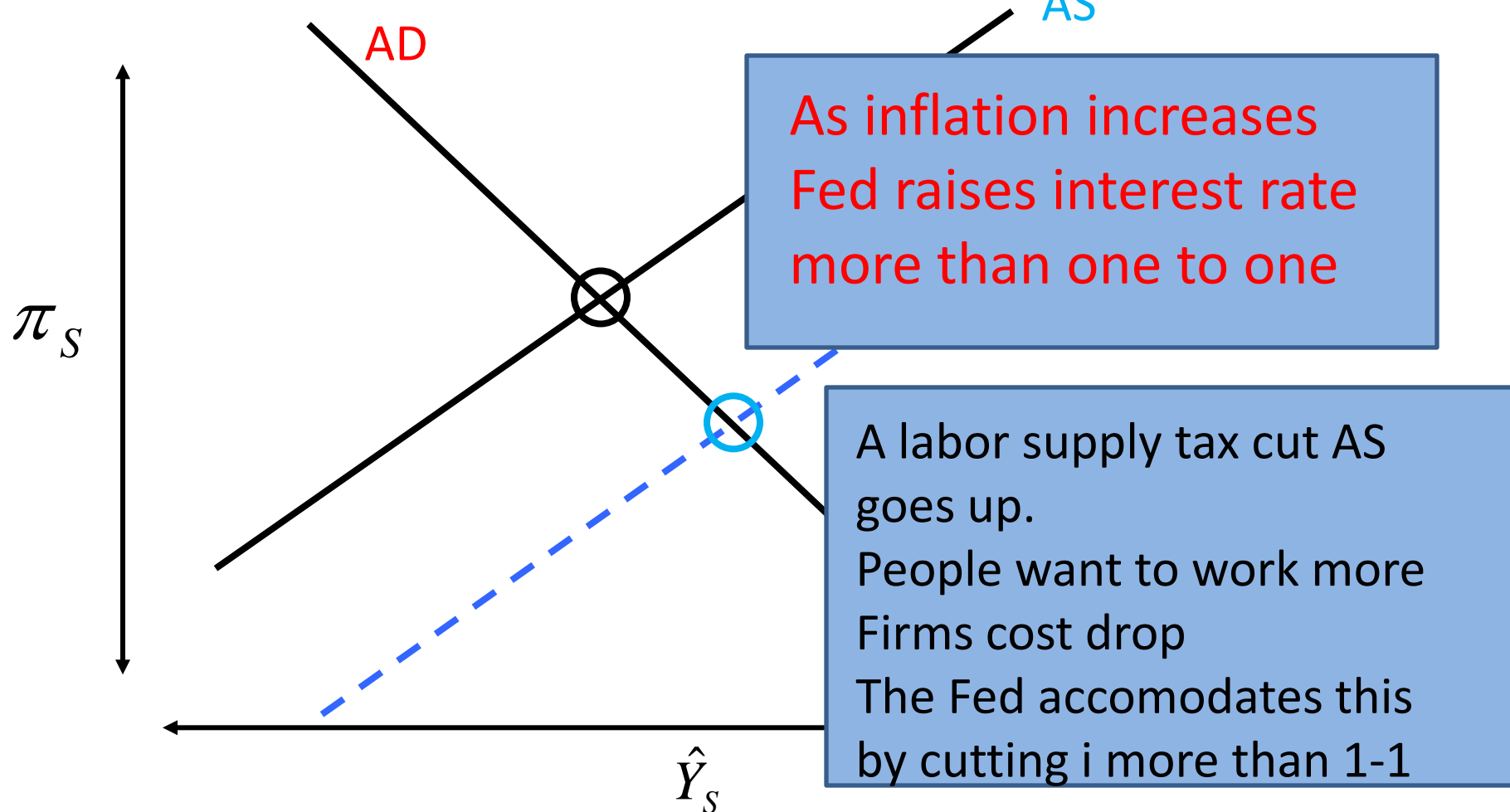
$$\text{and } i_t = r_S^e + \phi_\pi \pi_S$$

AD

$$\hat{Y}_S = -\sigma \frac{\varphi_\pi - \mu}{1 - \mu} \pi_S - \frac{\sigma}{1 - \mu} \varepsilon_S + \hat{G}_S - \sigma \hat{\tau}_S^s$$

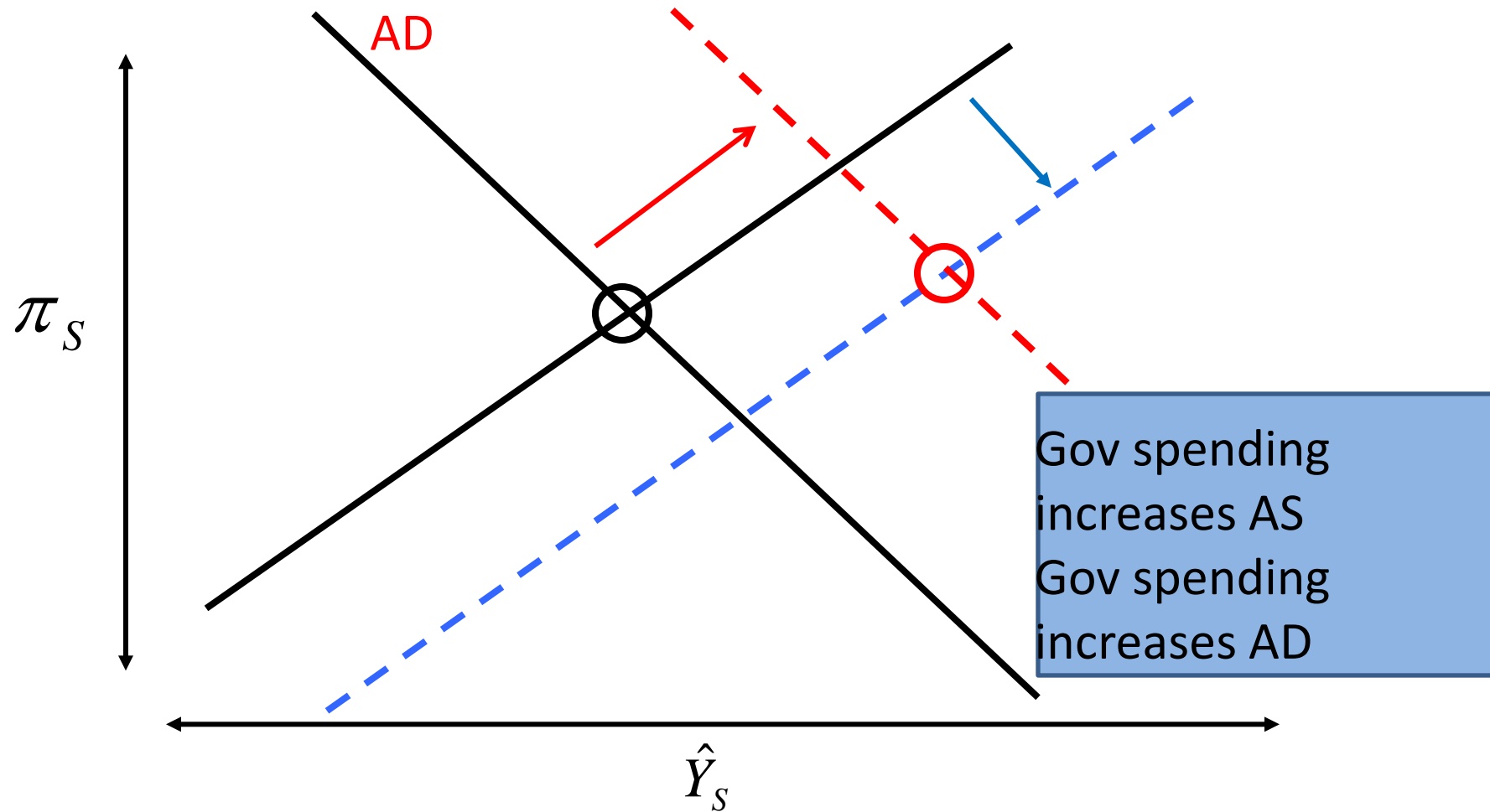
AS

$$\pi_S = \frac{\kappa}{1 - \mu\beta} \hat{Y}_S + \frac{\kappa\psi}{1 - \mu\beta} \hat{\tau}_S^w - \frac{\kappa\psi\sigma^{-1}}{1 - \mu\beta} [\hat{G}_S - \sigma \hat{\tau}_S^s]$$



$$\text{AD} \quad \hat{Y}_S = -\sigma \frac{\varphi_\pi - \mu}{1 - \mu} \pi_S - \frac{\sigma}{1 - \mu} \varepsilon_S + \hat{G}_S - \sigma \hat{\tau}_S^s +$$

$$\text{AS} \quad \pi_S = \frac{\kappa}{1 - \mu\beta} \hat{Y}_S + \frac{\kappa\psi}{1 - \mu\beta} \hat{\tau}_S^w - \frac{\kappa\psi\sigma^{-1}}{1 - \mu\beta} [\hat{G}_S - \sigma \hat{\tau}_S^s]$$

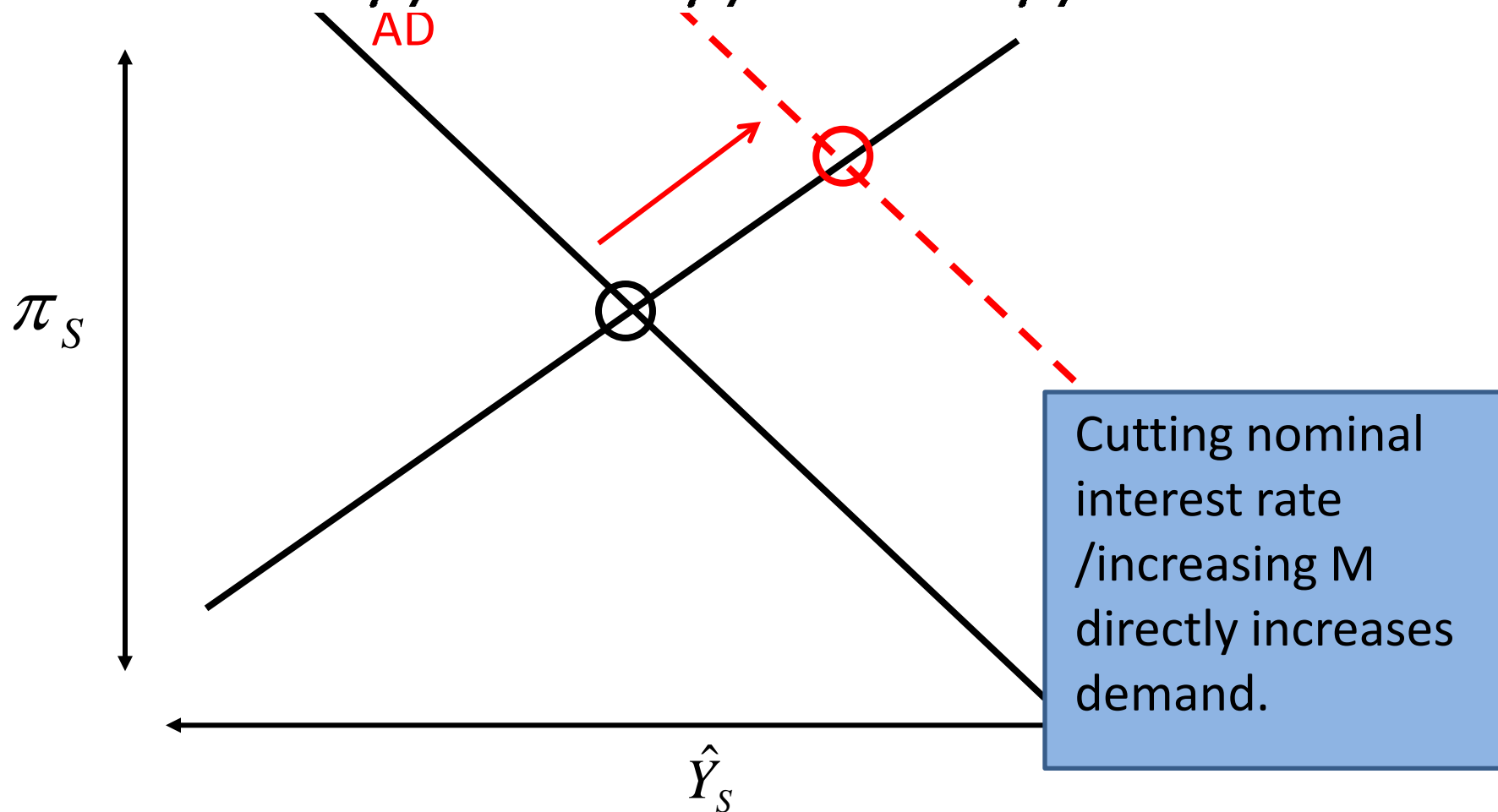


AD

$$\hat{Y}_S = -\sigma \frac{\varphi_\pi - \mu}{1 - \mu} \pi_S - \frac{\sigma}{1 - \mu} \varepsilon_S + \hat{G}_S - \sigma \hat{\tau}_S^s$$

AS

$$\pi_S = \frac{\kappa}{1 - \mu\beta} \hat{Y}_S + \frac{\kappa\psi}{1 - \mu\beta} \hat{\tau}_S^w - \frac{\kappa\psi\sigma^{-1}}{1 - \mu\beta} [\hat{G}_S - \sigma \hat{\tau}_S^s]$$



# Under regular circumstances

- “Standard” intuition applies
- No funny business in the model
- Undergraduate textbooks work just as well as graduate ones
- Will now talk about the peculiar circumstances that arise when interest rate zero [paradox of toil and thrift) and a very large gov. spending and (some) tax cut multipliers] . Now the option of cutting interest rate not possible.

# Solution at zero interest rates:

Boils down to only two equations!

In two unknowns!

$$\left. \begin{aligned} \hat{Y}_S &= \mu \hat{Y}_S + \sigma \mu \pi_S + \sigma r_S^e + (1 - \mu) [\hat{G}_S^N - \sigma \hat{\tau}_S^s] + \sigma \hat{\tau}_S^A \\ \pi_S &= \kappa \hat{Y}_S + \mu \beta \pi_S + \kappa \psi [\hat{\tau}_S^s + \hat{\tau}_S^w] - \kappa \psi \sigma^{-1} \hat{G}_S^N \end{aligned} \right\}$$

Purely forward looking

Before we also had the term  $t < T^e$

$$- \sigma \phi_\pi \pi_S$$

For  $t \geq T^e$

$$\hat{Y}_L = \pi_L = 0$$

For  $t < T^e$

$$E_t \hat{Y}_{t+1} = (1 - \mu) \cdot 0 + \mu \cdot \hat{Y}_S$$

$$E_t \pi_{t+1} = (1 - \mu) \cdot 0 + \mu \cdot \pi_S$$

$$\text{and } i_t = i_S = 0$$

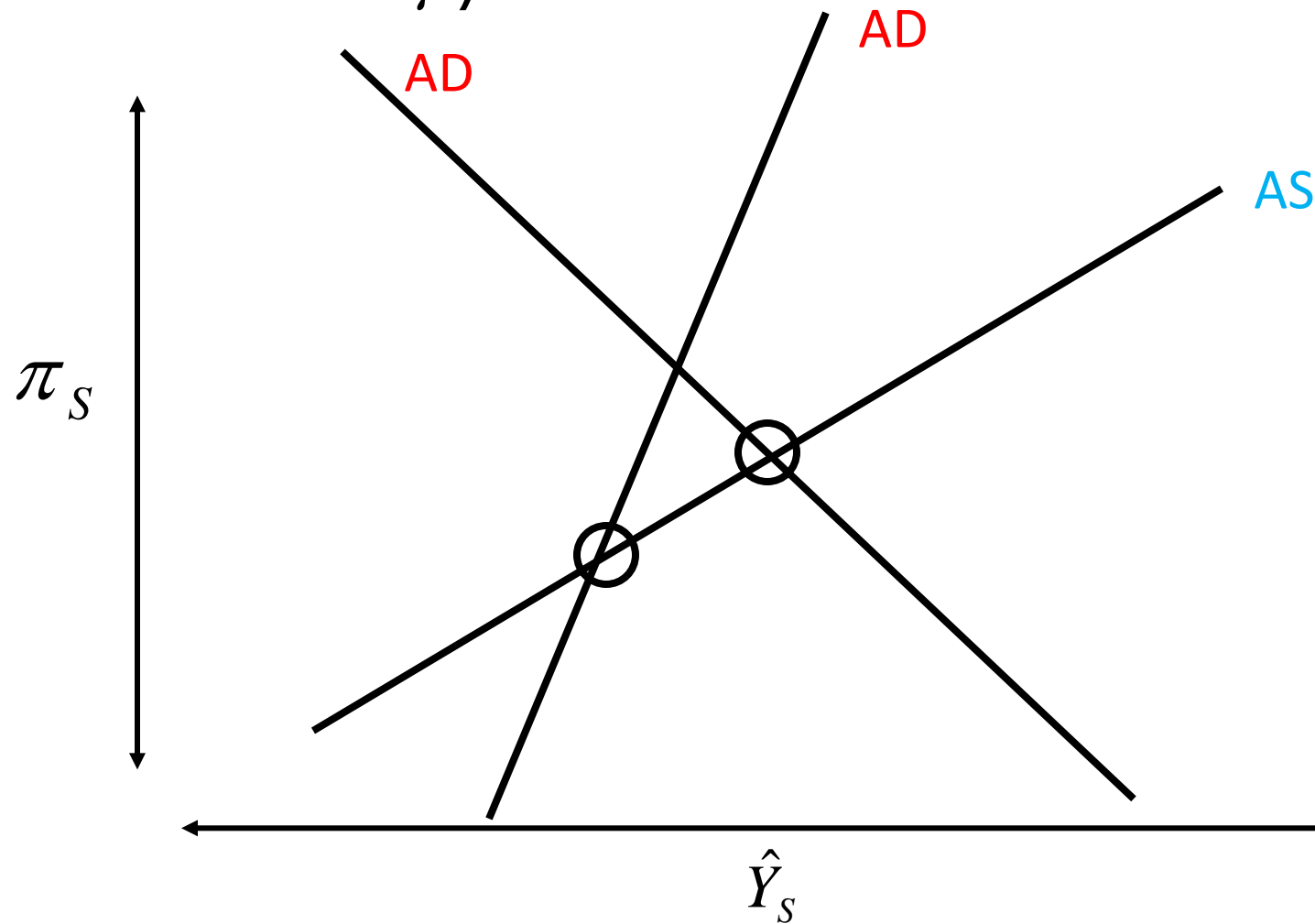


AD

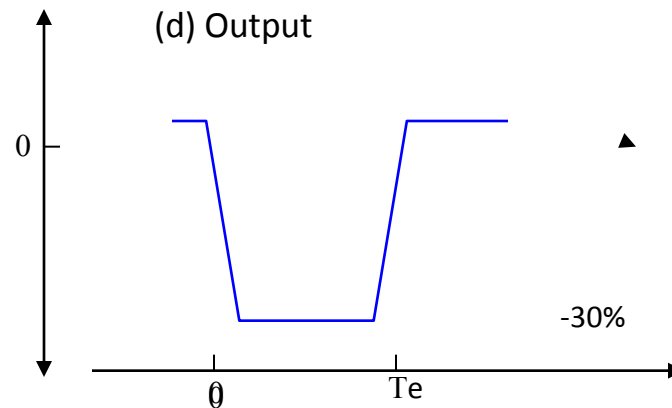
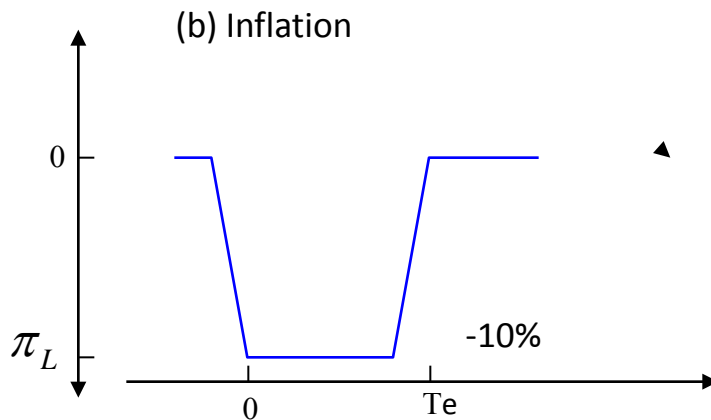
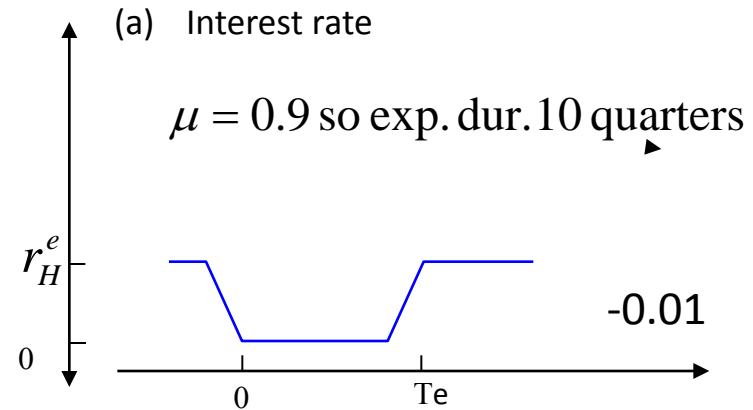
$$\hat{Y}_S = -\sigma \frac{\phi_\pi - \mu}{1 - \mu} \pi_S \quad \Rightarrow \quad \hat{Y}_S = \sigma \frac{\mu}{1 - \mu} \pi_S + \frac{\sigma}{1 - \mu} r_S^e$$

AS

$$\pi_S = \frac{\kappa}{1 - \mu\beta} \hat{Y}_S$$



# Output collapse



Why output collapse?

Expectations of future deflation  $\rightarrow EY(t+1)$  very negative  $\rightarrow$  vicious cycle  $\rightarrow$  Output collapse

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \underbrace{\sigma(i_t - E_t \pi_{t+1} - r_t^e)}_{\text{Real interest rates were in double digits in 29-33 due to deflation}}$$

Real interest rates were in double digits in 29-33 due to deflation

## 2. Basic policy responses: A New Keynesian Approach

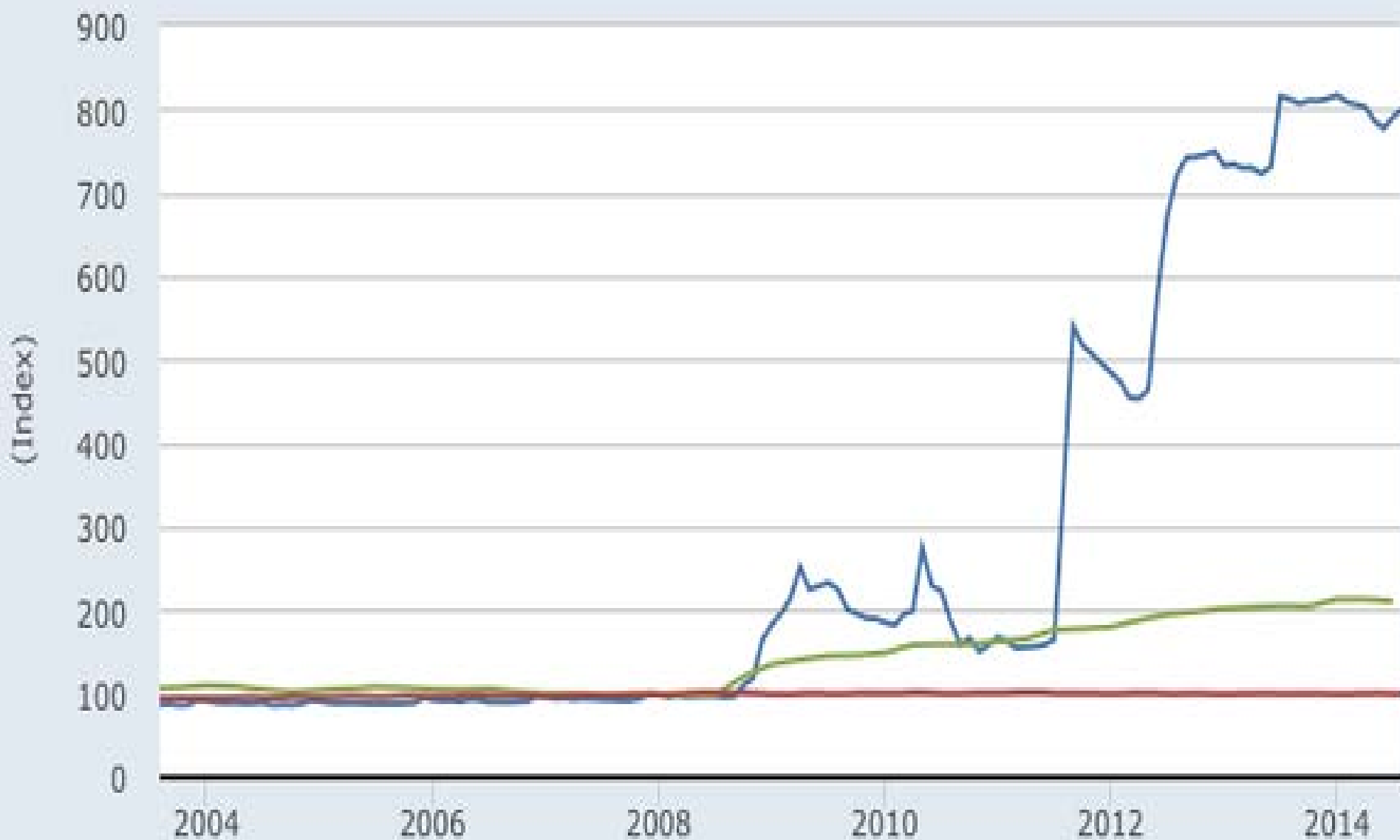
- First questions: Does printing money do anything at zero interest rate?
- Common response of many Central Banks throughout the world throughout the crisis.
- Answer in our model: NO

$$\frac{\chi_m \left( \frac{M_t}{P_t} \right)}{u_c(C_t)} = \frac{\dot{i}_t}{1 + i_t}$$

# Irrelevance results

- Satiation  $\chi_m = 0$  when  $\dot{i}_t = 0$
- Printing money at that point does nothing – unless it changes expectation about future policy when ZLB not binding any more
  - But here as in Eggertsson and Woodford (2003) policy given by a Taylor rule.
  - Krugman (1998) shows a similar irrelevance result if future money supply fixed.
  - Eggertsson (2006) shows a similar result when policy is set under discretion

- Swiss Monetary Base Aggregate, 2007-12=100
- M1 for Switzerland©, 2007:Q4=100
- Consumer Price Index: All Items for Switzerland©, 2007-12=100

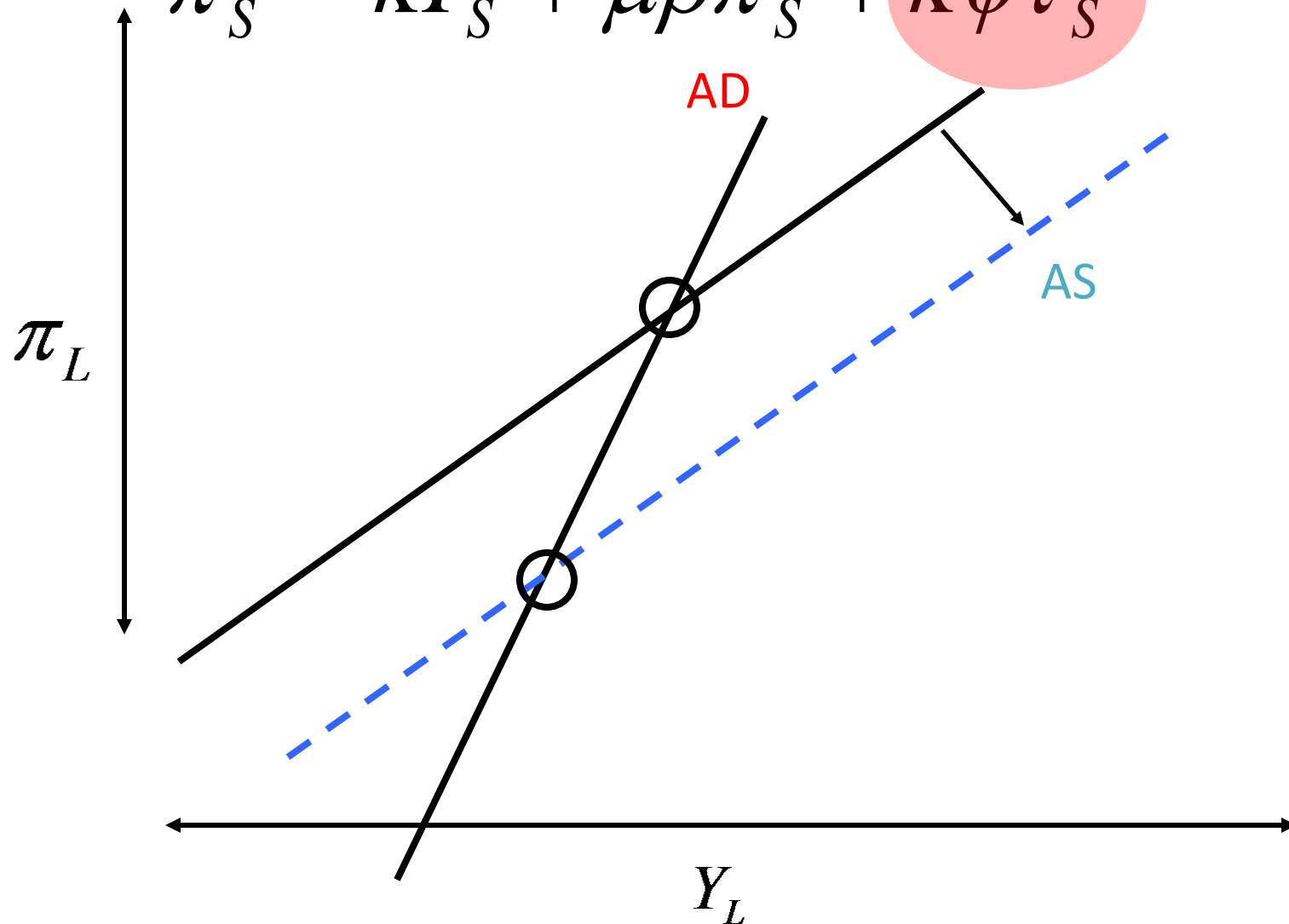


# Basic property of model: Policy multipliers can be large at zero interest rate

- Why?
- Basic reason:
  - Nominal interest rate do not rise/drop to offset policy
  - Expectation of the same thing as long as shock negative
    - Negative spiral (shock)
    - Virtuous spiral (spending/taxes)

$$\hat{Y}_S = \mu \hat{Y}_S + \sigma \mu \pi_S + \sigma r_S^e$$

$$\pi_S = \kappa \hat{Y}_S + \mu \beta \pi_S + \kappa \psi \hat{\tau}_S^w$$



# Labor tax cuts are contractionary

$$\frac{\Delta Y_s}{-\Delta \tau_s^w} = \frac{\mu \kappa \psi}{(1 - \mu)(1 - \beta) - \mu \sigma \kappa} = -1.01 < 0$$

Intuition

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e) \quad \left| \quad \pi_t = \kappa \hat{Y}_t + \beta E_t \pi_{t+1} + \kappa \phi \hat{\tau}_t^w$$

	Payroll tax cut multiplier	Gov spending multiplier
Positive interest rate	0.1612	0.46
Zero interest rate	-1.02	2.27



# Paradox of Toil

**Paradox of toil** : Giving people the incentive **to work more** counterproductive. More supply of labor -> lower wages -> deflationary pressures → higher real rates. [in equilibrium this reduces aggregate work ].

It is counterproductive to increase production capacities of the economy when the problem is insufficient aggregate spending

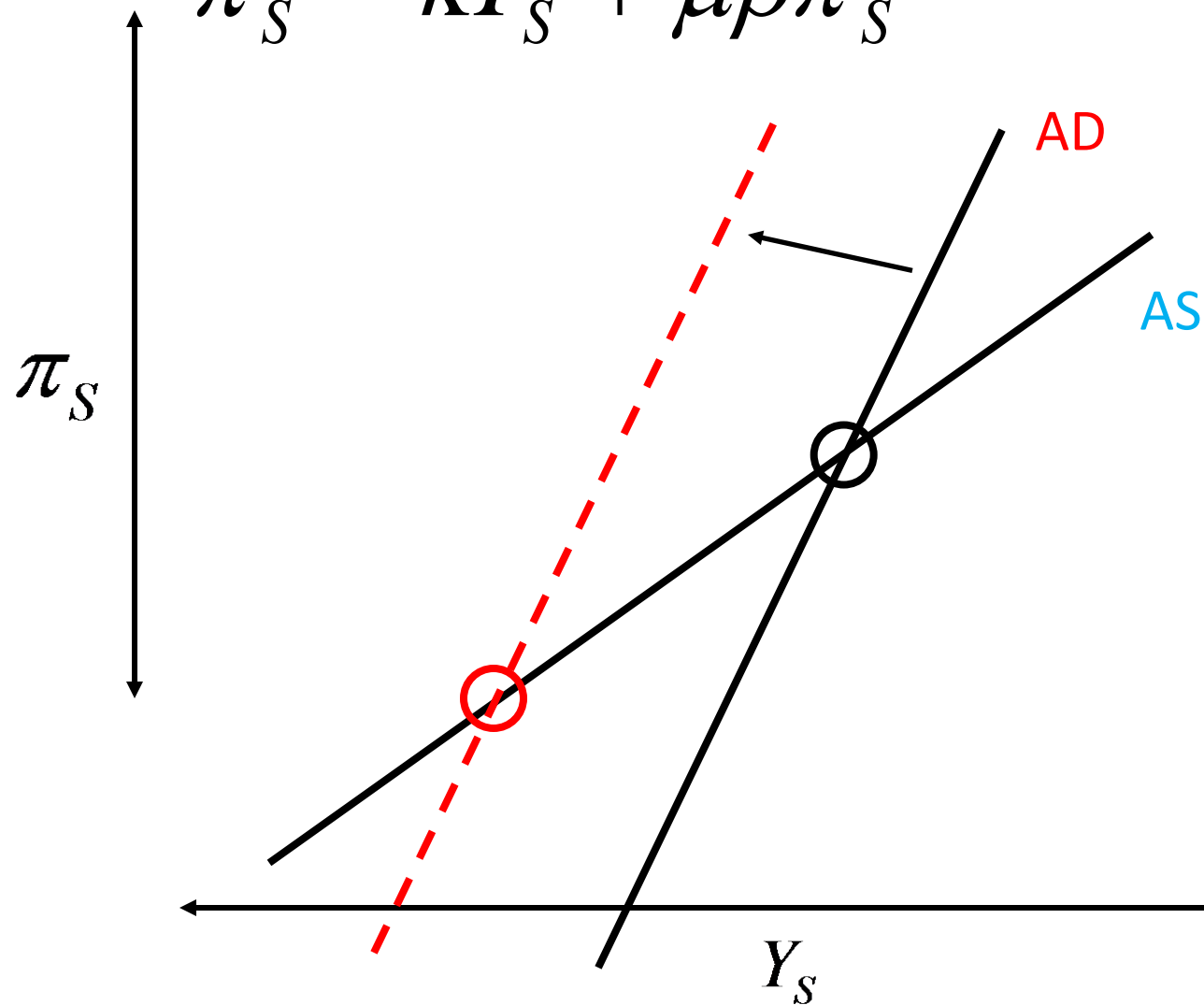
Was the New Deal Contractionary? Eggertsson (2012).

Can Structural Reform Help Europe (Ferrero at (2014).

Basic point: To solve a demand problem focus on demand, not supply.

$$\hat{Y}_S = \mu \hat{Y}_S + \sigma \mu \pi_S + \sigma r_S^e + \sigma \tau_S^A$$

$$\pi_S = \kappa \hat{Y}_S + \mu \beta \pi_S$$



# Cutting taxes on capital

- Contractionary because it gives people an incentive to save when the model cries out for spending.
- Note, no endogenous investment, so no savings in aggregate apart from government debt.
- What happens with capital (savings = investment)
- Turns out that increasing people's incentive to save
  - reduces aggregate demand
  - reduces people's ability to save
  - **Aggregate savings** (investment) collapses because everyone tries to save!
  - Paradox of thrift (Keynes (1936), Christiano (2004))

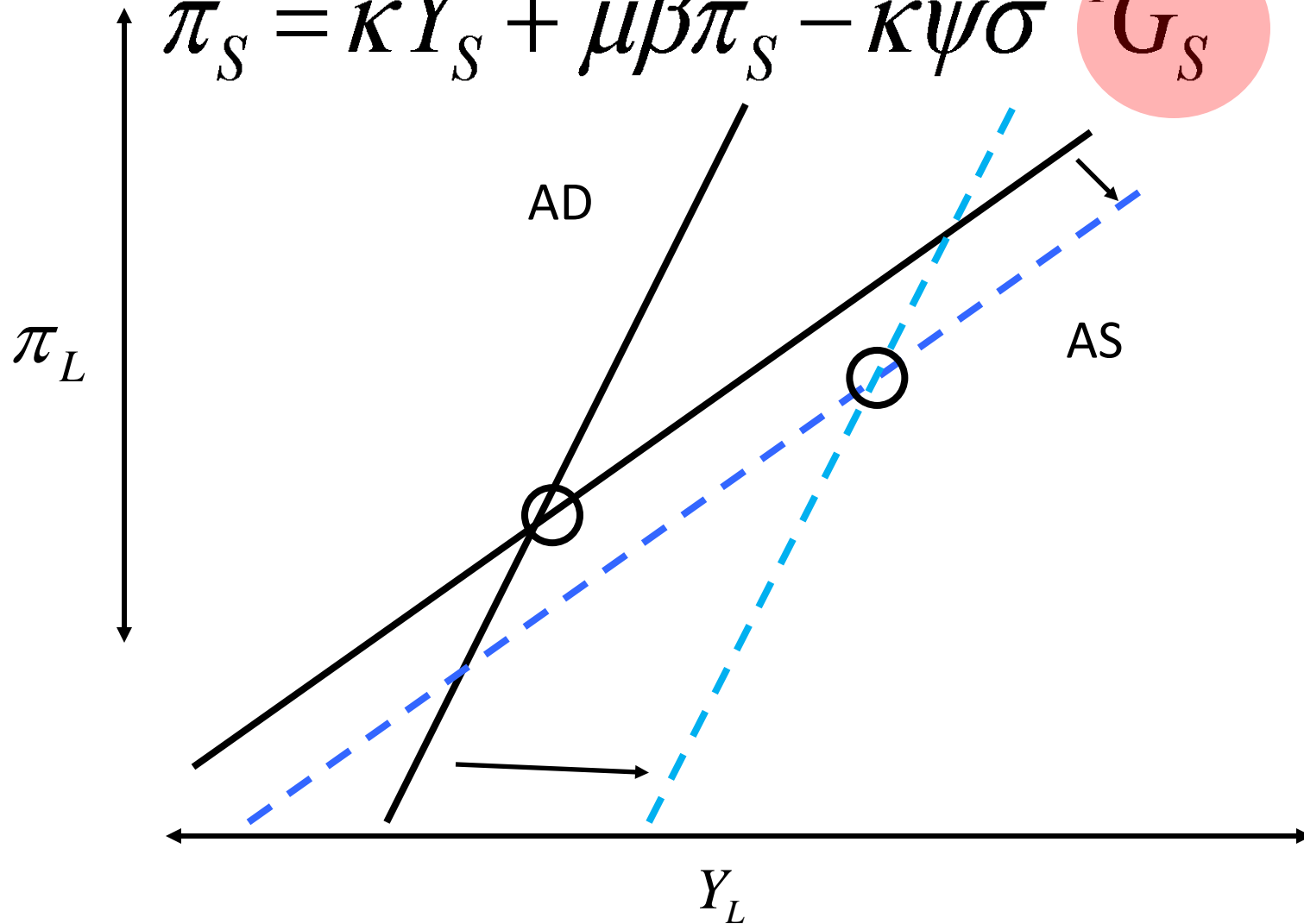
	Labor tax cut multiplier	Capital tax cut multiplier
Positive interest rate	0.16	-0.0013
Zero interest rate	-1.02	-0.1

## 2. Expansionary Government Spending

$$\max E_t \sum_{T=t}^{\infty} \beta^{T-t} \left[ u(C_T) + g(G_T) - \int_0^1 v(L_T(j)) dj \right] \xi_T$$

$$\hat{Y}_S = \mu \hat{Y}_S + \sigma \mu \pi_S + \sigma r_S^e + (1 - \mu) \hat{G}_S$$

$$\pi_S = \kappa \hat{Y}_S + \mu \beta \pi_S - \kappa \psi \sigma^{-1} \hat{G}_S$$



# Spending is Expansionary

$$\frac{\Delta Y_s}{\Delta G_s^N} = \frac{(1-\mu)(1-\beta\mu) - \mu\kappa\psi}{(1-\mu)(1-\beta) - \mu\sigma\kappa} = 2.27 > 1$$

- Intuition

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e) + E_t(\hat{G}_t - \hat{G}_{t+1})$$

	Payroll tax multiplier	Gov spending multiplier
Positive interest rate	0.16	0.47
Zero interest rate	-1.02	2.28

# Implications

- Can show that spending increases welfare, even if it contributes nothing to utility
- Digging ditches and filling them up.
- Regular cost benefits analysis does not apply to public spending.
- Even better if government spending actually adds to utility.
- Not crucial if delay: Expectation doing most of the work [relevant for “Obama stimulus”. ]
- Needs to be explicitly “temporary” and last as long as “the emergency”.

	$i > 0$		$i = 0$	
	$GD$	$GR$	$GD$	$GR$
	[5% , 95%]	[5% , 95%]	[5% , 95%]	[5% , 95%]
$\frac{\Delta \hat{Y}_s}{\Delta \hat{G}_s}$	<b>0.4</b> [0.2 , 0.6]	<b>0.4</b> [0.3 , 0.6]	<b>2.2</b> [1.4 , 3.2]	<b>1.2</b> [1.1 , 1.5]
$\frac{\Delta \hat{Y}_s}{\Delta \hat{\tau}_S^s}$	<b>-0.3</b> [-0.5 , -0.2]	<b>-0.3</b> [-0.5 , -0.2]	<b>-1.8</b> [-3, -0.9]	<b>-0.9</b> [-1.3, -0.5]
$\frac{\Delta \hat{Y}_s}{\Delta \hat{\tau}_S^I}$	<b>-0.5</b> [-0.8 , -0.3]	<b>-0.5</b> [-0.7 , -0.3]	<b>0.4</b> [0.2 , 0.5]	<b>0.1</b> [0.06 , 0.3]



# What happens to deficits?

- Usually cutting gov. spending reduces deficit about one to one.
- At zero interest rates: Austerity measures can increase rather than decrease the deficit.
- Same applies to sales tax increases (Laffer type result).
- Income tax increases close the deficit and are expansionary on output.
- To reduce deficit, government have mainly focused on spending cuts AND sales tax increase .....  
..... while “stimulating” via income tax cuts.

# The government budget constraint

## Summary

$$\frac{\bar{b}}{\bar{Y}} \hat{b}_t - \frac{\bar{b}}{\bar{Y}} (1 + \bar{i}) \hat{b}_{t-1} =$$

**Deficits**

$$\frac{\bar{b}}{\bar{Y}} (1 + \bar{i}) [i_{t-1} - \pi_t] - (\bar{\tau}^I + \bar{\tau}^s) \hat{Y}_t$$

**Endogenous  
component**

$$+ \hat{G}_t - \hat{\tau}_t^s - \hat{\tau}_t^I - \frac{\bar{T}}{\bar{Y}} \hat{T}_t$$

**Policy driven  
component**

[fig1\_incometax.eps] [The Great  
Depression and the Great Recession in the  
model.]

	$i > 0$		$i = 0$	
	$GD$	$GR$	$GD$	$GR$
	[5% , 95%]	[5% , 95%]	[5% , 95%]	[5% , 95%]
$\frac{\Delta \hat{D}_S}{\Delta \hat{G}_S}$	1.1 [1.03 , 1.3]	1.2 [1.09 , 1.5]	-0.3 [-1 , 0.3]	0.5 [0.2 , 0.6]
$\frac{\Delta \hat{D}_S}{\Delta \hat{\tau}_S^s}$	-1.1 [-1.2 , -1]	-1.2 [-1.3 , -1]	0.3 [-0.3 , 1.1]	-0.4 [-0.5 , -0.1]
$\frac{\Delta \hat{D}_S}{\Delta \hat{\tau}_S^I}$	-0.6 [-0.8 , -0.4]	-0.6 [-0.7 , -0.3]	-1.4 [-1.6 , -1.2]	-1.2 [-1.3 , -1.1]

# Do budget deficits matter?

- Depends on how we think they affect long run policy.
- Can do both ways
- Need to be more explicit about policy regime.
- Do deficit trigger higher future labor taxes? (contractionary).
- Do deficit trigger higher future inflation or sales taxes (expansionary).

# What if you can move many policy instruments at the same time

- Can in principle do away with all the distortions
- Cut sales taxes and wage taxes on wages.

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r^e(\xi_t)) - \sigma E_t (\hat{\tau}_t^s - \hat{\tau}_{t+1}^s)$$

$$\pi_t = \kappa \hat{Y}_t + \beta E_t \pi_{t+1} + \kappa \psi [\hat{\tau}_t^s + \hat{\tau}_t^w]$$

- But, zero bound on sales taxes. Wage taxes here relatively special.
- Eggertsson and Woodford (2004), Correia, Farhi, Nicolini, Teles (2013)

# Other policies

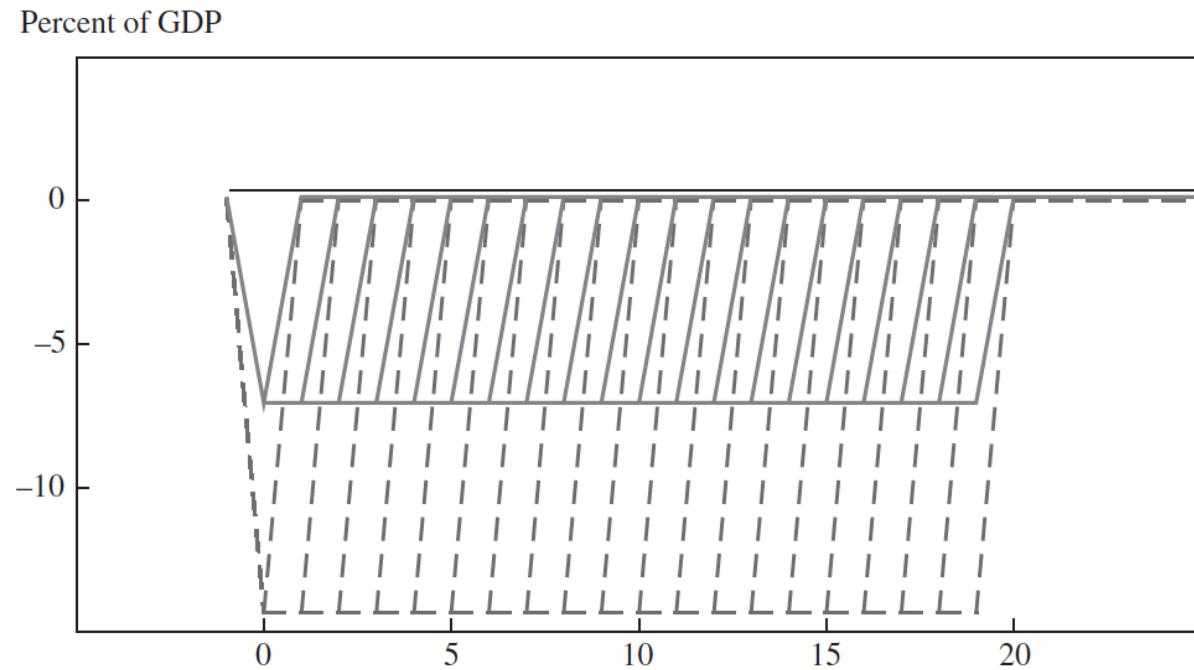
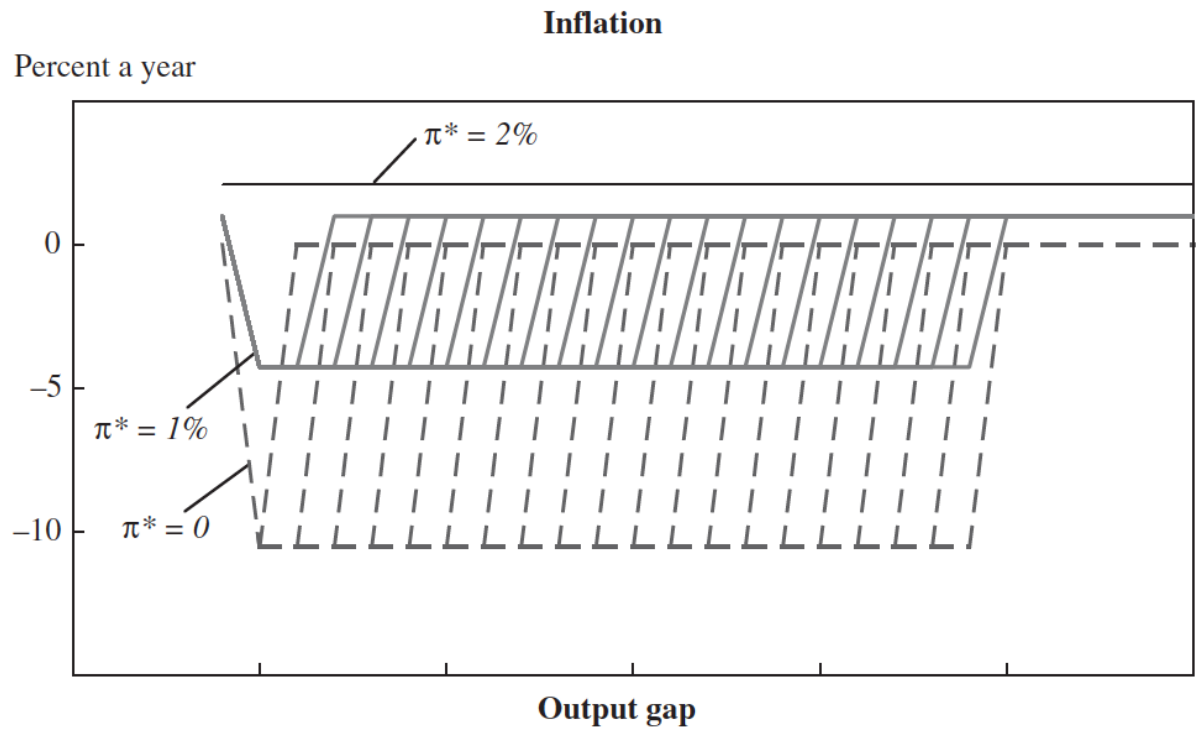
- Once you model the shock in more detail, you have other options.
- Private sector debt write-down
- Asset swaps

# Policy regime changes

- So far we have only talked about policy options in the absence of being able to change the monetary policy regime (and only change policy instruments in short run).
- Now let us consider a new policy regime.
- What is a policy regime change?
  - Going off gold standard
  - Trying to use “forward guidance”.
- First off: Simple inflation targeting
- What is the best thing monetary policy can do?
- How can it be implemented?
- Then link this to policy regime change



**Most  
basic  
example:  
Credibly  
raise  
Inflation  
target**



# Optimal policy under commitment

- Problem:

$$\min E_0 \left\{ \sum_{t=0}^{\infty} \beta^t (\pi_t^2 + \lambda x_t^2) \right\}$$

subject to

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1} + u_t,$$

$$x_t \leq E_t x_{t+1} + \sigma(r_t^n + E_t \pi_{t+1})$$

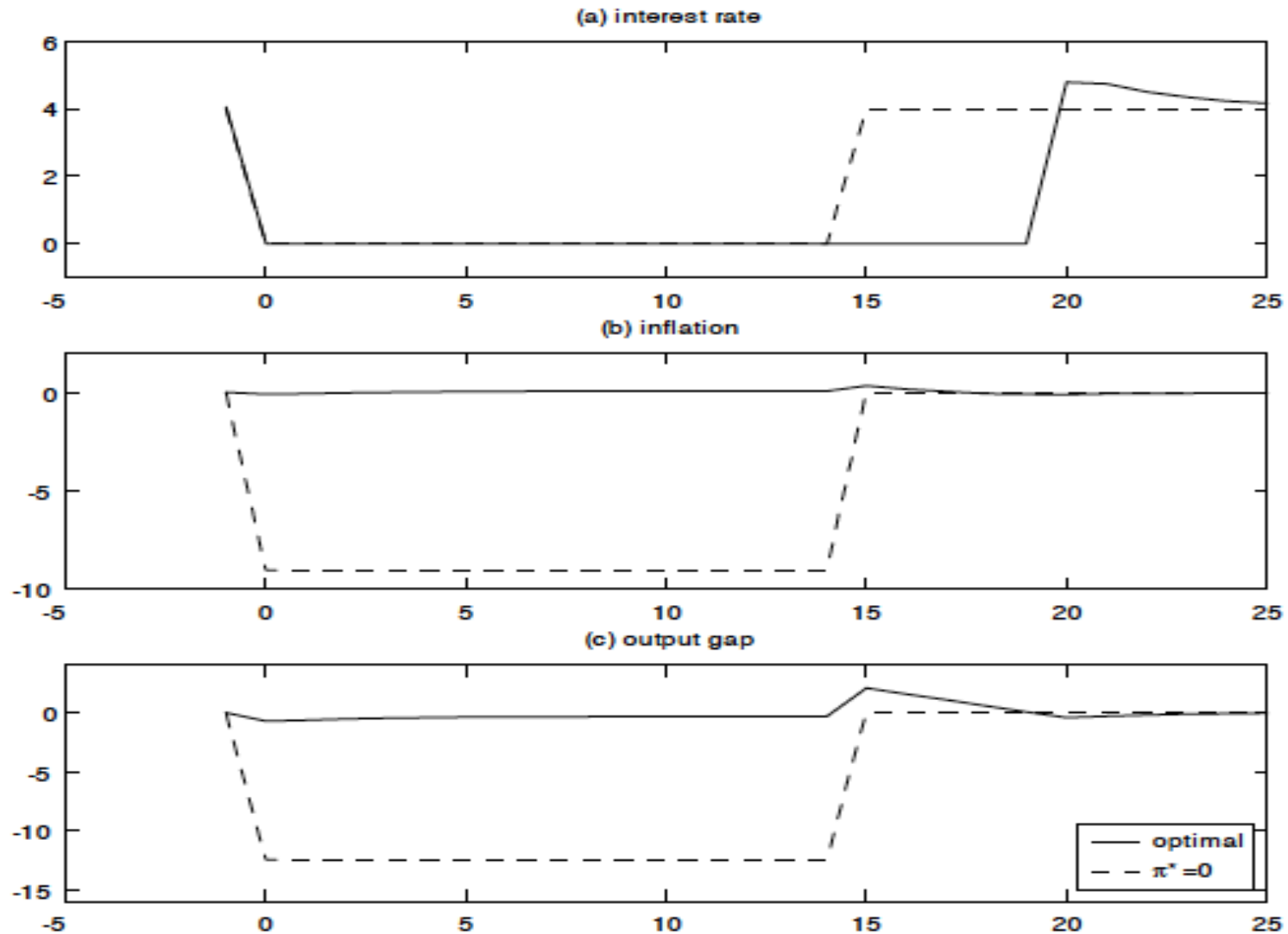
- FOCs:

$$\pi_t + \phi_{2t} - \phi_{2t-1} - \beta^{-1} \sigma \phi_{1t-1} = 0$$

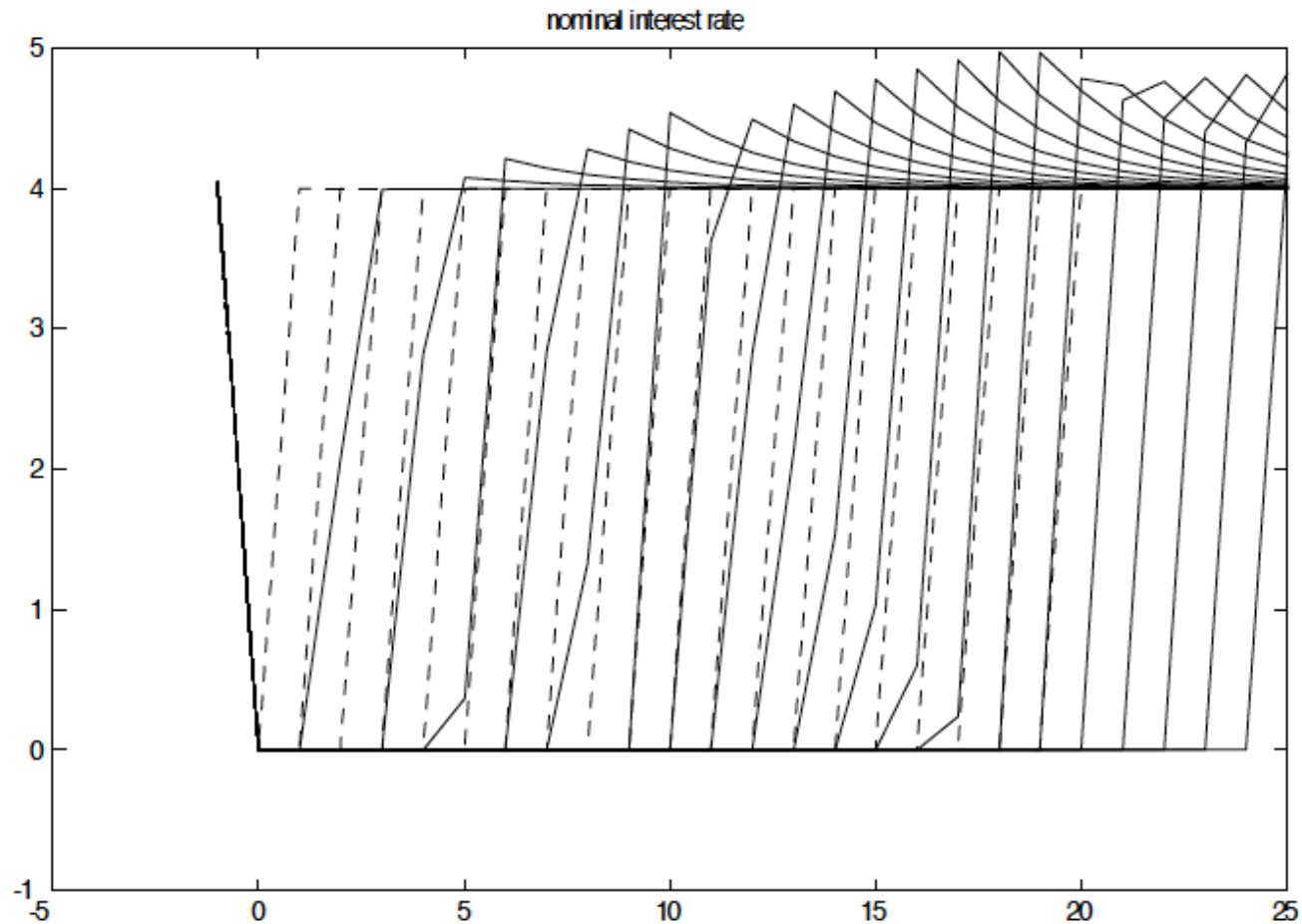
$$\lambda x_t + \phi_{1t} - \beta^{-1} \phi_{1t-1} - k \phi_{2t} = 0$$

$$\phi_{1t} \geq 0, \quad i_t \geq 0, \quad \phi_{1t} i_t = 0$$

# Optimal policy under one contingency



# How can this be implemented?



# One implementation: Price level targeting

- Show that above FOCs are satisfied if CB behaves as follows:
  - [i] Each period, there is a predetermined price-level *target*  $p_t^*$ . CB chooses interest rate  $i_t$  so as to achieve the target relation

$$\tilde{p}_t \equiv p_t + (\lambda_x / \kappa) x_t = p_t^*$$

if possible; if this is not possible, even setting  $i_t = 0$ , then  $i_t = 0$ .

- [ii] The target for next period is determined as

$$p_{t+1}^* = p_t^* + \beta^{-1}(1 + \kappa\sigma)\Delta_t - \beta^{-1}\Delta_{t-1}$$

where  $\Delta_t$  is the period  $t$  *target shortfall*

$$\Delta_t \equiv p_t^* - \tilde{p}_t.$$

# Problem: Is this credible?

- The problem of dynamic inconsistency
- The fable of the fox and the lion
- Even if the government says it will inflate, and then the economy recovers, why would it follow up on this promise?

# What can be done to make things “credible”?

- First step is to say what you aim to do. If you are very clear it would be an embarrassment not to fulfill your promise.
- Another things: Do a bunch of stuff that makes it costly to renege on your promise.
- Like what?
  - Issue bunch of government debt
  - Buy long term treasuries
  - Buy private debt

# III. Historical Analogies

*unified theory of the US recovery from the Great Depression*



# Credible regime change in practice:

Driven by a commitment of the government to inflate the price level

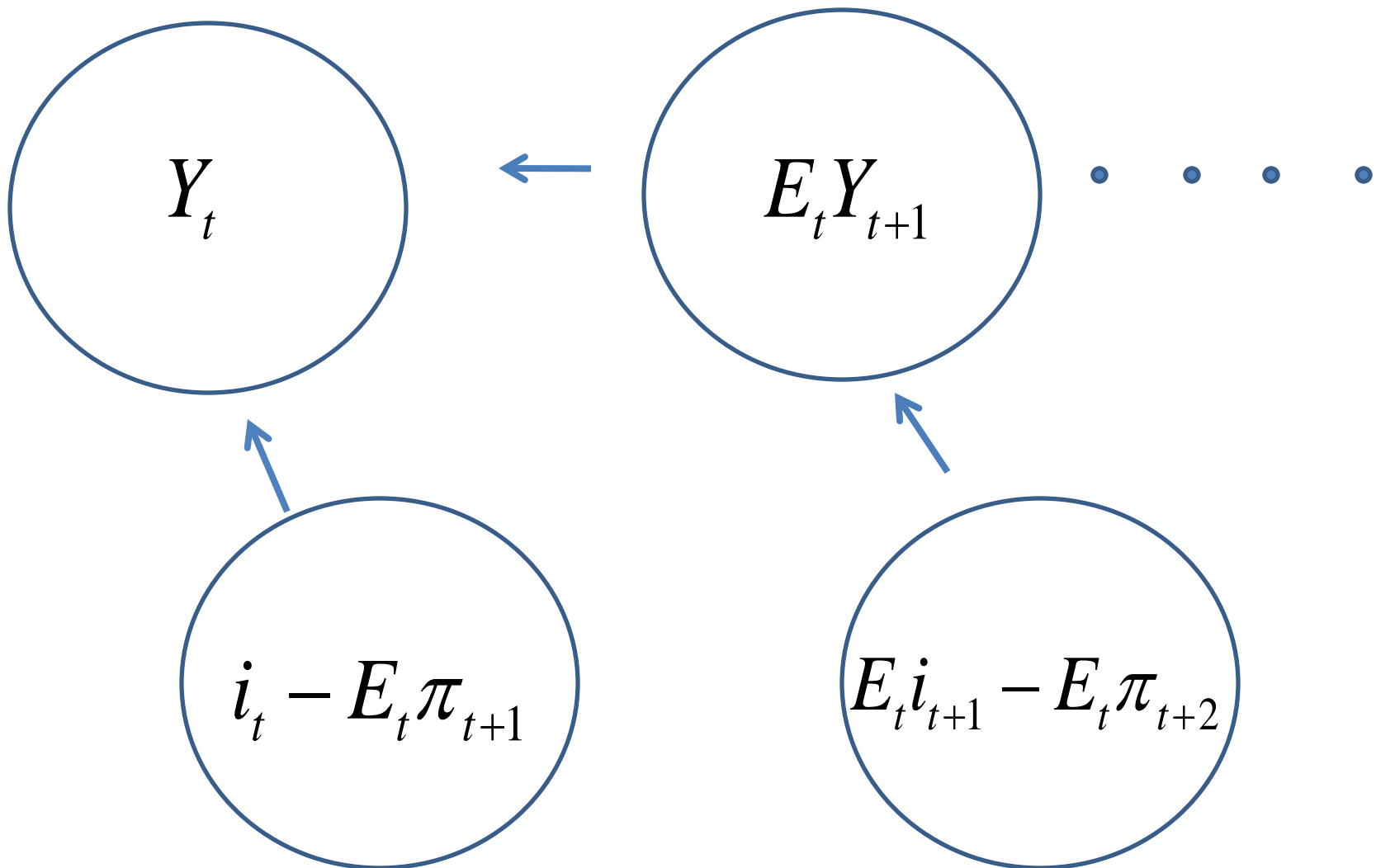
-- and with an increase in government spending and deficits helping to make this credible.

As long as that commitment was pursued, the recovery was brisk.

Talk based on:

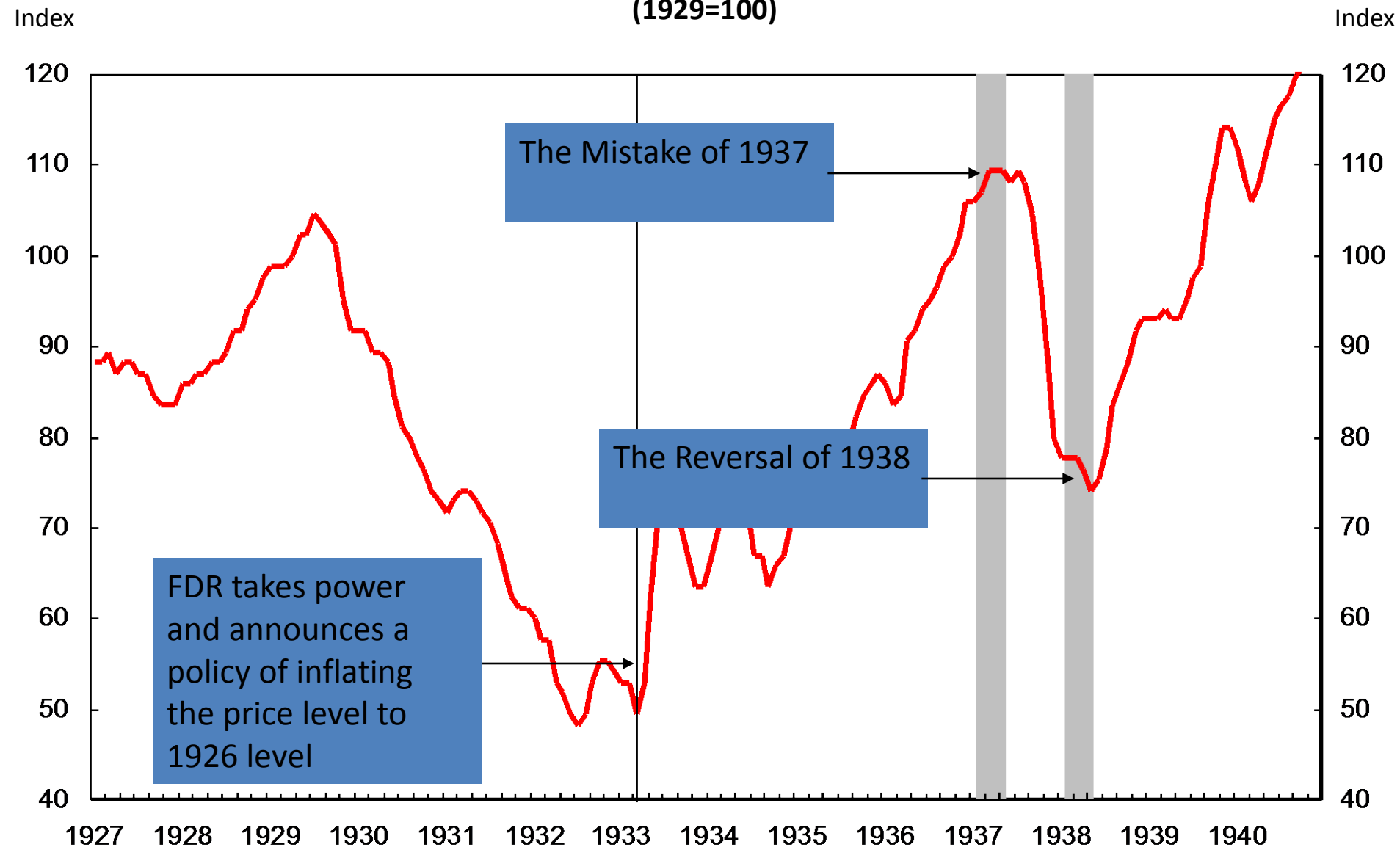
1. The recovery in 1933-37: Great Expectations and the end of the Depression (AER, 2008)
2. The Mistake of 1937 (MES, 2006).
3. Complementary policies: Was the New Deal Contractionary (AER, 2012)

Basic underlying framework:  
New Keynesian DSGE model



# Industrial Production

(1929=100)



FDR takes power and announces a policy of inflating the price level to 1926 level

The Mistake of 1937

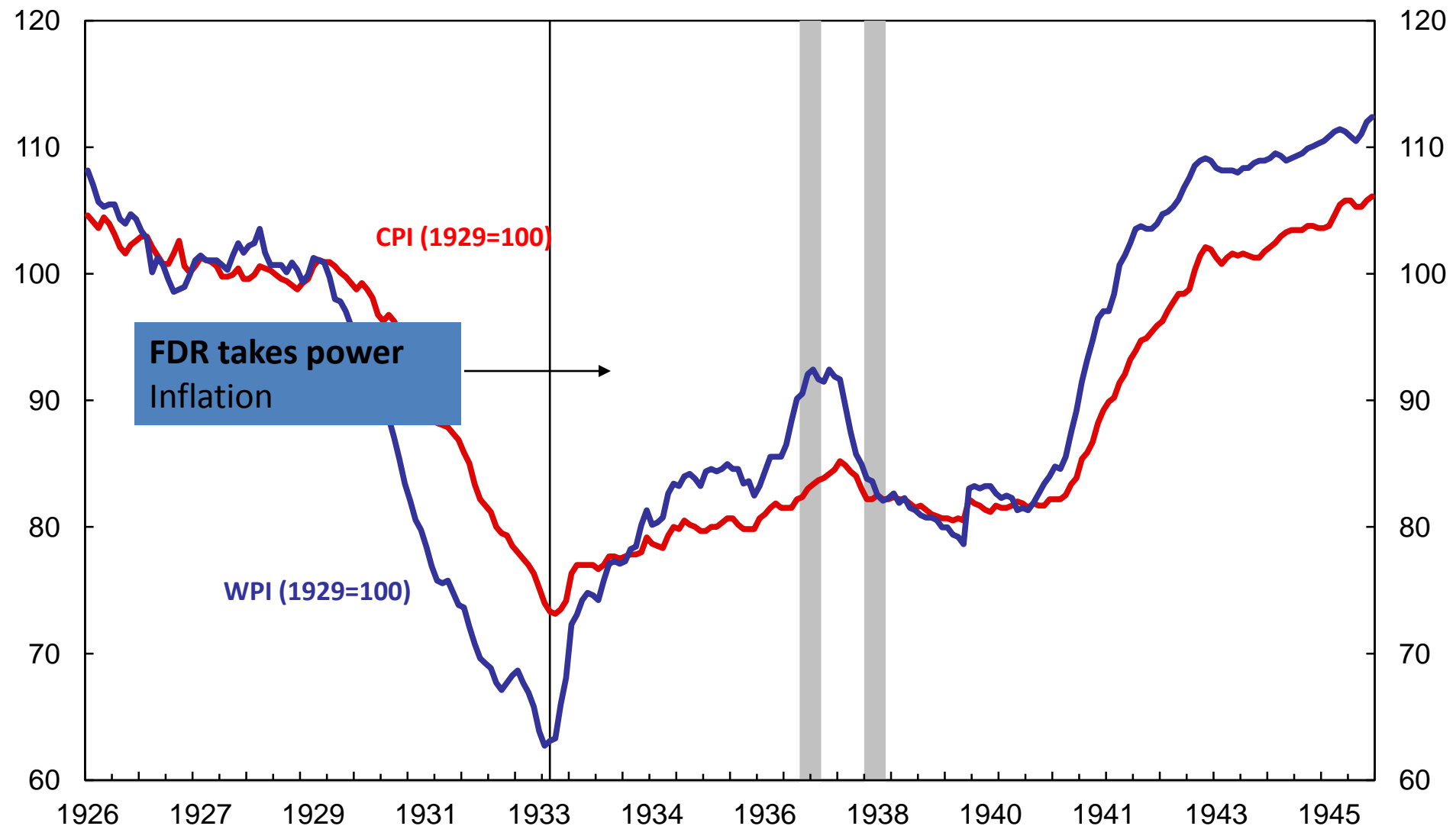
The Reversal of 1938

# Price Indices

(1929=100)

Index

Index

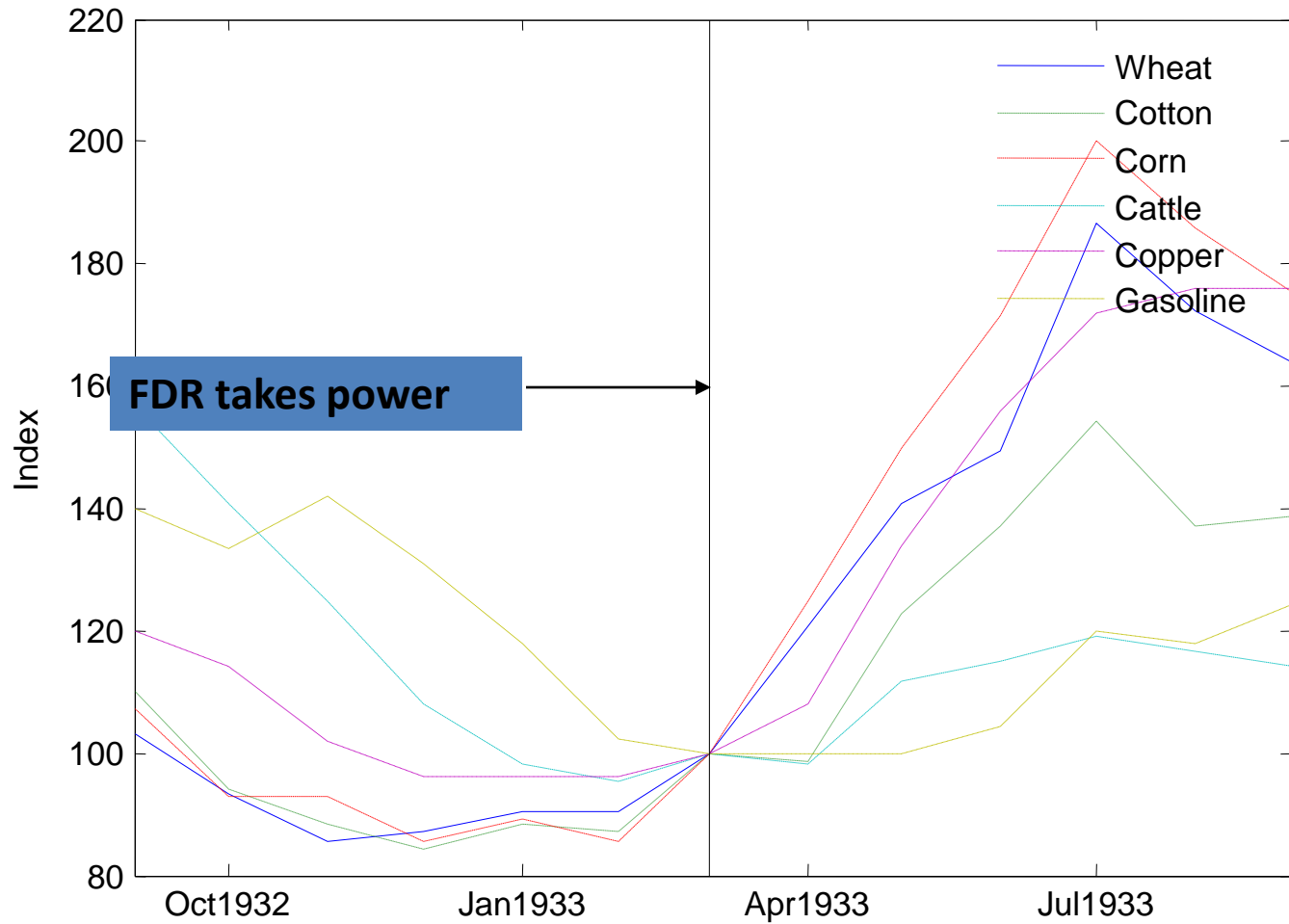


- It is hard to rationalize the turnaround by interest rate cuts since they had already been lowered close to zero by 1933.
- It is also hard to argue that increases in the monetary base (or M2) were responsible since the base did not increase around the turning point.
- The expectations about policy regime in the future were crucial. How future interest rates, money supply and fiscal spending would be determined.
- This perspective of the turning point, also helps explain 1938.

**NEXT THREE SLIDES: THE FIRST 100 DAYS**

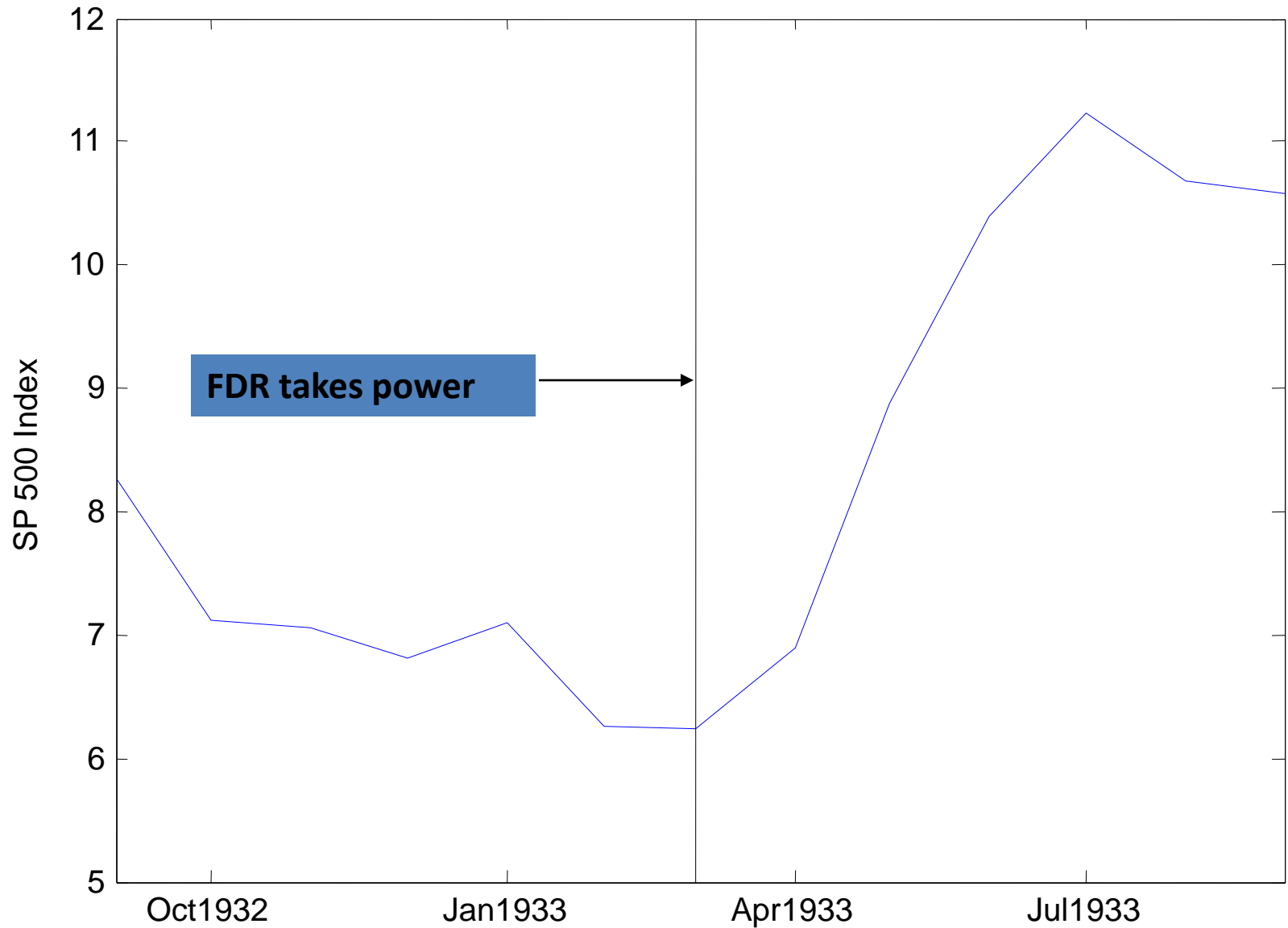
A shift in expectations

# Commodity Prices



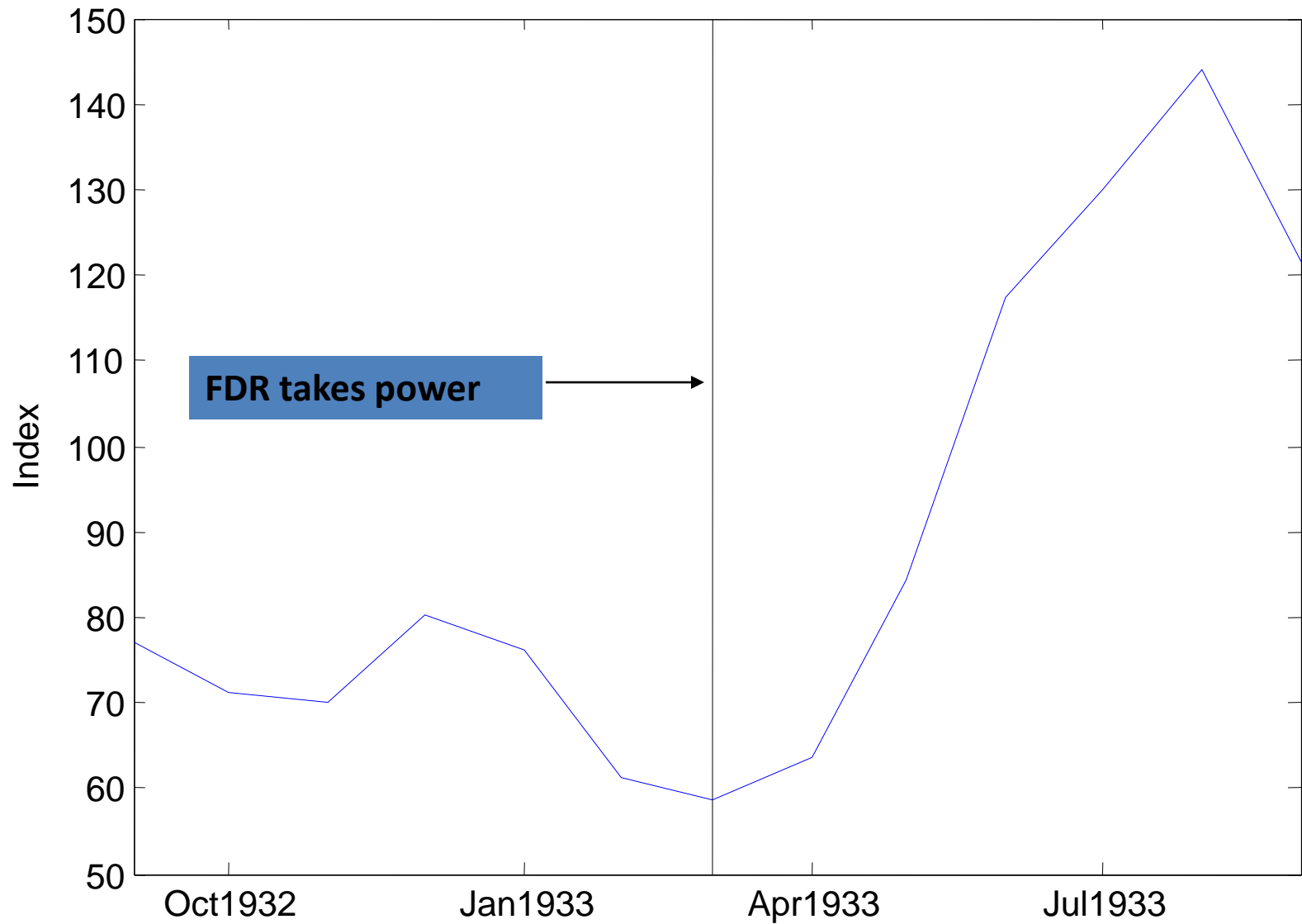
Source: NBER Macro History Database

# Stock Market Prices



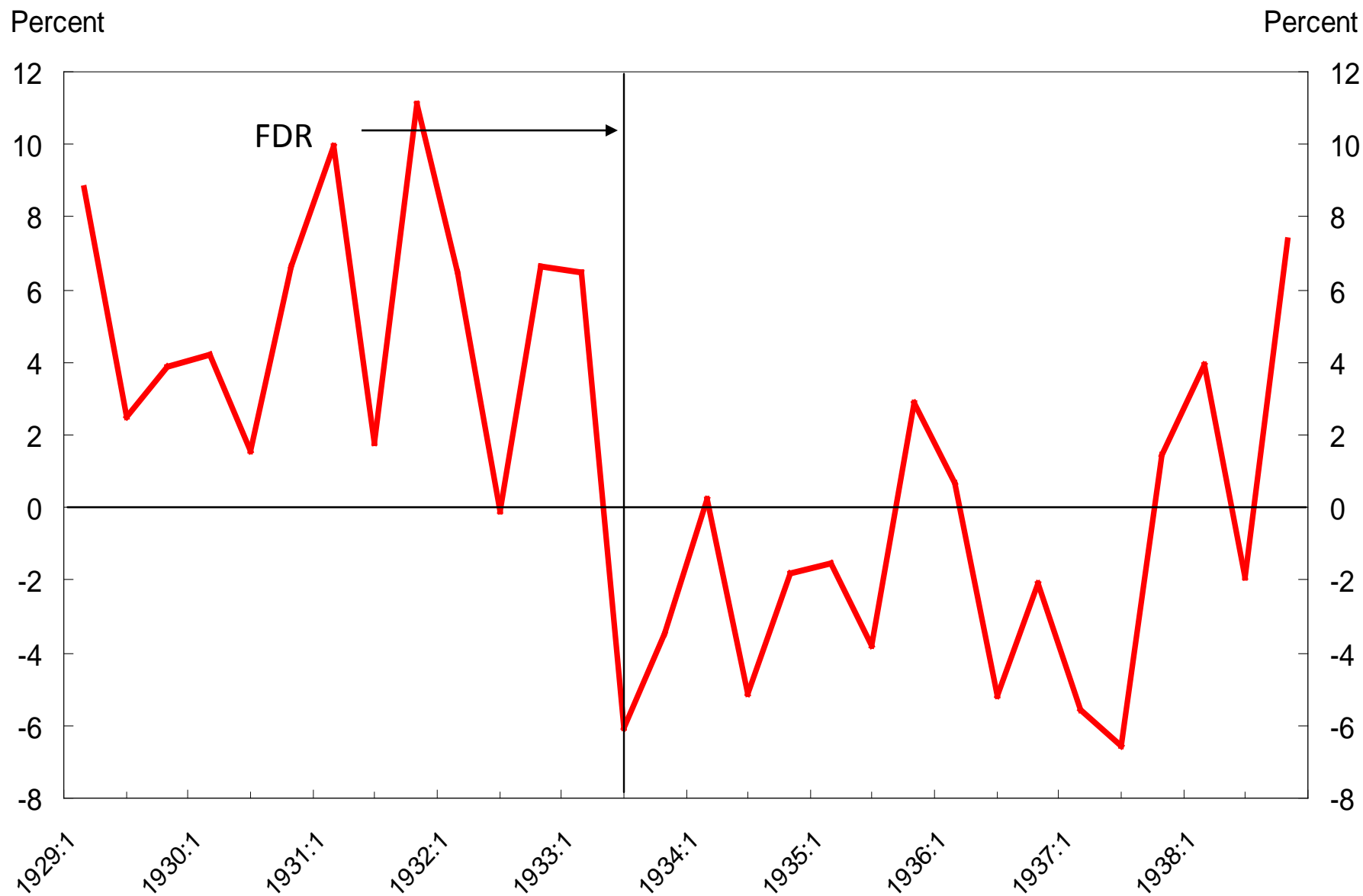


# Investment



Source: Moody's Industrial Manual, 1937

# Ex Ante Real Interest Rates



Source: Hamilton and Cecchetti

# Theoretical framework

- New Keynesian stochastic general equilibrium model.
- Hoover regime: The model can explain an output collapse of the same order as observed in the data
- FDR regime: Can explain a rapid recovery of the order observed in the data.

Dogma: An authoritative principle, belief, or statement of ideas or opinion, especially one considered to be absolutely true

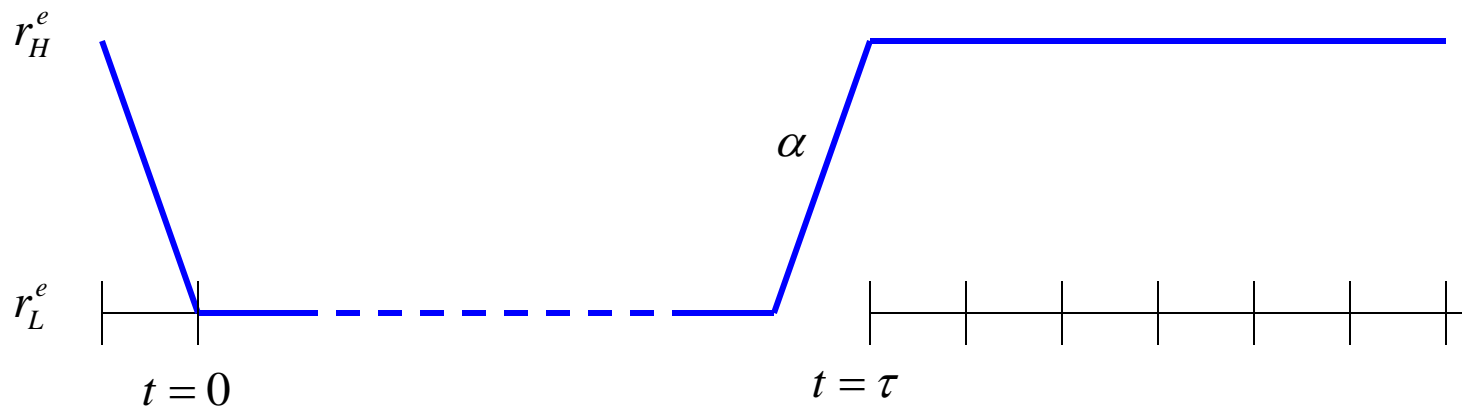


NO PRESUMPTION THAT A DOGMA IS BAD!!

Rules vs discretion

# The source of the Great Depression

## Structural Shocks



# The Hoover Policy Regime

- maximizes social welfare under discretion
- Subject to Policy Dogmas or “rules”

## 1. Balanced Budget dogma

- “Prosperity cannot be restored by raids on the public Treasury.”
- $w_t = w_{t-1} = w$

## 2. No Additional Spending Dogma

- “We can carry our present expenditures without jeopardy to national stability. We can carry no more without grave risks.”
- $F_t = \bar{F}$  at all times

## 3. The Gold Standard Dogma



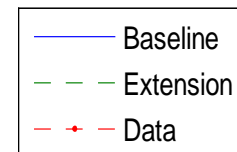
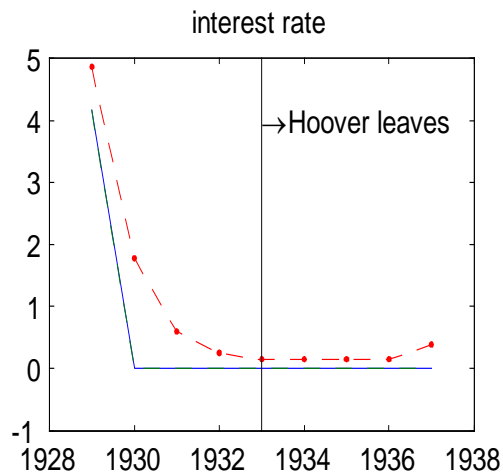
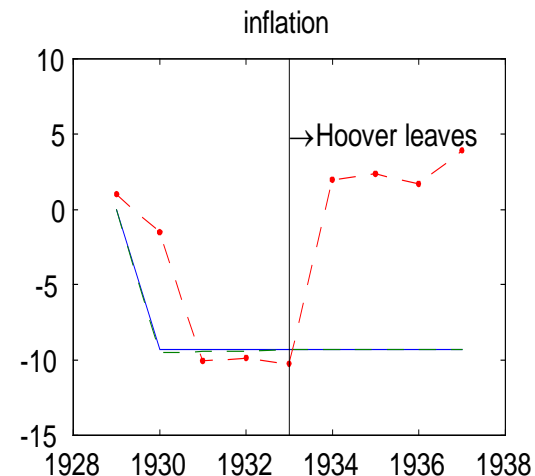
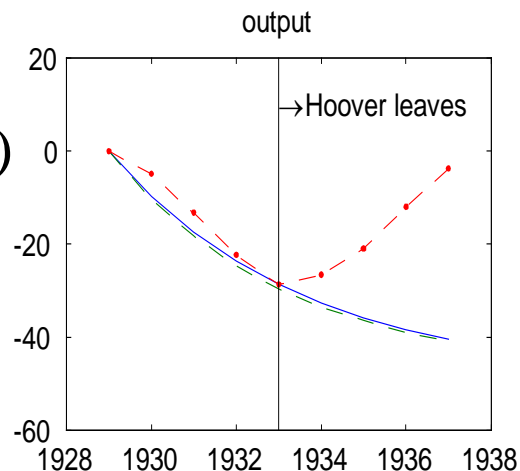
# An output collapse under the Hoover Regime

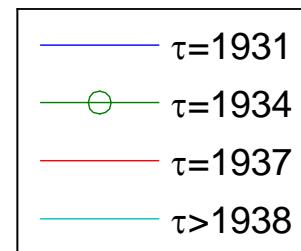
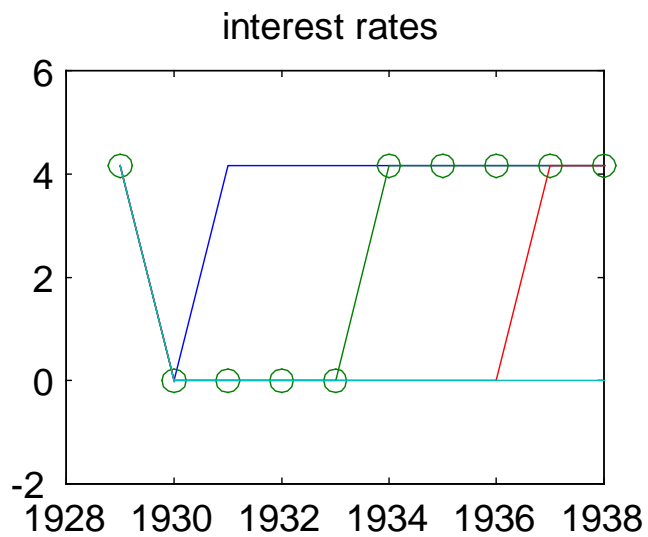
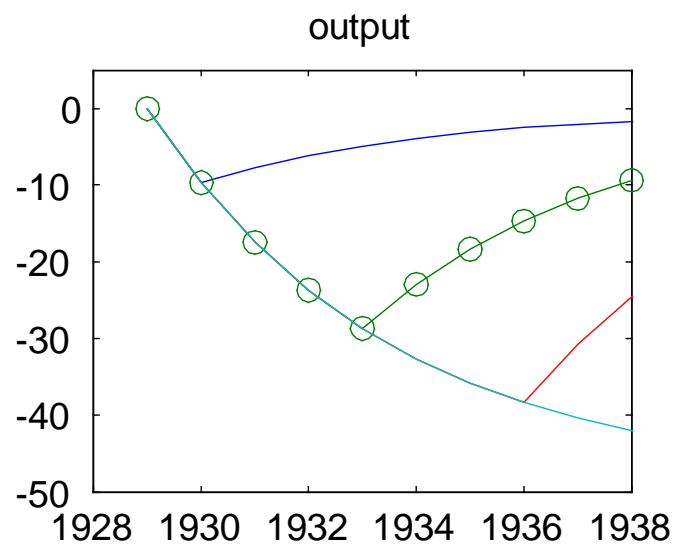
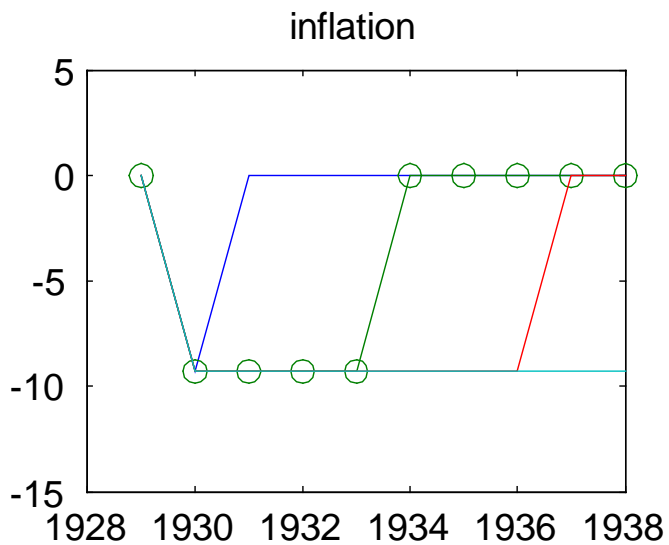
Why output collapse?

$$Y_t = E_t Y_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e)$$

Real interest rates were in double digits in 29-33 due to deflation

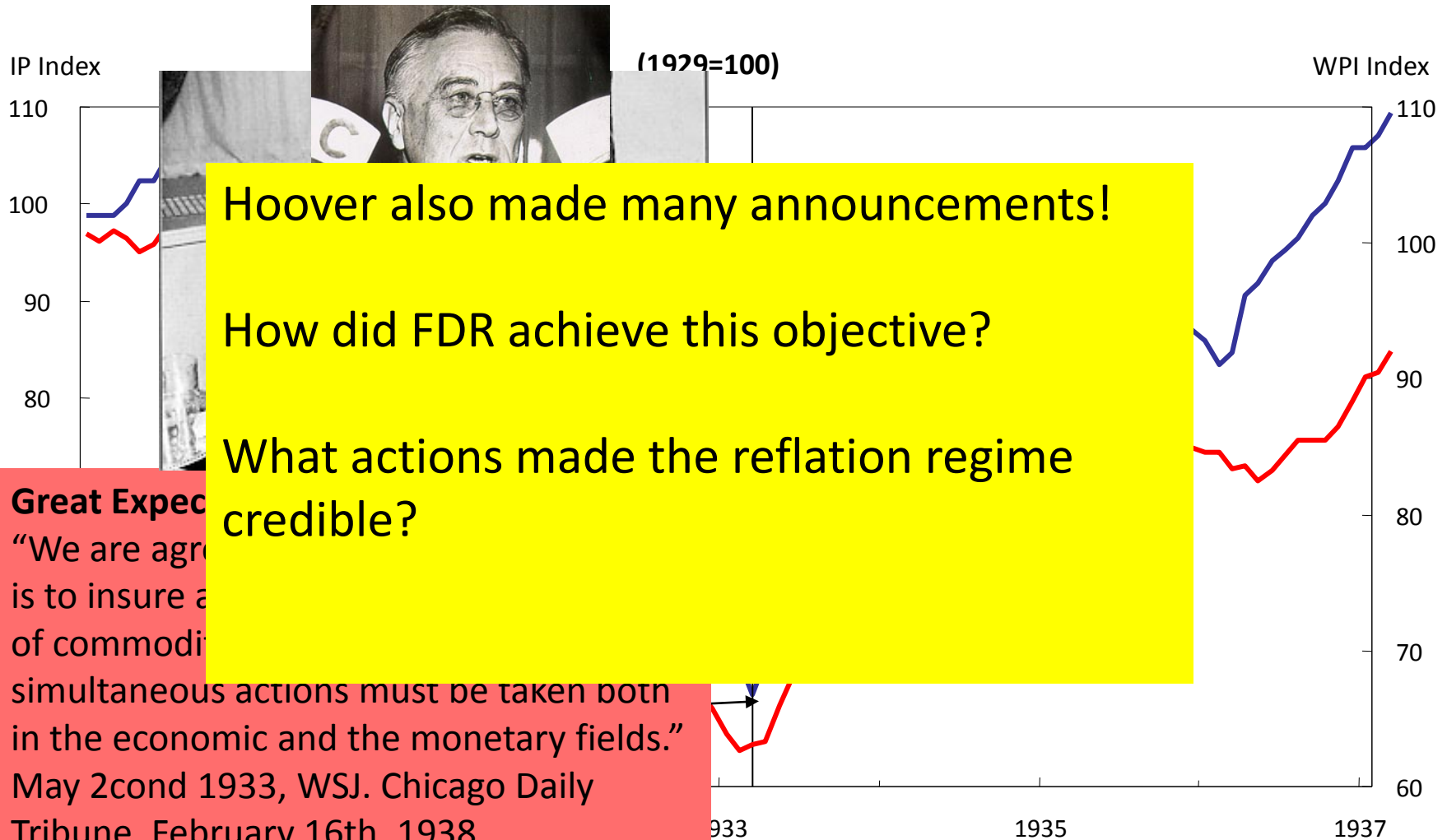
Expectations of future deflation  $\rightarrow$   
 $EY(t+1)$  very negative  $\rightarrow$  vicious  
 cycle  $\rightarrow$  Output collapse





I'm showing you one realization  
of a stochastic process in the last figure.  
Reversal of shocks,  
alternative theory of the recovery?

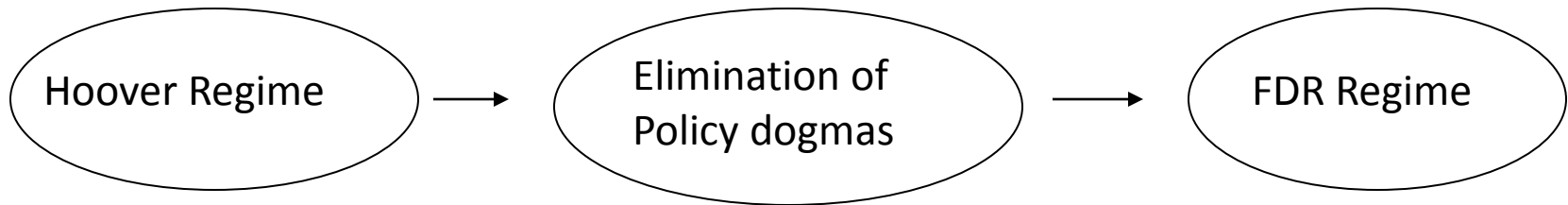
# FDR Policy Regime: Reflation





# The FDR Policy Regime:

- maximizes social welfare
- Markov Perfect Equilibrium
- unconstrained discretion



1. “Balanced budget dogma” eliminated  
Deficit spending 9 percent of GDP in 1934!
2. “No additional spending dogma” eliminated  
Spending up 90 percent 1934 vs. 1932!
3. “Gold standard dogma” eliminated  
Fiscal and monetary expansion technically feasible.

“This is the end of Western Civilization,”  
declared Douglas Lewis, Director of the Budget.

## FDR policy regime

### Relaxing the no additional spending dogma

- Increasing real government spending to increase demand.
- Consistent with FDR reflation program.

“Our greatest primary task is to put people to work. [..] It can be accomplished in part by direct recruiting by the government itself, treating the task as we would treat the emergency of war, but at the same time, through this employment, accomplishing greatly needed projects to stimulate and reorganize the use of our natural resources”.

# FDR policy regime

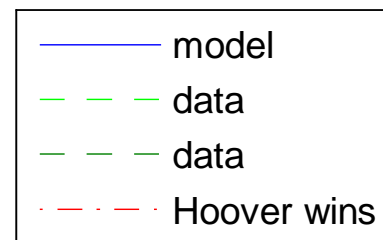
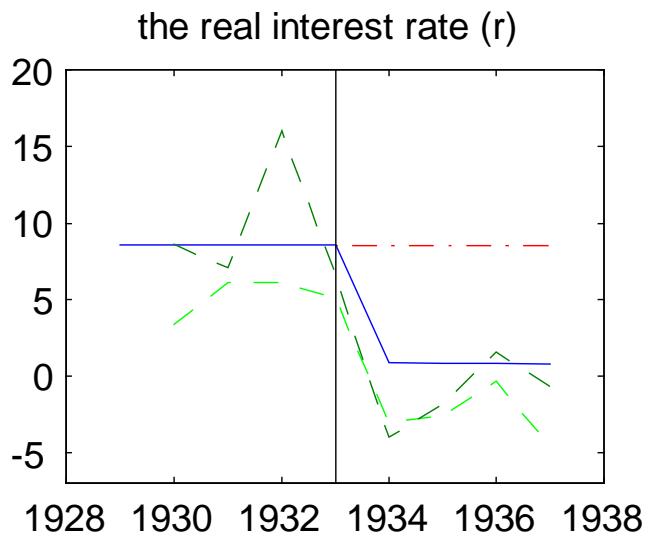
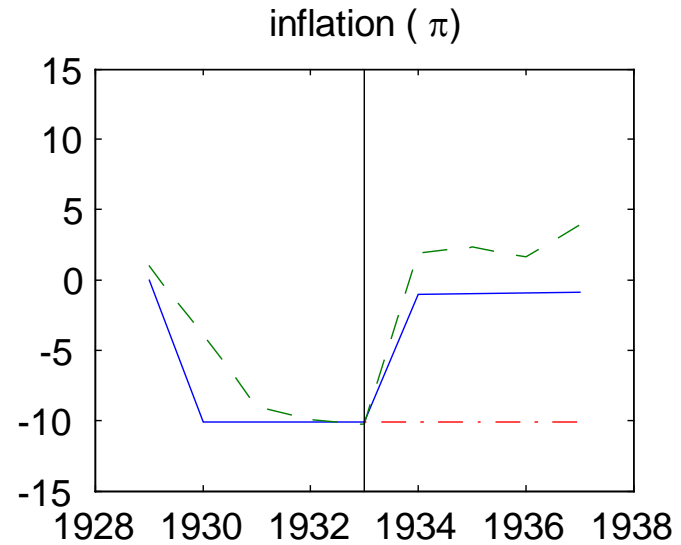
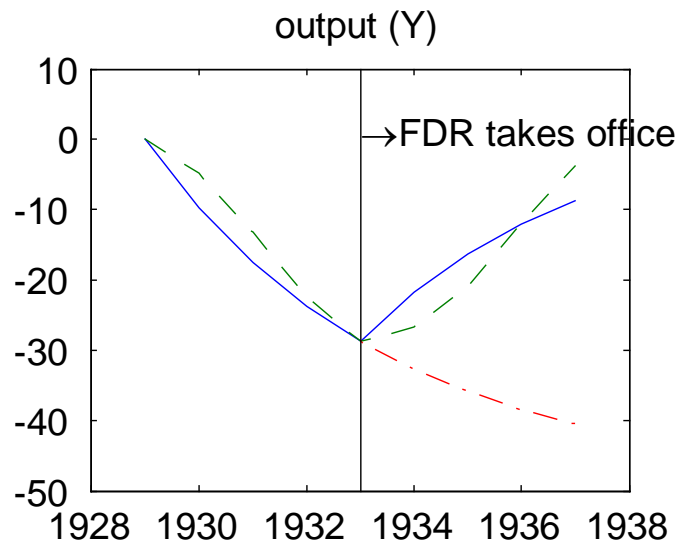
## Relaxing the “Balanced Budget Dogma”

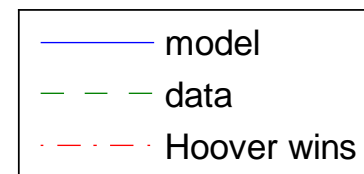
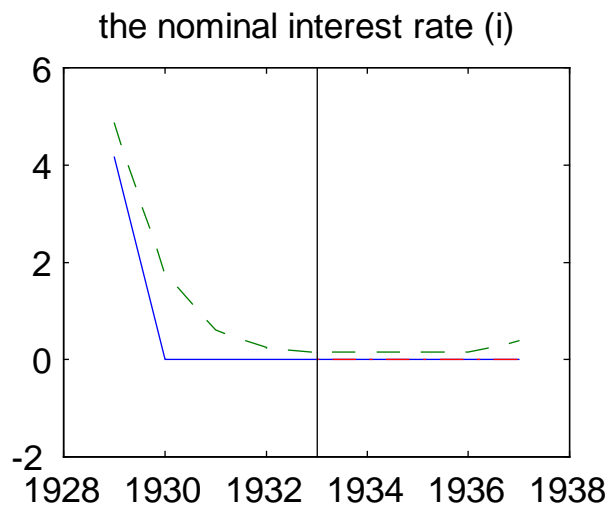
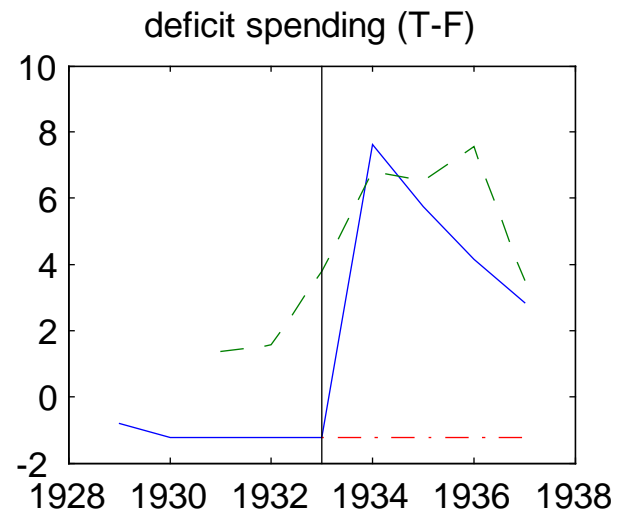
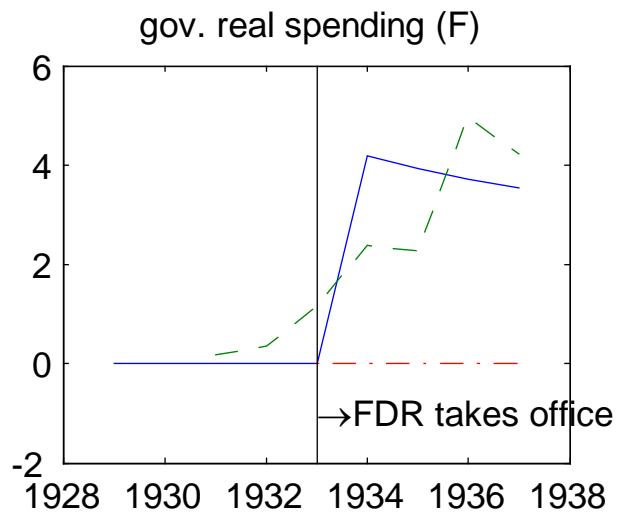
- Cutting taxes and increasing debt to increase inflation expectations.
- Consistent with FDR reflation program and a way of making the program credible.

“that is why powers are being given to the Administration to provide, if necessary, for an enlargement of credit [...] These powers will be used when, as, and if it may be necessary to accomplish the purpose [i.e. increasing inflation].”

- FDR's actions satisfied Sargent's (1983) criteria for a regime change:

There must be an abrupt change in the continuing government policy, or strategy, for setting deficits now and in the future that is sufficiently binding to be believed.





# What was the Mistake of 1937?

- Confusing communication about the objective of policy (had committed to reflation to 1926 level and then changed their mind).
- Fiscal policy set in reverse as well, using similar rationales (no agreement about the relative importance of each).
- Result a costly collapse in output and prices.
- Key point: The result of a mistake in a contractionary direction extremely costly because we can't correct for it by cutting rates.
  - Deflationary spiral. Vicious interactions between output slack → Deflation and expected deflation → Real rate high → Contract output by more → More deflation → etc
- Implication: Excess sensitivity of outcomes to communications at zero interest rate.

# Examples of communications

April 2, 1937, Franklin D. Roosevelt”

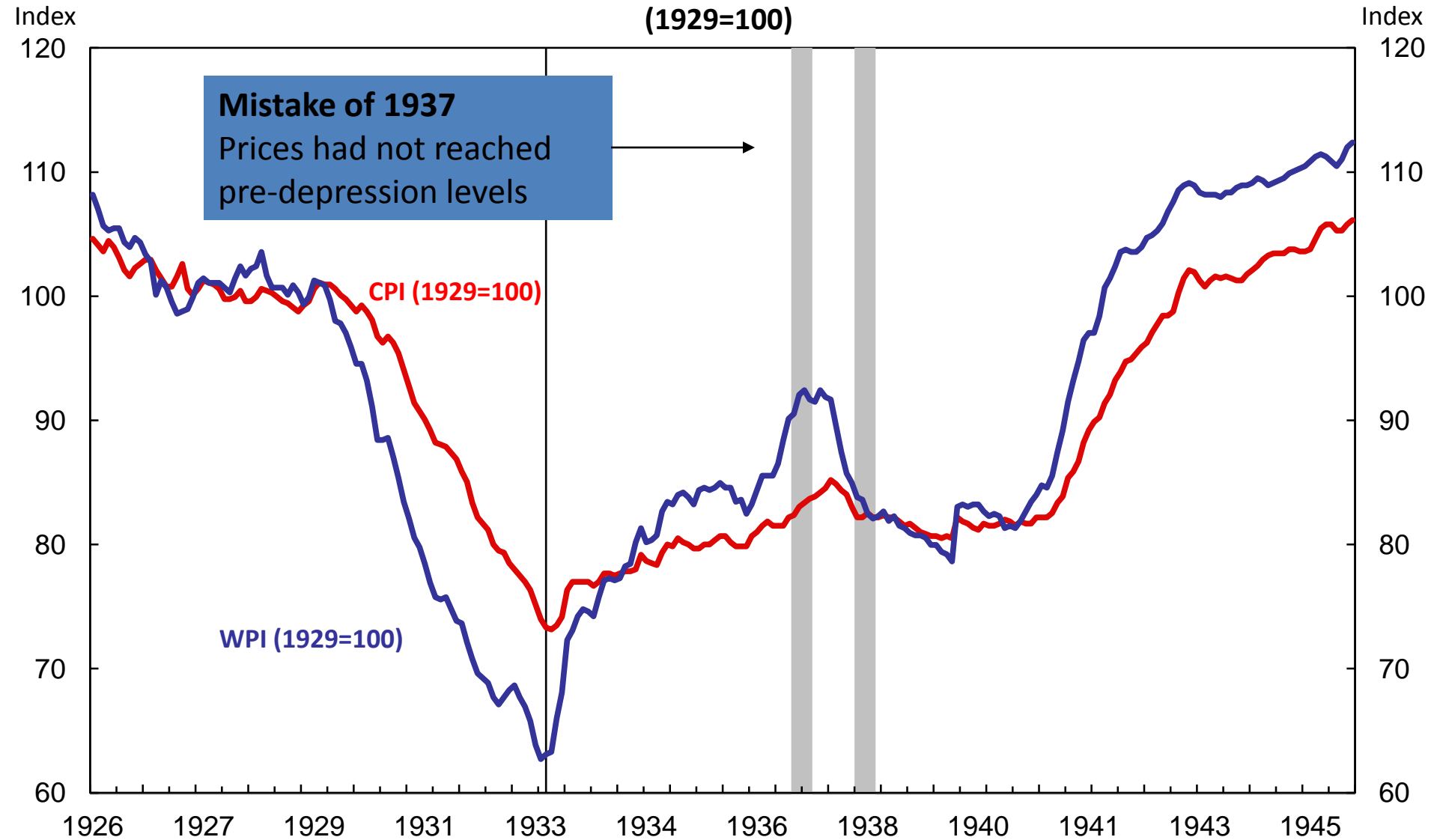
“I am concerned, we are all concerned, over the rise in certain commodity prices.”

February 16, 1938, Chicago Daily Tribune:

“At his press conference today, the President said that he believes now, as he did in 1933, that achievement of permanent prosperity depends on raising the general price levels to those prevailing in 1926.”

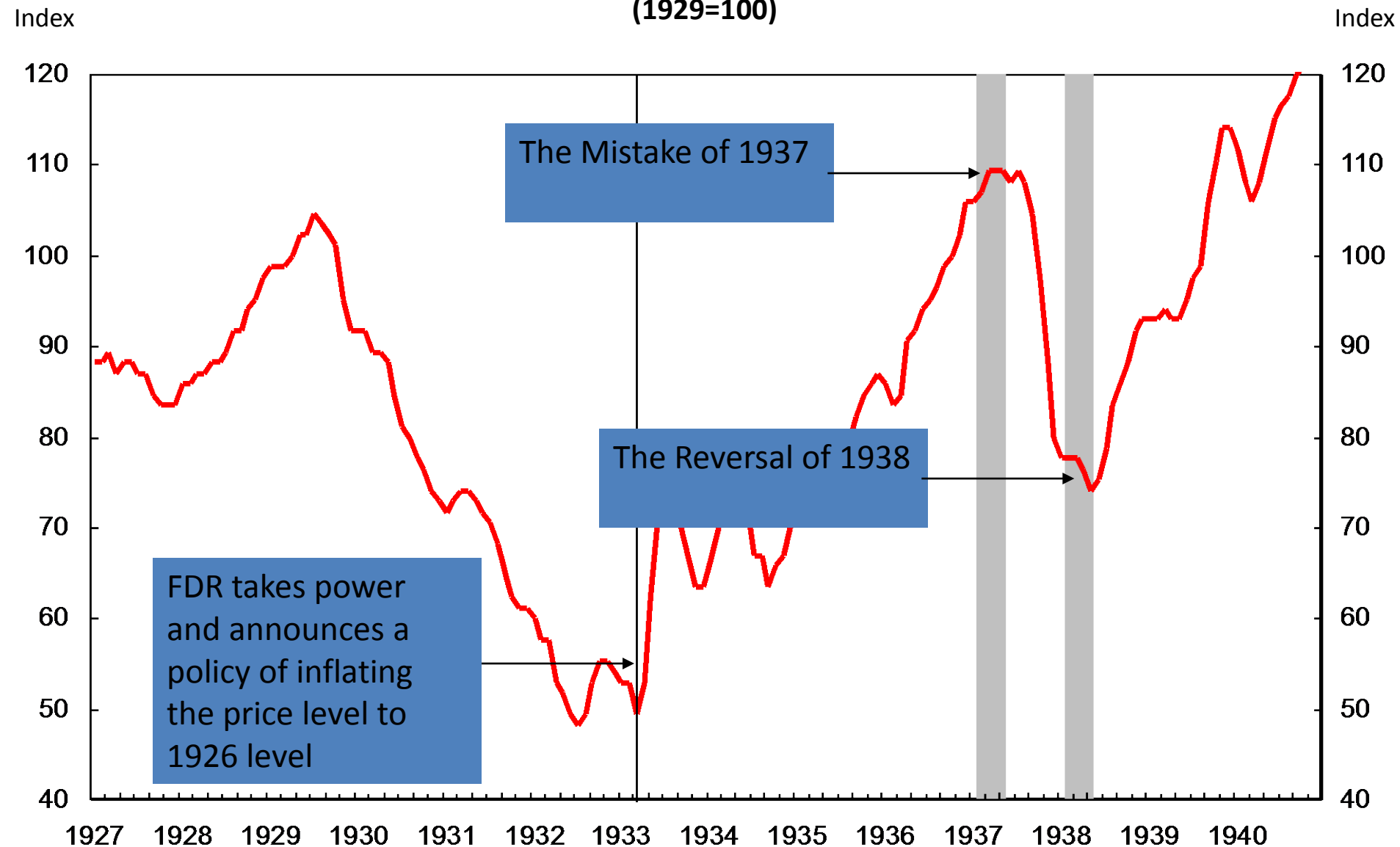


# Reminder!



# Industrial Production

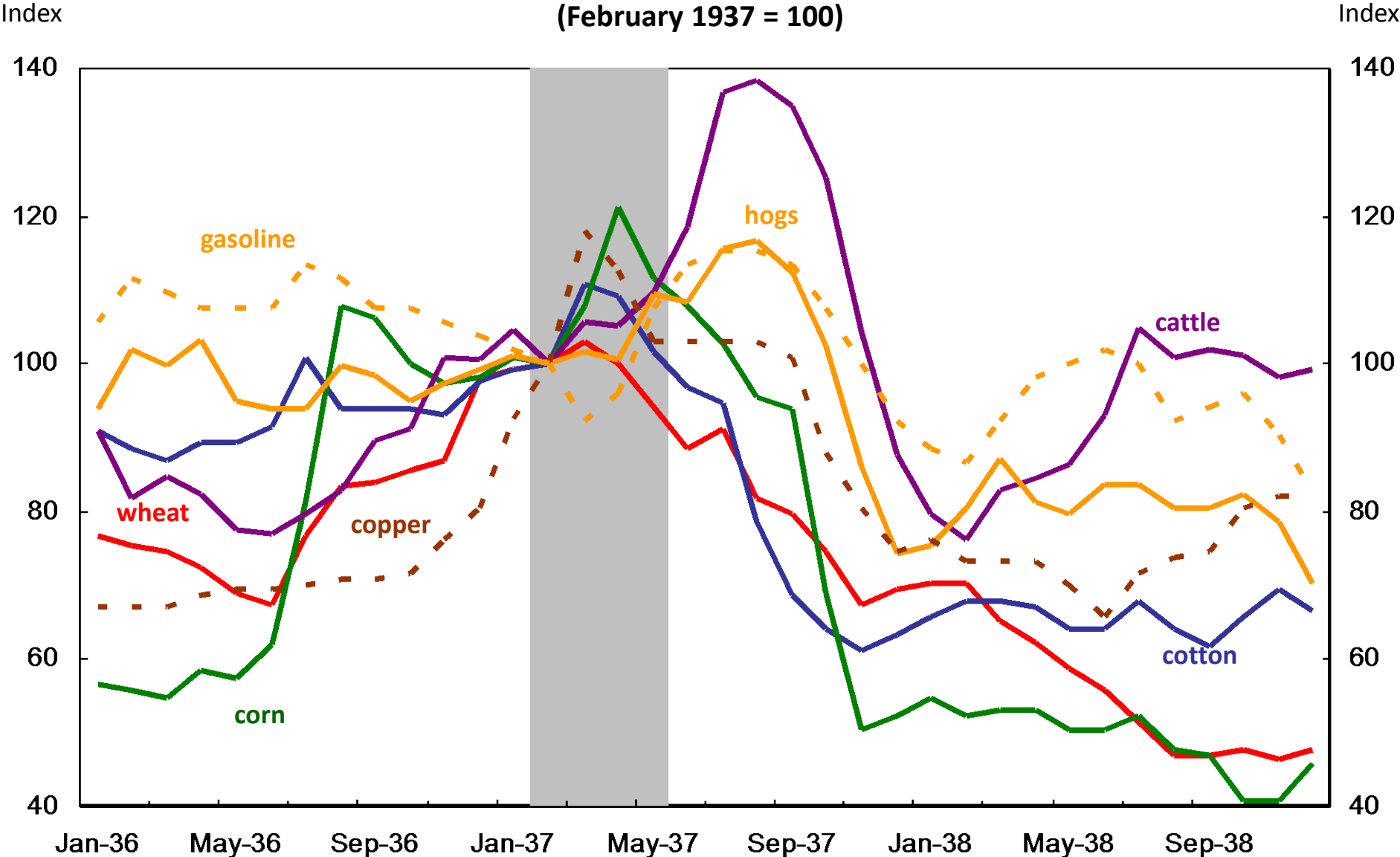
(1929=100)



A shift in expectations

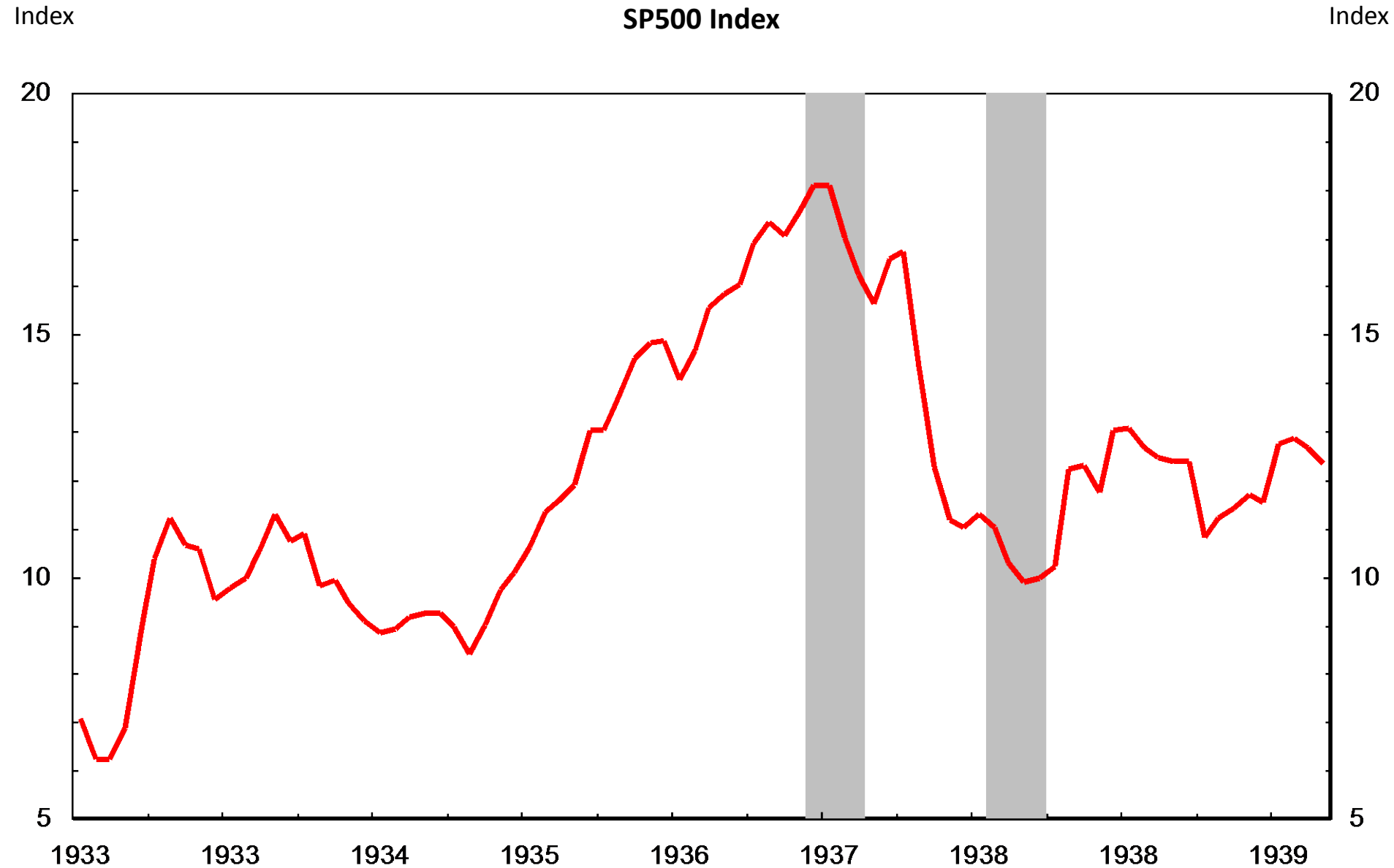
# Commodity Prices

(February 1937 = 100)



Source: NBER Macro History Database

# Stock Prices collapsed around the Mistake of 1937



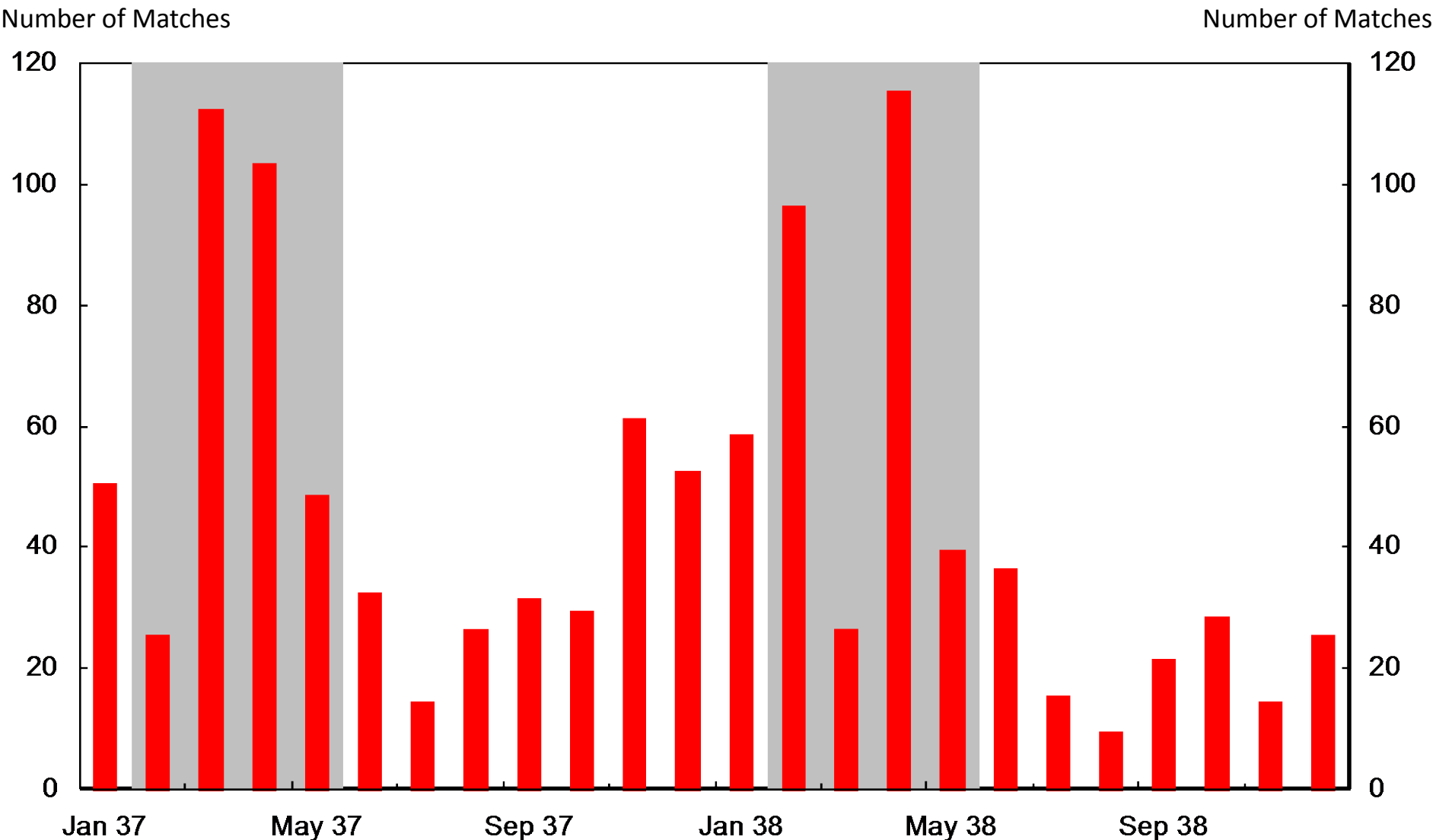
**Table 1: The Mistake of 1937: Anti-inflationary Communcation**

---

- |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. July 14, 1936     | The Federal Reserve announces the first reserve requirement increase which will become effective on the 15th of August.                                                                                                                                                                                                                                                                                                                                                             |
| 2. January 30, 1937  | The Federal Reserve announces the second and third reserve requirement increases which will become effective the 1st of March and 1st of May.                                                                                                                                                                                                                                                                                                                                       |
| 3. February 18, 1937 | Marriner Eccles, Chairman of the Board of Governors, in Senate hearings:<br>"The short term rates are excessively low and there may be a tendency for rates near the vanishing point to increase."<br>--- Wall Street Journal, February 19, 1937, pg. 1.                                                                                                                                                                                                                            |
| 4. March 15, 1937    | Marriner Eccles, Chairman of the Board of Governors, gives a statement:<br>"The upward spiral of wages and prices into inflationary levels can be as disastrous as the downwards spiral of deflation."<br>--- Chicago Daily Tribune, March 16, pg. 1.                                                                                                                                                                                                                               |
| 5. March 17, 1937    | Commerce Secretary Daniel C. Roper and Secretary of Agriculture Henry A. Wallace hold press conferences: Both Secretaries warn against excessive inflation.<br>--- Wall Street Journal, March 18, 1937, pg. 8.                                                                                                                                                                                                                                                                      |
| 6. March 24, 1937    | Marriner Eccles, Chairmain of the Board of Governors, on inflation:<br>"Chairmain Eccles outlines five steps to avert 'dangerous inflation' in Forbes Magazine which are (i) reserve requirement increases "to eliminate excess reserves", (ii) fiscal policy that balances the budget, (iii) reduction in the gold price of the dollar, (iv) increase in the labor share of national income, and (v) antitrust legislation."<br>--- The Christian Science Monitor, March 25, 1937. |
| 7. April 2, 1937     | Franklin Delano Roosevelt holds a press conference:<br>"I am concerned -- we are all concerned -- over the price rise in certain materials."                                                                                                                                                                                                                                                                                                                                        |
| 8. August 3, 1937    | <del>Franklin Delano Roosevelt's views on price level targeting revealed:</del> Senator Elmer Thomas published a letter from Franklin Delano Rosevelt to him rejecting his proposal that the Federal Reserve should formally target the 1926 price level.<br>--- Wall Street Journal, August 4, 1937, pg. 6.                                                                                                                                                                        |
-

# Intensity of Policy Discussion

Mentions of Inflation by Eccles, Morgenthau, Roosevelt, or his Cabinet



# Was the New Deal Expansionary?

## **Motivation NIRA:**

A national Emergency productive of widespread unemployment and disorganization of industry [...] is hereby declared to exist.

This title shall cease to be in effect until [...] the emergency recognized by section 1 has ended

One interpretation guided by theory:  
A tool to raise the price level



# Consistent with what policy makers said

“We are agreed in that our primary need is to insure an increase in the general level of commodity prices. To this end simultaneous actions must be taken both in the economic and the monetary fields”

FDR, in the Wall Street Journal 1st of May of 1933:

- The actions in the "economic field" FDR referred to were the NIRA and AAA.

“If we cannot do this [reflation] one way we will do it another. Do it, we will.”

President Franklin Delano Roosevelt,  
October 22th, 1933



# Key Result

- A policy that *reduces* natural level of output *increases actual output* and welfare.

$$\hat{Y}_t^n = \hat{Y}_t^e - \frac{1}{\sigma^{-1} + \nu} \hat{\omega}_t$$

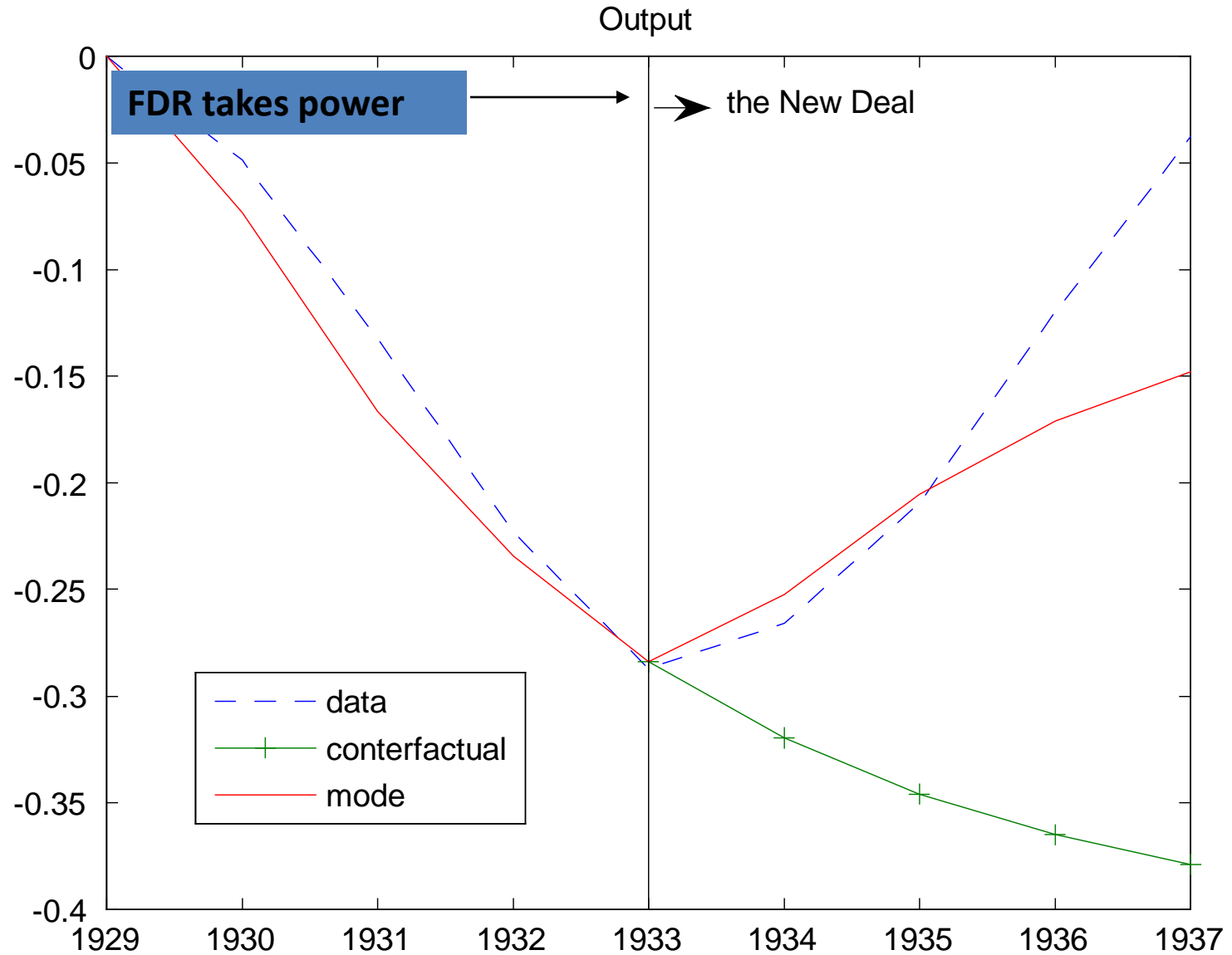
- Intuition in linearized model:

$$\hat{Y}_t = E_t \hat{Y}_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^e) \quad \left| \quad \pi_t = \kappa \hat{Y}_t + \beta E_t \pi_{t+1} + \kappa \frac{1}{\sigma^{-1} + \nu} \hat{\omega}_t \right.$$

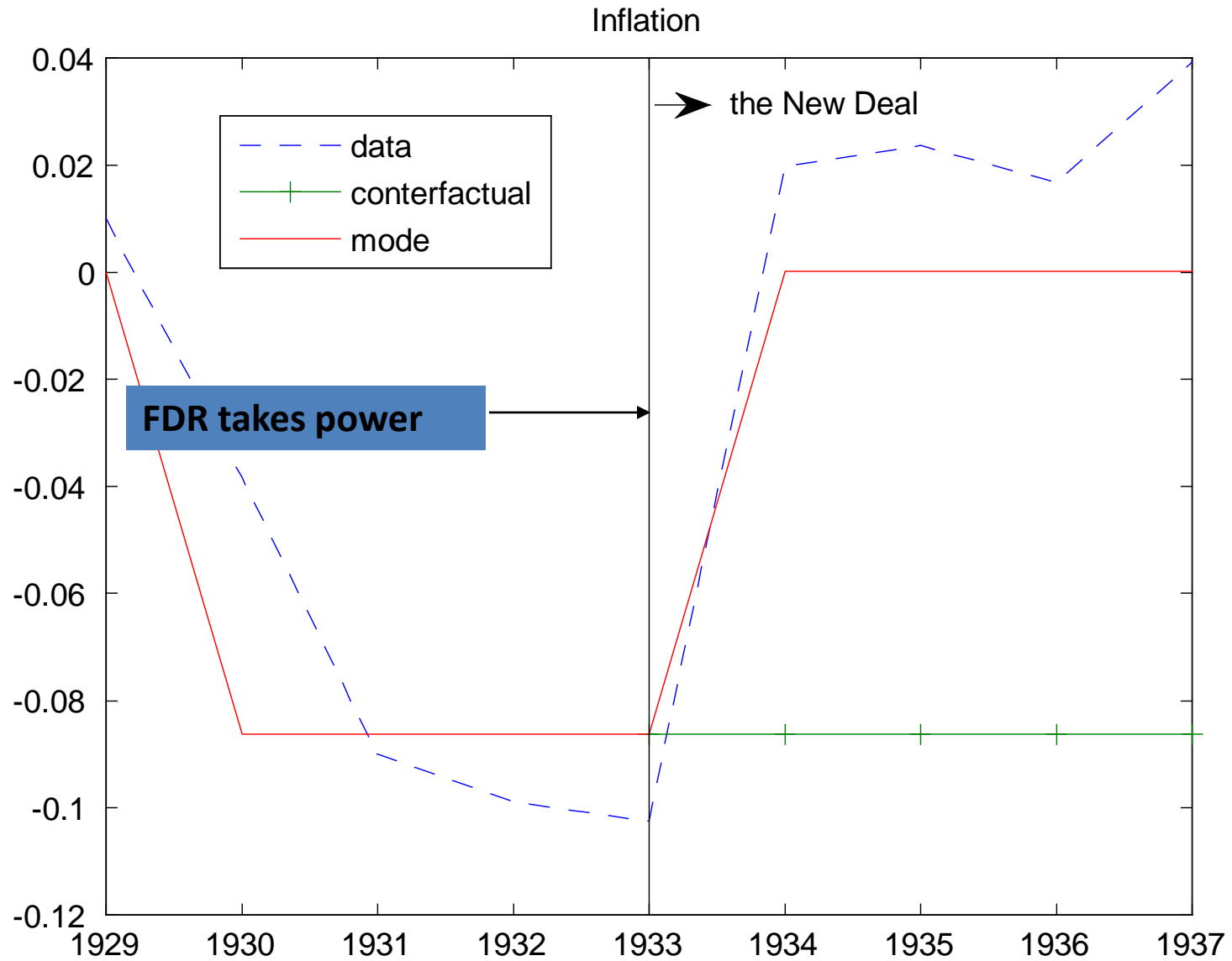
## NYT April 1933:

A higher price level which will be sanctioned by the act, it was said, will encourage banks to pour industry the credit now frozen in their vaults because of the continuing downward spiral of commodity prices.

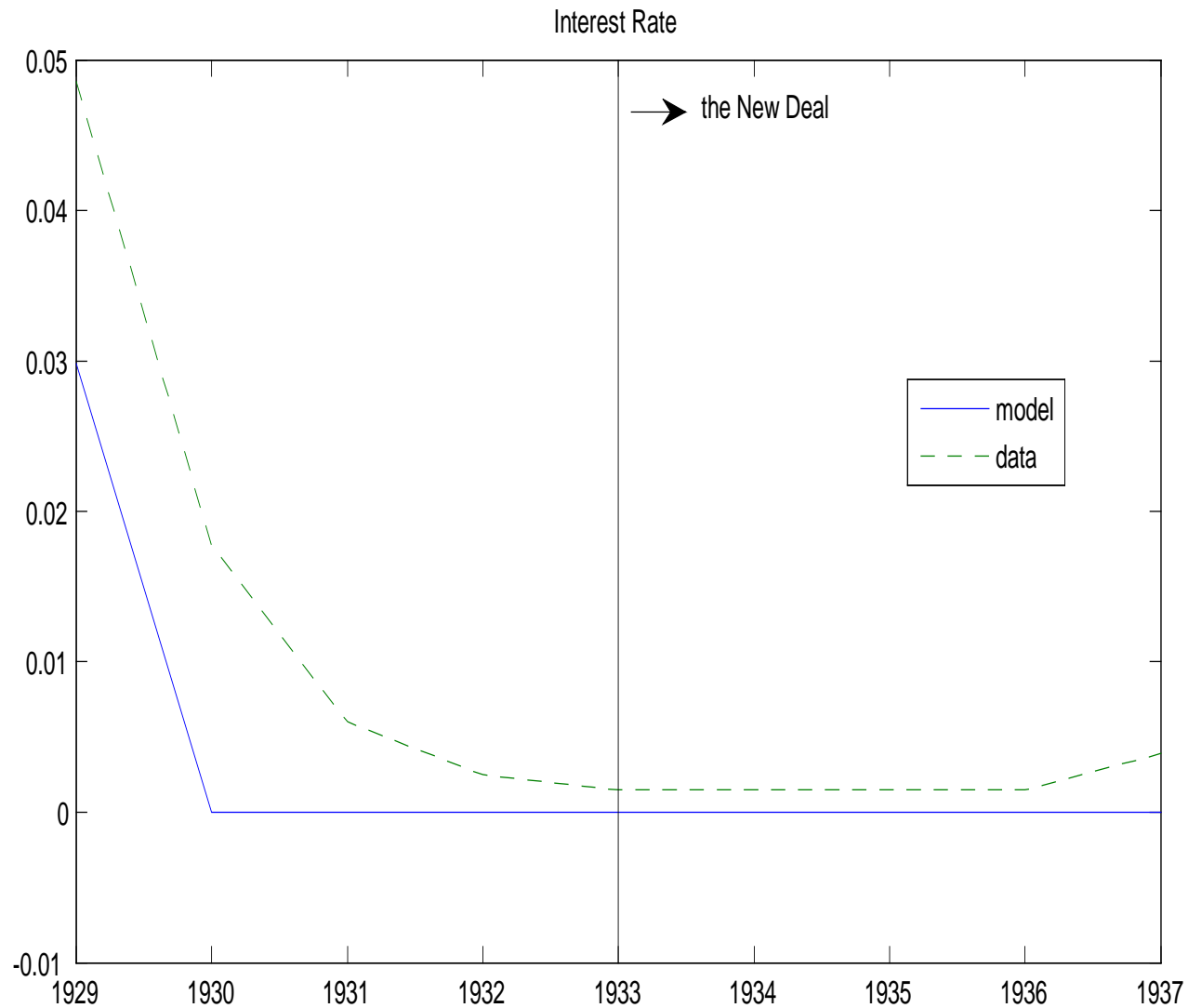
# Output



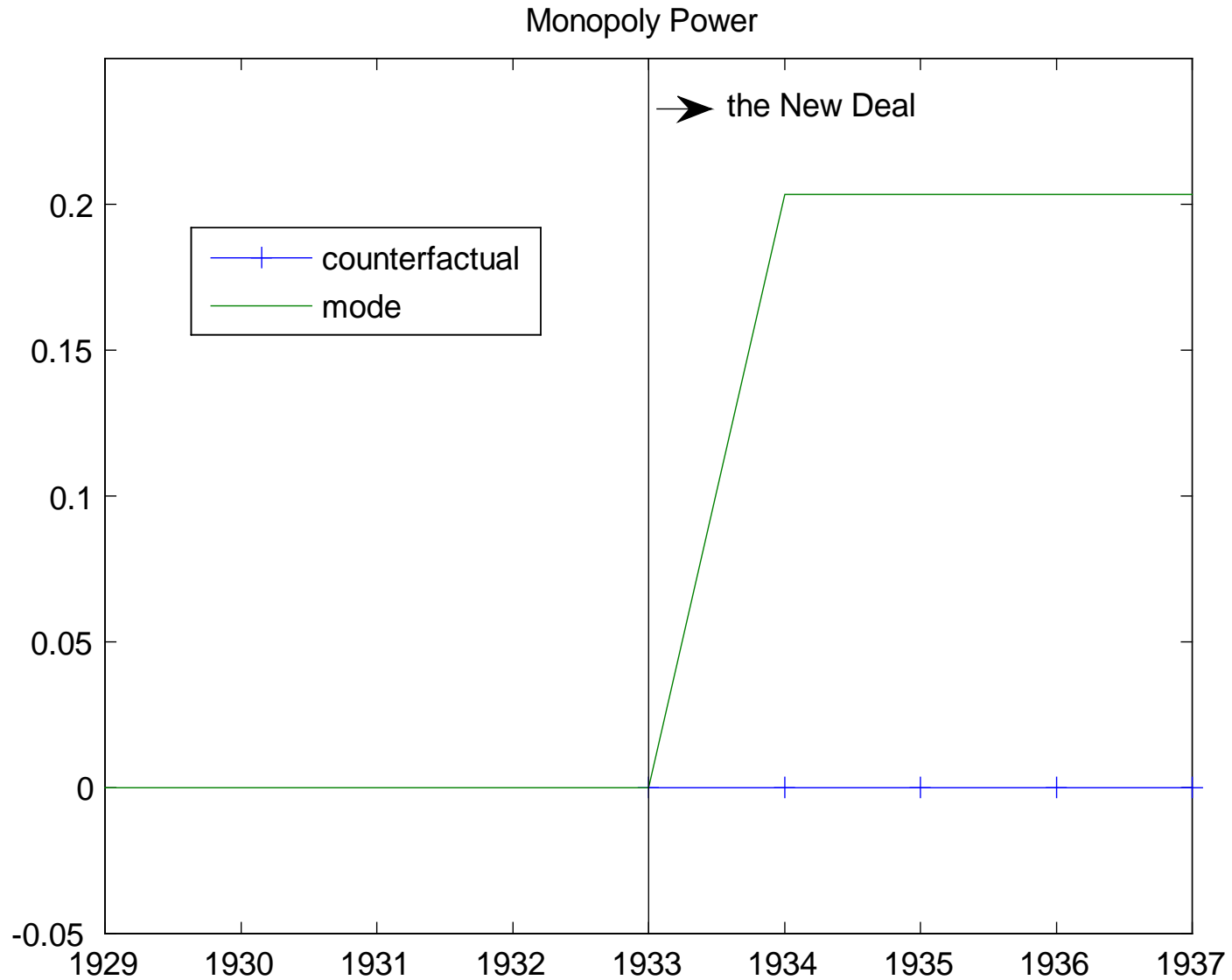
# Inflation



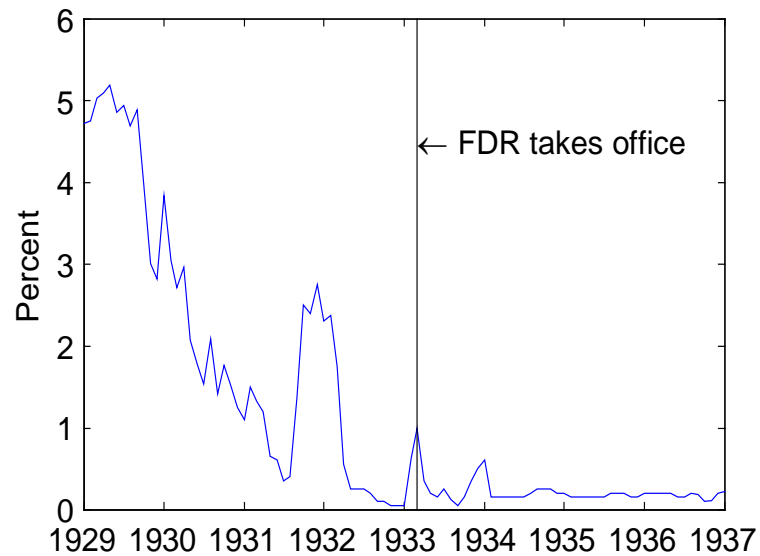
# Interest Rates



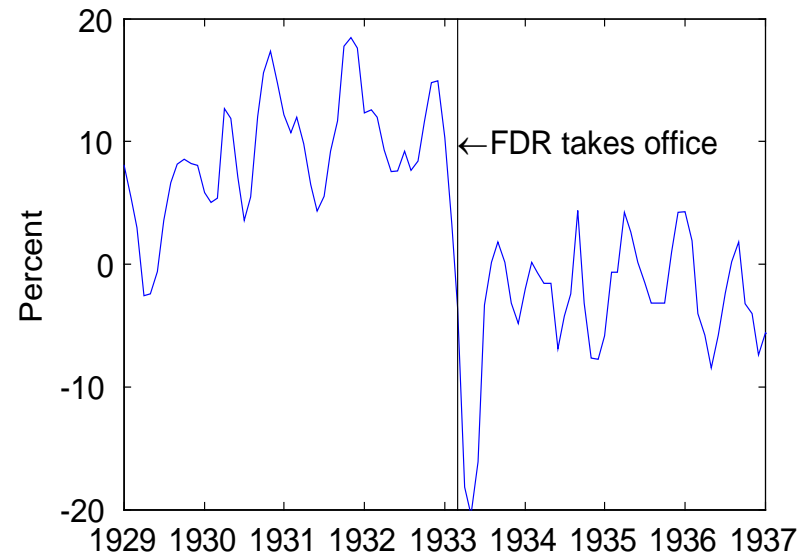
# Policy Instrument



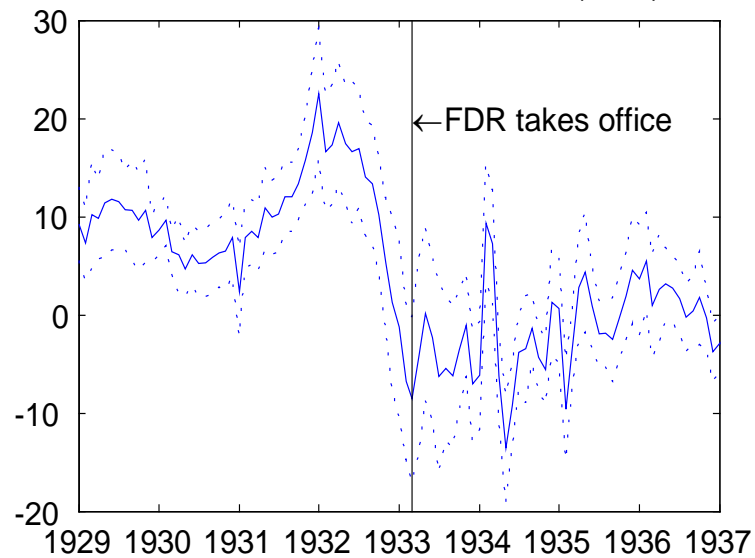
Short-term Interest Rate



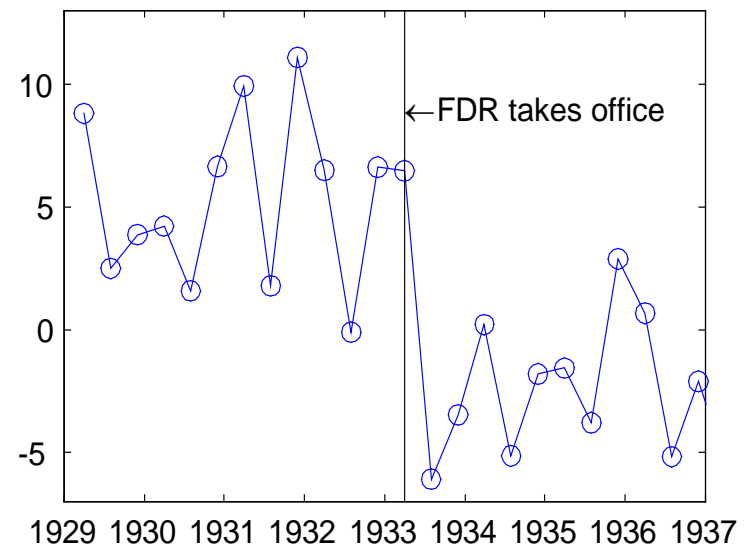
Ex Post Real Rate



Ex Ante Real Rate from Cecchetti (1992)



Ex Ante Real Rate from Hamilton (1992)



The battle with deflation was the center piece of the New Deal policies.

**And yet, amid the chaos of the Hundred Days, and indeed through the tense stand-off of the interregnum that preceded it, one threat flashed and dove like a scarlet skein shot through brocade:**

**inflation.**

David M. Kennedy in "The American People in the Great Depression".



# IV. The Secular Stagnation Hypothesis and the Liquidity Trap

*A brief discussion of a terrifying idea*

# The liquidity trap and the Secular Stagnation hypothesis

- What is the secular stagnation hypothesis?
- That the natural rate of interest negative arbitrarily long.
- Can show the existence of such a phenomena in an overlapping generation economy. Triggered by
  - inequality
  - population dynamics
  - relative price of investment can put downward pressure
- Even stronger reason for a reflationary program.
  - Law of the excluded middle, timidity trap, inflation target needs to be high enough to have any effect
  - Government spending very effective
  - Increases in government debt solve the problem.

# Conclusion

- Recent 15 years of research have provided us with a framework that allows us to analyze crisis of the type we see today.
- Large part of this literature emerged before the crisis, in response to the Japanese crisis and by applying this theory to the Great Depression
- Do not see any major embarrassment of this theory as of yet. Not perfect, but gives us a coherent picture, with strong policy conclusion, most of which have not been followed to the full extent.

# AEA CONTINUING EDUCATION PROGRAM



## MONETARY POLICY

JEFF FUHRER, FEDERAL RESERVE BANK OF BOSTON

JANUARY 5-7, 2015

# EXTRAORDINARY FED POLICIES DURING THE FINANCIAL CRISIS

AEA Continuing Education  
January 5-7, 2015

Jeff Fuhrer, EVP and Senior Policy Advisor

Federal Reserve Bank of Boston

Not this lady



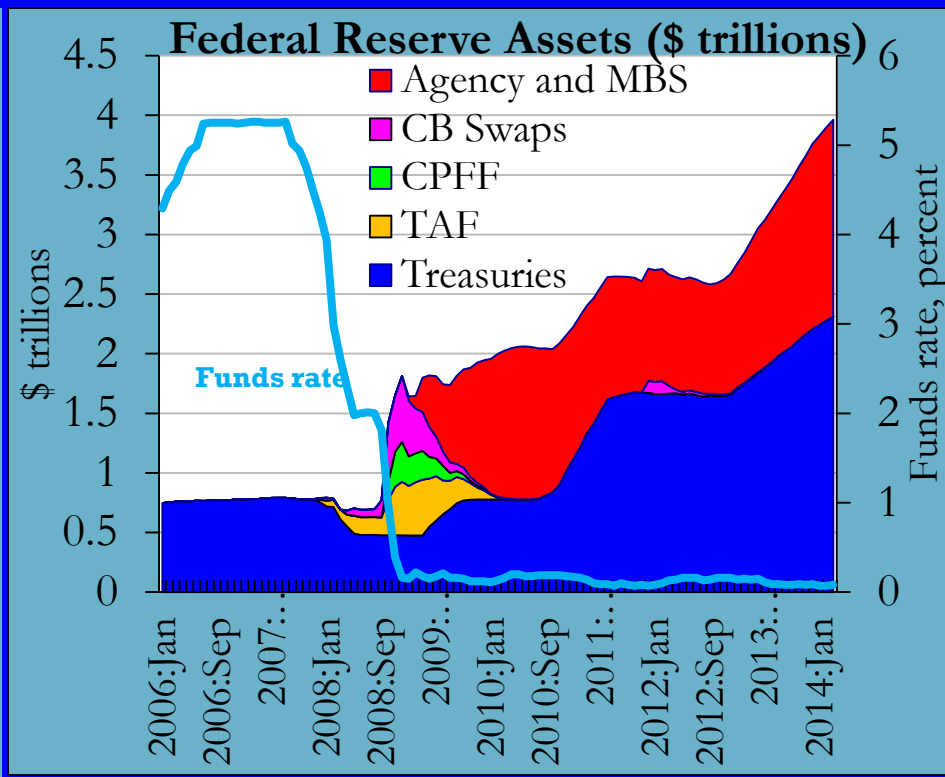
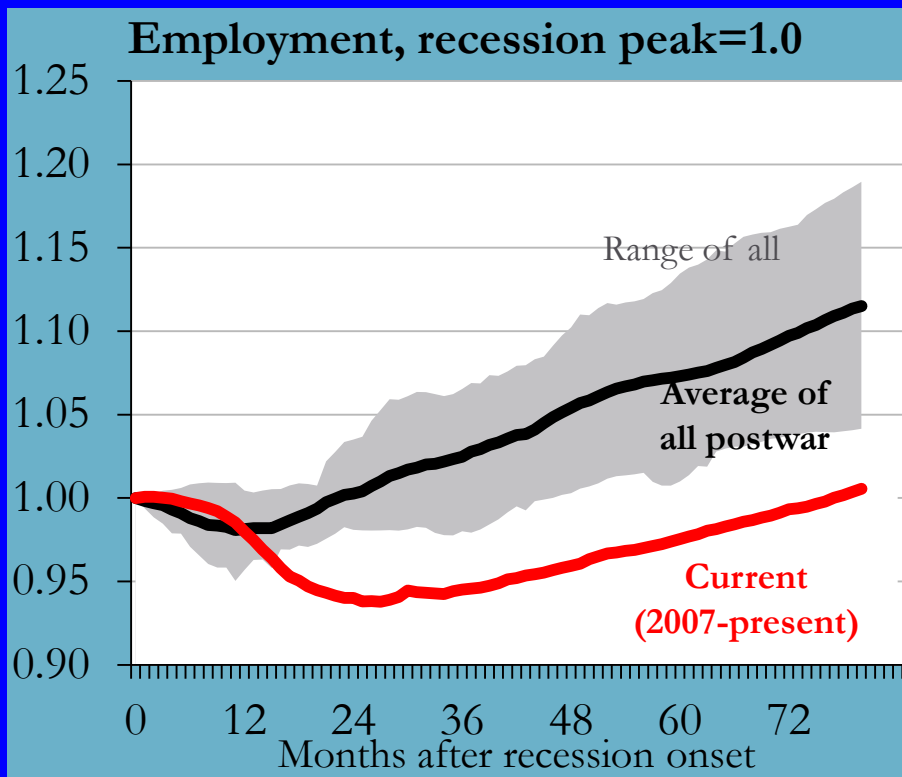
Not this guy

Disclaimer:

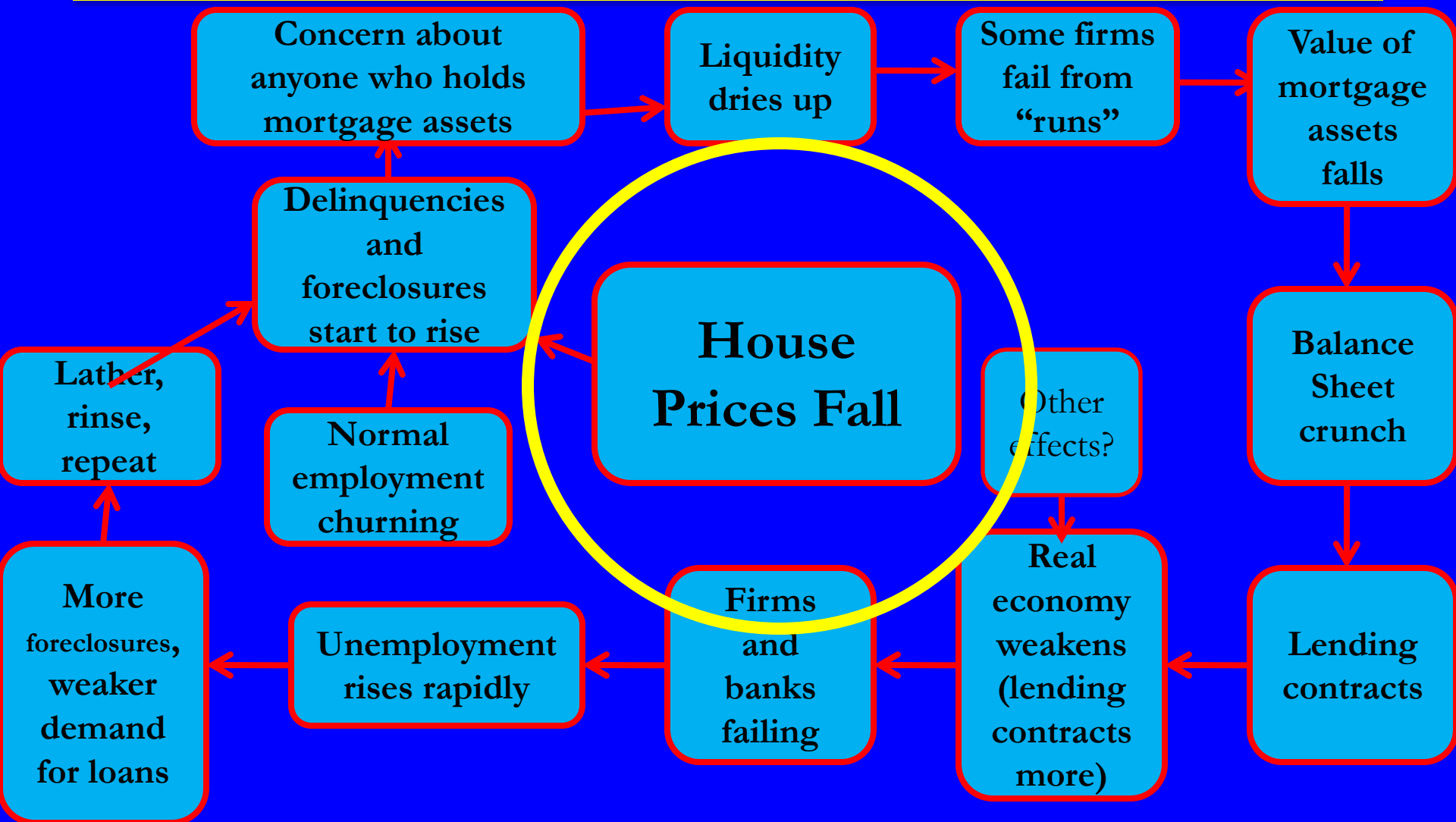
The views expressed in this talk do not represent those of the Board of Governors of the Federal Reserve System, the Federal Reserve Bank of Boston, or any members of the Federal Reserve System. Except for me.

# What an “interesting” time

1. Unprecedented depth and duration of recession
2. Extraordinary policy responses
3. Complications going forward as a consequence



# The Big Picture: What Happened During the Crisis

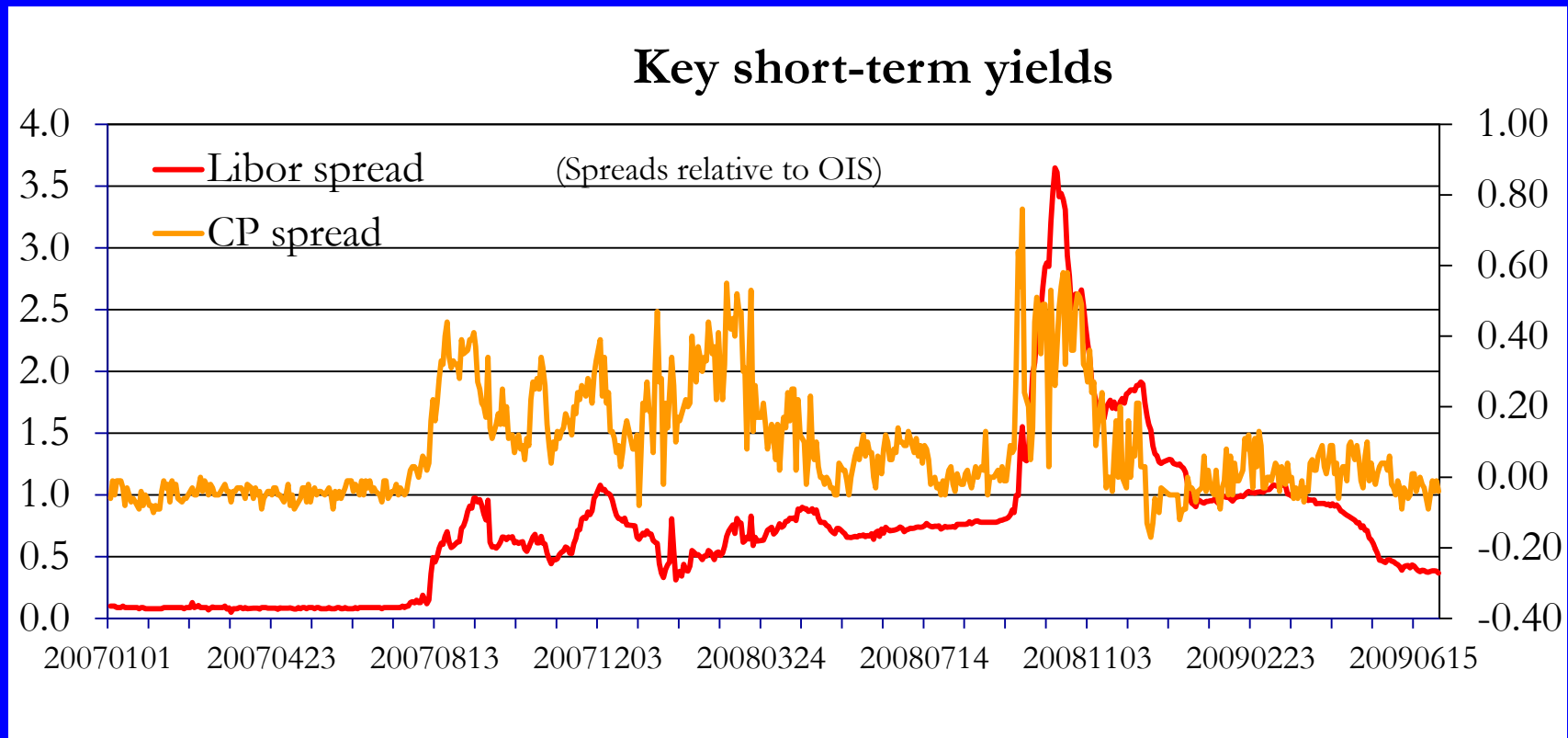




FIRST SIGNS OF CRISIS:  
LIQUIDITY (SHORT-TERM BORROWING)  
CRUNCH

# Summer/Fall 2007: Short-term funding pressures

- After the hedge fund problems at Bear and BNP, some more generalized signs of difficulties in short-term funding markets



# WHAT THE FED CAN AND CAN'T DO (CIRCA 2007)

# Fed Lending

---

- ▣ Intent of the Federal Reserve Act:
  - Subject to legal interpretation, but generally, expect Fed to lend to banks/DIs
- ▣ Lending to depository institutions
  - Most authorized under section 10(B), which gives broad authority
  - Collateral may include a wide array of private assets
  - Collateral must be deemed satisfactory by Reserve Bank making the loan
- ▣ To individuals, partnerships and corporations
  - Only when authorized by invoking the old 13(3) “unusual and exigent circumstances” clause of the Federal Reserve Act
  - Wide variety of private assets may serve as collateral
  - Changes with Dodd-Frank—much harder to invoke the 13(3) clause
- ▣ The perception or reality of “credit allocation” is always a concern

# Fed open-market operations

---

- ▣ Authorized in Section 14 of the FR Act
- ▣ No provision to accept private-sector instruments such as
  - Mortgages (unless guaranteed by federal government)
  - Corporate bonds
  - Equities
- ▣ Allowable are
  - “any bonds, notes, or other obligations which are direct obligations of the United States or which are fully guaranteed by the United States [**or by an Agency of the US**] as to the principal and interest may be bought and sold without regard to maturities but only in the open market.”
  - Certainly any *issue* of the US government
  - Also issues that are guaranteed by the US government or US agency
  - State and local government debt is allowable (with some restrictions on the purpose for which the S&L debt was issued)

# Fed Credit Risk

---

- ▣ For lending
  - All loans should be collateralized “to the satisfaction of the discount window officer at the Federal Reserve Bank”
  - If collateral value falls during term of loan, Fed will ask DI to pledge more—so borrower bears risk
- ▣ For open market operations
  - Fed can take on credit risk, but its exposure is limited by the type of assets the Fed can take on its balance sheet

# THE LIQUIDITY PROGRAMS

# Overarching principles

---

- ▣ Addressed a number of specific short-term funding needs
  - Why? To help financial institutions?
    - ▣ No, because these finance working capital—payroll, inventory, trade credit—necessary to basic functioning of economy
- ▣ Priced to go out of business when conditions returned to normal
  - Rates were above “normal” market rates
  - All the facilities worked their way out of business, as they improved short-term market conditions, and they became too expensive relative to market options



# The Term Auction Facility (TAF)

---

- ▣ What is it?
- ▣ Why was it needed?
  - We already had the “Discount Window” (now the Primary Credit Facility)
- ▣ How did it work?

# TAF: What is it?

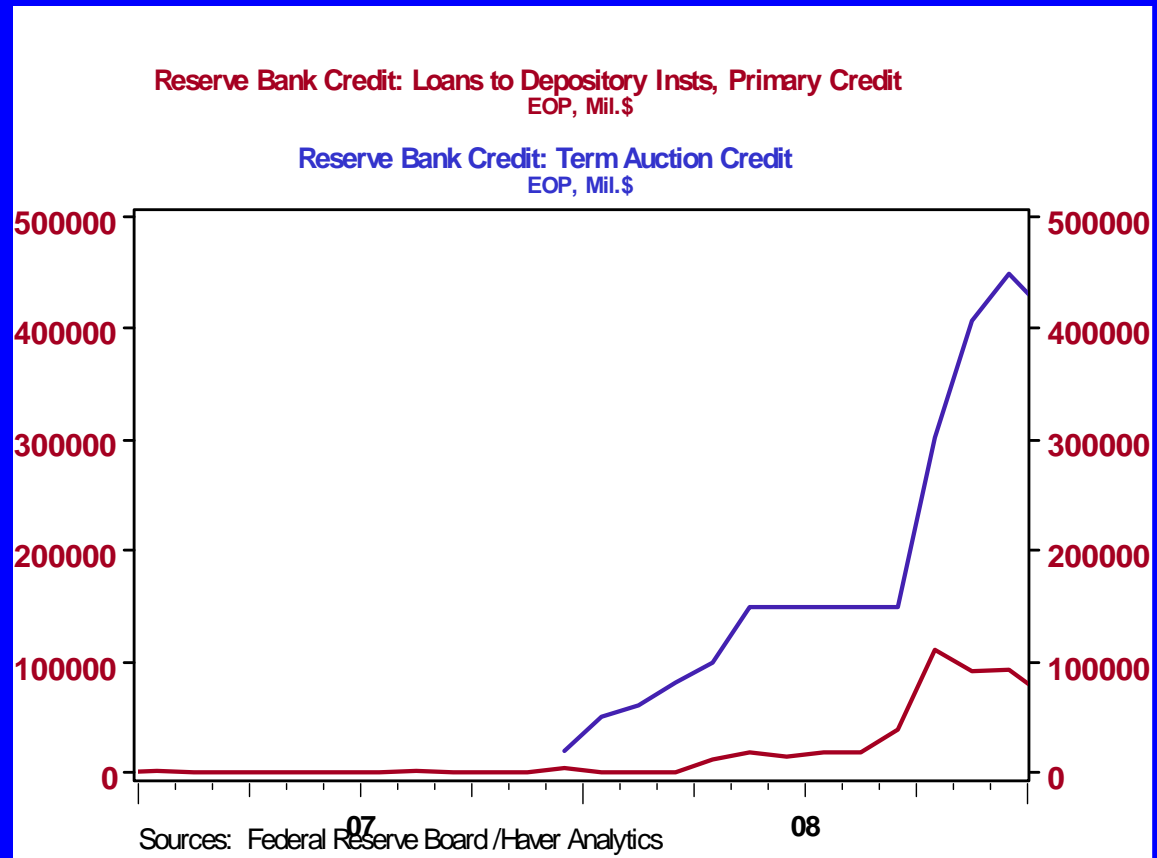
---

- ▣ Lend funds for relatively short periods to depository institutions
  - Eligibility:
    - ▣ Anyone who qualifies for “primary” credit (bank in good standing)
  - Rates:
    - ▣ Determined by competitive auction
  - Collateral:
    - ▣ All loans fully collateralized—must pledge collateral to the Fed; the Fed then applies “haircuts”
    - ▣ Same eligible collateral as was eligible for the primary credit facility
  - Term
    - ▣ Initially, all were 28 days
    - ▣ Later, extended to 84 days

# TAF: Why was it needed?

## ▣ Summer/Fall 2007

- Banks need short-term funds
- But aren't using the PCF
- “Stigma” of borrowing from CB
- A way of circumventing stigma—auction plus “safety in numbers”—a coordination strategy
- Did it work?



# A sample auction: January 12, 2008

---

**For release at 10:00 a.m. EST**

- ▣ On January 14, 2008, the Federal Reserve conducted an auction of \$30 billion in 28-day credit through its Term Auction Facility. Following are the results of the auction:
  - **Stop-out rate:** 3.95 percent
  - **Total propositions submitted:** \$55.526 billion
  - **Total propositions accepted:** \$30.000 billion
  - **Bid/cover ratio:** 1.85 ( $=55.526/30$ )
  - **Number of bidders:** 56
- ▣ The awarded loans will settle on January 17, 2008, and will mature on February 14, 2008. The stop-out rate shown above will apply to all awarded loans.

# Things changed over time—Jan 13, 2009

---

**For release at 10:00 a.m. EST**

- ▣ On January 12, 2009, the Federal Reserve conducted an auction of \$150 billion in 28-day credit through its Term Auction Facility. Following are the results of the auction:
  - **Stop-out rate:** 0.250 percent
  - **Total propositions submitted:** \$107.747 billion
  - **Total propositions accepted:** \$107.747 billion
  - **Bid/cover ratio:** 0.72
  - **Number of bidders:** 97
- ▣ The awarded loans will settle on January 15, 2009, and will mature on February 12, 2009. The stop-out rate shown above will apply to all awarded loans.

# Central Bank Liquidity Swaps

---

- ▣ Announced at the same time as TAF
- ▣ Which central banks?
  - At first, just the European Central Bank, Swiss National Bank
    - ▣ Later, added Reserve Bank of Australia, the Banco Central do Brasil, Bank of Canada, Danmarks Nationalbank, Bank of England, Bank of Japan, Bank of Korea, Banco de Mexico, Reserve Bank of New Zealand, Norges Bank, Monetary Authority of Singapore, Sveriges Riksbank
- ▣ What does it do?

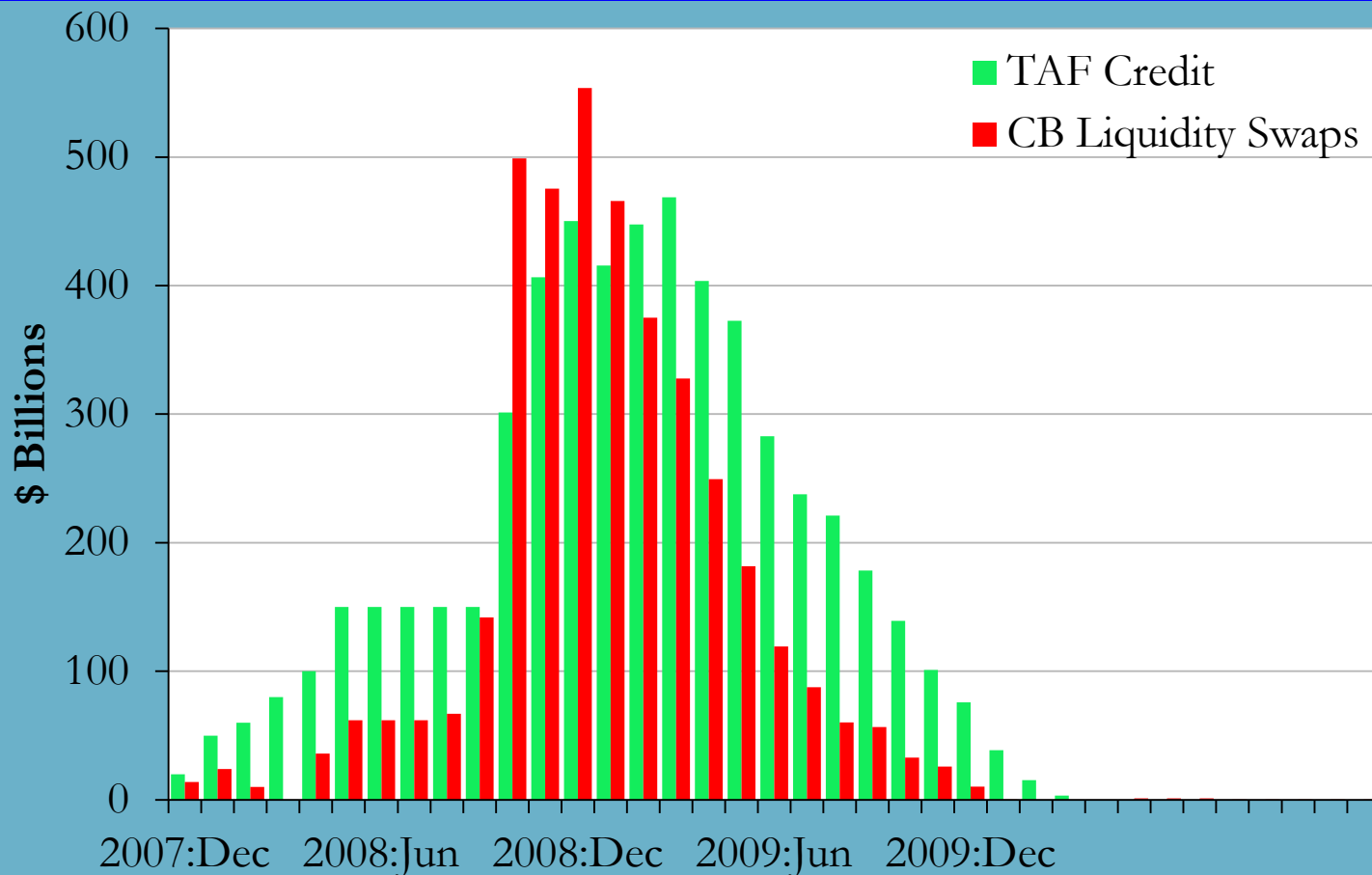
# CB Swaps, continued

---

## ▣ Two transactions:

- Foreign CB draws on swap line with the Fed, selling a specified amount of its currency to the Fed in exchange for dollars at the prevailing market exchange rate.
  - The Fed holds the foreign currency in an account at the foreign CB.
  - The dollars that the Fed provides are deposited in an account that the foreign CB maintains at the NY Fed.
  - At the same time, the Fed and the foreign CB agree to a second transaction that obligates the foreign CB to buy back its currency on a specified future date at the same exchange rate, plus interest.
  - (The second transaction undoes the first.)
  - Maturities range from overnight to three months.
- ▣ Note: When foreign CB takes the dollars and lends them to a private institution, this **IN NO WAY** causes the Fed to incur credit risk
- ▣ The only risk is if the foreign CB becomes insolvent/goes out of business/etc

# How big were these facilities?





# Why did Bear fail?

---

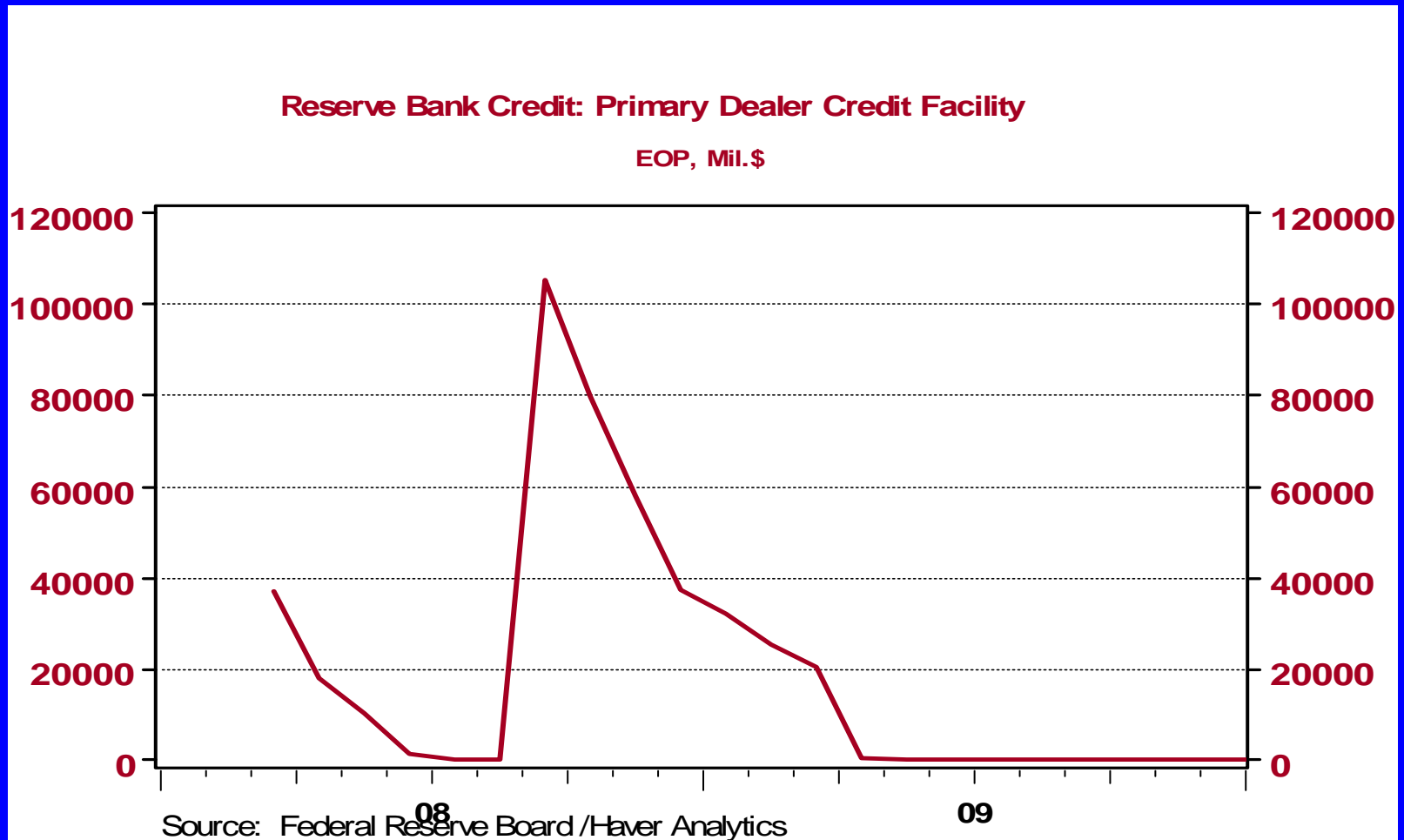
- ▣ The investment bank model
  - Raise funds in short-term (low interest rate) markets
  - Purchase longer-term (high interest rate) assets
  - Make money
- ▣ Why is this risky?
  - Short-term funding is “runnable”
    - In this case, concerns over B-S’s exposure to mortgages made short-term lenders reluctant to lend
    - In a very short period of time, Bear didn’t have enough money to continue operating
    - A liquidity problem, but motivated by underlying credit concerns
- ▣ Note: It’s not just I-Banks that use this funding model

# Primary Dealer Credit Facility

---

- ▣ Who are primary dealers?
  - Banks and brokerage firms that trade US government securities with the Federal Reserve (the NY Fed “Desk”)
- ▣ What’s the PDCF?
  - An overnight, fully-secured lending facility
  - Collateral subject to haircuts
- ▣ “to improve the ability of primary dealers to provide financing to participants in securitization markets and promote the orderly functioning of financial markets more generally.”
- ▣ Rate = primary credit rate
- ▣ Range of collateral accepted
  - All collateral eligible for tri-party repurchase agreements arranged by the Federal Reserve Bank of New York
  - All investment-grade corporate securities, municipal securities, mortgage-backed securities and asset-backed securities for which a price is available.
- ▣ The last condition is unusual, but was necessary

# Size of the PDCF program



# Why all this problem with short-term funding?

---

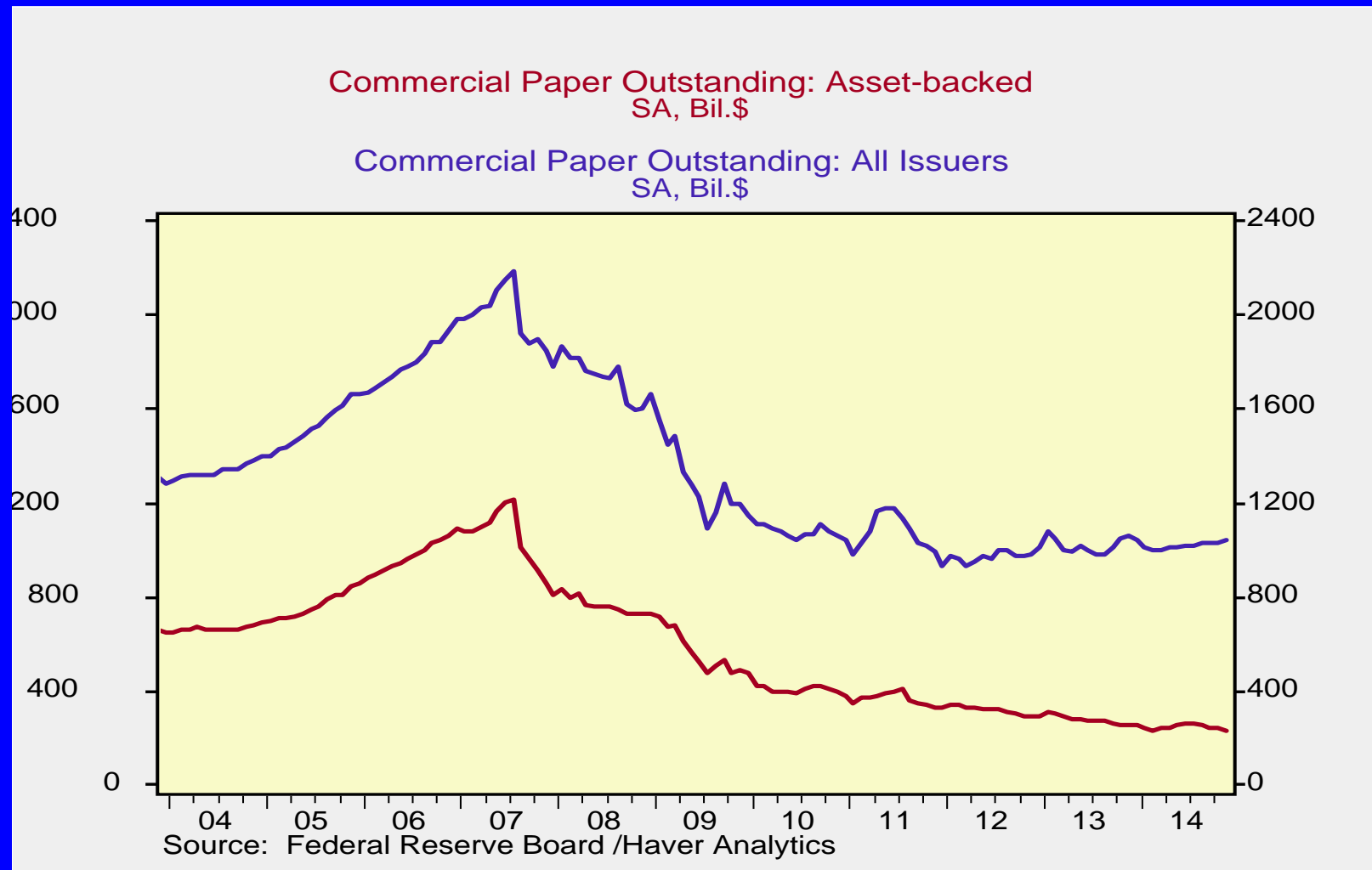
- ▣ It was a function of exposure to mortgage securities
  - Libor market: Large, usually stable counterparties, borrowing for 1-3 months
    - ▣ But what if they had lots of mortgage securities?
    - ▣ Could become insolvent quickly, and repayment at risk
  - Banks/TAF borrowers
    - ▣ Large mortgage exposures
    - ▣ “Emergency” short-term borrowing would signal weakness
  - Primary dealers
    - ▣ Had mortgage exposure
    - ▣ Needed to raise funds nearly every day in credit markets
    - ▣ What if their exposure was larger than was widely known?

# Commercial paper and MMMFs: The tentacles of Lehman

---

- ▣ Recall the MMMF business model
  - Take in deposits (uninsured)
  - Invest in higher-yielding, but still short-term stuff
    - ▣ A fair amount in “asset-backed commercial paper”
    - ▣ What is that?
      - Regular CP: backed by the good faith of the company (GE, GM)
      - Pays a modest return
      - Asset-backed: backed by assets, such as mortgages
      - Pays a somewhat higher return
      - Investors like it, because it can be rated “AAA” = safe, and earns a somewhat better return
      - MMMFs invested a fair amount in it (about 1/2 of ABCP issue at peak)
  - A large chunk of ABCP was Lehman’s CP

# How big is (was) this market?



# What happened?

---

- ▣ A MMMF “broke the buck”
  - Made other depositors worry about getting their money out dollar-for-dollar
  - A “run” on MMMFs
  - Why is that a problem?
    - ▣ To meet the redemption requests of depositors, MMMFs have some cash on hand (usually about 10%)
    - ▣ Once that’s exhausted, need to sell some investments
    - ▣ But if those investments are ABCP (with MBS), who wants to buy them?
    - ▣ This is a problem

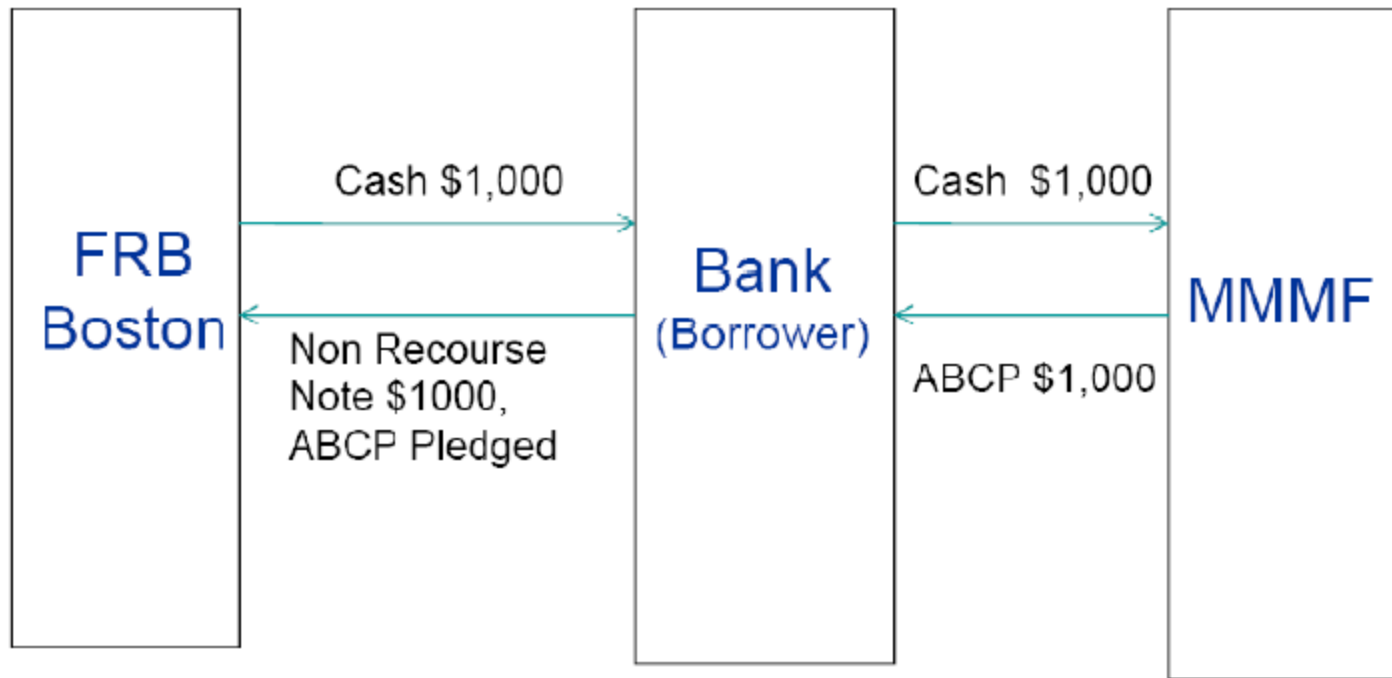
# Boston Fed to the rescue!

---

- ▣ The AMLF (Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility)
- ▣ What did it do?
  - We can't lend directly to MMFs
  - So we lent to their banks
  - Who used the proceeds of the loan to purchase ABCP from MMMFs
  - They paid us the loan interest (less than 1%) and earned the interest on the ABCP (3-4%)
  - Not a bad deal
  - Stopped the run on MMMFs



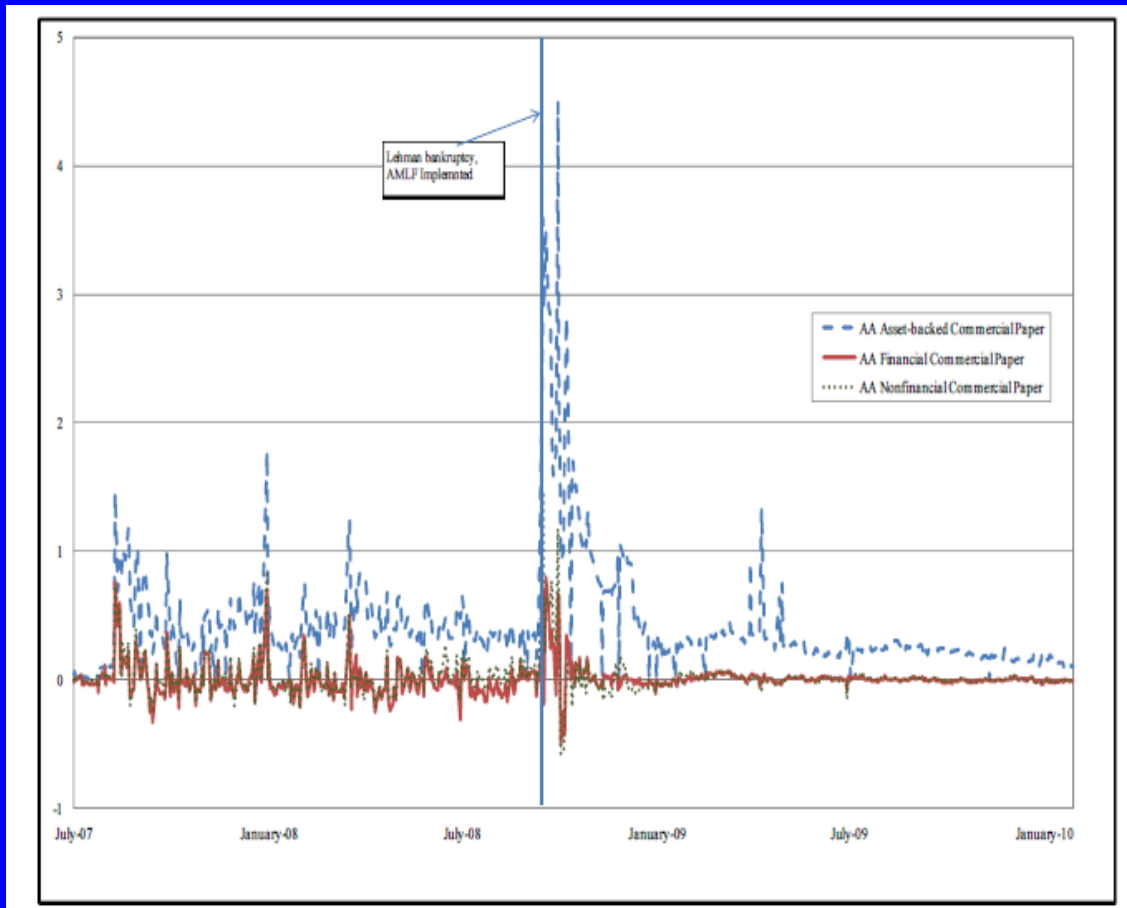
# Schematic of the AMLF



See Duygan-Bump, Parkinson, Rosengren, Suarez, Willen (2010) "How Effective Were the Federal Reserve Emergency Liquidity Facilities? Evidence from the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility," Working Paper No. QAU10-3 *Federal Reserve Bank of Boston*

# Signs of success

Spreads of overnight commercial paper over the effective fed funds rate



- ▣ Stabilized MMMF industry
- ▣ Losses to Fed:
  - 0
- ▣ All loans repaid in full, balance now down to zero
- ▣ Questions:
  - What would work as a backstop next time?
  - Do we need one?

# The other commercial paper facility

---

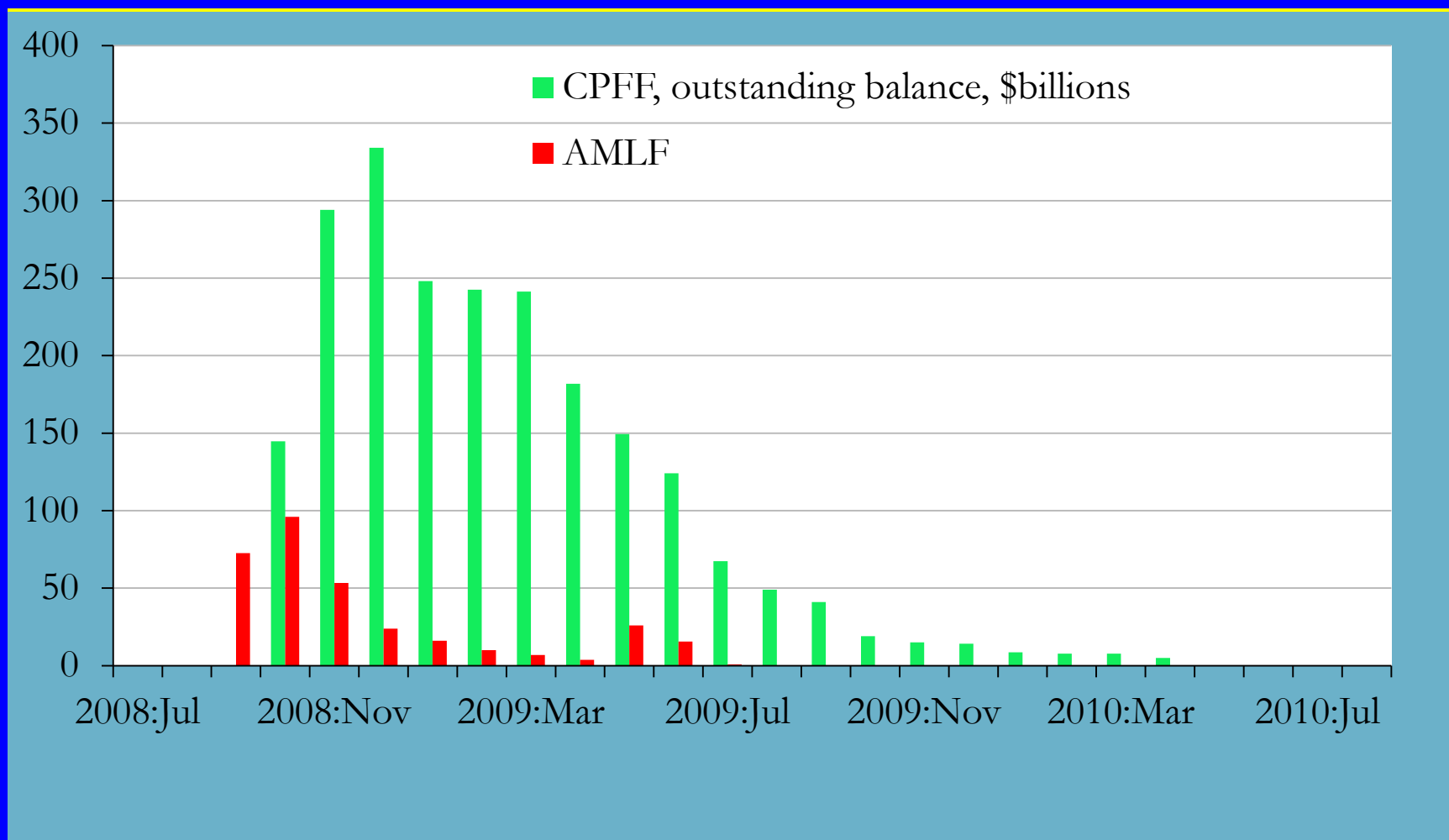
- ▣ At the same time, others who issued commercial paper had difficulties placing the paper
- ▣ Finance companies (GE Capital, GMAC) who issue commercial paper for large nonfinancial firms, also needed a place to sell CP
  - Often had to “roll over” CP daily—that’s not fun
- ▣ NY Fed set up the Commercial Paper Funding Facility (CPFF)
  - Once again, we couldn’t lend directly to CP issuers
  - So we set up a special “vehicle,” the CPFFF

# How the CPFF worked

---

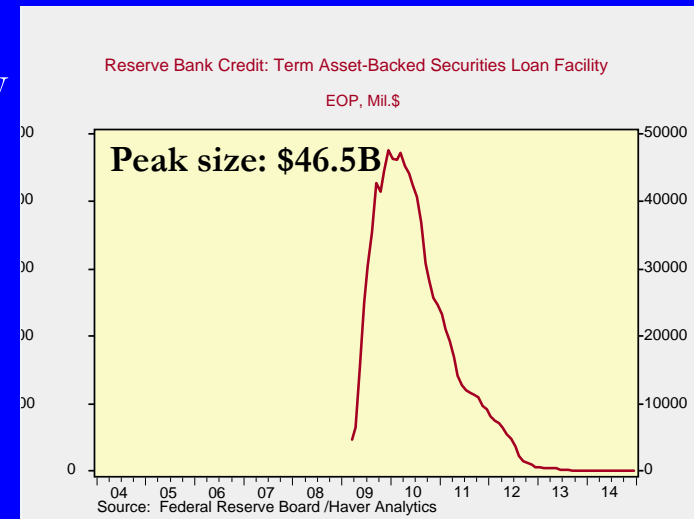
- ▣ The Fed set up a “Special-Purpose Vehicle” to which the Fed lent through a new credit facility, under a 13(3) exception (recourse loans, secured by all the assets of the SPV)
- ▣ Terms
  - SPV purchases three-month new-issue U.S. dollar-denominated commercial paper through the New York Fed’s primary dealers from eligible issuers (or repurchase outstanding CP)
  - Eligible: U.S. issuers of commercial paper, domestic or foreign
  - Rated at least A-1/P-1/F1 by rating agency (with a few complications)
  - Amount limited by maximum issuance of borrower over fixed period
  - Rate on loan: Penalty rate compared to normal times
- ▣ CPFF holds CP to maturity, then sells to pay back loan to Fed
- ▣ Private manager (PIMCO) and administrator/custodian (State Street) hired to run SPV

# How big did these programs get?



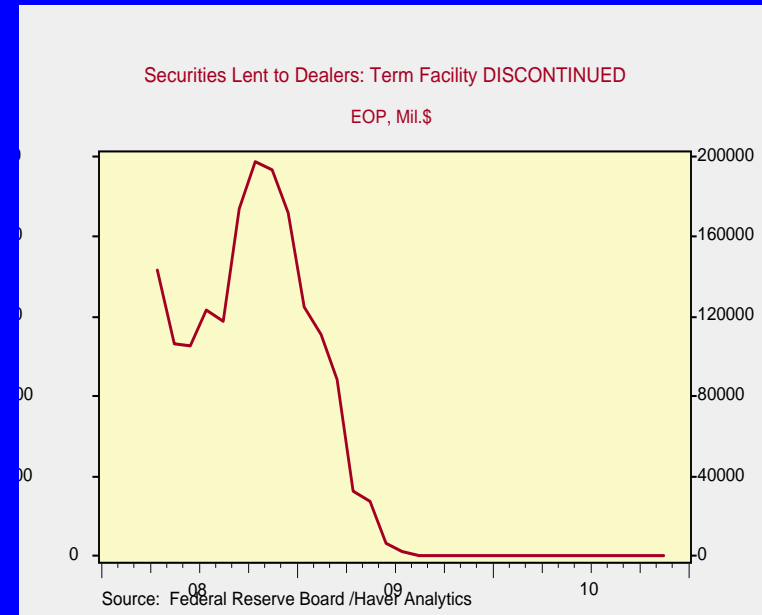
# The Fed's program to help with securitized markets: TALF

- ▣ Term asset-backed securities loan facility (announced November 2008)
- ▣ A “13(3)” facility (couldn't do this in normal times)
- ▣ The plan:
  - Make loans of up to 5 years to institutions who wished to purchase ABS
    - ▣ Why? Issuers were having a hard time selling ABS
  - Included a host of asset-backed securities, backed by
    - ▣ Student loans
    - ▣ Auto loans (including floor plan financing loans)
    - ▣ Credit cards
    - ▣ Small business administration (SBA)-guaranteed loans
    - ▣ Commercial mortgages (approved later)
- ▣ Credit risk to the Fed?
  - TARP money backs up, so some credit insurance
- ▣ Later expanded list of eligible assets
  - Business equipment, vehicle leases, “legacy securities”, i.e. “toxic assets”



# The Term Securities Lending Facility (TSLF)

- ▣ Weekly loan facility, 28-day term loans.
- ▣ “...intended to promote liquidity in the financing markets for Treasury and other collateral”
- ▣ Offer to lend Treasury securities held by the System Open Market Account (SOMA) over a one-month term against other program-eligible general collateral (less-liquid, lower-quality assets)
- ▣ For primary dealers, rate based on a competitive single-price auction (highest rates considered first, up to aggregate offering amount)
- ▣ No impact on reserve levels—in essence, exchange GC Treasury issues for other eligible assets



# Back to Fed restrictions: How did these apply to Fed programs?

---

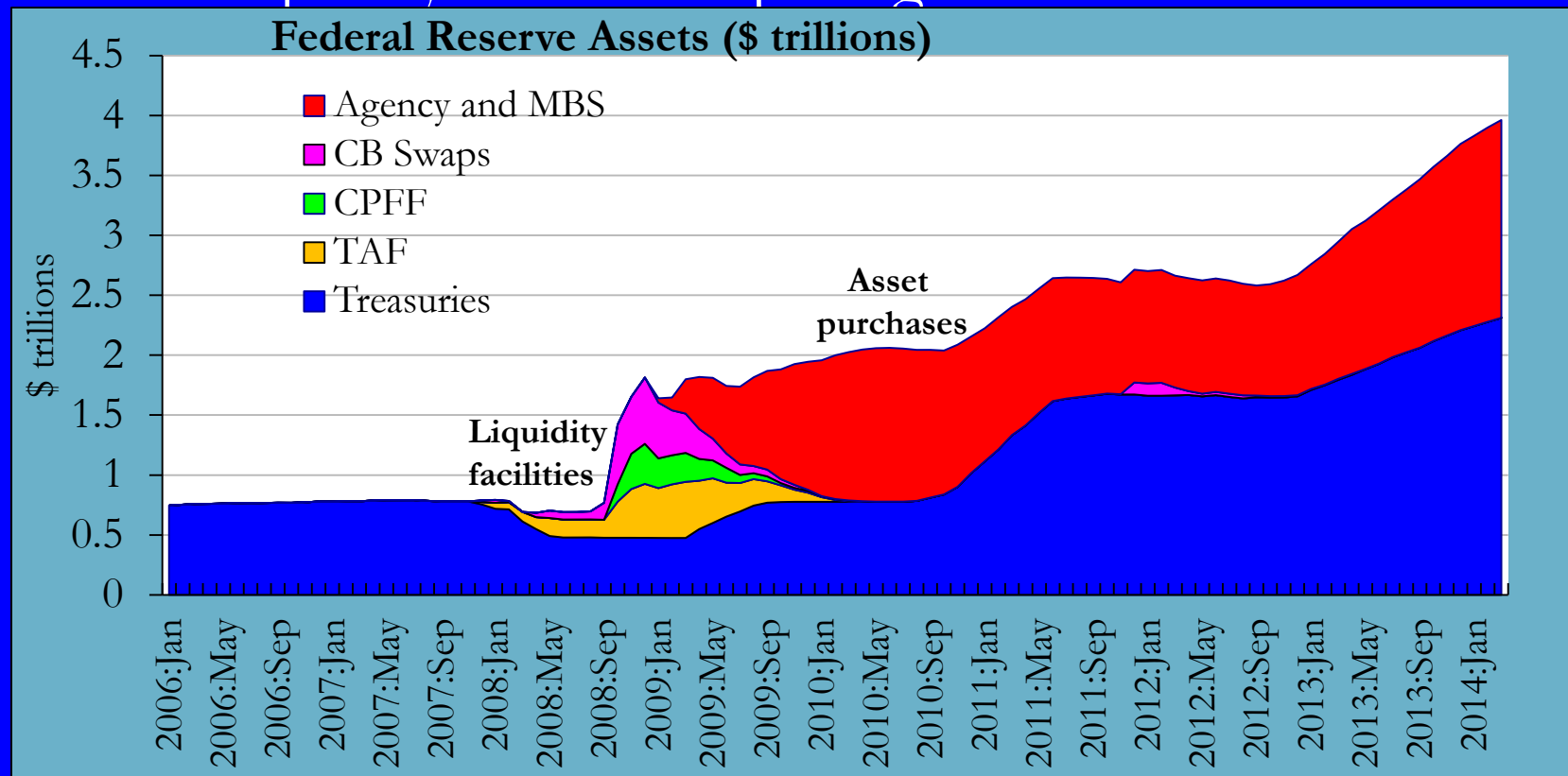
- ▣ TAF
  - Not a 13(3) facility; Depository institutions only
  - Lending still requires standard collateral, with haircuts
  - *Process* for distributing funds changed (auction)
- ▣ AMLF
  - **Not** a 13(3) facility (lending to depository institutions)
  - Still only a lending program, collateralized loans, with collateral quality as specified (ABCP with an A1/P1/F1 rating), to satisfaction of the lending Reserve Bank
- ▣ CPFF\*
- ▣ TALF\*
  - Sets up a new LLC
  - 13(3) facility (lend to ABS issuers), collateral is the ABS in eligible categories
  - Haircuts applied to collateral
  - Up to five year non-recourse loans
  - There is an up-front fee, which helped capitalize the LLC at first
  - Planned up to \$1T, actually backed about \$50B
- ▣ TSLF
  - Standard collateral requirements, 28-day vs. normal overnight term, GC versus specific issues
  - Not a 13(3) facility



FROM LIQUIDITY POLICIES  
TO MACRO POLICIES:  
MONETARY POLICY PHASE II  
(NOVEMBER 25, 2008-TODAY)

# Financial worries not over, but short-term problems are receding

## ▣ Fed liquidity facilities tapering off ...

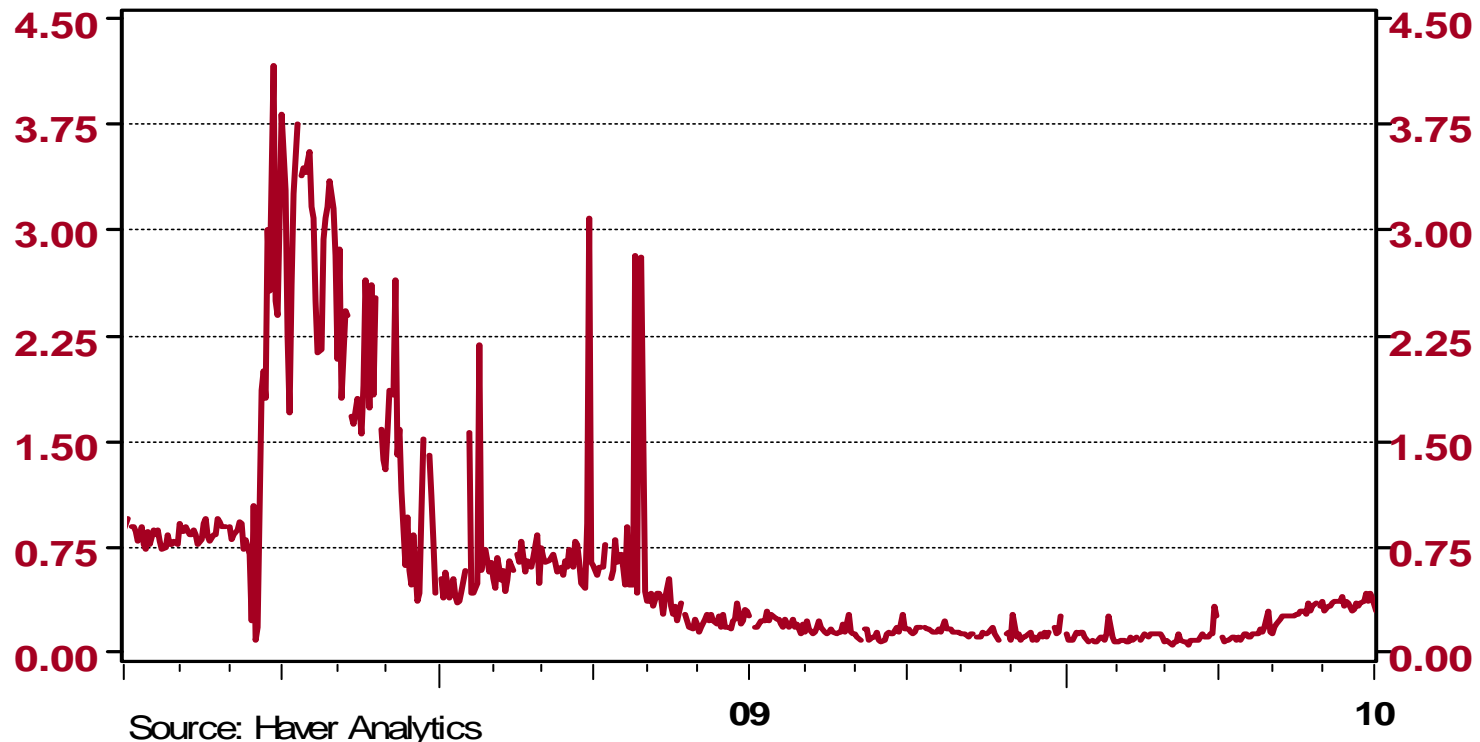


## ▣ ...largely because they were priced to be unattractive in normal times

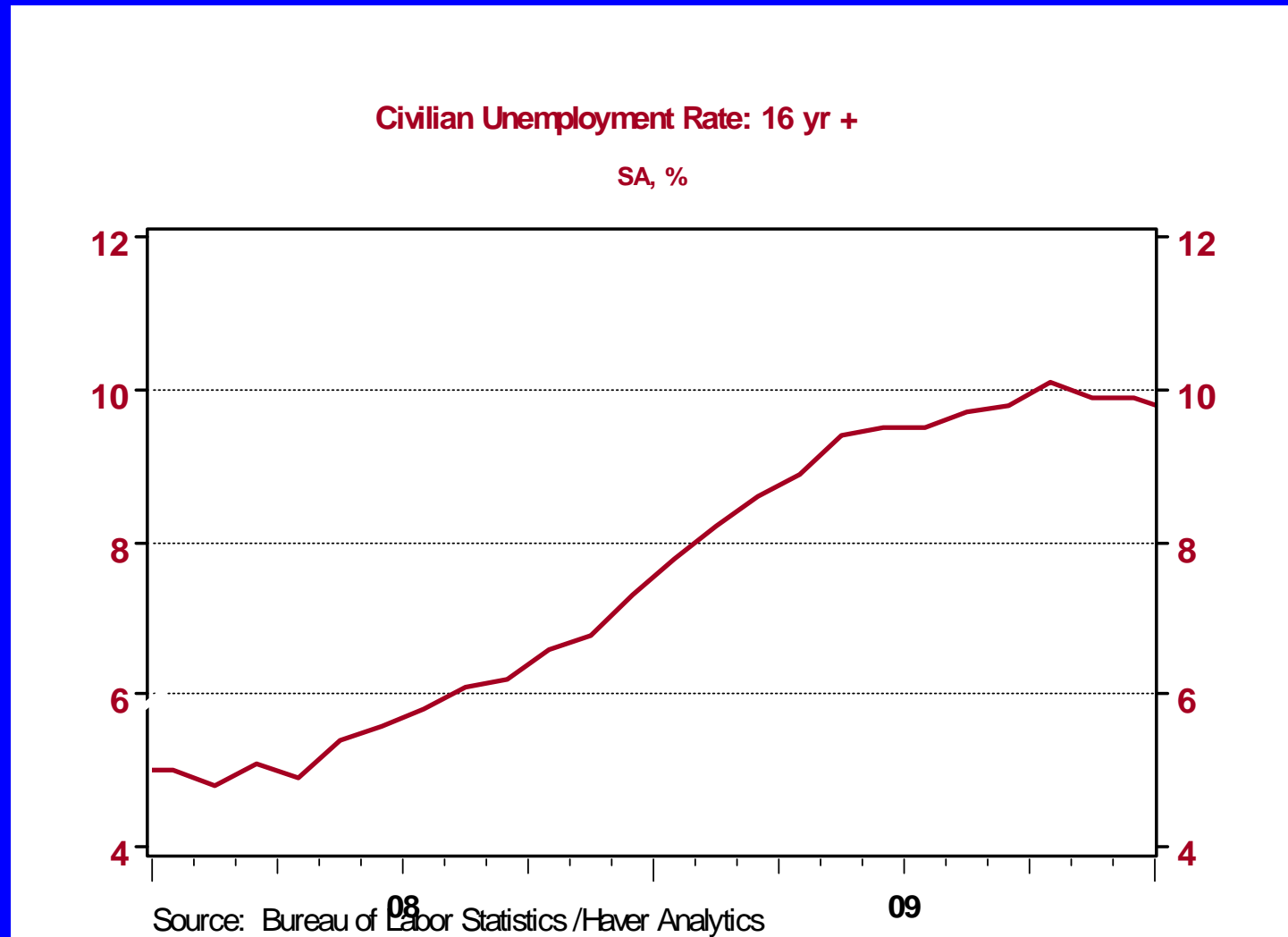
# Short-term financial problems receding...

- ▣ ... and spreads are easing

90-day ABCP yield less fed funds rate



# ...while real-side worries are rising



# We're at the ZLB, so what to do?

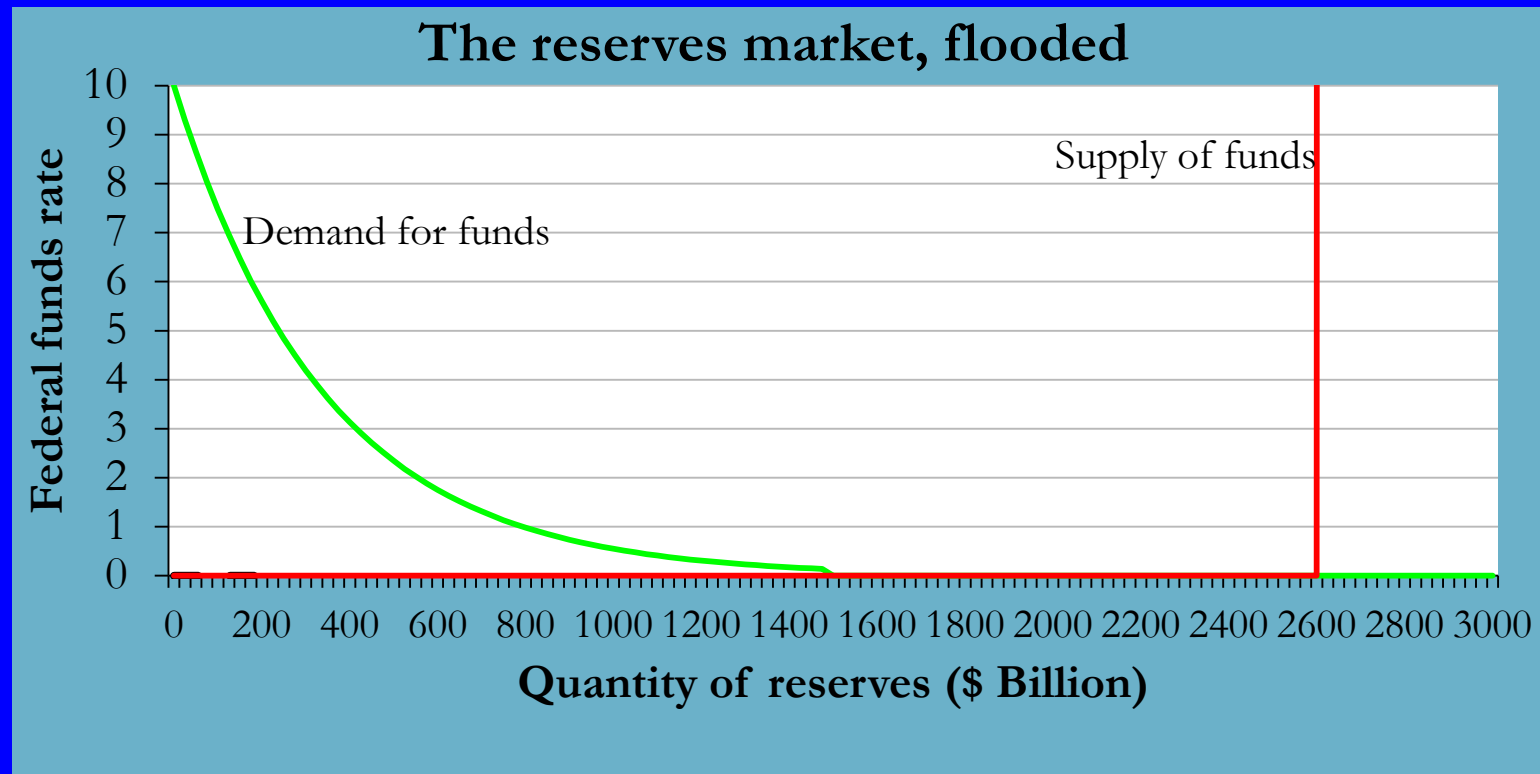
---

- ▣ Crisis has moved from financial/liquidity to real
- ▣ Conventional stimulus has done all it can
- ▣ The LSAP (large-scale asset purchase program)
- ▣ Announced November 25, 2008
  - Amount: \$500B of GSE-backed mortgage securities; \$100B of GSE's direct obligations (their bonds)
  - Goals: “Reduce cost and increase availability of credit for purchasing houses...support housing markets and ... improve conditions in financial markets more generally”

# The “Liquidity Trap”

Not possible to use conventional funds rate policy

- ▣ Not with this size balance sheet
  - So many funds available to lend/borrow that the funds rate is essentially pinned at zero



# What's the theory behind the LSAPs/QE?

---

- ▣ We purchase safe, long-duration assets
- ▣ There does not exist an infinite supply of perfect substitutes for these assets
- ▣ Thus reducing the supply available to the private market bids up their prices, lowers their yields
- ▣ This has some effect on other long-term interest rates
- ▣ Which stimulates the economy
- ▣ What about the signaling effect?
  - Come back to this

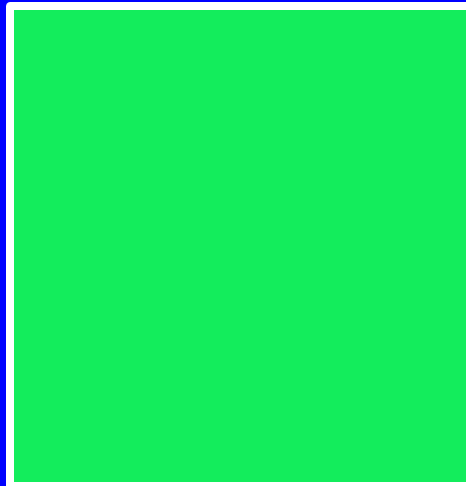
# How does QE work?

The stock that we hold is what matters most

---

- ▣ We buy long-term assets
  - Removes them from circulation in private markets
  - But private agents still want them
  - So they're willing to accept them for a lower yield
- ▣ Bottom line: we're trying to reduce long-term rates (and associated asset prices)

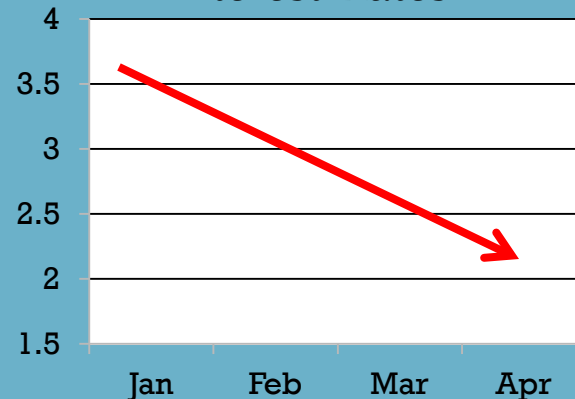
Fed's Securities



Private Markets' Securities



Interest Rates





# More on QE

---

- ▣ Early in 2009, amounts are expanded
  - March 18 FOMC meeting:
    - ▣ Additional \$750B of purchases, up to \$1.25T
- ▣ Fed goes to all two-day meetings for rest of 2009
- ▣ What are the effects on markets and the Fed's balance sheet?

# The QE Period

---



- ▣ “Do what it takes?”
- ▣ Sequence of communications
  - First, size of purchases indicated
  - Then, calendar date conditionality
  - Finally, economic conditionality
  - But the line was always blurred

# What we did and how we communicated

---

Date	Key pt.	Statement language
Jan. 2009	Whatever it takes	the Committee “will employ all available tools to promote the resumption of sustainable economic growth and to preserve price stability.”
	Goals	“The focus of the Committee's policy is to support the functioning of financial markets and stimulate the economy...”
		[The Fed] “...continues to purchase large quantities of agency debt and mortgage-backed securities to provide support to the mortgage and housing markets, and it stands ready to expand the quantity of such purchases and the duration of the purchase program as conditions warrant.”
	Treasury securities may be added	“The Committee also is prepared to purchase longer-term Treasury securities if evolving circumstances indicate that such transactions would be particularly effective in improving conditions in private credit markets.”

# What we did and how we communicated

Date	Key pt.	Statement language
Mar. 2009	Increase size of program, add Treasuries to the mix	<p>“To provide greater support to mortgage lending and housing markets, the Committee decided today to increase the size of the Federal Reserve’s balance sheet further by <u>purchasing up to an additional \$750 billion of agency mortgage-backed securities, bringing its total purchases of these securities to up to \$1.25 trillion</u> this year, and to increase its purchases of agency debt this year by up to \$100 billion to a total of up to \$200 billion. Moreover, to help improve conditions in private credit markets, the Committee decided to purchase up to \$300 billion of longer-term Treasury securities over the next six months.”</p>
Apr. 2009	Forward guidance	<p>[funds rate at 0 to 1/4 percent] “... and anticipates that economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an <b><u>extended period.</u></b>”</p>
Aug. 2009	Tapering round one	<p>“To promote a smooth transition in markets as these purchases of Treasury securities are completed, the Committee has decided to gradually slow the pace of these transactions and anticipates that the full amount will be purchased by the end of October.</p>

# What we did and how we communicated

Date	Key pt.	Statement language
Dec. 2009	Tapering	“In order to promote a smooth transition in markets, the Committee is gradually slowing the pace of these purchases, and it anticipates that these transactions will be executed by the end of the first quarter of 2010.”
Mar. 2010	Reiterate	“...and the remaining transactions will be executed by the end of this month.”
	End of liquidity programs	And by the way: “...the Federal Reserve has been closing the special liquidity facilities that it created to support markets during the crisis.” (only the TALF remains)
Aug. 2010	Initial worries about needing more--reinvest	“To help support the economic recovery ..., the Committee will keep constant the Federal Reserve's holdings of securities ...by reinvesting principal payments from agency debt and agency mortgage-backed securities in longer-term Treasury securities. The Committee will continue to roll over the Federal Reserve's holdings of Treasury securities as they mature.”

# What we did and how we communicated

---

Date	Key pt.	Statement language
Nov. 2010	Purchase more Treasury securities	“To promote a stronger pace of economic recovery and to help ensure that inflation, over time, is at levels consistent with its mandate, the Committee decided today to expand its holdings of securities...the Committee intends to purchase a further \$600 billion of longer-term Treasury securities by the end of the second quarter of 2011, a pace of about \$75 billion per month.”
June 2011	End those purchases	“The Committee will complete its purchases of \$600 billion of longer-term Treasury securities by the end of this month and will maintain its existing policy of reinvesting principal payments from its securities holdings.”
Aug. 2011	Forward guidance-calendar based	“The Committee currently anticipates that economic conditions--including low rates of resource utilization and a subdued outlook for inflation over the medium run--are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013.”

# What we did and how we communicated

---

Date	Key pt.	Statement language
Sep. 2011	Twist 2 announced	Twist 2: “To support a stronger economic recovery and to help ensure that inflation, over time, is at levels consistent with the dual mandate, the Committee decided today to extend the average maturity of its holdings of securities. The Committee intends to purchase, by the end of June 2012, \$400 billion of Treasury securities with remaining maturities of 6 years to 30 years and to sell an equal amount of Treasury securities with remaining maturities of 3 years or less.”
Nov., Dec. 2011	Continue Twist	
Jan. 2012	Extend forward guidance	“In particular, the Committee decided today to keep the target range for the federal funds rate at 0 to 1/4 percent ... at least through late 2014.”



# What we did and how we communicated

Date	Key pt.	Statement language
June 2012	Extend Twist	“The Committee also decided to continue through the end of the year its program to extend the average maturity of its holdings of securities.”
Sep. 2012	QE3, new forward guidance	<p>1. To support a stronger economic recovery...the Committee agreed today to increase policy accommodation by purchasing additional agency mortgage-backed securities at a pace of \$40 billion per month. The Committee also will continue through the end of the year its program to extend the average maturity of its holdings of securities ...These actions... together will increase the Committee’s holdings of longer-term securities by about \$85 billion each month through the end of the year...”</p> <p>2. The Committee “exceptionally accommodative policy will remain appropriate for a considerable time after the economic recovery strengthens,” “currently anticipates that exceptionally low levels for the federal funds rate are likely to be warranted at least through mid-2015.”</p>
	Conditions	“If the outlook for the labor market does not improve substantially, the Committee will continue its purchases...”
	Costs, efficacy	“In determining the size, pace, and composition of its asset purchases, the Committee will... take account of the likely efficacy and costs...”



# What we did and how we communicated

---

Date	Key pt.	Statement language
Dec. 2012	Economic thresholds for QE3	<p>“...the Committee expects that a highly accommodative stance of monetary policy will remain appropriate for a considerable time <u>after the asset purchase program</u> ends and the economic recovery strengthens. In particular, the Committee decided to keep the target range for the federal funds rate at 0 to 1/4 percent and currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least <u>as long as the unemployment rate remains above 6-1/2 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee’s 2 percent longer-run goal, and longer-term inflation expectations continue to be well anchored.</u> ... When the Committee decides to begin to remove policy accommodation, it will take a balanced approach consistent with its longer-run goals of maximum employment and inflation of 2 percent.</p>

# What we did and how we communicated

Date	Key pt.	Statement language
Apr. 2013	Suggest purchases may be increased or decreased (tapering?)	“The Committee is prepared to increase or reduce the pace of its purchases to maintain appropriate policy accommodation as the outlook for the labor market or inflation changes. In determining the size, pace, and composition of its asset purchases, the Committee will continue to take appropriate account of the likely efficacy and costs of such purchases as well as the extent of progress toward its economic objectives.”
Sep. 2013	Recognize inflation risks  No Taper yet	“The Committee recognizes that inflation persistently below its 2 percent objective could pose risks to economic performance, but it anticipates that inflation will move back toward its objective over the medium term.”  “the Committee sees the improvement in ... labor market conditions since it began its asset purchase program ... However, the Committee decided to await more evidence that progress will be sustained before adjusting the pace of its purchases.”

# What we did and how we communicated

---

Date	Key pt.	Statement language
Dec. 2013	Tapering begins	“In light of the cumulative progress toward maximum employment and the improvement in the outlook for labor market conditions, the Committee decided to modestly reduce the pace of its asset purchases...” [to \$40/35 from 45/40 MBS/Treasuries]
	Condition-ing, caveats	“If incoming information broadly supports the Committee's expectation of ongoing improvement in labor market conditions and inflation moving back toward its longer-run objective, the Committee will likely reduce the pace of asset purchases in further measured steps at future meetings. However, asset purchases are not on a preset course...”
	It'll be a while	The Committee continues to anticipate ... that it likely will be appropriate to maintain the current target range for the federal funds rate well past the time that the unemployment rate declines below 6-1/2 percent, especially if projected inflation continues to run below the Committee's 2 percent longer-run goal
Jan-Jun	Steady as she goes	Continue tapering, note inflation risks, note continued progress in labor markets. Note change in guidance at Mar. 2014 meeting:

# What we did and how we communicated

---

Date	Key pt.	Statement language
Mar. 2014	Update guidance	“With the unemployment rate nearing 6-1/2 percent, the Committee has updated its forward guidance. The change in the Committee's guidance does not indicate any change in the Committee's policy intentions as set forth in its recent statements.”
Sep. 2014	Ending tapering at next meeting	“If incoming information broadly supports the Committee's expectation of ongoing improvement in labor market conditions and inflation moving back toward its longer-run objective, the Committee will end its current program of asset purchases at its next meeting.”
Oct. 2014	Tapering ended, note economic conditions around “considerable time”	“...if incoming information indicates faster progress toward the Committee's employment and inflation objectives than the Committee now expects, then increases in the target range for the federal funds rate are likely to occur sooner than currently anticipated. Conversely, if progress proves slower than expected, then increases in the target range are likely to occur later than currently anticipated.”

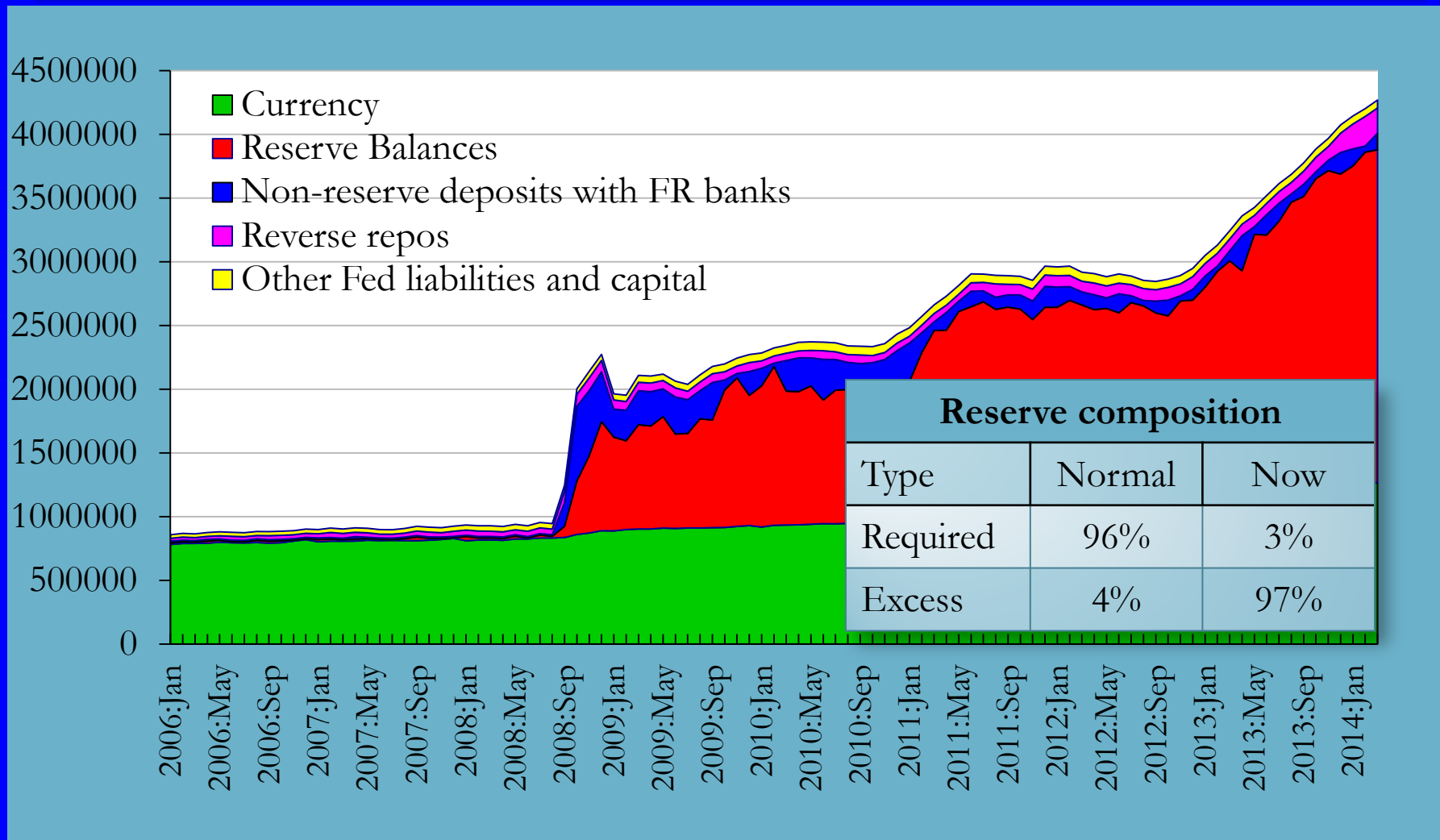
# What we did and how we communicated

---

Date	Key pt.	Statement language
Dec. 2014	Alter forward guidance—less date-dependent, more data-dependent?	<p>“Considerable period” → “Patience” in removing monetary accommodation.</p> <p>“Based on its current assessment, the Committee judges that it can be patient in beginning to normalize the stance of monetary policy. The Committee sees this guidance as consistent with its previous statement that it likely will be appropriate to maintain the 0 to 1/4 percent target range for the federal funds rate for a considerable time following the end of its asset purchase program in October, especially if projected inflation continues to run below the Committee's 2 percent longer-run goal, and provided that longer-term inflation expectations remain well anchored.”</p>

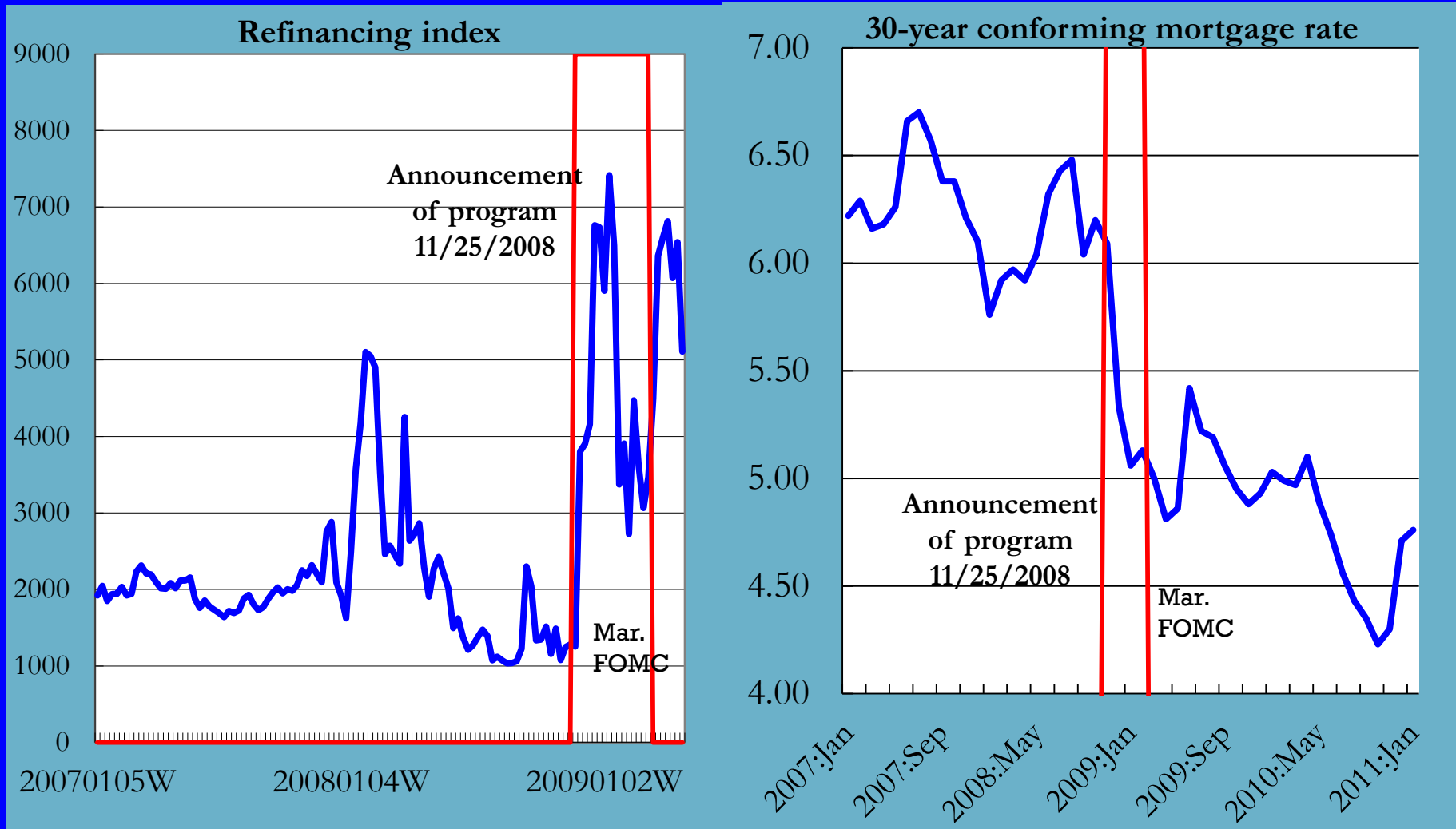
# Effects of QE

## Fed's balance sheet: Liabilities side



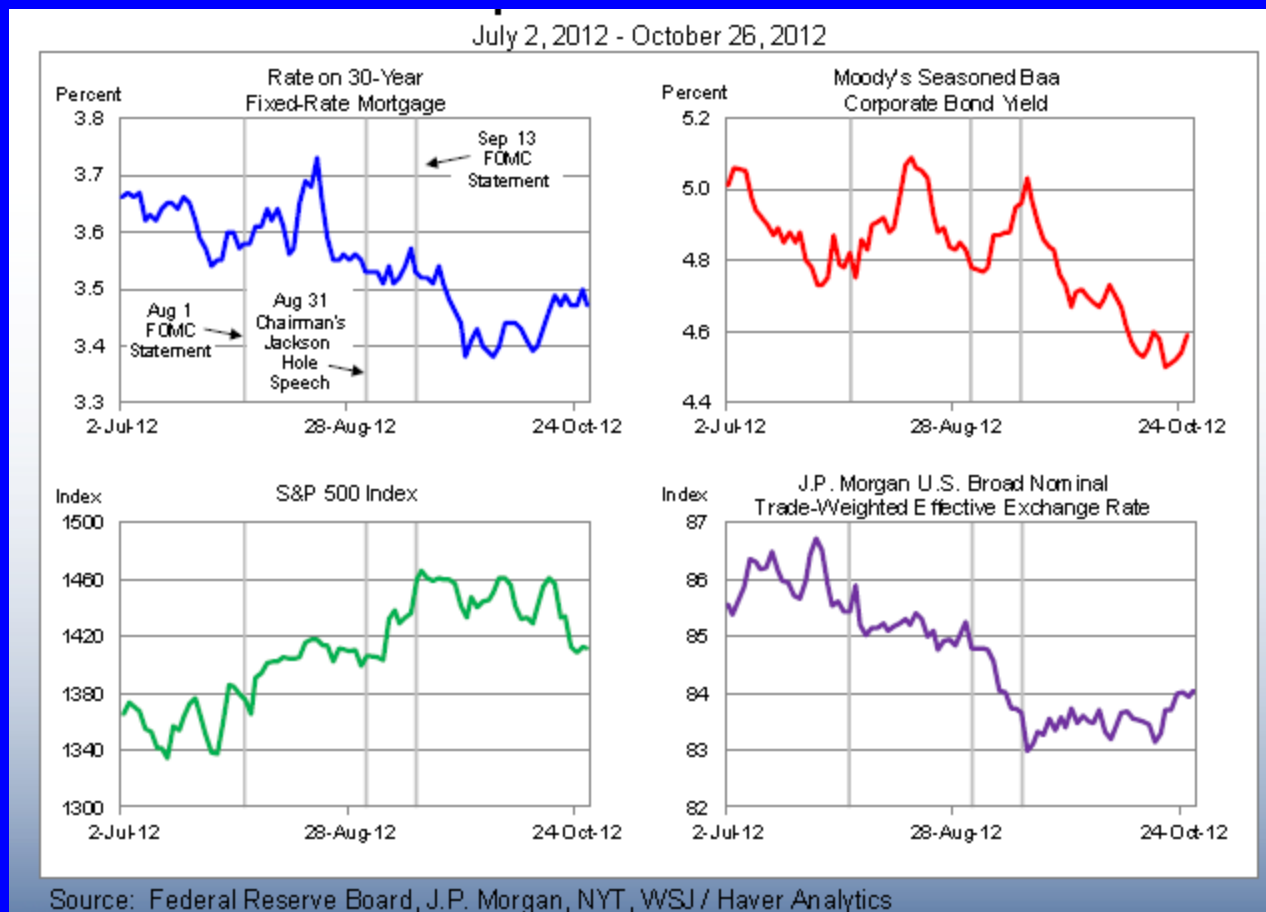


# Effects on the markets—the first purchases (QE1)



# Effects on key interest rates and asset prices, QE 3

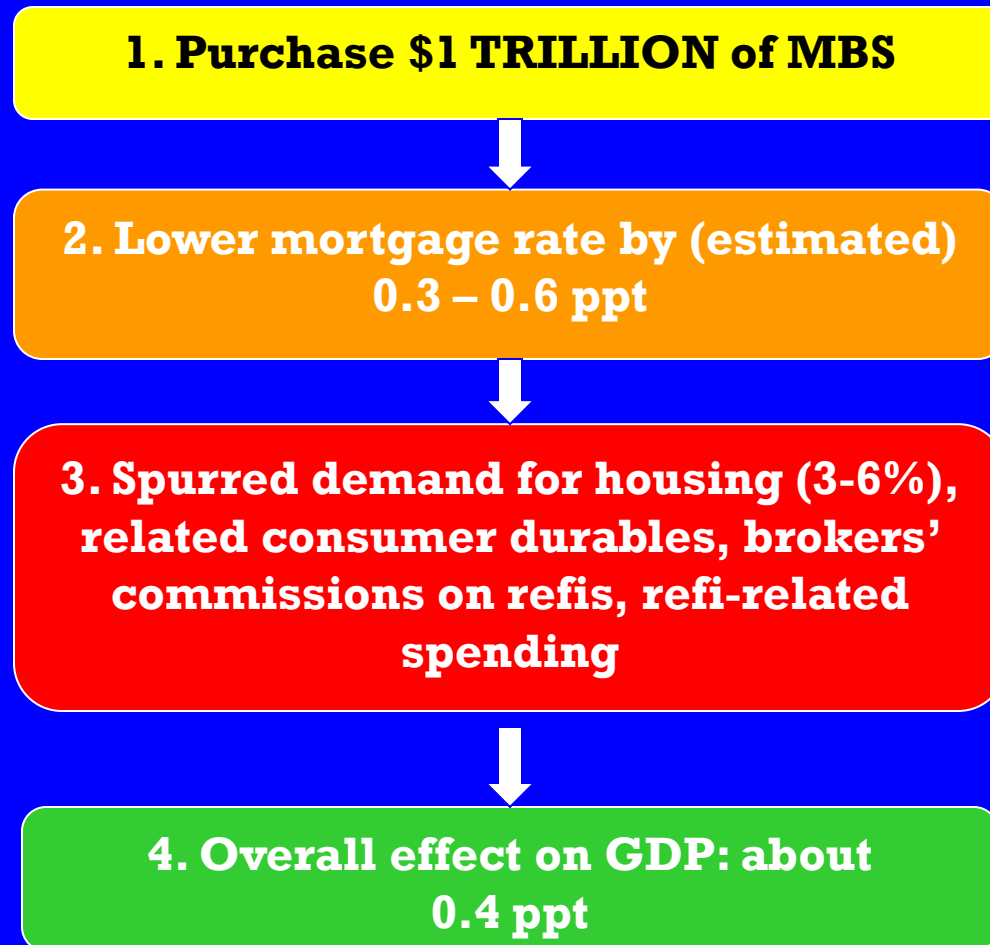
- Can we affect interest rates, exchange rate, etc?
  - Can't be 100% sure, but it looks like the answer is “YES”





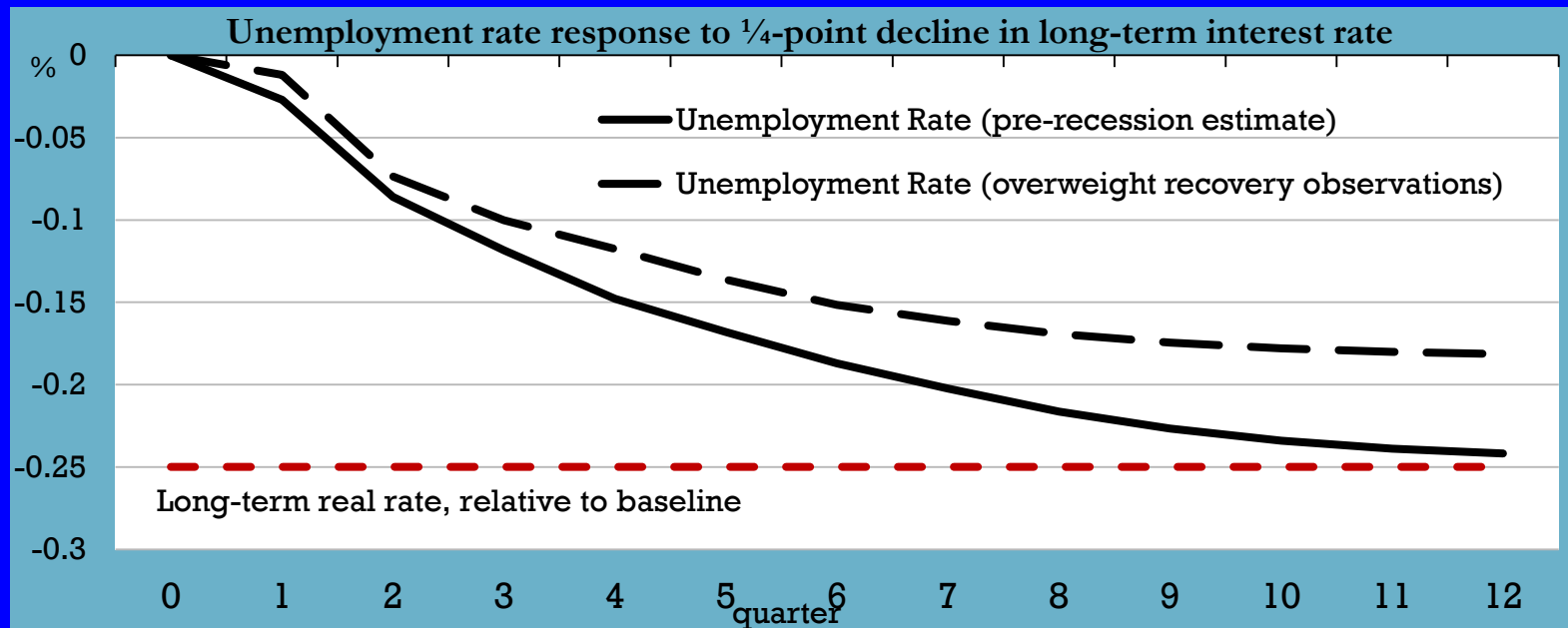
# Quantifying the effects of QE on the economy (model-based estimates)

---



# SVAR-based estimate of real rate effects, pre- and post-recession

- ▣ The effect of rates on output and employment has likely changed only modestly in recent years



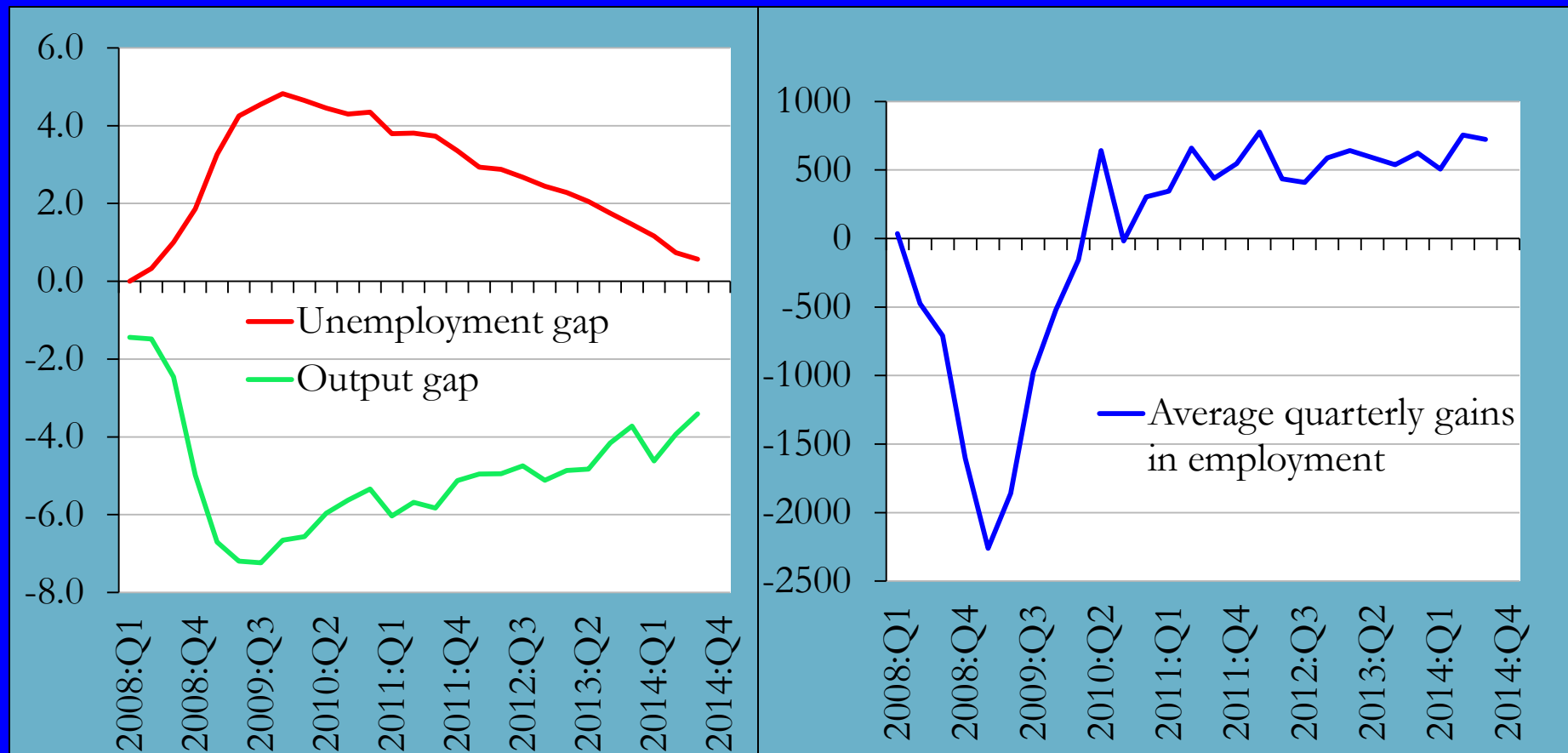
- ▣ But our actions have taken a different form—direct purchase of long bonds, versus indirect effects via short rates—does that matter?

# Selected references for quantifying QE effects

---

- ▣ A Krishnamurthy, A Vissing-Jorgensen “The effects of quantitative easing on interest rates: channels and implications for policy” NBER working paper, 2011
- ▣ S D'Amico, TB King, “Flow and stock effects of large-scale treasury purchases: Evidence on the importance of local supply,” *Journal of Financial Economics*, 2013
- ▣ John Williams, “The Federal Reserve's Unconventional Policies”, FRB San Francisco *Economics Letters*
- ▣ M Joyce, D Miles, A Scott, D Vayanos, “Quantitative Easing and Unconventional Monetary Policy—an Introduction,” *The Economic Journal*, 2012
- ▣ James Hamilton and Cynthia Wu, “The effectiveness of alternative monetary policy tools in a zero lower bound environment,” *Journal of Money, Credit and Banking*, 2012
- ▣ H Chen, V Curdia, A Ferrero, “The Macroeconomic Effects of Large-scale Asset Purchase Programmes,” *The Economic Journal*, 2012
- ▣ Christopher J. Neely, “Unconventional Monetary Policy Had Large International Effects,” Federal Reserve Bank of St. Louis Working Paper, 2010

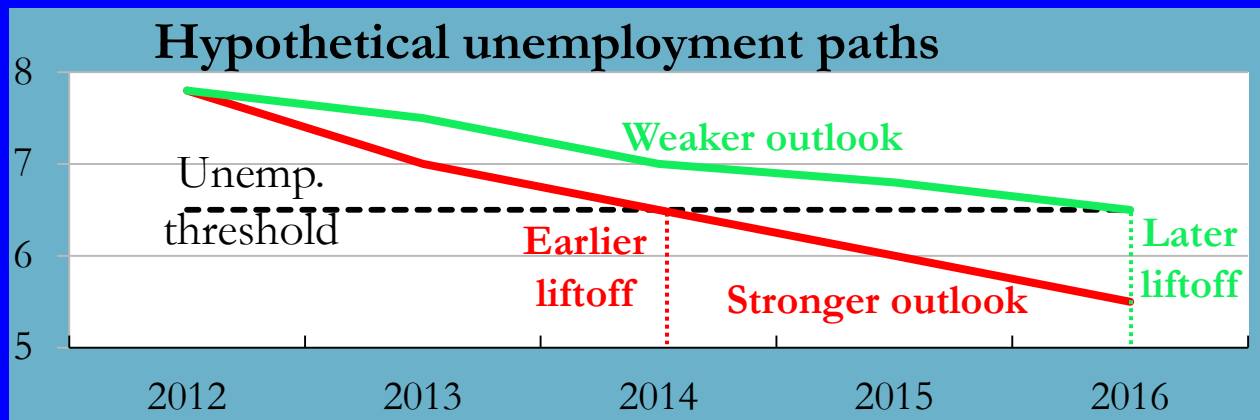
# The recovery progresses, gradually



Sources: Bureau of Labor Statistics (unemployment, employment), CBO (Natural rate), BEA (GDP), Haver Analytics

# New forward guidance with economic conditions: How does this help? (late 2012)

- ▣ Make the conditioning of our guidance more explicit
  - May lead to market interest rates that are better-aligned with our policy desires
- ▣ Allow for automatic adjustment of the implied time of liftoff



- ▣ May help avoid continuous negotiation of exit date and attendant language

# We begin to talk about the end to QE (i.e. Tapering)

- ▣ Two analogies:
  - The car (Bernanke's analogy):
    - ▣ We have been pushing down on the accelerator pedal more and more in recent months
    - ▣ In months to come, we will push on it a bit less
    - ▣ This is NOT like applying the brakes
  - The scale (mine):
    - ▣ The total amount of securities we hold exerts downward pressure on rates
    - ▣ The amount we add to that total each month MAY decrease going forward
    - ▣ But the overall amount of downward pressure on interest rates—total STIMULUS—will INCREASE

**TODAY**



**Downward pressure on  
Interest rates**

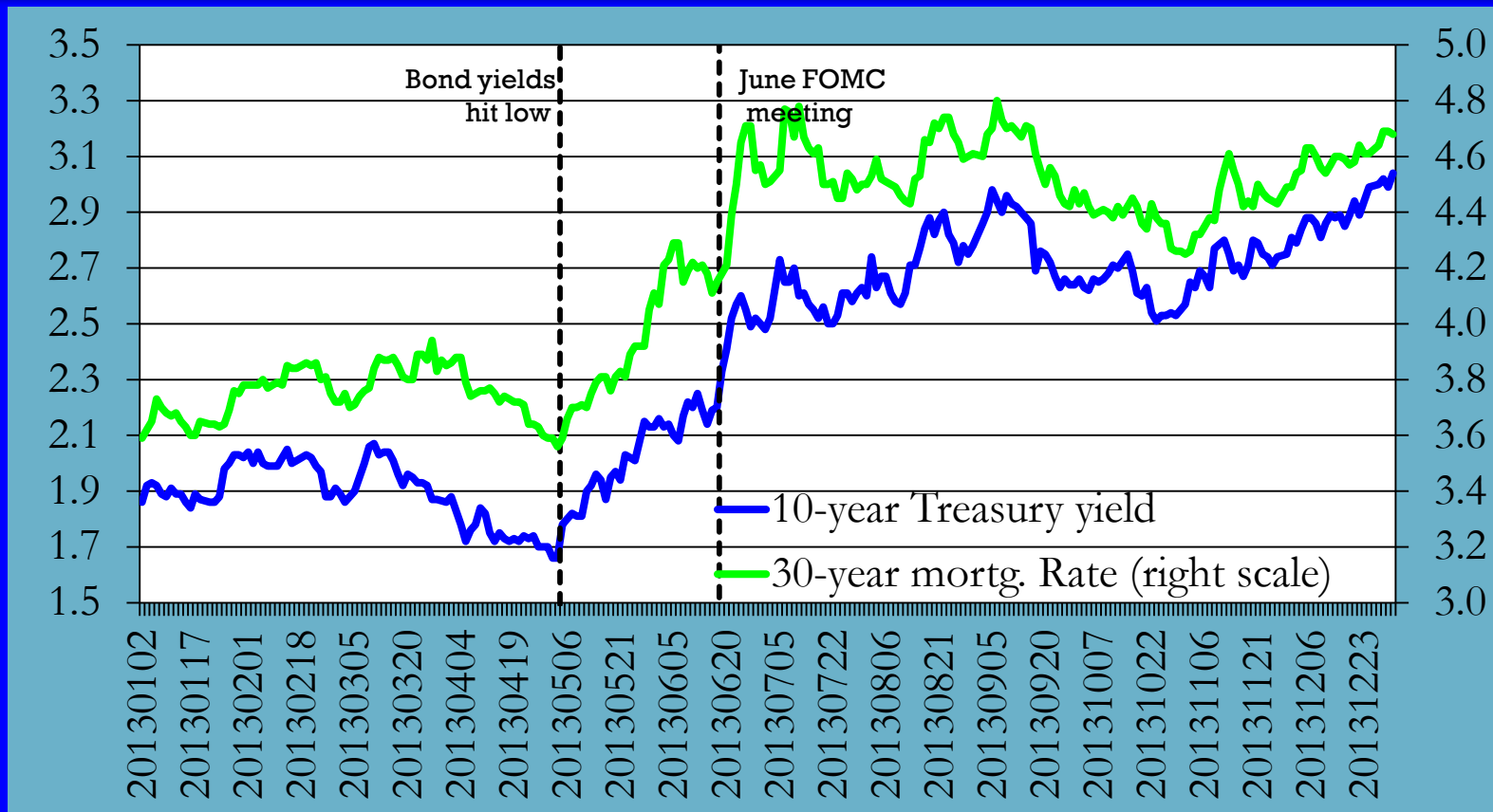
**LATER**

(depends on economy)



**MORE downward pressure on  
interest rates**

# Market response to tapering—the “Taper Tantrum” (mid-2013)



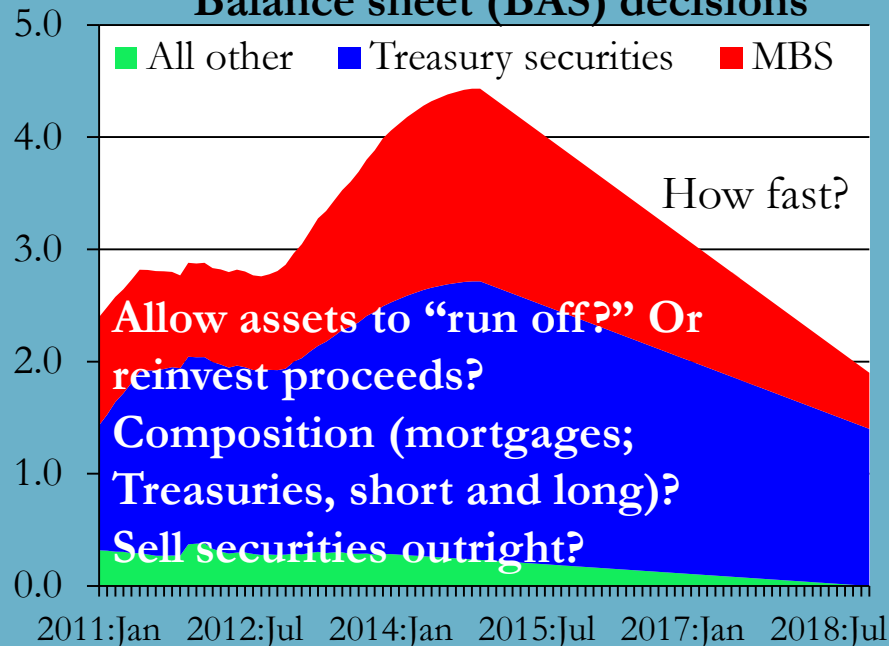
- Why such a big response?
  - Over-positioned for low long rates?
  - Betting on QE Infinity?

And talk turns once again  
to the “Exit Strategy”...

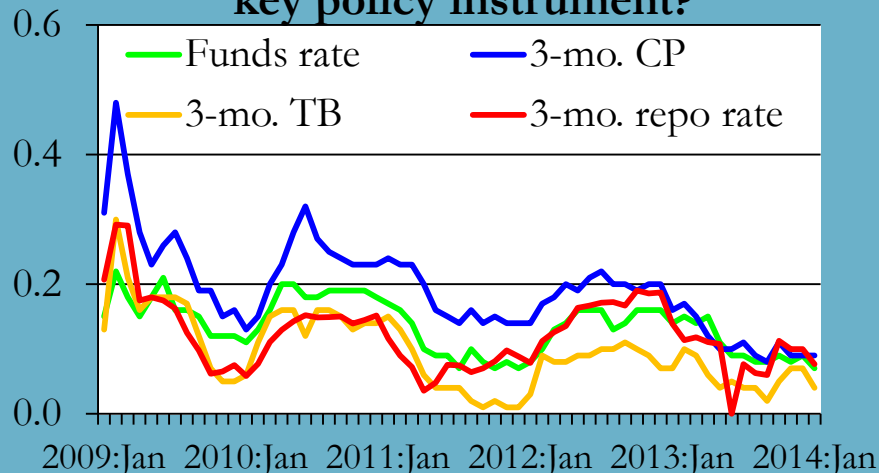


# Exit strategy: Some of the issues

## Balance sheet (BAS) decisions



## Use another short-term rate as our key policy instrument?



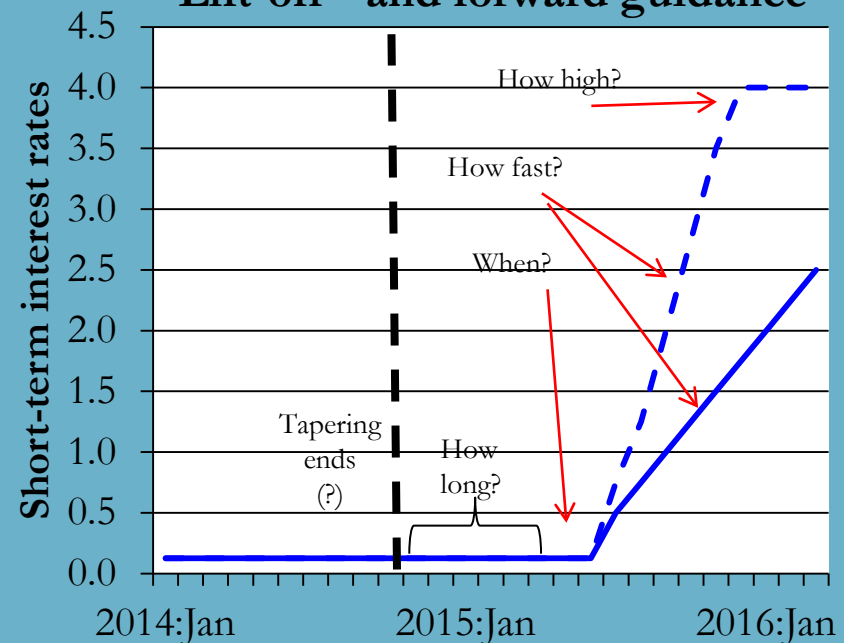
## “Reinvestment” policy

Affects the rate at which the balance sheet declines in size

- Affects pressure on long-term interest rates.
- Affects ability to control federal funds rate

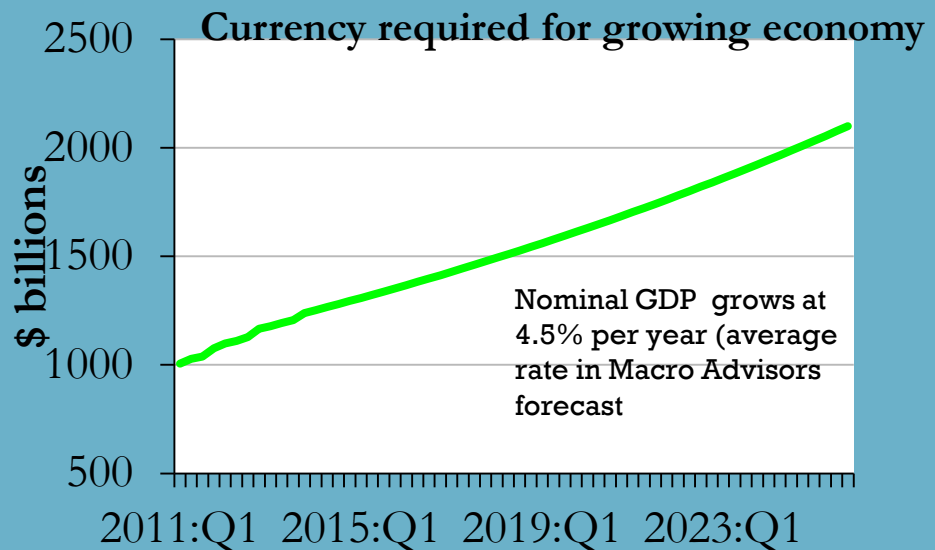
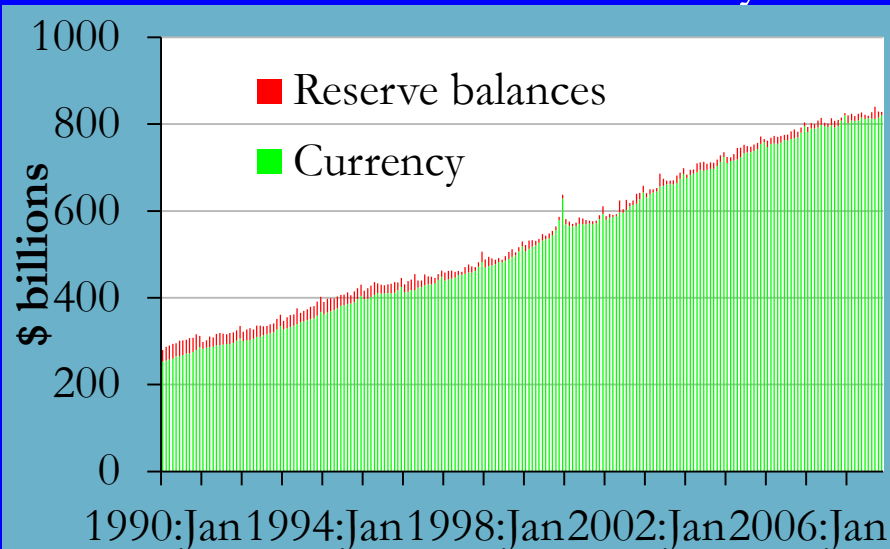


## “Lift-off” and forward guidance



# Balance sheet issues: What's a “normal” size for the Fed balance sheet?

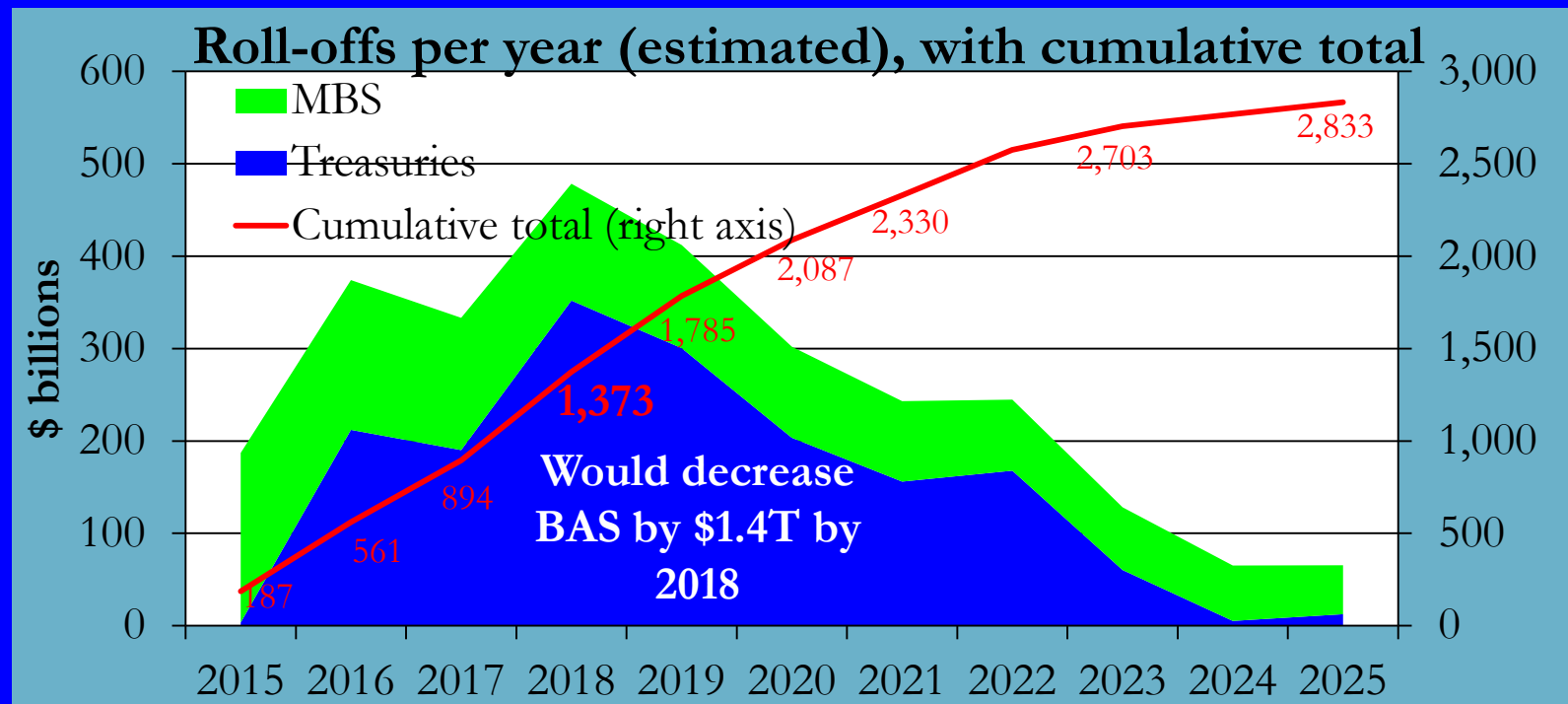
- ▣ In normal times, we need to do two things:
  - Put currency in circulation so the economy can function normally
  - Have some reserves on hand to manipulate short-term interest rates
  - The first is usually MUCH bigger than the second
- ▣ How much currency do we need in normal times?



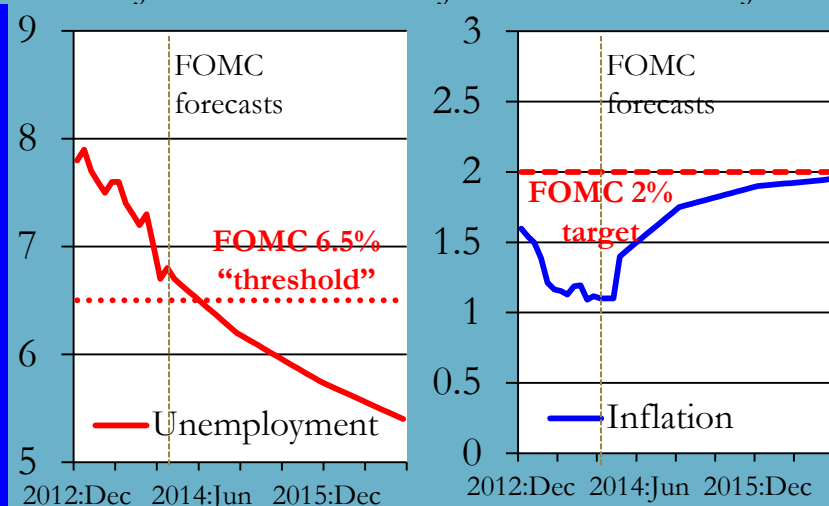
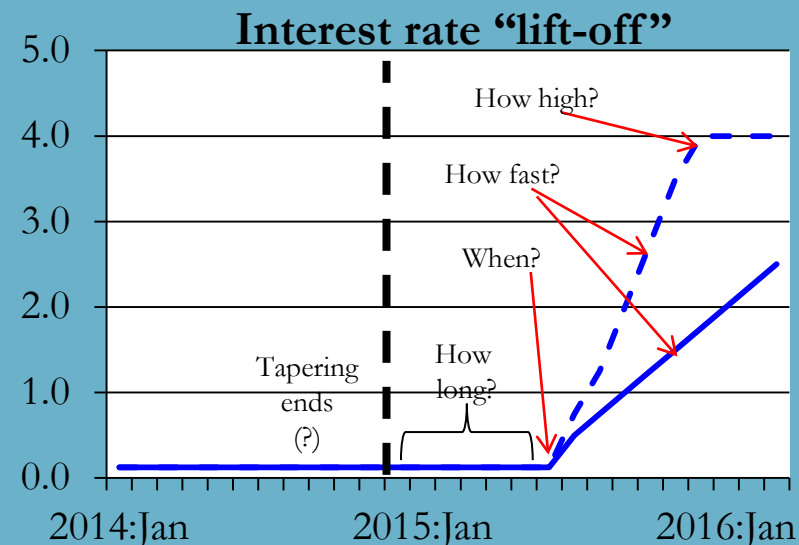
# Balance sheet issues: Do we continue reinvesting proceeds?

It makes a big difference for the size of the BAS

- ▣ Two kinds of “roll-off”
  - Treasuries mature, and roll off our balance sheet
  - MBS are prepaid (refis, purchases, etc.) and (much later) mature
- ▣ Two options: Re-invest proceeds, or let BAS shrink



# Lift-off (raising short-term interest rates) and associated communication, aka “forward guidance”



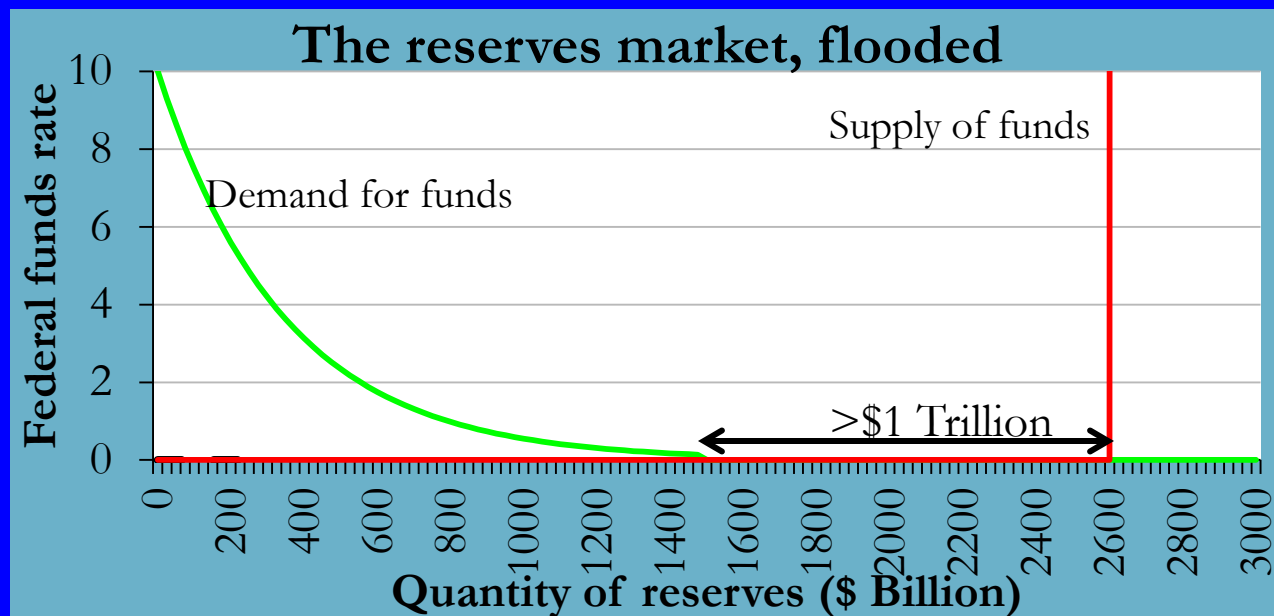
- ▣ How long: Gap from end of tapering to lift-off
  - “Considerable time”
  - Committee will “assess progress” towards its Dual Mandate goals (maximum sustainable employment, 2% inflation)
- ▣ How fast: Not too fast
  - “Balanced approach”
  - Below normal “for some time” after we reach goals
- ▣ How high: May be below historical norms
- ▣ Communication: Some change was necessary, sooner or later

Sources: Bureau of Labor Statistics (historical unempl. rate), Haver Analytics, author’s calculations

# Controlling the economy with a large BAS:

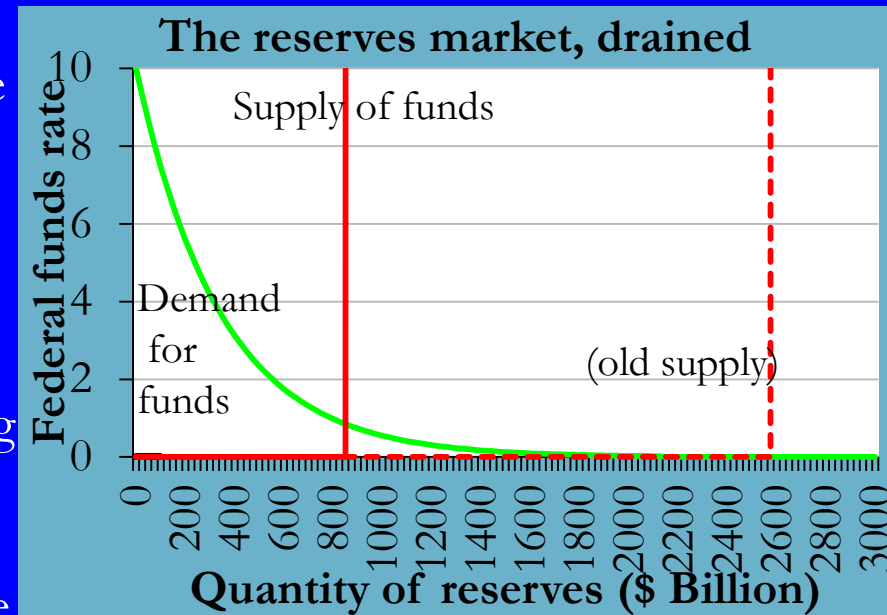
Can we use conventional funds rate policy?

- ▣ Not with this size balance sheet
  - So many funds available to lend/borrow that the funds rate will almost surely be pinned at zero
- ▣ Rate of roll-off not sufficient to regain control of fed funds rate by 2015/2016



# So what do we do about that?

- ▣ Two options:
  1. “Drain” reserves out of the banking system
    - ▣ Allows us to control the funds rate the old-fashioned way
  2. Use another interest rate
- ▣ Draining options
  - Sell Treasuries or MBS
    - ▣ Banks will pay us in reserves, removing them from the banking system
    - ▣ Capital losses are a potential issue
  - Use term deposits, reverse repurchase agreements
    - ▣ These temporarily remove reserves from the system



# Shrinking the BAS by selling assets: Capital losses

---

**Asset: MBS, 3.5%  
coupon rate, original  
purchase price = \$1000**

Market interest rate	New market price
3.5%	\$1000
4.5%	<b>\$850</b>
2.5%	\$1150

- ▣ Market rates will rise at some point
  - If we sell some of these bonds, it will likely be for less than we bought them
- ▣ If we suffer a capital loss, we return less to the Treasury
- ▣ If losses large enough, we book a “deferred asset” (accounting entry)
  - Main risk is political
- ▣ Roll-off rate suggests we may not need to sell assets
  - Depends on effectiveness of using other interest rates (next pages)
- ▣ So maybe we don't sell assets or drain reserves



# Can remittances turn negative?

- ▣ Strictly speaking, no
  - If our income falls short of expenses, we book a “deferred asset”—a negative liability
  - Subsequent (positive) net income will be used to pay down that asset
  - See Carpenter et al, “The Federal Reserve’s Balance Sheet and Earnings: A Primer and Projections,”; and Greenlaw et al, Crunch Time: Fiscal Crises and the Role of Monetary Policy
- ▣ But practically speaking yes, for two reasons
  - We sell an asset off our balance sheet for less than we bought it (capital loss)
  - We pay a higher rate of interest on a large stock of reserves (currently 25 bps, could rise to 3-4%)
- ▣ Is this a problem?

Normal times	
Asset	Liability
Net income \$20B	Interest due to Treasury \$20B
Special times	
Asset	Liability
Net income -\$40B	Interest due to Treasury (deferred asset) -\$40B



# Use another interest rate to set a floor: The rate paid on bank reserves (IOR)

---

- Currently pay  $\frac{1}{4}$  percentage point per annum on a large stock of outstanding required and excess reserves
  - Vast majority (\$2537B versus \$86B) are excess reserves
- Can change that rate just by saying so
  - Governance issue: Board of Governors, not FOMC, votes on it
  - Revenue issue: Our interest payments rise, decreasing net revenue
- Will that affect other rates, similar to the funds rate?
  - Should put floor on lending rates, for banks



Push

Earn  
3%



OR

Pull

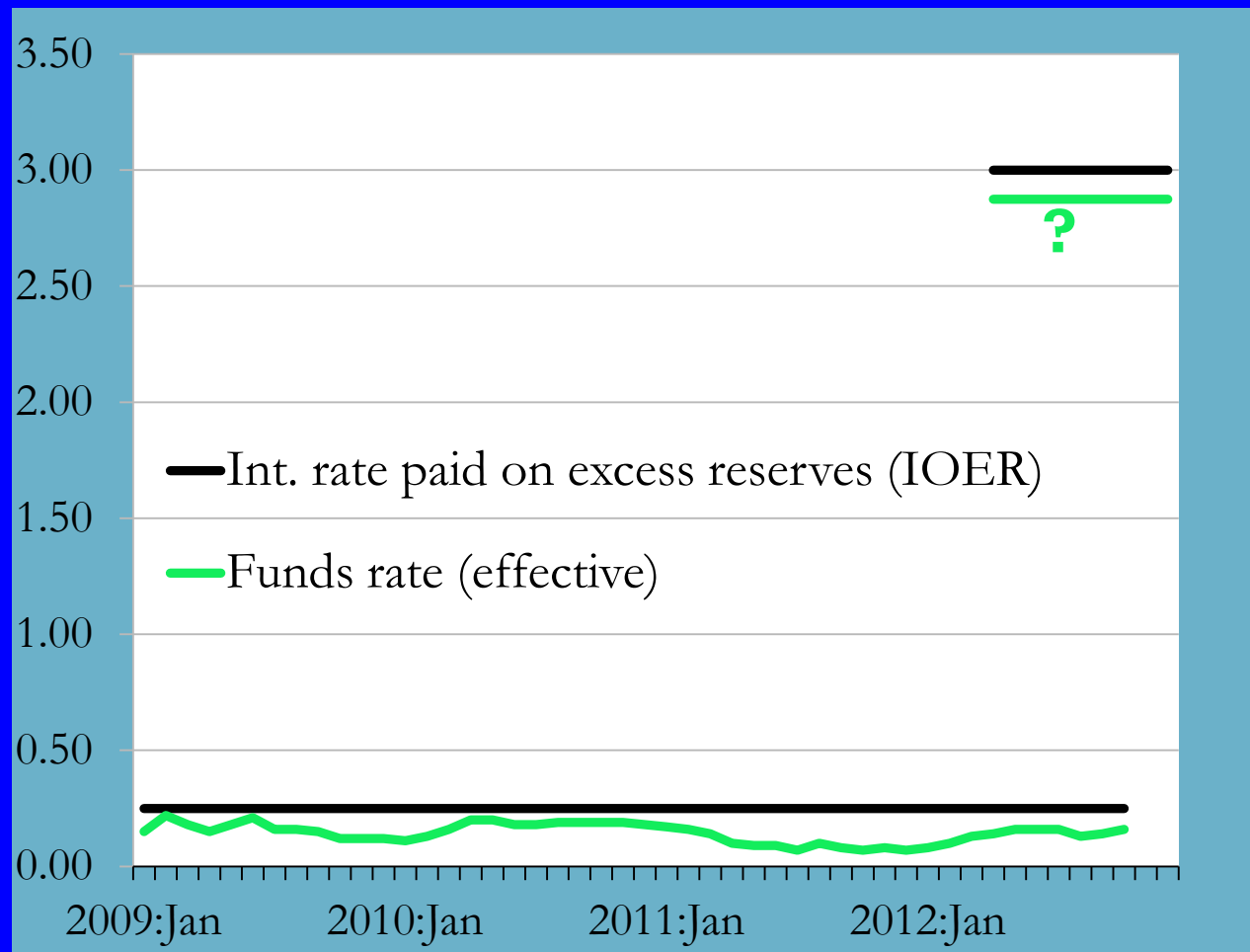
Earn  
5%



# IOER/short rate slippage – a problem?

## ▣ The issue

- Suppose we need to “normalize” policy, and there are still huge reserves in circulation
- Can we tighten by setting a higher interest rate on reserves?
- Probably—otherwise a big arbitrage opportunity

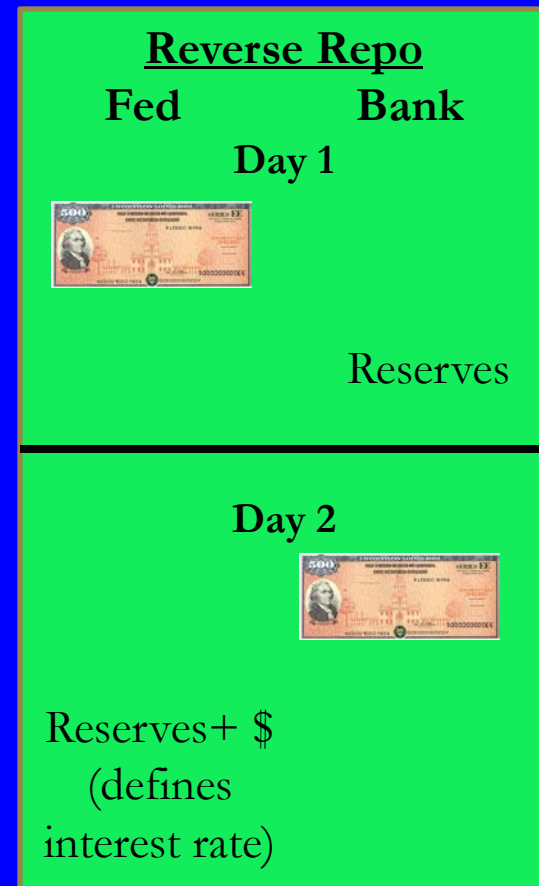


# Use another interest rate to set a floor:

## (2) Reverse repurchase agreements (RRPs)

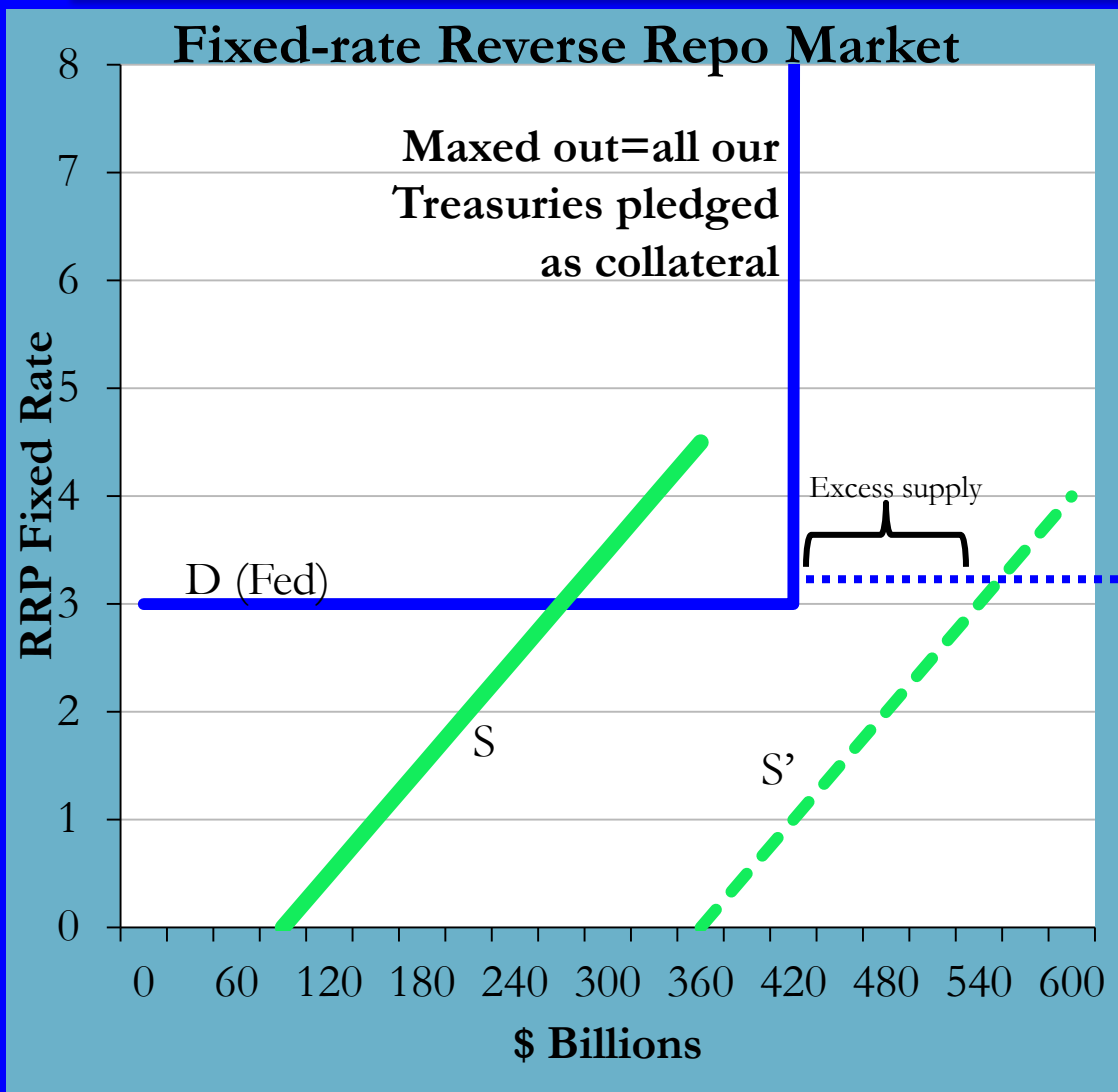
---

- ▣ What are they?
  - Counterparty lends the Fed money with securities as collateral
  - The Fed can set that interest rate unilaterally
  - We have plenty of assets to sell → can affect rates
  - Could be a decision of the FOMC (not the Board)
  - Many counterparties: MMMFs, Banks, GSEs, primary dealers → broader effects than IOR
- ▣ Would this rate influence other interest rates?
  - Somewhat like the IOR—can be used to put a floor on rates—why lend out at a lower rate?
- ▣ Probably move IOR and RRP together
  - Both would affect prevailing funds rate as well



**Note: Repo market ≈ \$2T  
vs. normal fed funds =  
\$50-100B**

# Repo market dynamics



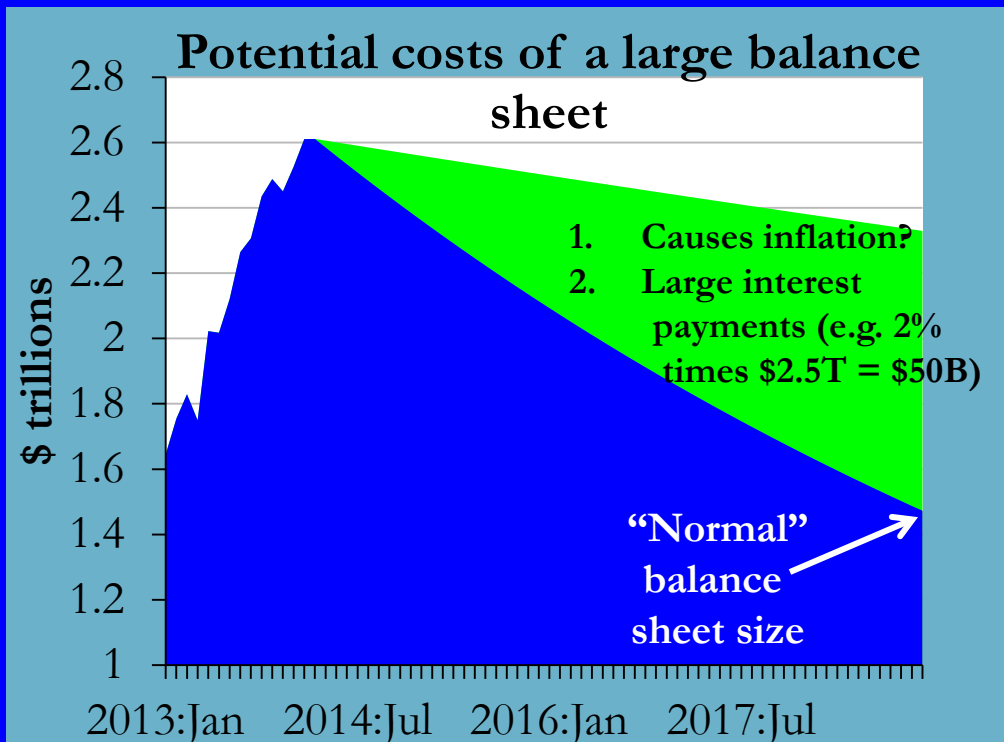
## Sequence:

- Normal times,  $D=S$  at 3% (FOMC-set floor)
- Stress: Supply of lending into safe assets soars, exceeds our limit—or our cap (\$400B)
- Lending ( $S'-D$ ) goes elsewhere
- Market rates on other assets fall, so RRP rate not as effective as a floor

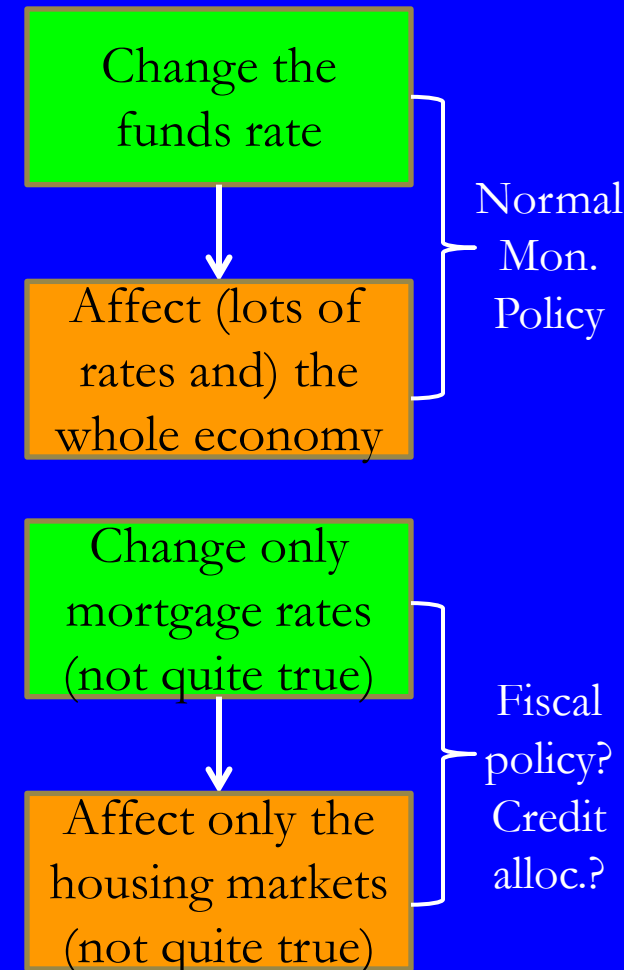
# Some people don't like these options

## □ How come?

- Designed to gain control of short-term interest rates even when we have a large balance sheet

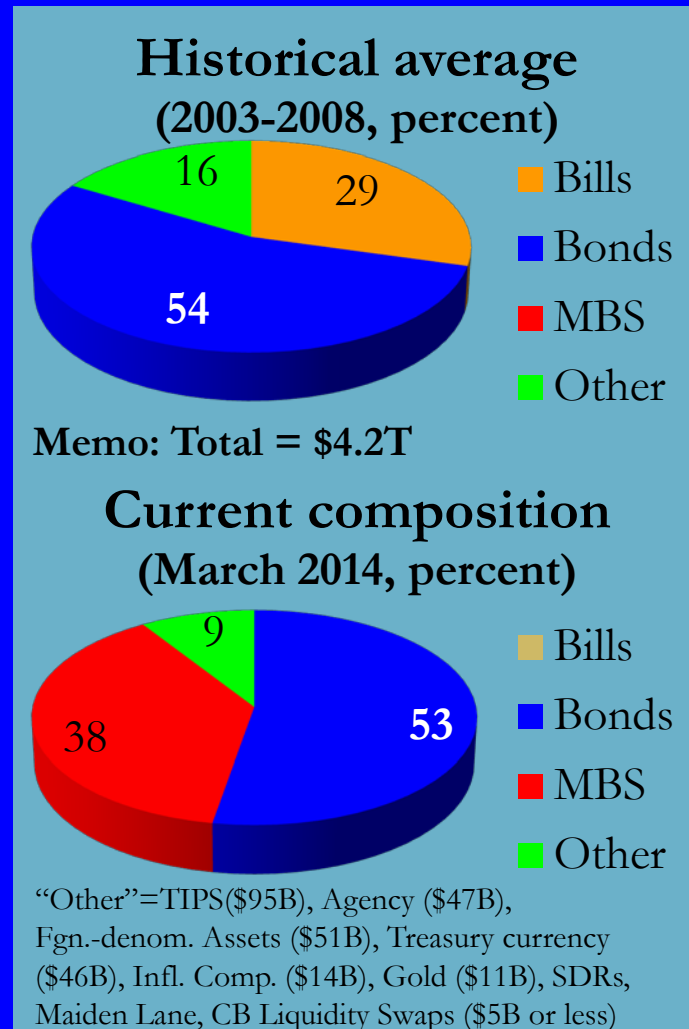


## 3. “Credit allocation?”



# Communication issues

- ▣ How much to say about the balance sheet
  - Composition (Long-term versus short-term Treasuries, MBS), rate of decline, “roll-offs,” etc.
- ▣ How much to say about the “operating instrument” and when?
  - Change IOR/RRP but express goal in terms of funds rate? Or in terms of IOR/RRP?
  - High interest payments have revenue effects like capital losses—is this a problem?
- ▣ Calendar versus data conditioning
  - “Considerable time”, “Patience”, etc.



# Welcome to our world

---

- ▣ There's loads more to talk about
- ▣ But we don't have time
- ▣ Thanks for your attention and your questions!

# AEA CONTINUING EDUCATION PROGRAM



## MONETARY POLICY

ELLEN MCGRATTAN, UNIVERSITY OF MINNESOTA

JANUARY 5-7, 2015





# AEA Continuing Education Program

MONETARY POLICY AND EMPLOYMENT

ELLEN R. McGRATTAN

JANUARY 2015



# Fed's Dual Mandate

In setting **monetary policy**, the FOMC seeks to mitigate

1. deviations of inflation from its longer-run goal and
2. deviations of **employment** from the Committee's assessments of its maximum level.

— Source: Federal Reserve Board of Governors



# Fed's Dual Mandate

- From perspective of:
  - Fed communications
  - Recent U.S. data
  - Economic theory
- Should legislation be changed to a single mandate?



# Debates about Full Employment Mandate

- Opponents concerned about:
  - Inflationary pressures
  - Public debt
  - Centralized planning
- Proponents argued for:
  - Opportunities to earn a living
  - Economic stability



## Full Employment Mandate after 2008

- Opponents renewed calls for:
  - Ending dual mandate and focusing on prices
  - Rules rather than discretion
- Proponents (Bernanke, Yellen) prevailed



# Outline of Lecture

- Historical overview
- Accounting approach to summarize data
- Models of monetary policy
  - Conventional (interest rates)
  - Unconventional (intermediation)
- Quantitative predictions
- Policy implications

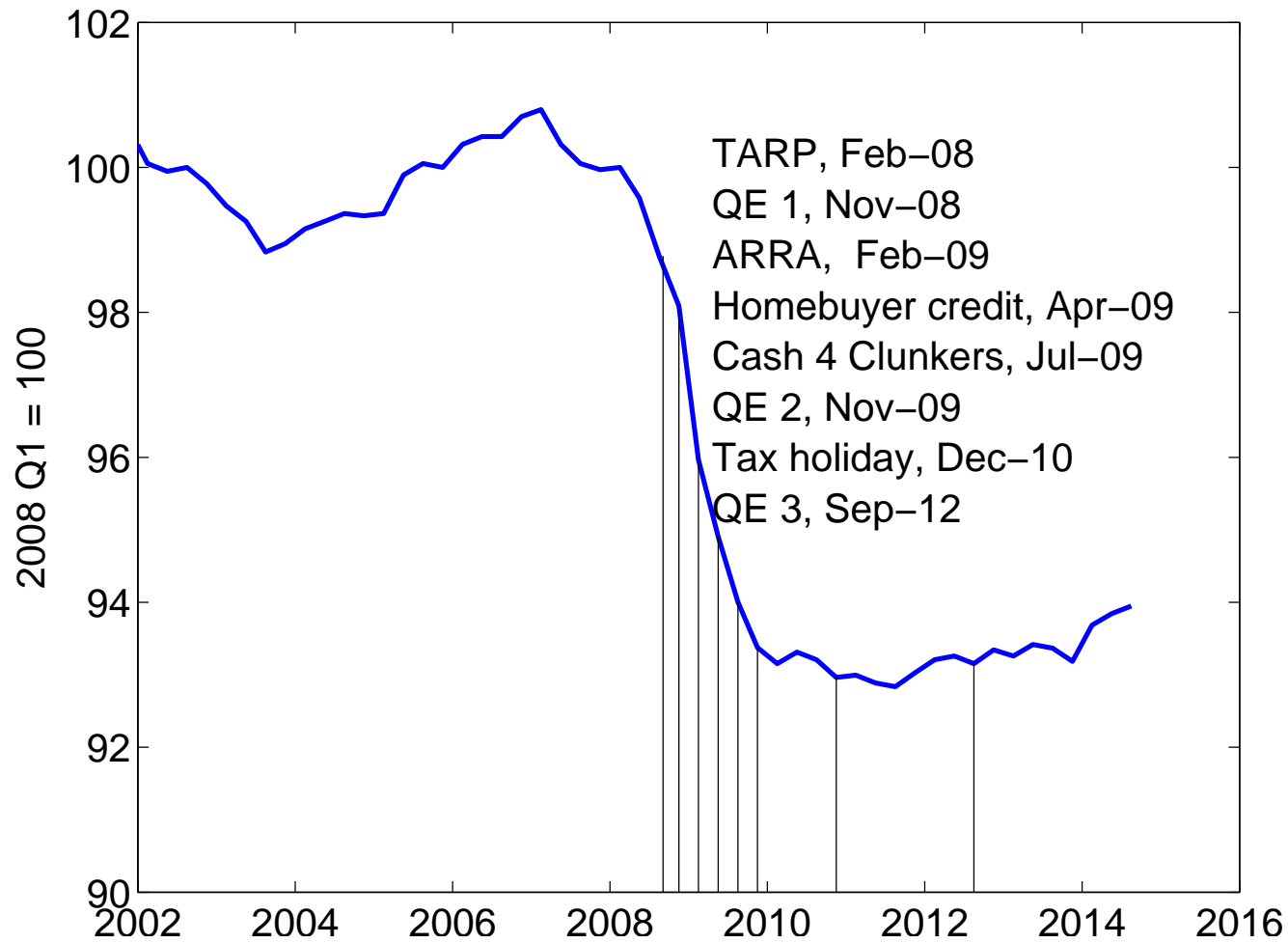


# Historical Overview

- Federal Reserve Act of 1913
  - Create an institution to contain future crises
- Employment Act of 1946
  - “Assure continuing full employment”
- Full Employment and Balanced Growth Act of 1978
  - “Use all practicable programs” to promote it
- Current language:
  - “Mitigate deviations” from its maximum level



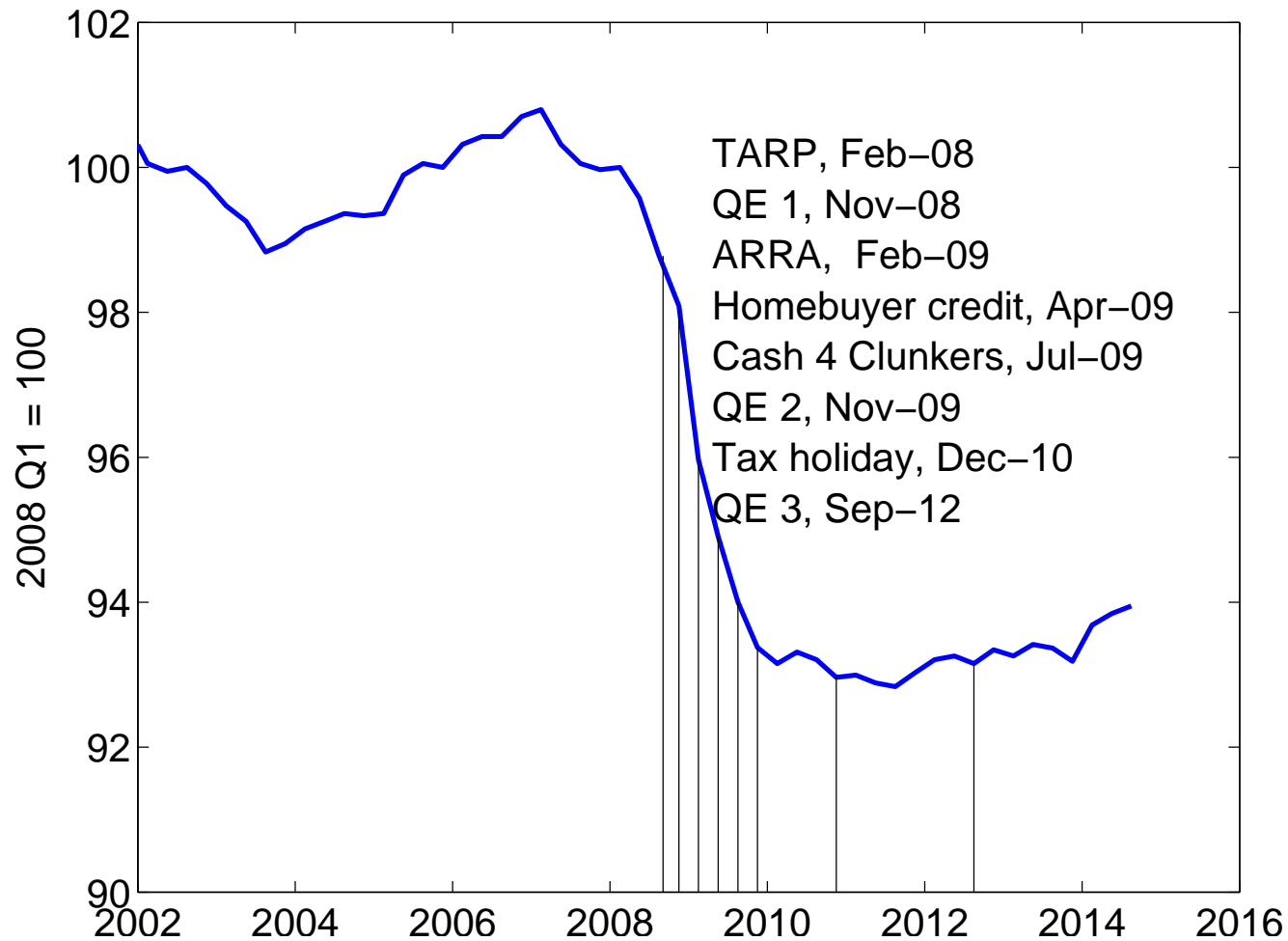
# Interpretations of Employment-Population Trend







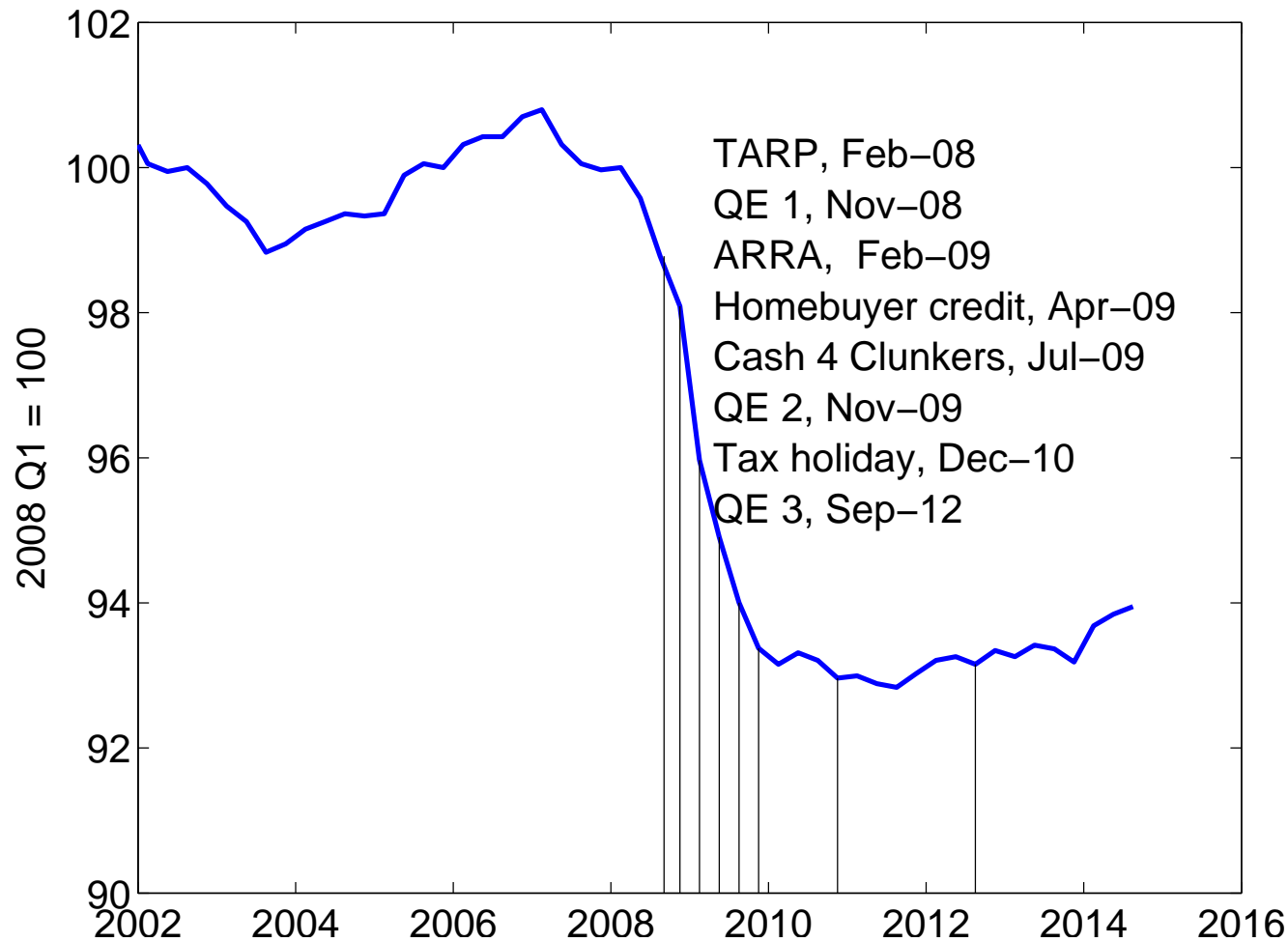
# Interpretations of Employment-Population Trend



Interpretation 1: Fed policy had no effect



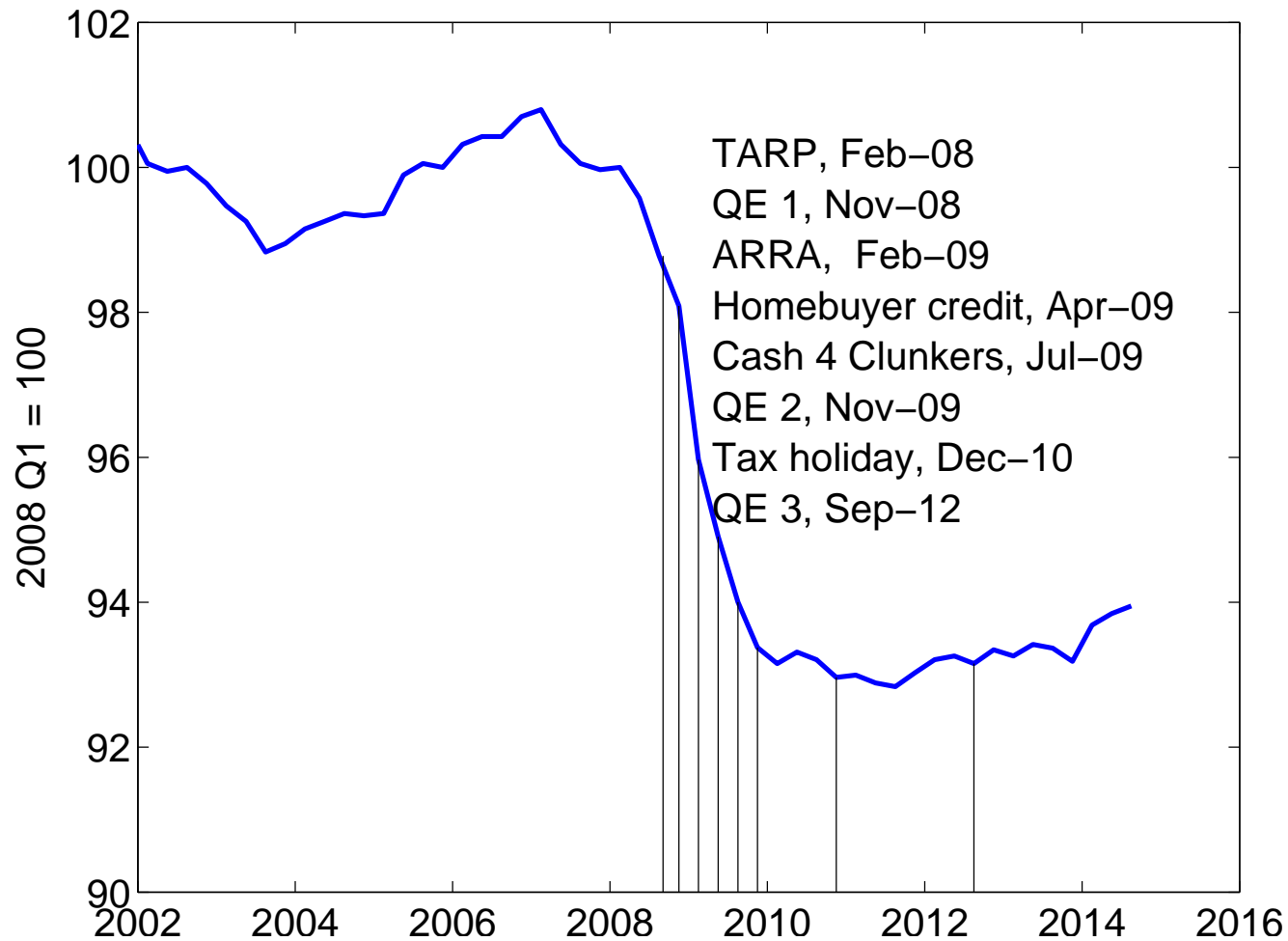
# Interpretations of Employment-Population Trend



Interpretation 2: would be worse without Fed policy



# Interpretations of Employment-Population Trend



Need theory to sort this out!



## Two Approaches Using Theory

1. Apply a *business cycle accounting* approach
2. Examine predictions of current monetary models



## Two Approaches Using Theory

1. Apply a *business cycle accounting* approach
2. Examine predictions of current monetary models

Both point to negligible role of Fed for employment



# Business Cycle Accounting

REFERENCE: CHARI, KEHOE, MCGRATTAN, *Econometrica* 2007



# Business Cycle Accounting

- Preliminary data analysis technique
- Goals:
  - Isolate promising classes of models/theories/stories
  - Guide development of theory



## Idea of Approach

- Equivalence results:
  - Detailed models with frictions equivalent to
  - Prototype growth model with time-varying “wedges”
- Accounting procedure:
  - Use theory plus data to measure wedges
  - Estimate stochastic process governing expectations
  - Feed wedges back one at a time and in combinations
  - How much of U.S. aggregates accounted for by each?





# Prototype Growth Model

- Consumption ( $c$ ), labor ( $l$ ), investment ( $x$ ) solve

$$\max_{\{c_t, l_t, x_t\}} E \sum_{t=0}^{\infty} \beta^t U(c_t, l_t)$$

subject to

$$c_t + (1 + \tau_{xt})x_t \leq (1 - \tau_{lt})w_t l_t + r_t k_t + T_t$$

$$k_{t+1} = (1 - \delta)k_t + x_t$$

- Production:  $y_t = A_t F(k_t, \gamma^t l_t)$
- Resource:  $c_t + g_t + x_t = y_t$



# Equations for Prototype Growth Model

- Efficiency wedge:

$$y_t = A_t F(k_t, \gamma^t l_t)$$

- Labor wedge:

$$-\frac{U_{lt}}{U_{ct}} = (1 - \tau_{lt})(1 - \alpha)y_t/l_t$$

- Investment wedge:

$$(1 + \tau_{xt})U_{ct} = \beta E_t U_{ct+1} [\alpha y_{t+1}/k_{t+1} + (1 + \tau_{xt+1})(1 - \delta)]$$

- Government consumption wedge:

$$c_t + g_t + x_t = y_t$$

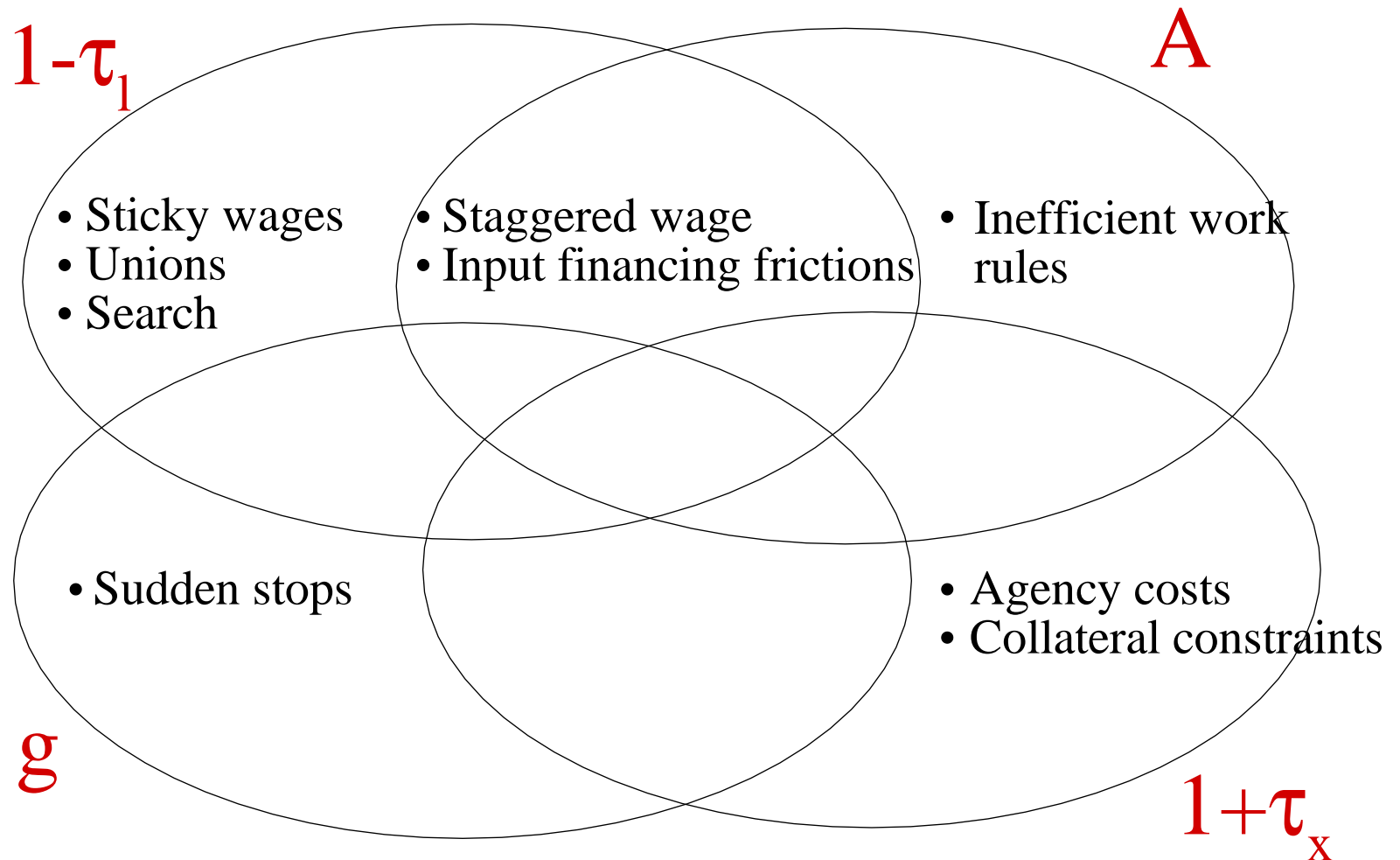


# The Accounting Procedure

- Estimate stochastic processes for  $A$ ,  $\tau_l$ ,  $\tau_x$ ,  $g$
- Compute equilibria for prototype economy
- Generate realization by feeding in
  - $A$  only
  - $1 - \tau_l$  only
  - $1 + \tau_x$  only
  - $g$  only
  - combinations



# Mapping Between Original and Prototype Models





# Equivalence Results: Examples



# Efficiency Wedges

$$y_t = A_t F(k_t, \gamma^t l_t)$$

- Changes in blueprints
- Misallocation of inputs across tasks/production units
  - Within firms (work rules)
  - Across firms (input financing frictions)



## Example: Input Financing Frictions

- Technologies:

- Aggregate gross output  $q = q_1^\phi q_2^{1-\phi}$

$$\max_{q_1, q_2} q - p_1 q_1 - p_2 q_2$$

- Sectoral outputs,  $q_i = m_i^\theta z_i^{1-\theta}$

$$\max_{z_i, m_i} p_i q_i - v z_i - R_i m_i, \quad R_i = R(1 + \tau_i), \quad R_1 > R_2$$

- Composite value-added,  $z = z_1 + z_2 = F(k, l)$

$$\max_{l, k} v z - w l - r k$$

- Resource constraint:

$$c_t + k_{t+1} + m_{1t} + m_{2t} = q_t + (1 - \delta)k_t$$



## Example: Input Financing Frictions

- Households:

$$\max_{\{c_t, l_t\}} \sum_{t=0}^{\infty} \beta^t U(c_t, l_t)$$

$$\text{s.t. } c_t + k_{t+1} = r_t k_t + w_t l_t + (1 - \delta)k_t + T_t$$

$$l_t = l_{1t} + l_{2t}$$

- Lump-sum transfers:  $T_t = R_t \sum_i \tau_{it} m_{it}$





## Equivalent Prototype

- Slightly modified consumer budget constraint:

$$c_t + k_{t+1} = (1 - \tau_{kt})r_t k_t + (1 - \tau_{lt})w_t l_t + (1 - \delta)k_t + T_t$$

- *Proposition:* Let  $a_{1t} = \phi / (1 + \tau_{1t}^*)$ ,  $a_{2t} = (1 - \phi) / (1 + \tau_{2t}^*)$

$$A_t = \kappa (a_{1t}^{1-\phi} a_{2t}^{\phi})^{\theta/(1-\theta)} [1 - \theta \sum_i a_{it}]$$

$$\tau_{lt} = \tau_{kt} = 1 - (1 - \theta) [1 - \theta \sum_i a_{it}]^{-1}$$

$\Rightarrow$  allocations same in prototype and economy with frictions

$\Rightarrow$  if  $\sum_i a_{it}$  constant, only have efficiency wedge



# Labor Wedges

$$\frac{U_{lt}}{U_{ct}} = (1 - \tau_{lt})F_{lt}$$

- Sticky wages
  - Labor wedges in prototype model
  - Staggering yields efficiency wedges
- Cartels/unions
  - Labor wedges in prototype model



## Example: Sticky wages

- Economy:
  - Event  $s_t$ ,  $s^t = (s_0, \dots, s_t)$
  - Stochastic money growth  $\mu(s^t)$
  - Utility  $U(c, l, m) = u(c, l) + v(m)$
  - Production  $F(k, l)$
- Define  $\tau_l^*(s^t)$ , where '\*' indicates equilibrium values

$$\tau_l^*(s^t) = 1 - \frac{U_l^*(s^t)}{U_c^*(s^t)} \frac{1}{F_l^*(s^t)}$$



# Equivalent Prototype

- Real prototype economy with
  - Stochastic labor taxes  $\tau_l(s^t)$
  - Utility  $u(c, l)$
  - Production  $F(k, l)$
- *Proposition:* Allocations same in two economies if

$$\tau_l(s^t) = \tau_l^*(s^t)$$



# Investment Wedges

$$(1 + \tau_{xt})U_{ct} = \beta E_t U_{ct+1} [\alpha y_{t+1}/k_{t+1} + (1 + \tau_{xt+1})(1 - \delta)]$$

- Models with financial frictions, e.g.,
  - Bernanke-Gertler
  - Carlstrom-Fuerst
  - Kiyotaki-Moore
- Map into prototype with investment wedges



# Application to the Great Recession



## Measuring Wedges

- Stochastic process for wedges  $s_t = [\log A_t, \tau_{lt}, \tau_{xt}, \log g_t]$

$$s_{t+1} = P_0 + P s_t + Q \eta_{t+1}$$

- Preferences and technology

$$U(c, l) = \log c + \psi \log(1 - l)$$

$$F(k, l) = A k^\theta l^{1-\theta}$$

- With postwar quarterly US data
  - Fix parameters of technology and preferences
  - Compute MLE estimates of  $P_0, P, Q$



## Recovering Wedges

- Model decision rules are  $c(s_t, k_t), x(s_t, k_t), l(s_t, k_t)$
- Set
  - $c(s_t, k_t) = c_t^{DATA}$
  - $x(s_t, k_t) = x_t^{DATA}$
  - $l(s_t, k_t) = l_t^{DATA}$

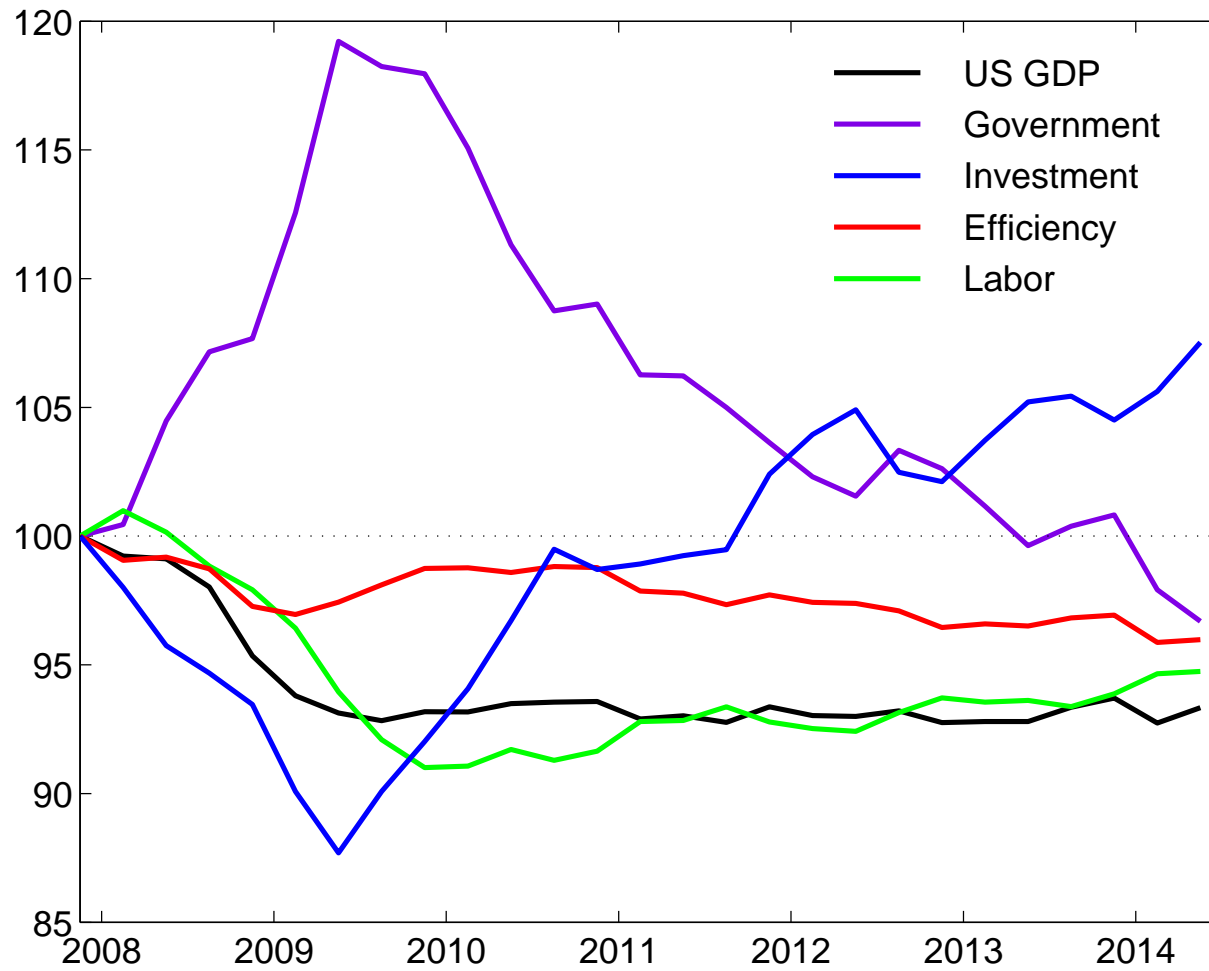
with  $k_t$  defined recursively from accumulation equation

- Solve for values of  $s_t = [\log A_t, \tau_{lt}, \tau_{xt}, \log g_t]$
- Inputting these values gives exactly same series as in data



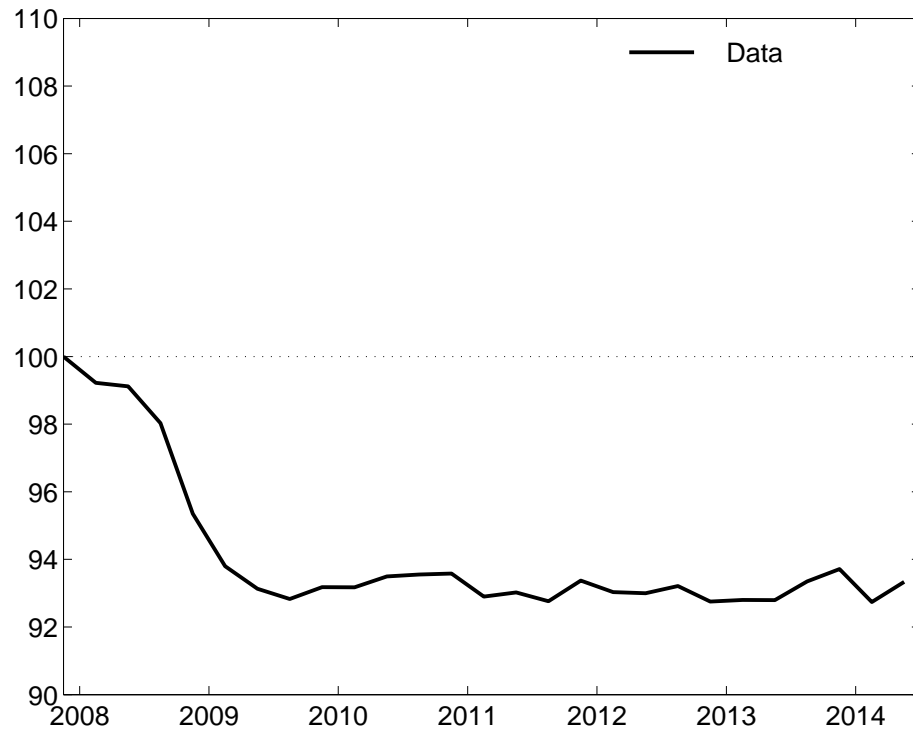


# The Wedges

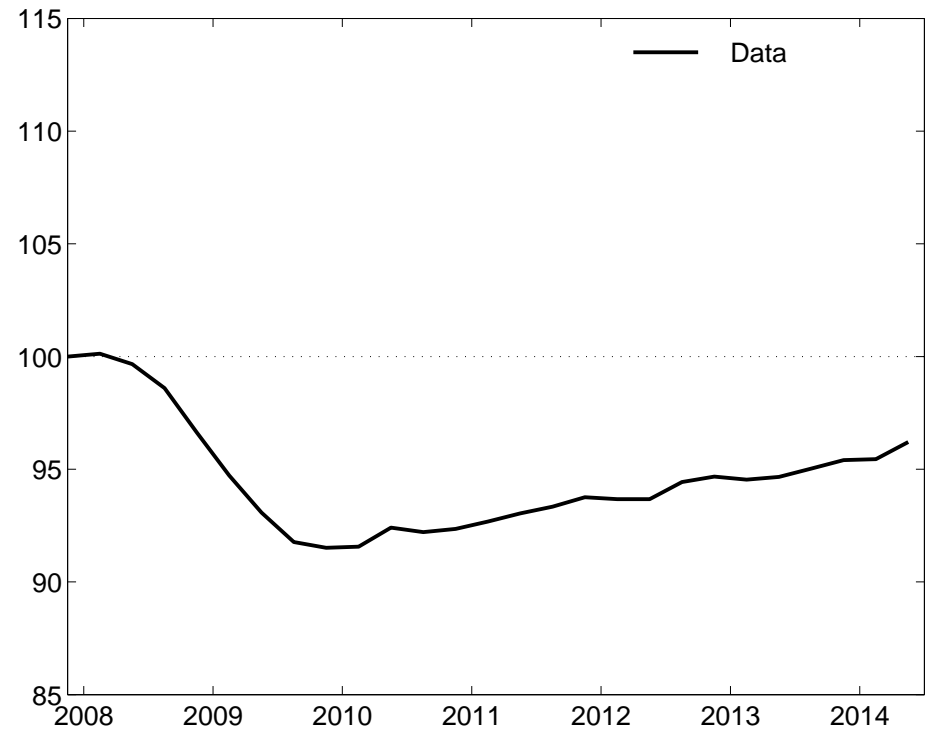




# Equilibrium Responses—One Wedge at a Time



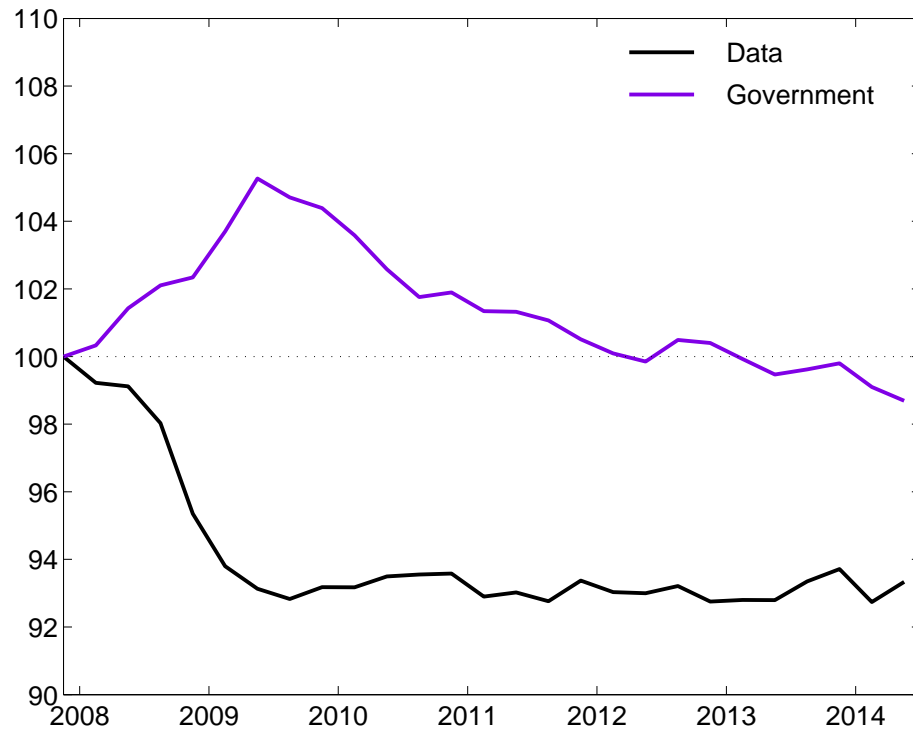
Output



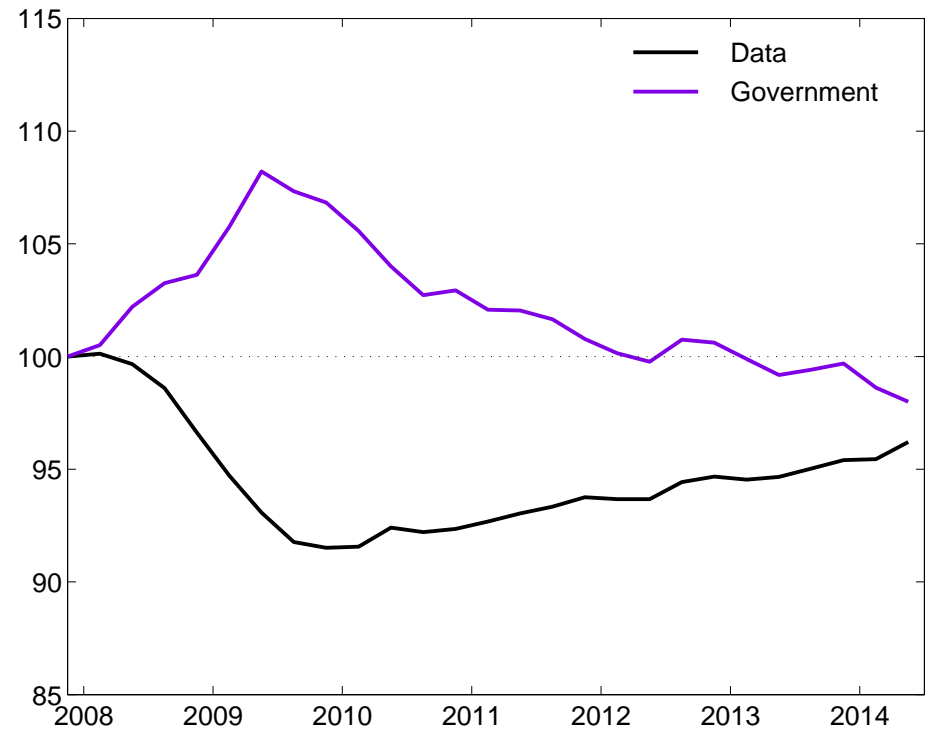
Total Hours



# Equilibrium Responses—One Wedge at a Time



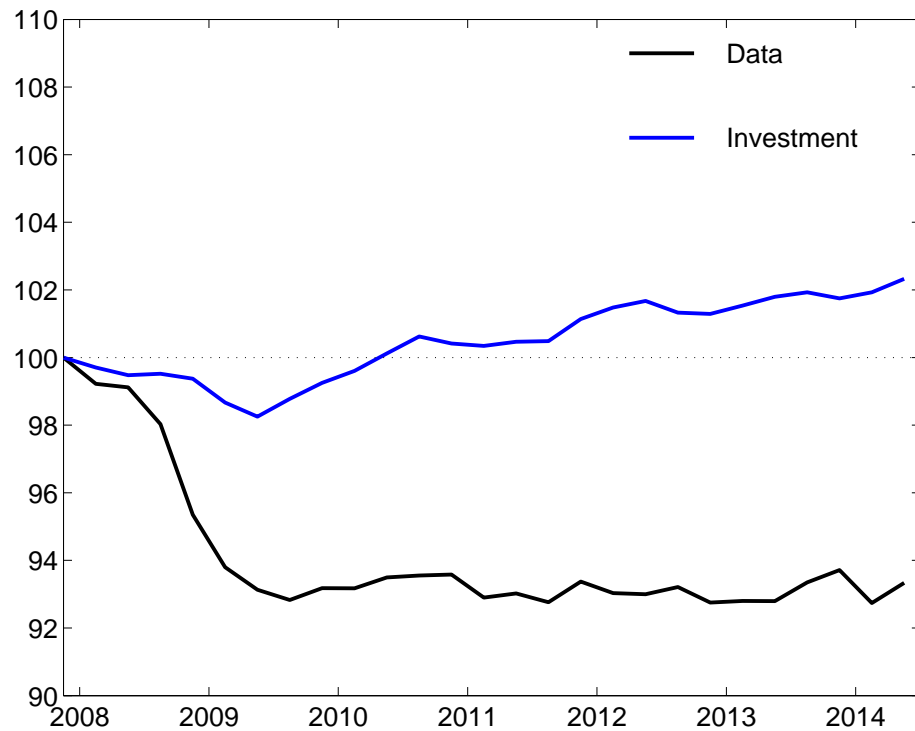
Output



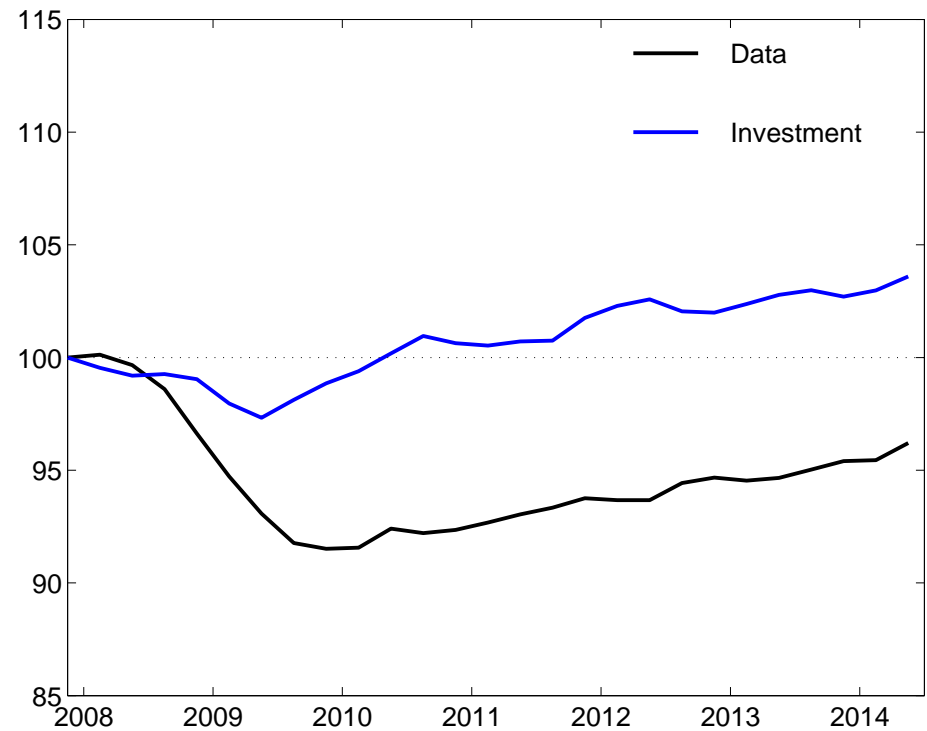
Total Hours



# Equilibrium Responses—One Wedge at a Time



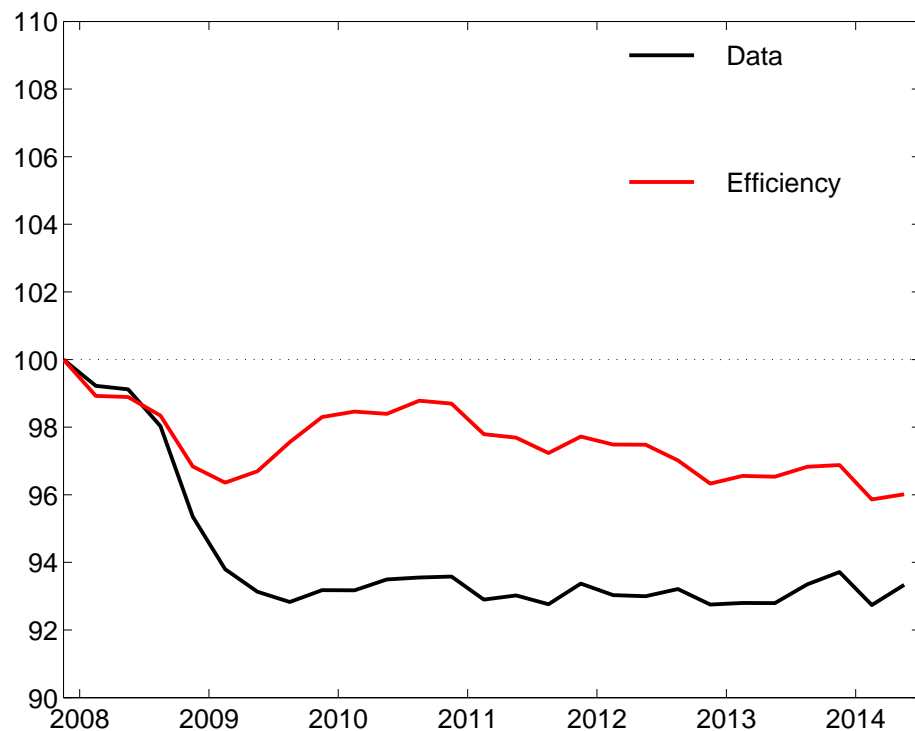
Output



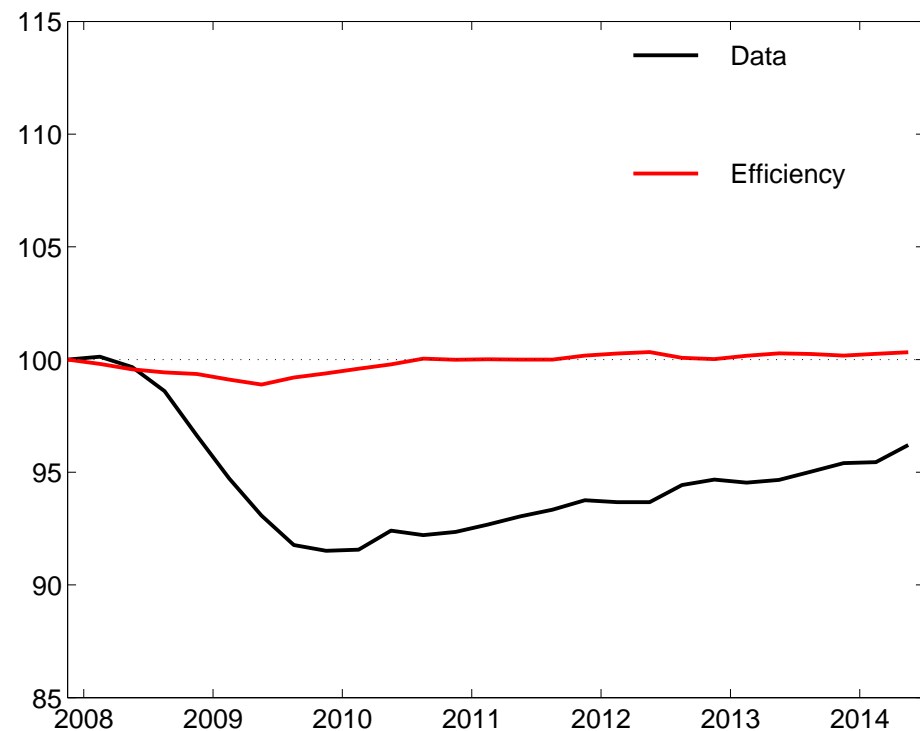
Total Hours



# Equilibrium Responses—One Wedge at a Time



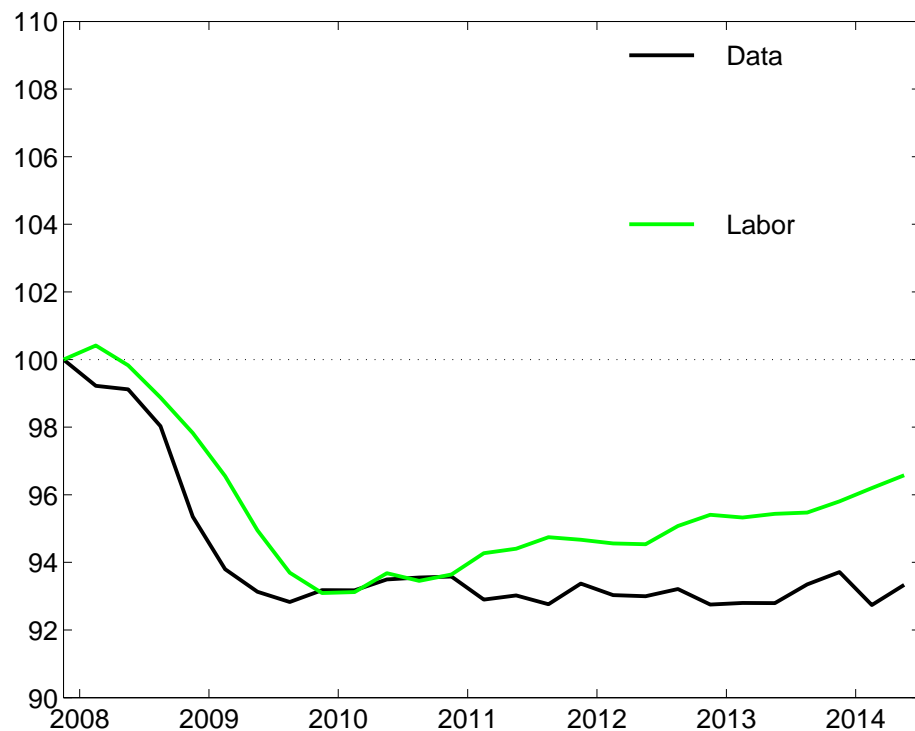
Output



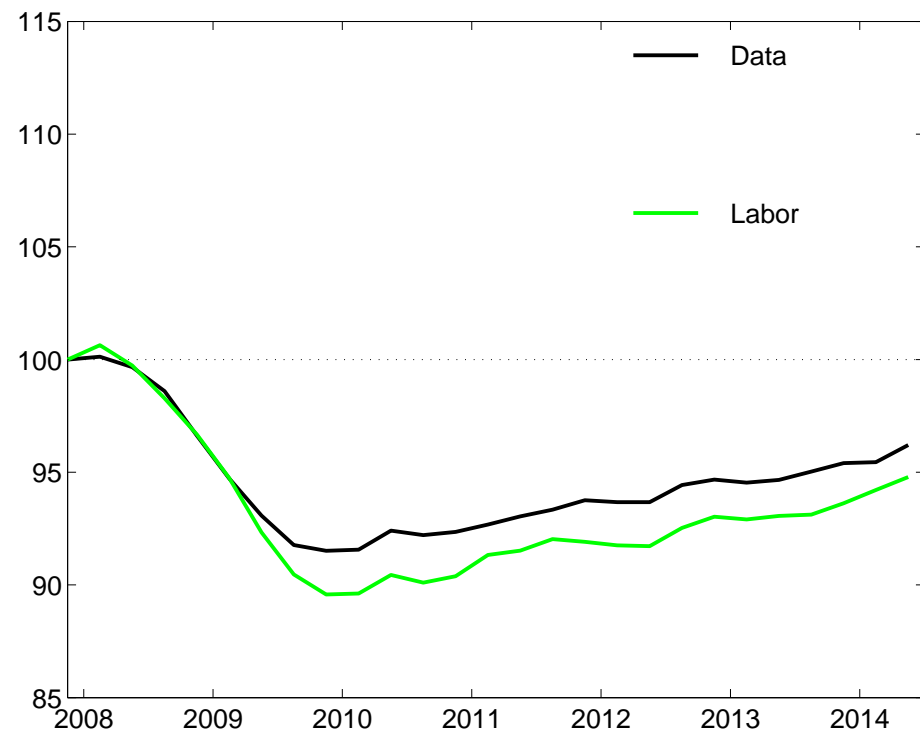
Total Hours



# Equilibrium Responses—One Wedge at a Time



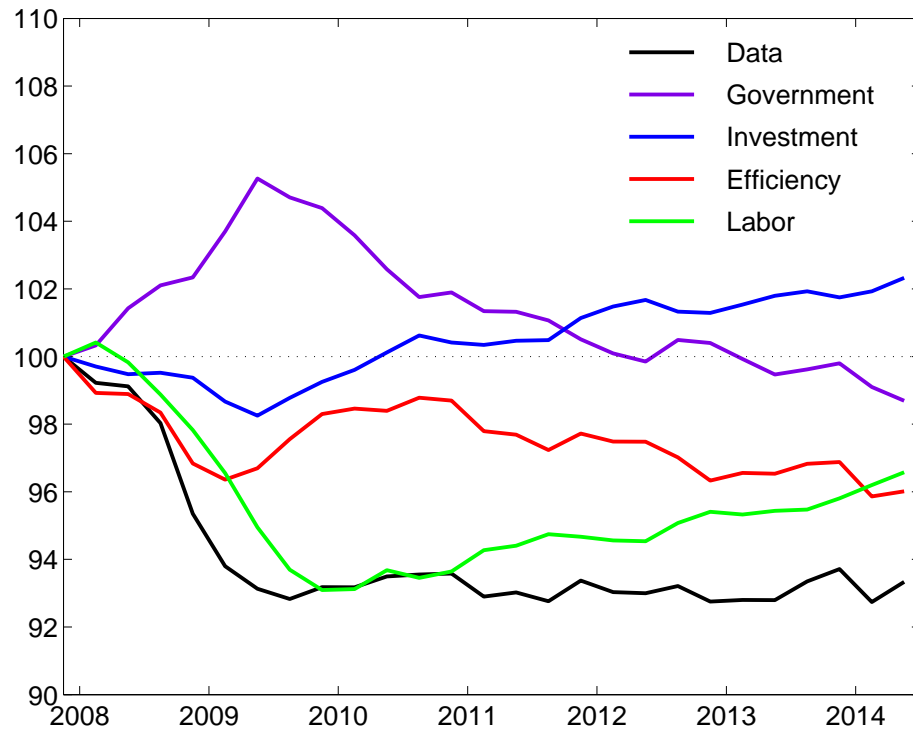
Output



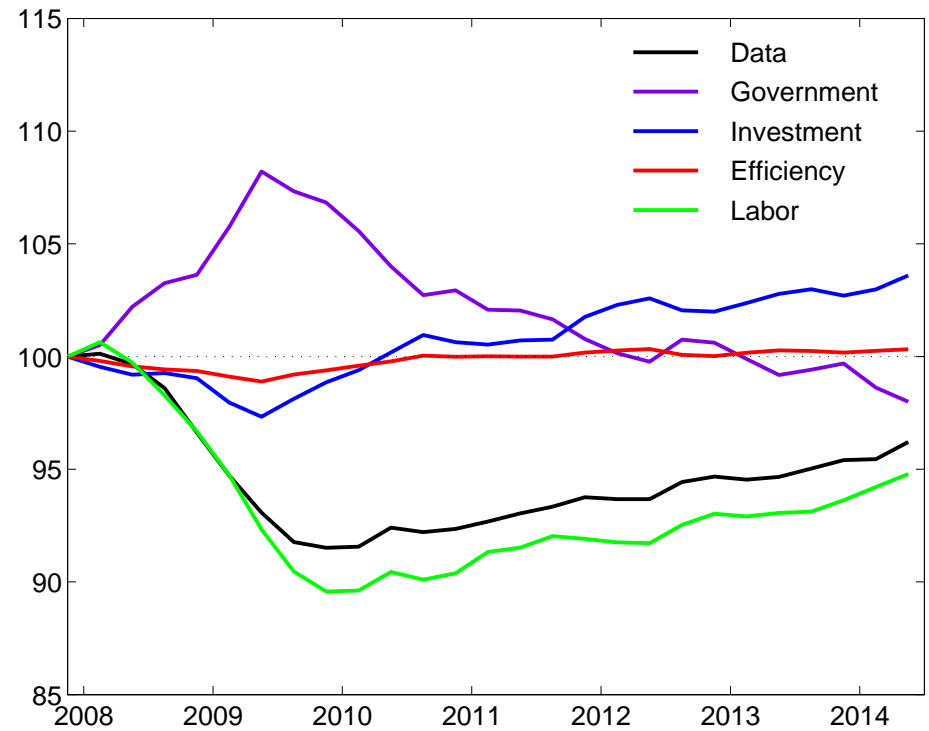
Total Hours



# Equilibrium Responses—One Wedge at a Time



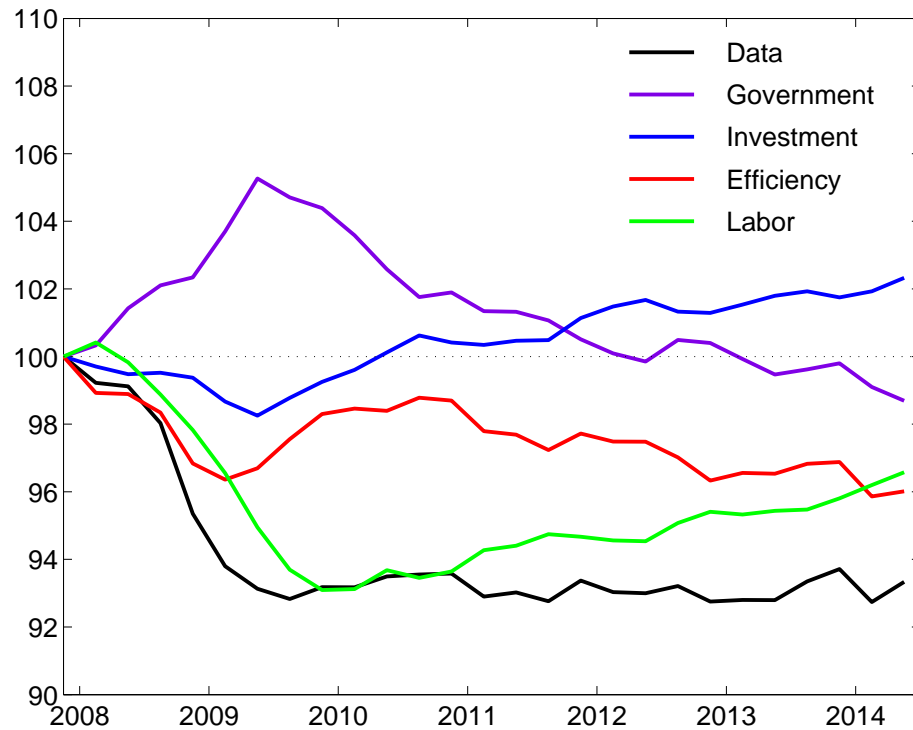
Output



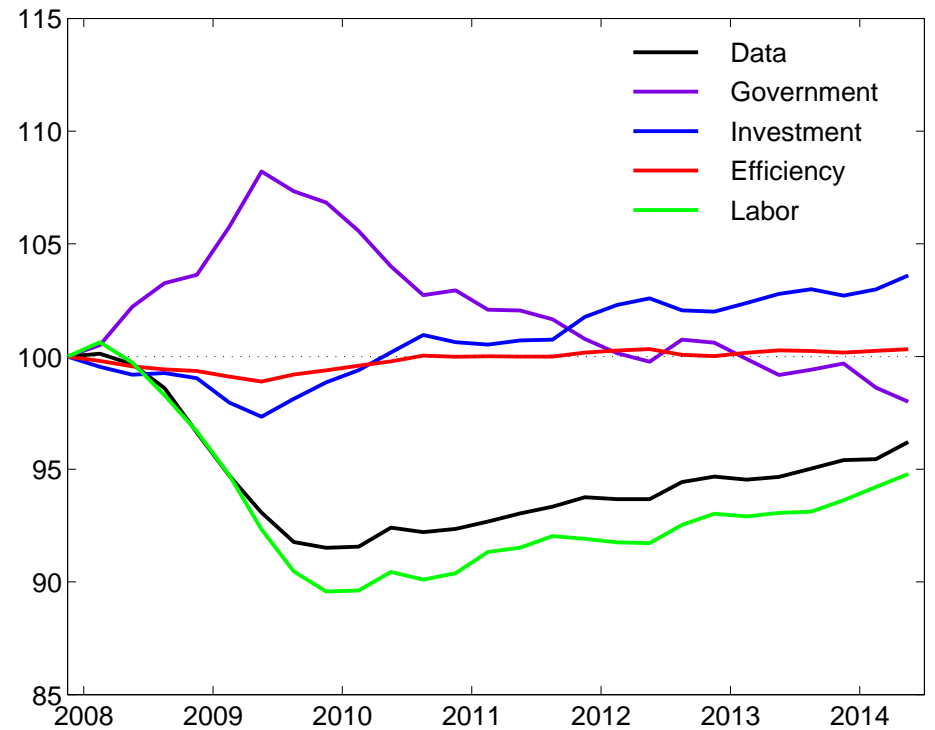
Total Hours



# Equilibrium Responses—One Wedge at a Time



Output



Total Hours

- Main result: labor wedge important for recession and stagnation





## Recap

- Approach useful for isolating relevant class of theories
  - Application to Great Recession shows
    - Equilibrium responses—not size of wedges—relevant
    - Labor wedge most important for accounting
- ⇒ Need theories that imply labor wedges in prototype



# Monetary Business Cycle Accounting

REFERENCE: SUSTEK, *Review of Economic Dynamics* 2011



# Monetary Business Cycle Accounting

- Sustek extends analysis to monetary economies
- New prototype with two additional
  - Variables: nominal interest rate and inflation
  - Wedges: that distort bond equation and Taylor rule



## Monetary BCA–Main Findings

- Many monetary models map into new prototype
- New prototype is block recursive
  - Original wedges affect real and nominal variables
  - New wedges affect *only* nominal variables

⇒ disconnect between monetary policy and employment



# Monetary Models



# Conventional vs. Unconventional

- Conventional tools:
  - Growth rate of money
  - Federal funds rate
- Unconventional tools:
  - Lending in private credit markets



# Conventional Monetary Policy

REFERENCES: CKM, *Econometrica* 2000

McGRATTAN, *Fed WP 598*, 1999



# Analyzing Conventional Policy

- Sticky-price model with
  - New-Keynesian Phillips curve (price-setting by firms)
  - Dynamic Euler equation (household optimization)
  - Taylor rule (Fed policy)
- What are predictions for output and employment?





# Analyzing Conventional Policy

- Sticky-price model with
  - $\Delta p_t = E_{t-1}\{\beta \Delta p_{t+1} + \gamma(y_t + \beta y_{t+1}) + \text{real shocks}\}$
  - Dynamic Euler equation (household optimization)
  - Taylor rule (Fed policy)
- What are predictions for output and employment?



# Analyzing Conventional Policy

- Sticky-price model with
  - New-Keynesian Phillips curve (price-setting by firms)
  - Dynamic Euler equation (household optimization)
  - Taylor rule (Fed policy)
- What are predictions for output and employment?



# Analyzing Conventional Policy

- Sticky-price model with
  - New-Keynesian Phillips curve (price-setting by firms)
  - $y_t = E_t y_{t+1} - \alpha(r_t - .5[\Delta p_t + \Delta p_{t+1}]) + \text{real shocks}$
  - Taylor rule (Fed policy)
- What are predictions for output and employment?



# Analyzing Conventional Policy

- Sticky-price model with
  - New-Keynesian Phillips curve (price-setting by firms)
  - Dynamic Euler equation (household optimization)
  - Taylor rule (Fed policy)
- What are predictions for output and employment?



# Analyzing Conventional Policy

- Sticky-price model with
  - New-Keynesian Phillips curve (price-setting by firms)
  - Dynamic Euler equation (household optimization)
  - $r_t = \rho r_{t-1} + (1 - \rho)[.5a[\Delta p_t + \Delta p_{t+1}] + by_t] + \epsilon_t$
- What are predictions for output and employment?



# Analyzing Conventional Policy

- Sticky-price model with
  - New-Keynesian Phillips curve (price-setting by firms)
  - Dynamic Euler equation (household optimization)
  - Taylor rule (Fed policy)
- What are predictions for output and employment?

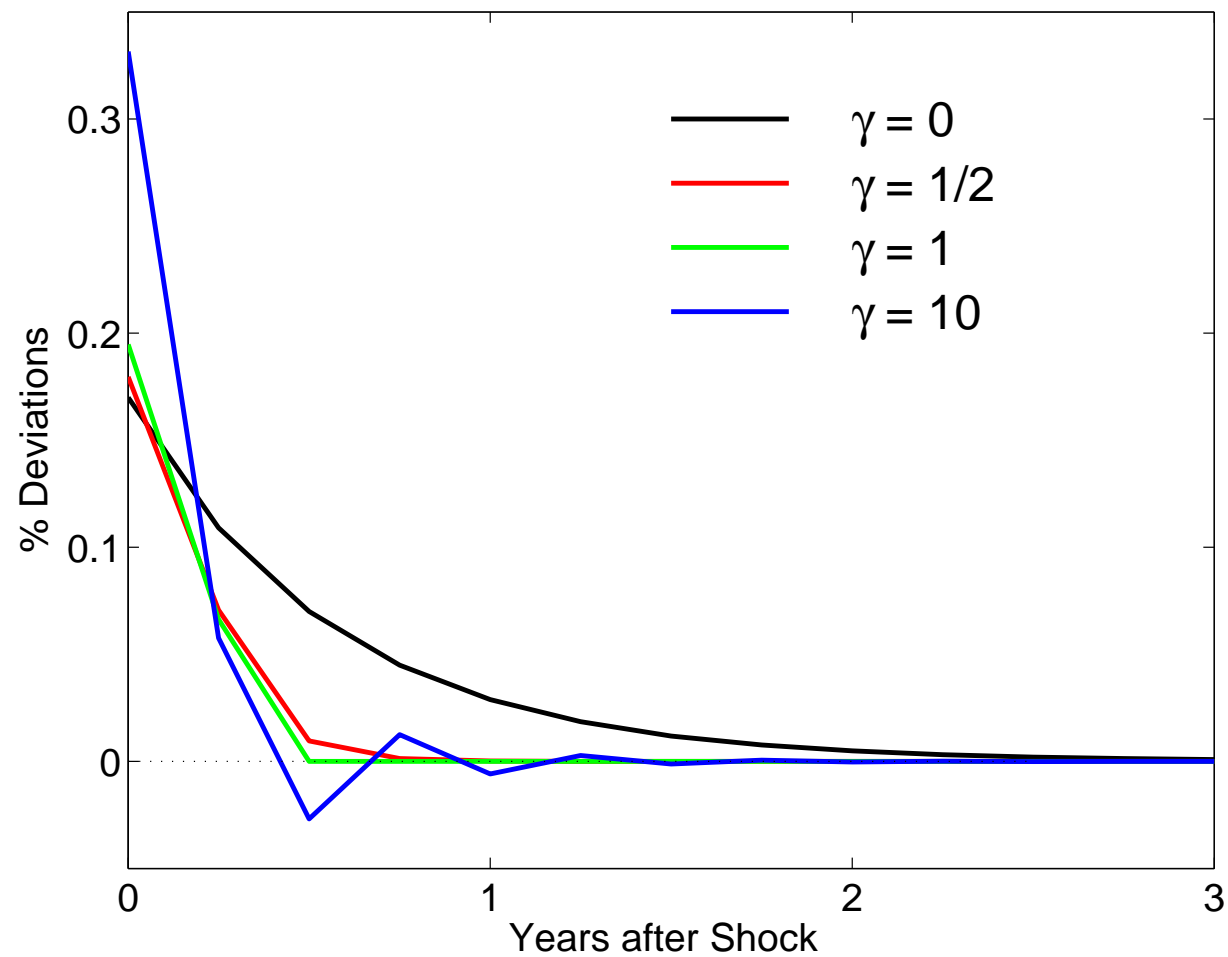


## Quantitative Predictions—Simplest Case

- Production:  $y = AF(k, l) = Al^{1-\alpha}$
- Prices are sticky:
  - Set in staggered fashion
  - Held fixed for 1/2 year
- Quantify variations in:
  - Responsiveness of prices to marginal costs ( $\gamma$ )
  - Fed's policy rule ( $\rho, a, b$ )



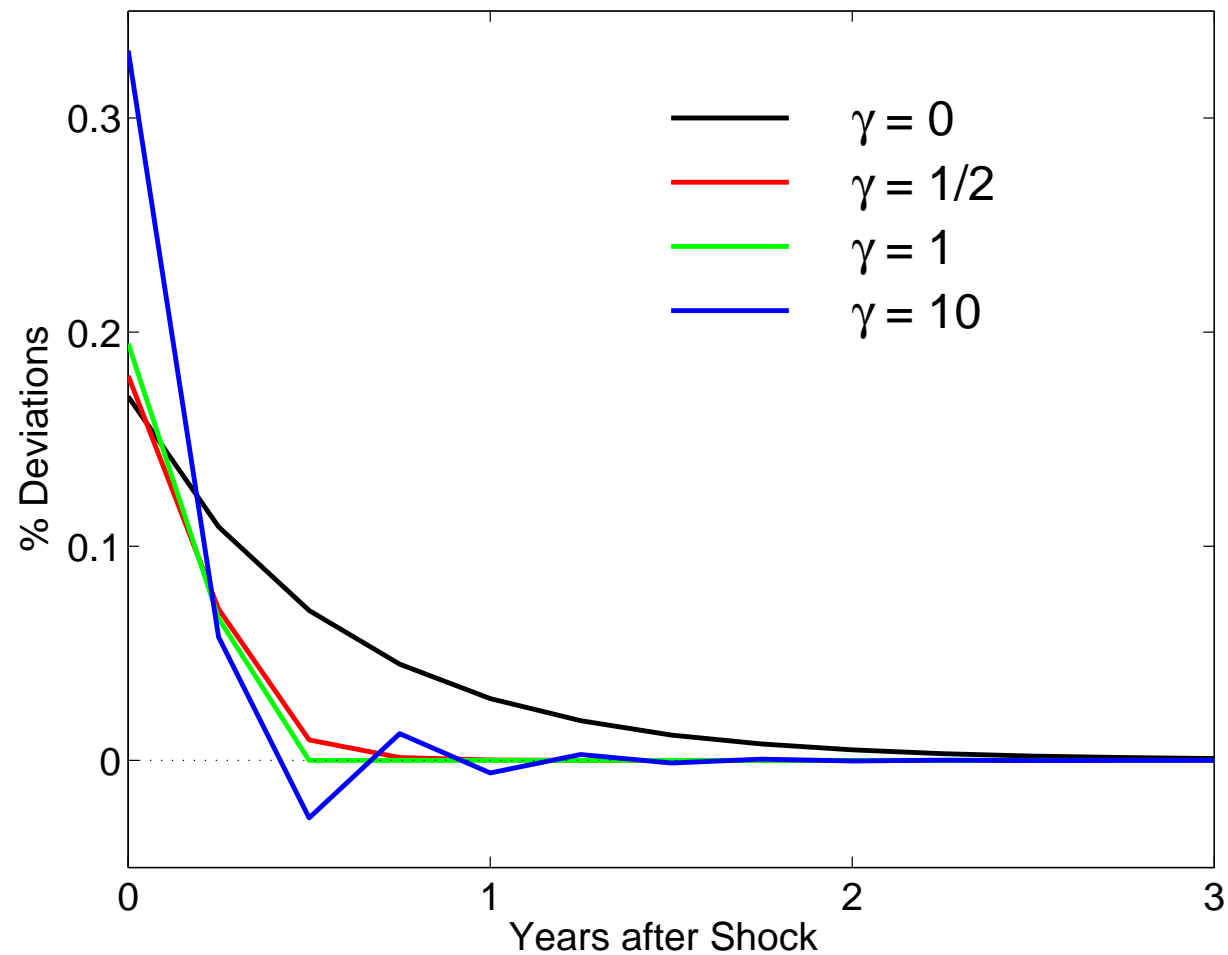
# Response of Output to Fed Policy Shock







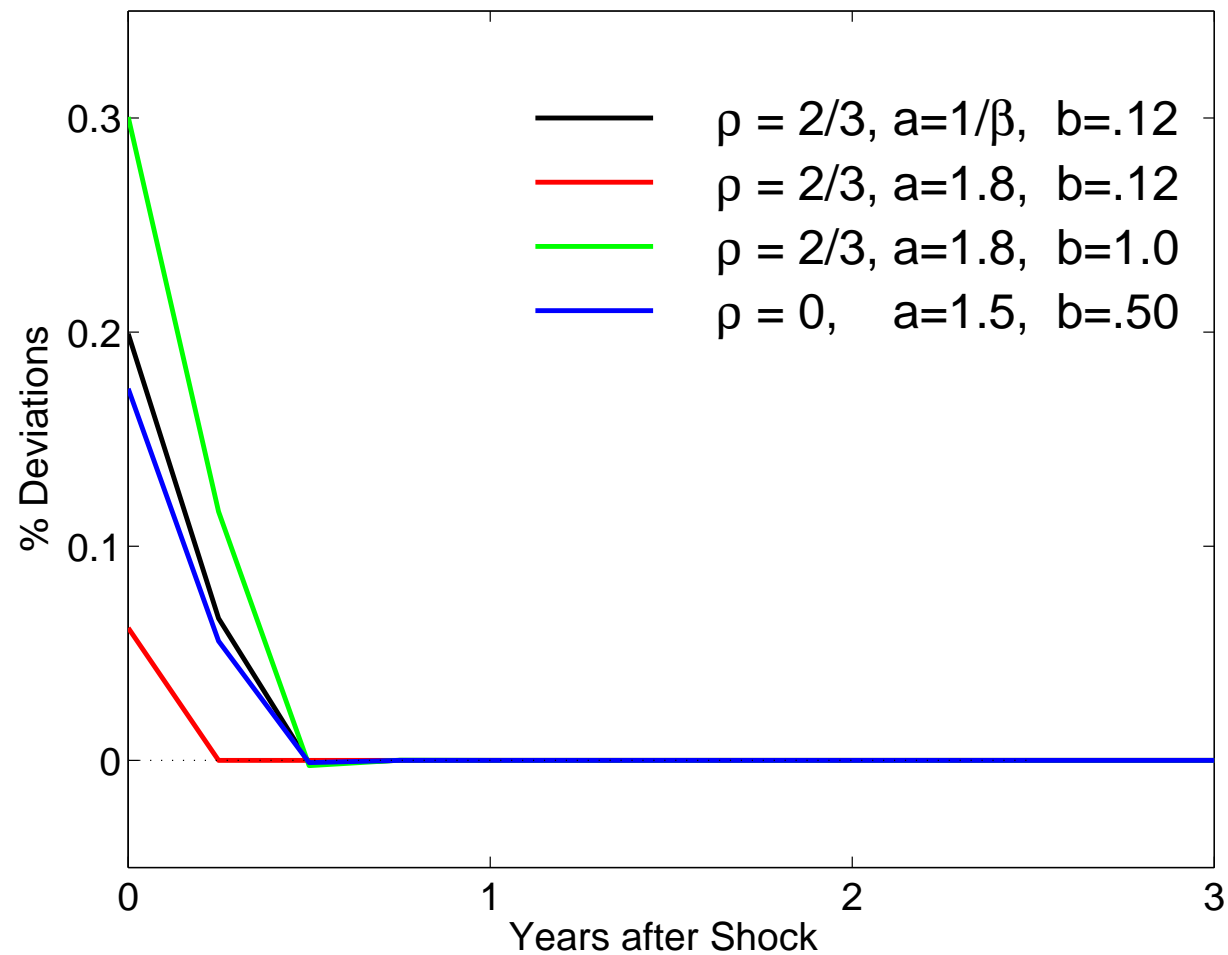
# Response of Output to Fed Policy Shock



- Main Result: no propagation for empirically plausible  $\gamma$ 's

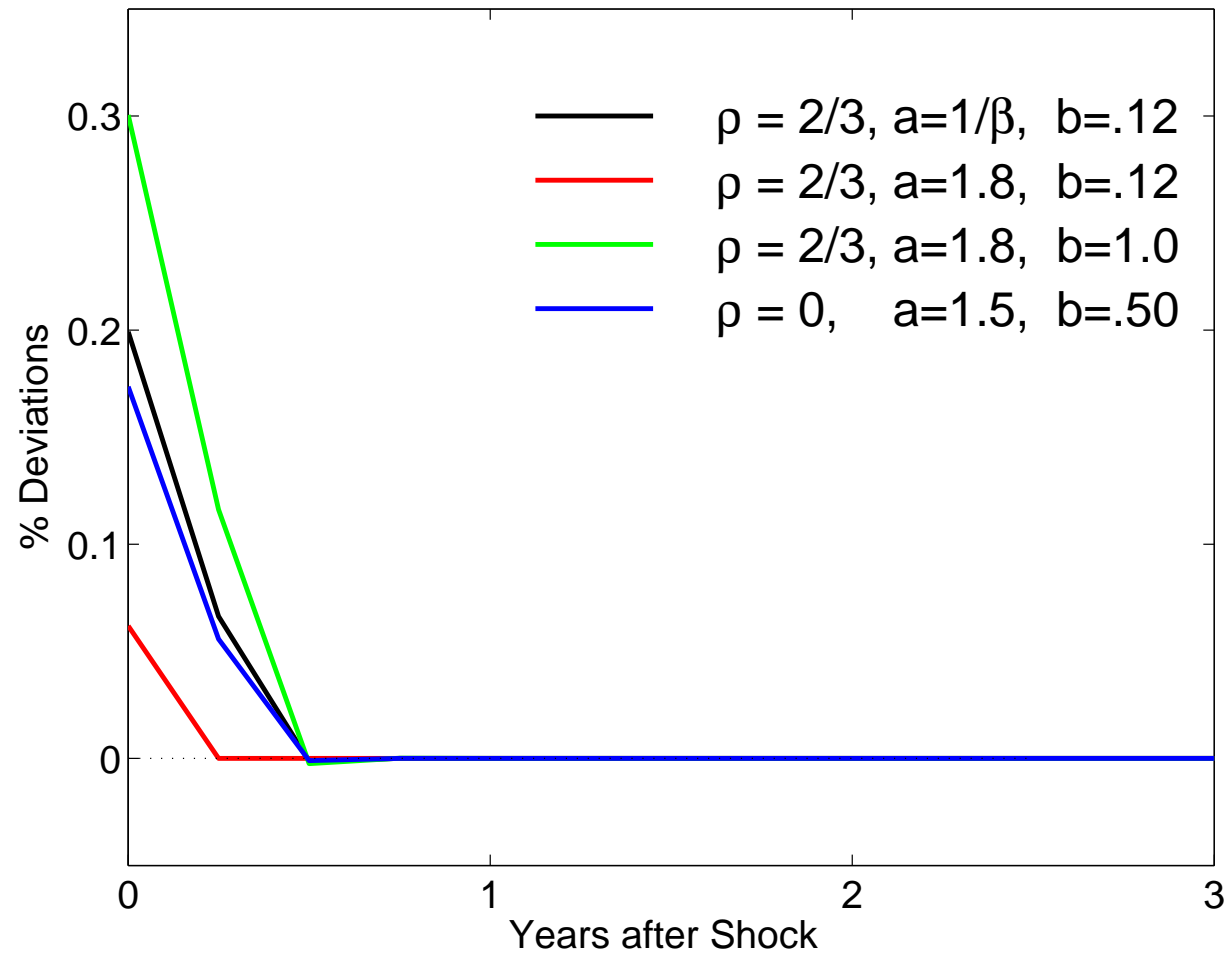


# Response of Output to Fed Policy Shock





# Response of Output to Fed Policy Shock



- Main Result: no propagation for any of these Taylor rules

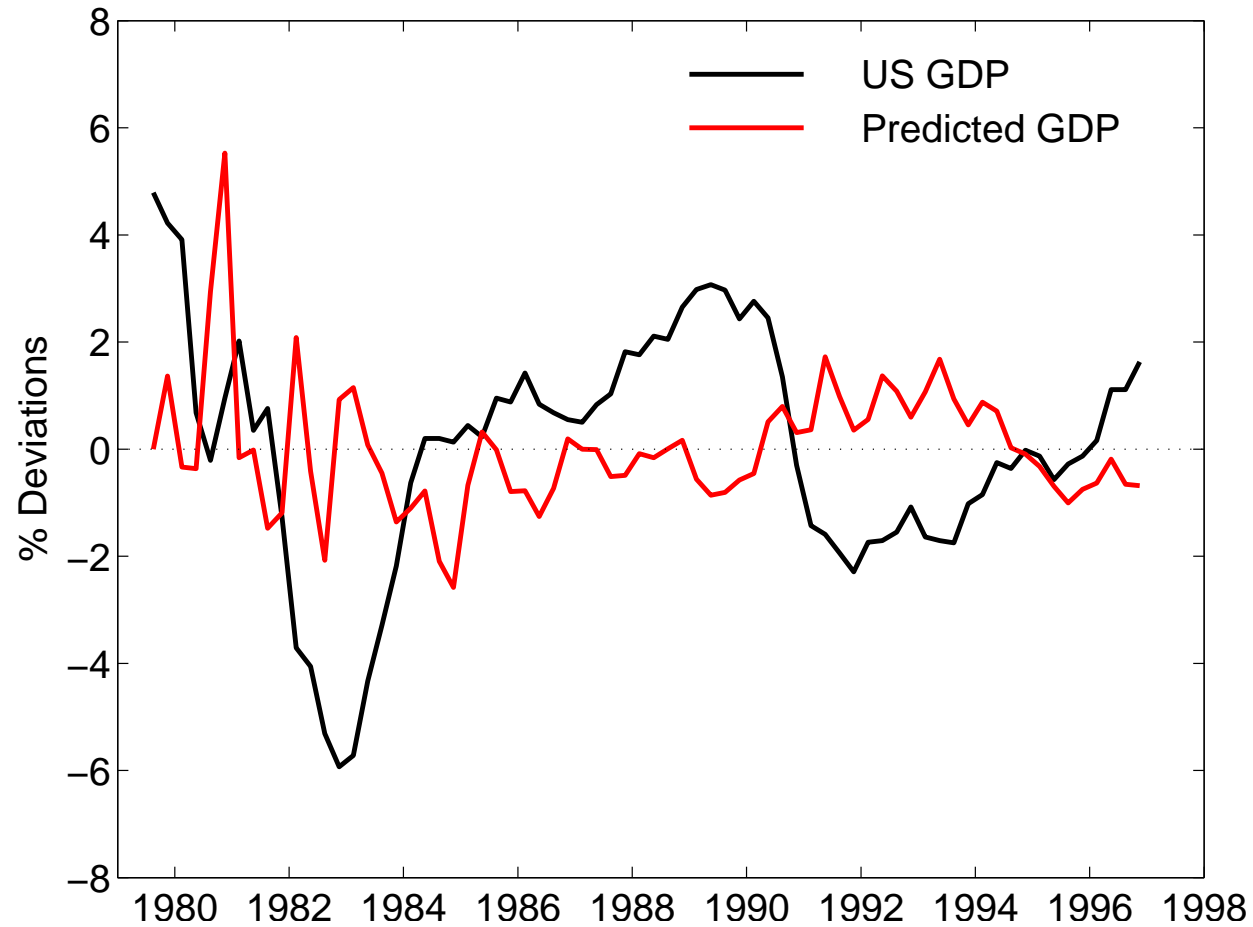


# Equilibrium Paths

- Estimate Taylor rule for US data
- Use rule errors as Fed policy shocks
- Compute model equilibrium
- Simulate paths for model time series

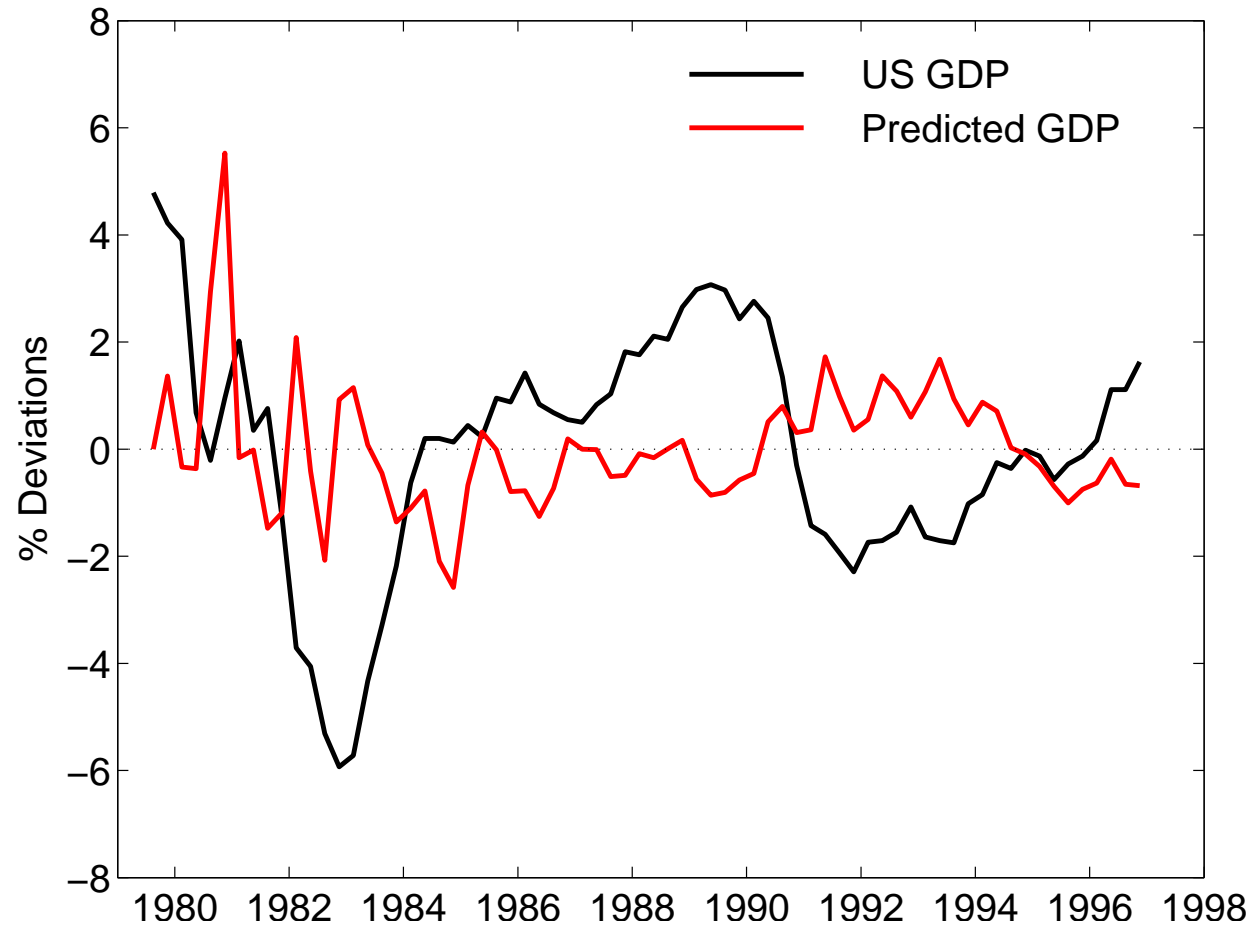


# Impact of Fed Policy Shocks





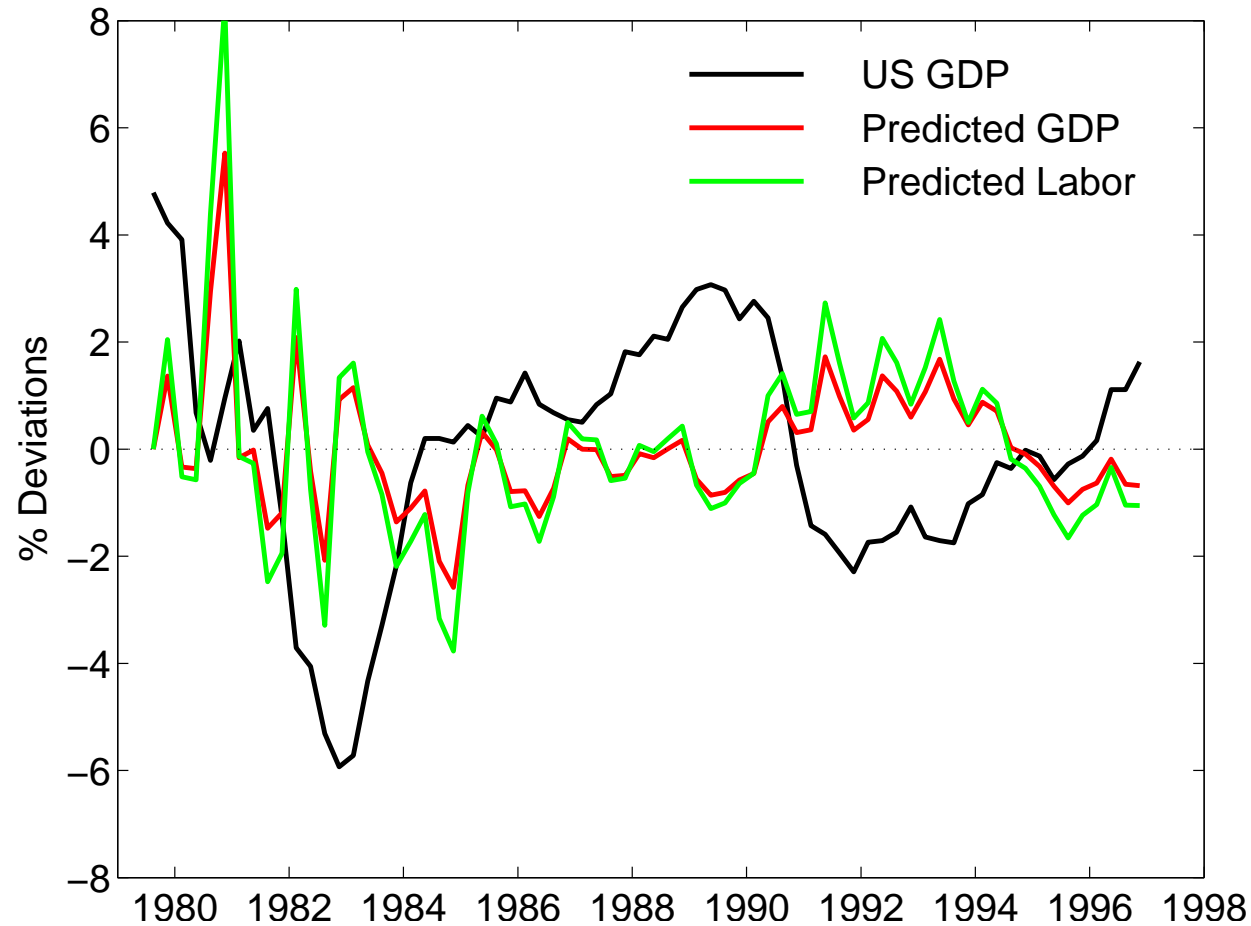
# Impact of Fed Policy Shocks



- Main Result: not main source of business cycles



# Impact of Fed Policy Shocks



- Main Result: not main source of employment variation



## Recap

- Conventional monetary models:
  - Fluctuations driven by shocks to Fed's policy rule
  - Propagation due to sticky prices and staggered contracts
- Main quantitative results:
  - No *endogenous* stickiness
  - Changes in Fed policy not main source of fluctuations





## Recap

- Conventional monetary models:
  - Fluctuations driven by shocks to Fed's policy rule
  - Propagation due to sticky prices and staggered contracts
- Main quantitative results:
  - No *endogenous* stickiness
  - Changes in Fed policy not main source of fluctuations

What about unconventional monetary models?



# Unconventional Monetary Policy

REFERENCE: GERTLER AND KARADI, *J. Monetary Economics* 2011



# GK's Model of Financial Intermediation

- All household investment intermediated
- Intermediaries have:
  - Finite horizon
  - Ability to divert funds
- In “crisis,” Fed funds  $\psi_t$  of intermediated assets

$$\psi_t \propto E_t \underbrace{[\log R_{kt+1} - \log R_{t+1}]}_{\text{credit spread}}$$



## GK's Intermediaries

- Maximize terminal wealth  $V$
- Subject to incentive constraint:

$$V \geq \lambda \cdot \text{intermediated assets}$$

- Key parameter settings:
  - Expected horizon: 10 years
  - Divertable fraction:  $\lambda = 38\%$



## GK's Crisis

- Persistent decline in capital quality ( $\xi_t$ )

$$Y_t = A_t F(\xi_t K_t, L_t)$$

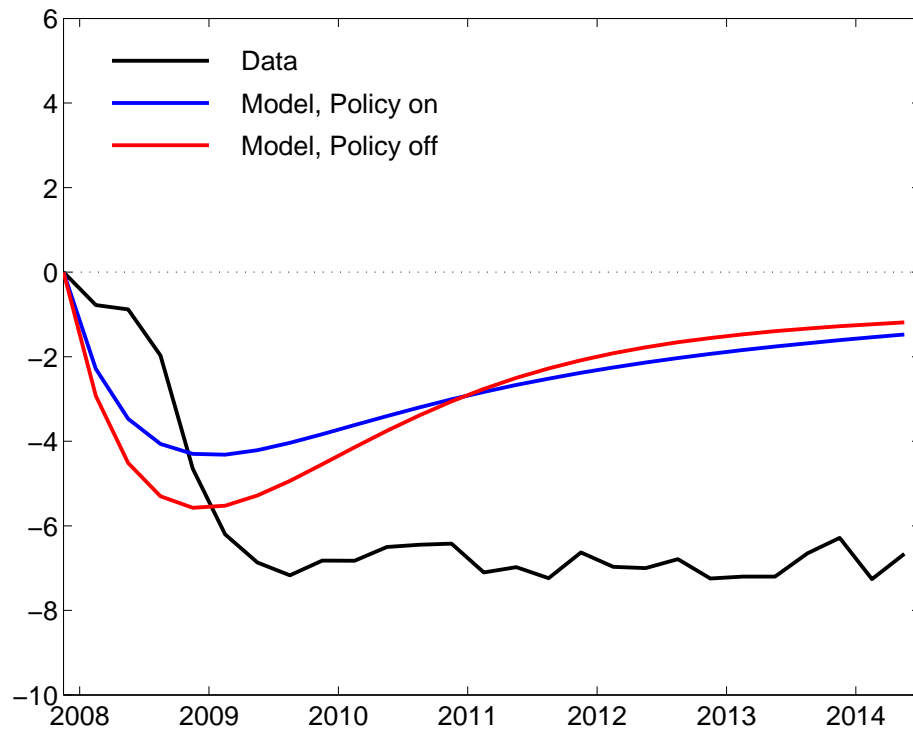
$$K_{t+1} = (1 - \delta)\xi_t K_t + I_t$$

$$\xi_{t+1} = 0.66\xi_t + \epsilon_{t+1}$$

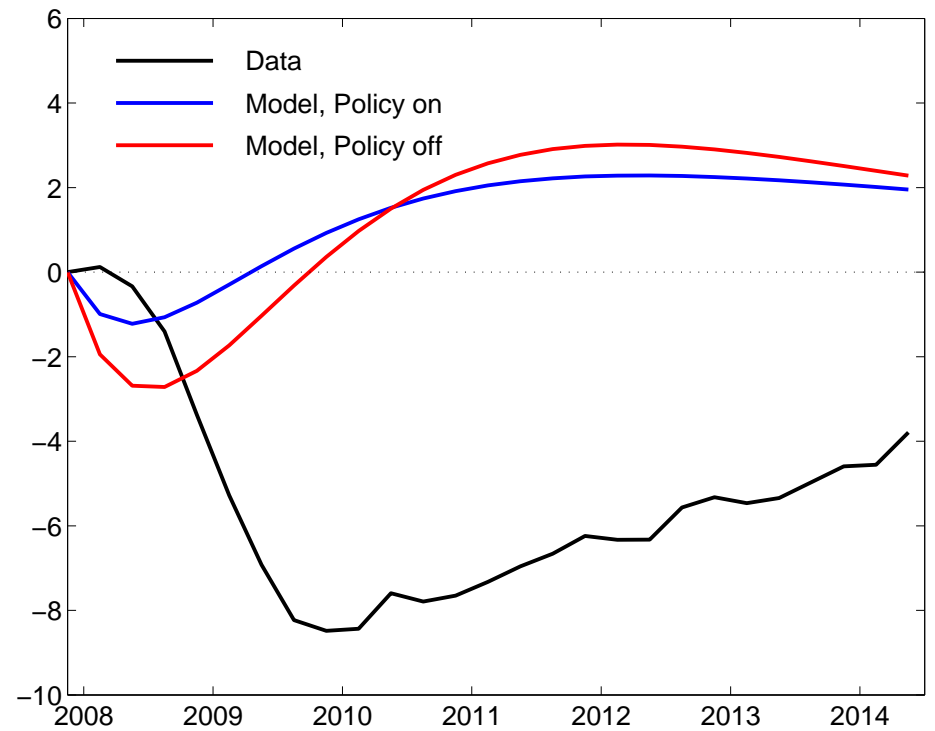
with initial  $\epsilon$  shock of  $-5\%$



# Impact of Fed Policy



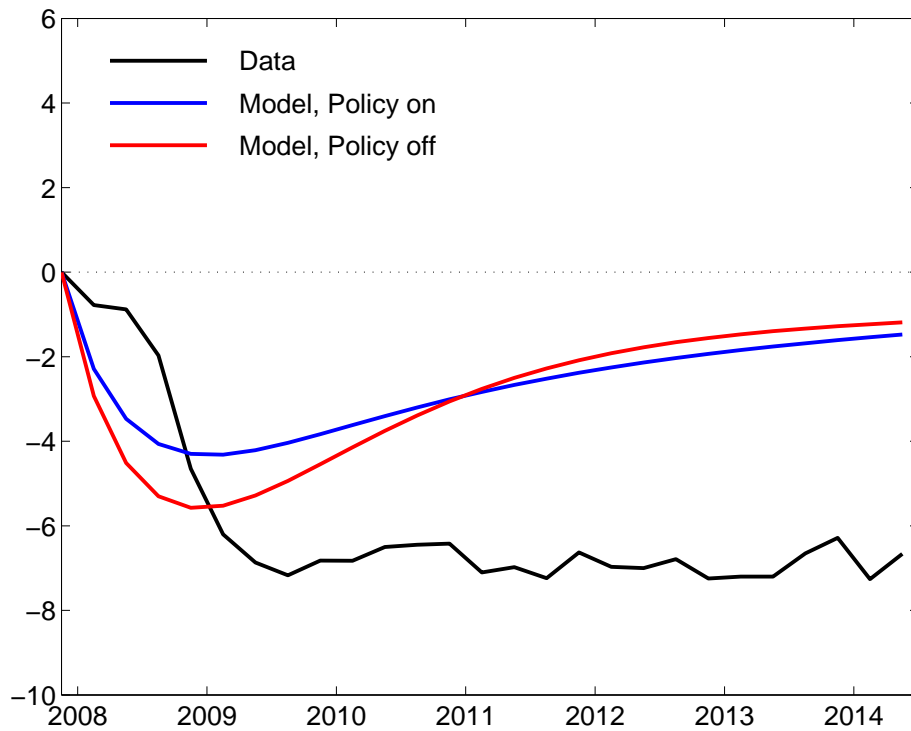
Output



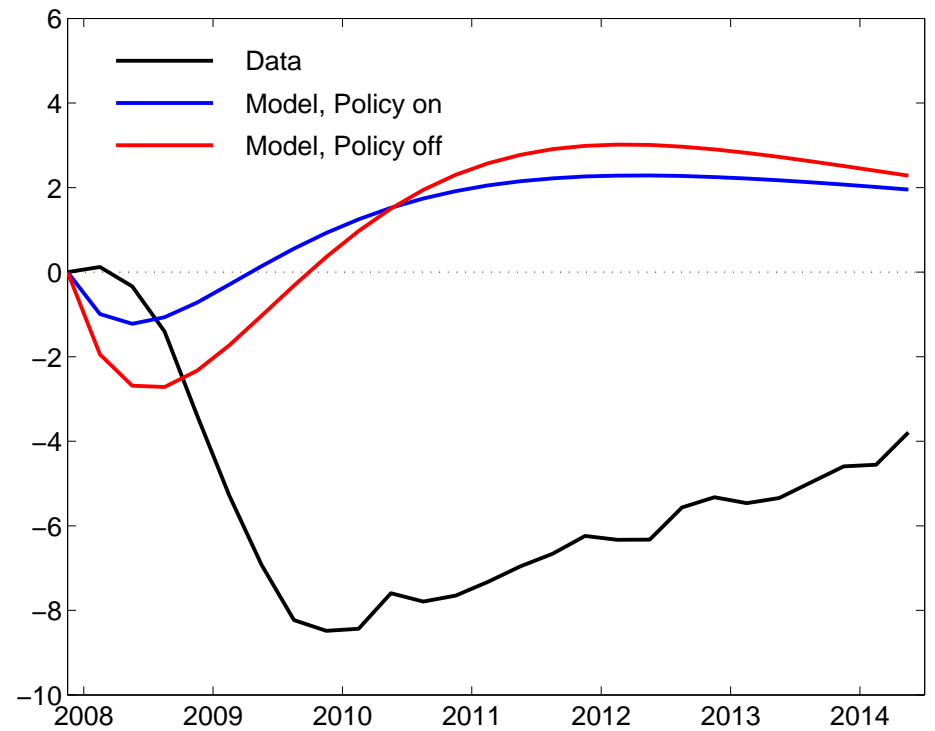
Total Hours



# Impact of Fed Policy



Output

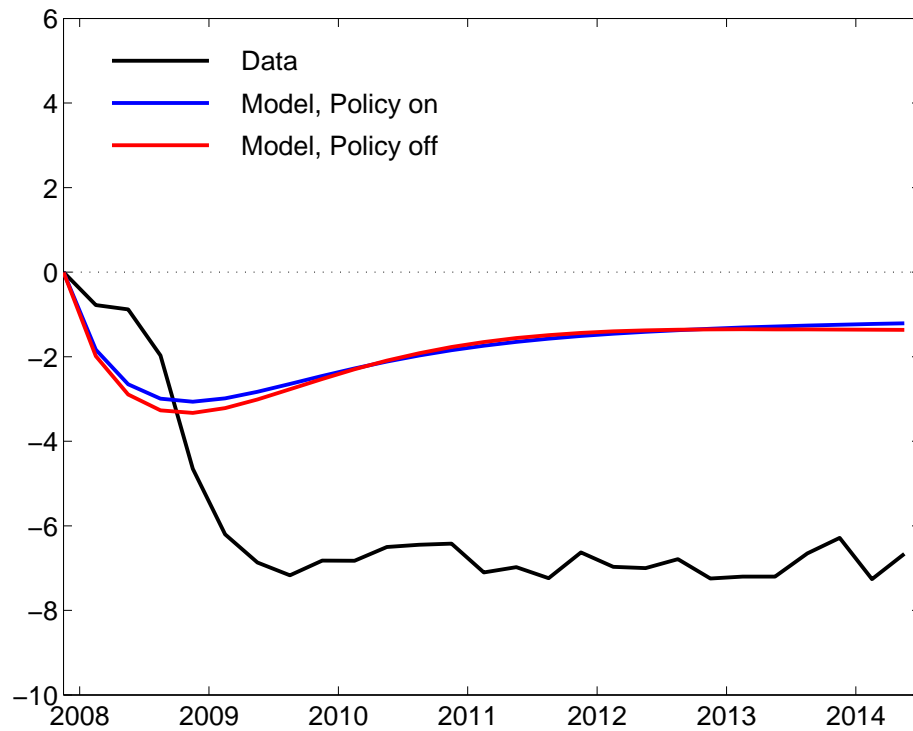


Total Hours

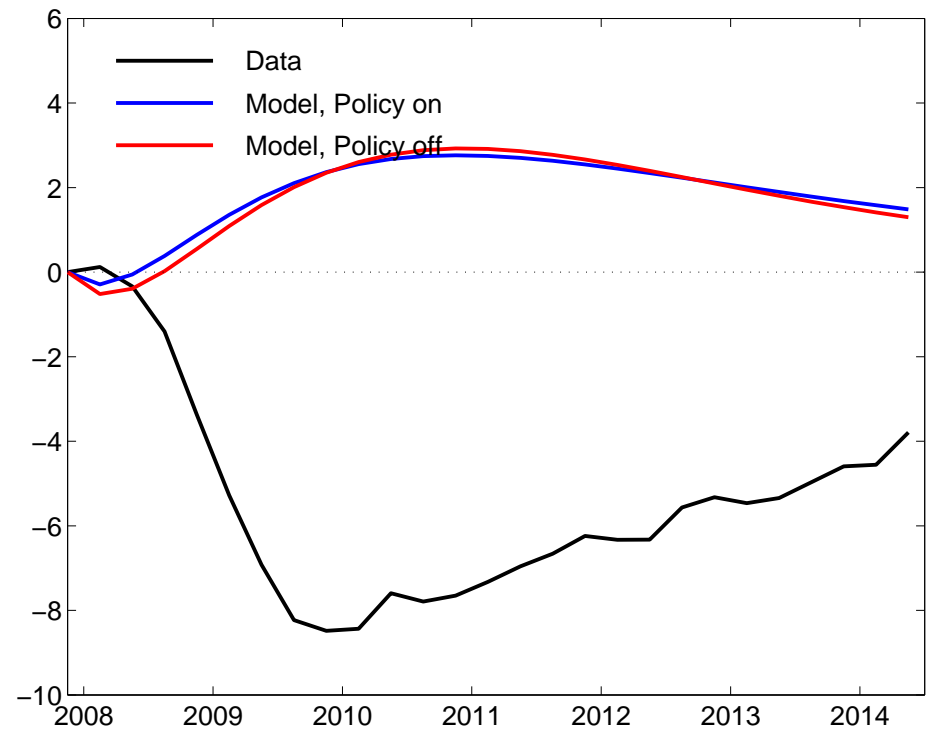
- Main result: small impact on labor



# Increase Bankers' Horizon



Output

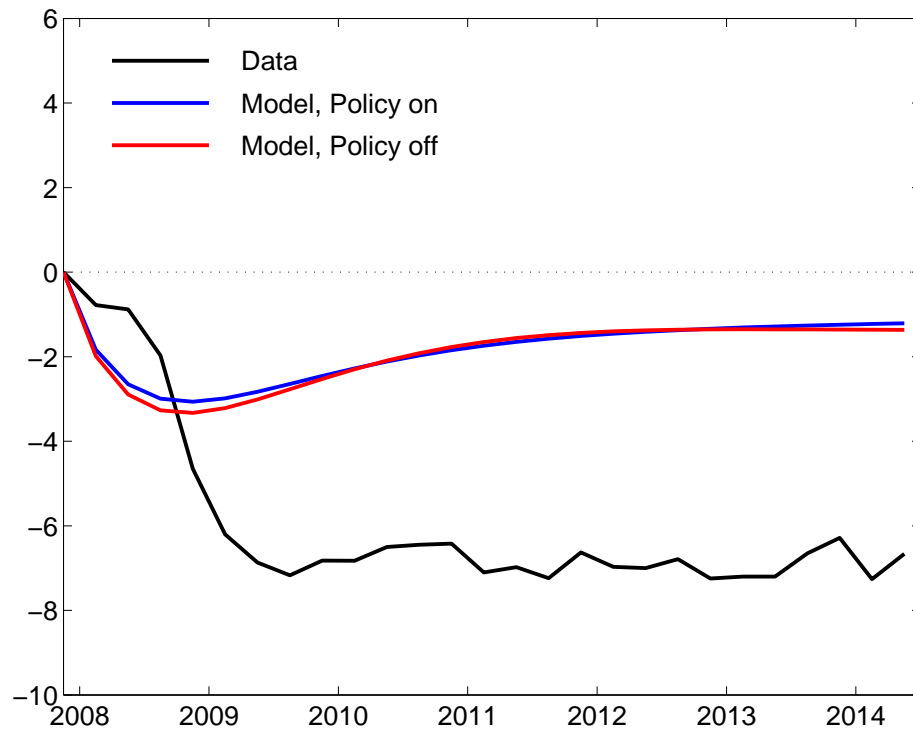


Total Hours

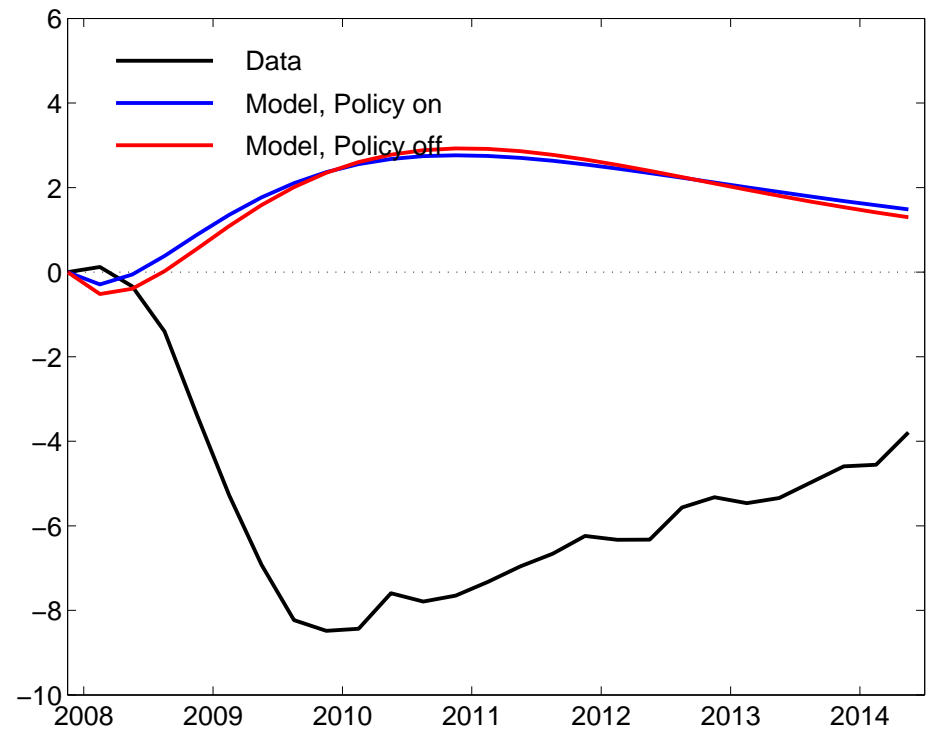




# Increase Bankers' Horizon



Output



Total Hours

- Main result: almost no impact on labor



## Recap

- Unconventional monetary models:
  - Crisis driven by persistent capital quality shocks
  - Finite horizons and agency problems perpetuate crisis
- Main quantitative results:
  - Model predictions for labor grossly at odds with data
  - Changes in Fed policy have little or no impact



## Recap

- Unconventional monetary models:
  - Crisis driven by persistent capital quality shocks
  - Finite horizons and agency problems perpetuate crisis
- Main quantitative results:
  - Model predictions for labor grossly at odds with data
  - Changes in Fed policy have little or no impact

But, quantitative predictions shouldn't surprise us



## Results Not Surprising

- From lens of business cycle accounting
    - Consumer problem almost same as prototype
    - GK add habit persistence which does little
    - GK add financial frictions which are central
- ⇒ Nothing generating variable labor wedge



## Results Not Surprising

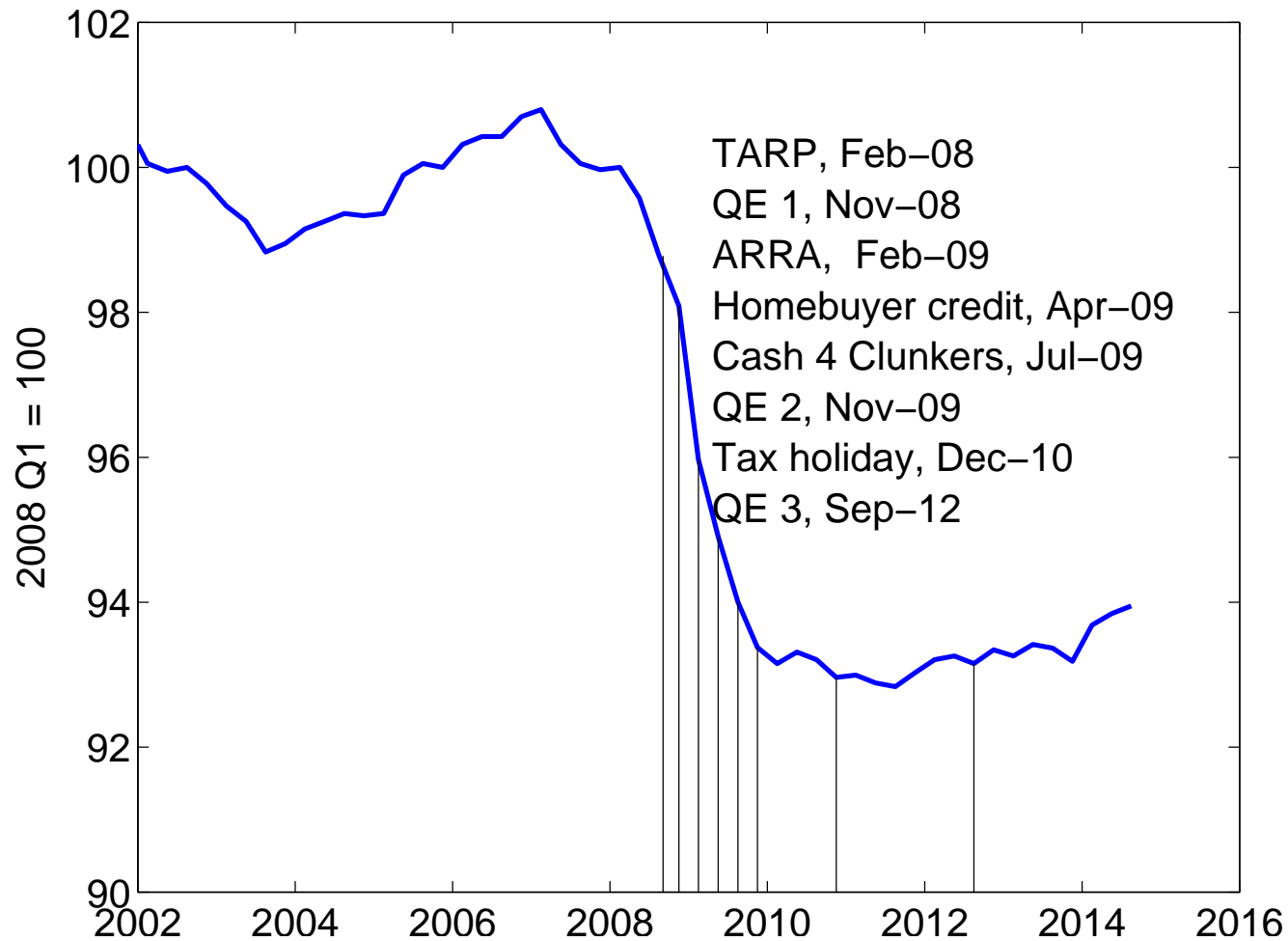
- From lens of business cycle accounting
  - Consumer problem almost same as prototype
  - GK add habit persistence which does little
  - GK add financial frictions which are central
- ⇒ Nothing generating variable labor wedge
- What is the implication for the full employment mandate?



# Implications for Full Employment Mandate



# Recall Plot of Employment-Population



Debates rage over impact of Fed policy



# Theory and the Full Employment Mandate

- Evidence:
  - Many actions taken by Fed
  - Employment-population ratio never recovered
  - Per capita hours never recovered
- Theory: not inconsistent with this evidence
  - Predicts Fed actions *shouldn't* have much impact





# What is Gained by Single Mandate

- Fewer opportunities for discretionary policy
- More accountability
- Greater transparency



# Summary

- Reviewed:
  - Historical debate about dual mandate
  - US data through lens of business-cycle accounting
  - Quantitative predictions of modern monetary models
- Found no scientific justification for dual mandate

# AEA CONTINUING EDUCATION PROGRAM



## MONETARY POLICY

RICARDO REIS, COLUMBIA UNIVERSITY

JANUARY 5-7, 2015

# How can a central bank control inflation?

## AEA continuing education – monetary policy

Ricardo Reis

Columbia University

January 2015

## Sims (2013), AEA presidential lecture conclusion

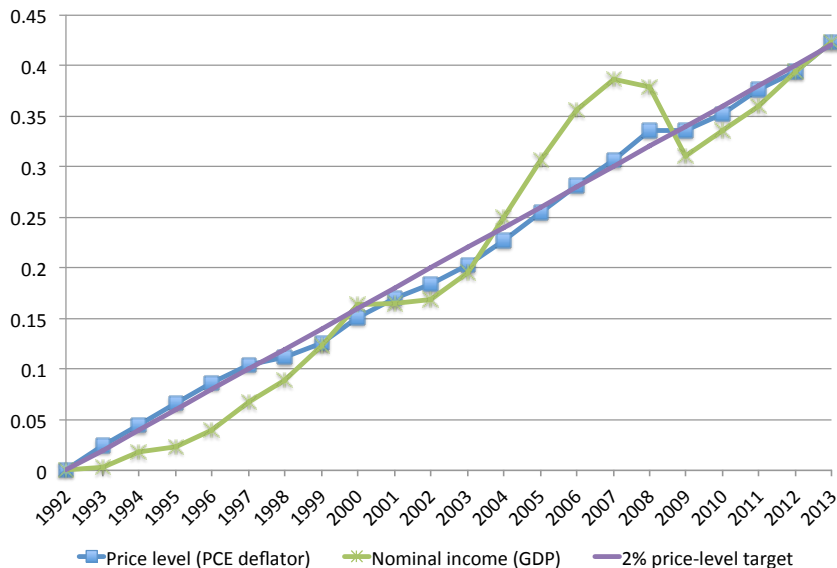
*The kinds of models that have been the staple of undergraduate macroeconomics teaching, with price level determined by balance between “money supply” and “money demand”, and money supply described using the “money multiplier”, are obsolete and provide little insight into the policy issues facing fiscal and monetary authorities in the last few years. There are relatively simple models available, though, that could be taught in undergraduate and graduate courses and that would allow discussion of current policy issues using clearer analytic foundations.*

Goal of this lecture: Explain the modern theory of how the price level is determined.

# How to control inflation?

- ▶ Why does it matter?
  1. Because inflation is one of the key macro variables.
  2. Because it affects welfare.
  3. Because it is *the* main goal of monetary policy.
  4. Because it is still elusive today (current undershooting of 2%).
  
- ▶ Why need to learn about it?
  1. Many old stories are not backed by sound theory.
  2. Alternative way of accomplishing it, with pros and cons.
  3. Require policy coordination, there are limits.
  4. Macro question, different parts must fit together (GE).
  
- ▶ What will be my approach?
  1. Want to achieve target  $P_t^*$ , assess macro conditions with error.
  2. Can monetary policy deliver  $P_t^*$ ?
  3. How large will deviations of  $P_t$  from  $P_t^*$  be?
  4. Theoretically driven, but with applications.

# Inflation in the U.S. data



Source: Reis (2014)

# Outline of this lecture

1. Role for policy: price level indeterminacy
  - ▶ What is the classical dichotomy?
  - ▶ Why is the price level indeterminate?
2. Fisher approach: choosing interest rates
  - ▶ The arbitrage condition
  - ▶ Payment on reserves
  - ▶ Wicksell and Taylor rules
3. Monetarist approach: choosing money
  - ▶ The money demand
  - ▶ Money supply rules
  - ▶ Seignorage rules
4. Gold standard approach: choosing pegs
  - ▶ The price index
  - ▶ Commodity standards
5. Budget approach: choosing borrowing
  - ▶ The integrated budget constraint of the government
  - ▶ Fiscal theory of the price level
6. Central bank independence
  - ▶ Policy coordination
  - ▶ Central bank solvency



Role for policy: price level  
indeterminacy

# The Euler equation

$$\mathbb{E}_t [M_{t+1}(1 + R_t)] = 1$$

- ▶  $M_{t+1}$  is a stochastic discount factor,  $R_t$  is the return on a real asset known at date  $t$  that pays at date  $t + 1$ .
- ▶ Economic intuition: 1 good today is worth  $M_{t+1}$  goods tomorrow. Must be at indifference point.
- ▶ Investment intuition: there cannot be arbitrage profits.
- ▶ Key assumption for this class:  $M_{t+1}$  is exogenous.

## Microfoundations...

Representative agent chooses  $\{C_t, K_{t+1}\}_{t=0}^{\infty}$  with preferences:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \ln C_t \right\}$$

and can save in real bonds:

$$P_t C_t + P_t K_{t+1} \leq P_t Y_t + P_t K_t (1 + R_{t-1}).$$

Uncertainty on income  $Y_t$ , exogenous endowment. Initial  $K_0(1 + R_{-1})$  and natural debt limit.

Optimal behavior characterized by (i) budget constraints with equality, (ii) initial condition plus transversality condition, and (iii)

$$\frac{1}{C_t} = \beta \mathbb{E}_t \left( \frac{1 + R_t}{C_{t+1}} \right).$$

## Microfoundations...

Market clearing conditions when capital is an inside asset:

$$K_t = 0,$$

$$C_t = Y_t.$$

*An equilibrium is a sequence of variables  $\{C_t, K_{t+1}, R_t, P_t\}_{t=0}^{\infty}$  with initial condition  $K_0$  and an exogenous process for  $Y_t$  such that:*

- 1. The representative household behaves optimally;*
- 2. Markets in goods and the two assets clear.*

Boils down to Euler equation with:

$$M_{t+1} = \frac{\beta Y_{t+1}}{Y_t}.$$

## ...and generalizations

- ▶ Finite lives: only need optimal behavior between two periods.
- ▶ Heterogeneity: as long as all at the margin and  $M_{t+1}$  can depend on distributions.
- ▶ Capital accumulation: Then  $M_{t+1}$  is endogenous, get extra equation from Solow model, still no significant difference.
- ▶ Richer real assets: long-lived and risky assets could be introduced, still a shadow  $K_t$  will exist.
- ▶ No arbitrage perspective: basic theorem from arbitrage pricing, no arbitrage implies that  $M_{t+1}$  exists and complete markets that it is unique.

## Price level indeterminacy

*A reduced-form equilibrium is a solution for  $\{R_t, P_t\}_{t=0}^{\infty}$  such that given an exogenous  $\{M_{t+1}\}_{t=0}^{\infty}$ , the Euler equation holds.*

- ▶ Solution for  $R_t$ :

$$R_t = \mathbb{E}_t [M_{t+1}]^{-1} - 1.$$

- ▶ Classical dichotomy: real outcomes do not depend on the price level.
- ▶ *Price level indeterminacy*: There is nothing here to pin down the price level!
- ▶ David Hume: agents do not suffer from money illusion. Dollars are just a unit of account. Failure of theory, not failure of reality. How to proceed? Policy chooses the unit of account, policy will pin down the price level.

## Introduce nominal bonds?

- ▶ I save  $B_{t+1}$  dollars at date  $t$ , receive  $B_{t+1}(1 + I_t)$  dollars at date  $t + 1$ . New optimality (Euler) condition:

$$\mathbb{E}_t \left[ M_{t+1} \left[ \frac{(1 + I_t)P_t}{P_{t+1}} \right] \right] = 1.$$

- ▶ *A reduced-form equilibrium is a solution for  $\{R_t, P_t, I_t\}_{t=0}^{\infty}$  such that given an exogenous  $\{M_{t+1}\}_{t=0}^{\infty}$ , the two Euler equations hold.*
- ▶ Indeterminacy remains.  $R_t$  is pinned down just as before, but must solve for  $\{P_t, I_t\}$  with only one condition:

$$(1 + I_t)^{-1} = \mathbb{E}_t \left[ M_{t+1} \left( \frac{P_t}{P_{t+1}} \right) \right].$$

## Conclusion on price level indeterminacy

- ▶ What is the unit of account? *Any one is as good as any other from perspective of fully rational agents that suffer from no money illusion. So, think of the government (or society) as picking a unit of account. Our goal is to pin it down.*
- ▶ Why is the price level indeterminate? *In the same way that measurements are indeterminate, centimeters versus inches, or cents versus dollars.*
- ▶ What is a key restriction in these classes? *Exogenous  $M_{t+1}$  so classical dichotomy. Not important to any of the main lessons, but will make life much easier for exposition.*



# Fisher approach: choosing interest rates

# The Fisher equation

$$\mathbb{E}_t \left[ M_{t+1} \left( 1 + R_t - \frac{(1 + I_t)P_t}{P_{t+1}} \right) \right] = 0$$

- ▶ Intuition: assets must give the same adjusted expected return.
- ▶ Will use log-linearizations sometimes.
  - ▶ Convenient mathematically because of linearity.
  - ▶ Economic implication is no risk premia.
  - ▶ Approximation point:  $M_{t+1} = \beta$ ,  $P_{t+1}/P_t = \Pi$  so other variables become:  $1 + R = \beta^{-1}$  and  $1 + I = \Pi\beta^{-1}$ .
  - ▶ Use lower cases for log-linear deviations, so  $r_t = \ln((1 + R_t)\beta)$ .
  - ▶ The Fisher equation becomes:

$$i_t - \mathbb{E}_t(\Delta p_{t+1}) = r_t.$$

## Introducing policy: fiscal policy

- ▶ Fiscal authority collects taxes (and transfers)  $T_t$ , spends on purchases  $G_t$ , receives dividends from central bank  $D_t$ . All real for now, but if nominal makes no difference.
- ▶ Budget constraint:

$$T_t + D_t = G_t,$$

assumed no government borrowing, inessential.

- ▶ Assume  $G_t$  is exogenous,  $D_t$  is set by rule or by central bank. So  $T_t$  is the policy choice. Completely constrained by equation above.

## Monetary policy: indexed reserves

- ▶ Central bank issues a liability, called reserves. (In reality, banks hold it.) It has two interesting features:
  1. It is denominated in dollars. So  $V_t^R$  dollars outstanding.
  2. It promises a real return  $1 + x_t$  on it at date  $t$ . So, if you have \$1000, then if I promise you 2% and price level tomorrow is 1.06, tomorrow I pay you  $1000 \times 1.02 \times 1.06$ .
- ▶ Budget constraint of the central bank:

$$V_{t+1}^R = P_t(1 + x_{t-1})V_t^R + P_t D_t.$$

Both  $x_t$  and  $V_t^R$  are *choice* variables, decided by policy.

- ▶ Consumers now have the option to hold this new asset. Must be indifferent between it and other assets...

## Equilibrium now

- ▶ Real equilibrium is still:

$$1 + R_t = \mathbb{E}_t [M_{t+1}]^{-1}$$

(although government purchases would change  $M_{t+1}$ ).

- ▶ Nominal equilibrium:  $\{P_t, I_t\}_{t=-\infty}^{\infty}$  such that:

$$(1 + I_t)^{-1} = \mathbb{E}_t \left[ M_{t+1} \left( \frac{P_t}{P_{t+1}} \right) \right],$$

$$\mathbb{E}_t \left[ M_{t+1} \left( \frac{P_t}{P_{t+1}} \right) [(1 + x_t) P_{t+1}] \right] = 1,$$

recalling that  $x_t$  is set by policy, chosen by the central bank.

- ▶ Choice of  $V_t^R$  has no effect on equilibrium because of Ricardian equivalence.

## Determining the price level

- ▶ An exogenous  $x_t$  choice implies

$$\begin{aligned} 1 &= \mathbb{E}_t \left( M_{t+1} \left( \frac{P_t}{P_{t+1}} \right) [(1 + x_t) P_{t+1}] \right) \\ &= [(1 + x_t) P_t] \mathbb{E}_t (M_{t+1}) = [(1 + x_t) P_t] (1 + R_t)^{-1} \\ \Rightarrow P_t &= \frac{1 + R_t}{1 + x_t} \end{aligned}$$

Price level has been pinned down!

- ▶ Policy rule, given an estimate of the real interest rate:

$$1 + x_t = (1 + \hat{R}_t) / P_t^*$$

automatically leads to  $P_t = P_t^* (1 + R_t) (1 + \hat{R}_t)$ .

- ▶ In logs, hit target with errors:

$$p_t = p_t^* + \varepsilon_t \text{ with } \varepsilon_t = \ln(1 + R_t) - \ln(1 + \hat{R}_t).$$

# Intuition and implementation

- ▶ Intuition: you promise a real payment, its real return is pinned down by arbitrage, therefore price level must adjust to ensure this is true.
- ▶ Governments have issued indexed bonds for a long time. No reason why central bank cannot do it as well.
- ▶ Control errors  $\varepsilon_t = \ln(1 + R_t) - \ln(1 + \hat{R}_t) \approx r_t - \hat{r}_t$ : related to mistakes in assessing state of economy. But insofar as observe  $R_t$  from government bonds, may be small.
- ▶ No central bank does this. But cleaner model of determining price level. Maybe they should.

## Nominal reserves now

- ▶ Reserves now promise a *nominal* return:  $I_t^V$
- ▶ Budget constraint of the central bank now is:

$$V_{t+1} = (1 + I_{t-1}^V)V_t + P_t D_t.$$

And  $V_t$  is essentially equivalent to a nominal bond.

- ▶ Nominal equilibrium:  $\{P_t, I_t\}_{t=0}^{\infty}$  such that:

$$(1 + I_t)^{-1} = \mathbb{E}_t \left[ M_{t+1} \left( \frac{P_t}{P_{t+1}} \right) \right],$$

$$I_t = I_t^V,$$

while  $M_{t+1}$  is exogenous as before from classical dichotomy.

- ▶ Log-linear approximation problem:

$$r_t = i_t^V - \mathbb{E}_t(\Delta p_{t+1}).$$



# The failure of nominal interest rate pegs

- ▶ Say exogenous path for  $i_t = i_t^v$ . To be consistent with target:

$$i_t = \hat{r}_t + \hat{p}_{t+1}^* - p_t^*,$$

noting that must make a forecast of what the future policy target will be as well.

- ▶ Then the equilibrium condition implies:

$$p_t - p_t^* = \mathbb{E}_t(p_{t+1}) - \hat{p}_{t+1}^* + r_t - \hat{r}_t.$$

Can't iterate forward, no boundary condition! There is no condition pinning down final or initial price level.

- ▶ Indeterminacy of interest-rate rules: if expect higher prices in future, prices today just jump to ensure that is valid.

## Feedback rule: Wicksellian rules

- ▶ Now commit to follow the rule, with  $\phi > 0$ :

$$\dot{i}_t = \hat{r}_t + \hat{p}_{t+1}^* - p_t^* + \phi(p_t - p_t^*).$$

- ▶ Combining with equilibrium condition and iterating forward:

$$p_t = p_t^* + \sum_{s=0}^T (1 + \phi)^{-s-1} \mathbb{E}_t [r_{t+s} - \hat{r}_{t+s} + p_{t+1+s}^* - \hat{p}_{t+1+s}^*] \\ + (1 + \phi)^{-T-1} \mathbb{E}_t (p_{t+T} - p_{t+T}^*).$$

Allowed for non-rational expectations: expectations of public and policymaker may not coincide.

- ▶ If last term goes to 0 as  $T$  goes to infinity, get unique bounded solution:

$$p_t = p_t^* + \sum_{s=0}^{\infty} (1 + \phi)^{-s-1} \mathbb{E}_t [r_{t+s} - \hat{r}_{t+s} + p_{t+1+s}^* - \hat{p}_{t+1+s}^*].$$

Price level pinned down.

# Taylor rules and the Taylor principle

- Instead:

$$i_t = \hat{r}_t + \hat{p}_{t+1}^* - p_t^* + \phi(\Delta p_t - \Delta p_t^*),$$

but now Taylor condition is  $\phi > 1$ .

- By same steps have new solution

$$\Delta p_t = \Delta p_t^* + \sum_{s=0}^{\infty} \phi^{-s-1} \mathbb{E}_t [r_{t+s} - \hat{r}_{t+s} + p_{t+1+s}^* - \hat{p}_{t+1+s}^*]$$

and where the boundary condition now is:

$$\lim_{T \rightarrow +\infty} \phi^{-T-1} \mathbb{E}_t (\Delta p_{t+T} - \Delta p_{t+T}^*) = 0.$$

Note that the solution works for  $t \geq 0$ , so we are pinning down the price level, not just inflation (as  $p_{-1} = 0$  wlog).

## Evidence on the Taylor rule

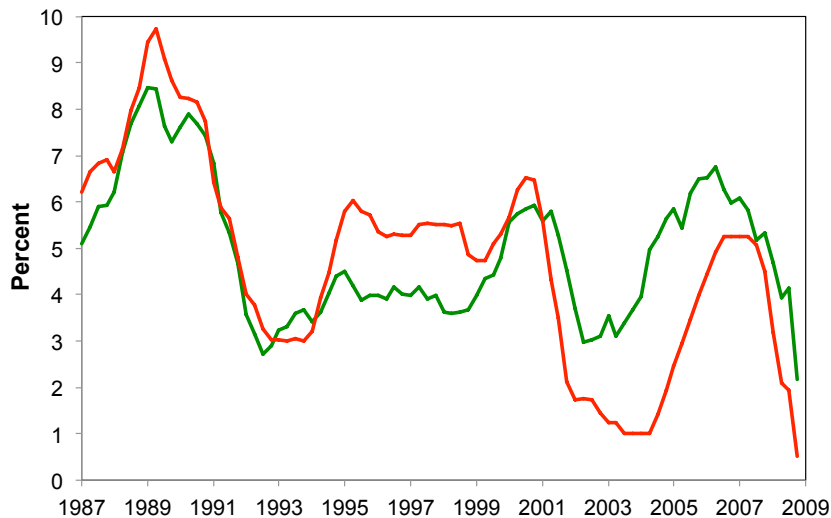
- ▶ Taylor principle: if prices were to deviate from the inflation target, CB will raise nominal interest rates aggressively, by more than the expected increase in inflation ( $\phi \geq 1$ ).
- ▶ John Taylor wrote down the following rule:

$$i_t = 2 + \Delta p + 0.5(\Delta p_t - 2) + 0.5(y_t - y_t^*),$$

so real interest rate of 2% and target for inflation of 2%.

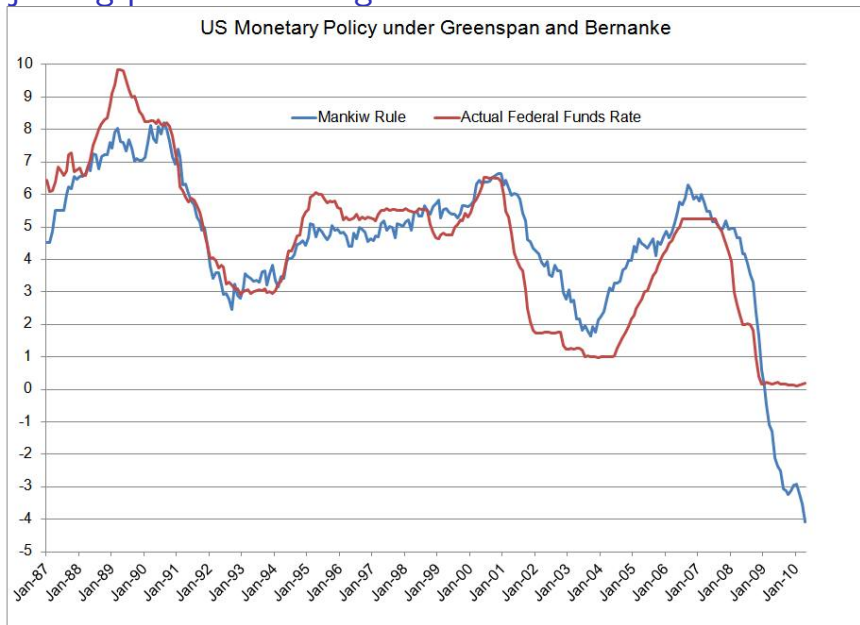
- ▶ Was for a few years at the center of monetary-policy debate:
  - ▶ Is Taylor principle satisfied?
  - ▶ Can this represent or approximate optimal monetary policy?
  - ▶ Can we come up with empirical generalizations?
  - ▶ Did the 2002-2005 deviation cause the current crisis?

## The Taylor rule in the U.S. data



Source: Mankiw *Intermediate Macroeconomics*

# Adjusting parameters to get better fit



Source: [gregmankiw.blogspot.com](http://gregmankiw.blogspot.com)

## But three issues with it...first

Error is large, especially when compared with payment-on-reserves rule:

$$\varepsilon_t = \sum_{s=0}^{\infty} \phi^{-s-1} \mathbb{E}_t \left[ r_{t+s} - \hat{r}_{t+s} + p_{t+1+s}^* - \hat{p}_{t+1+s}^* \right].$$

1. Current errors on real interest rate,
2. Errors on future real interest rates,
3. Mis-communication with public about future policy targets.

## But three issues with it...second

Relied on imposing a terminal condition that  $p_t$  should not explode. But where did that come from?

- ▶ Intuition (Taylor):  $\phi > 1$  says that if  $\Delta p_t$  rises, then via the rule  $i_t$  will be pushed up more than one-to-one. But, given the Fisher equation, this increases inflation tomorrow,  $\Delta p_{t+1}$  one-to-one with the increase in  $i_t$ . But then, on next period's Taylor rules, this raises  $i_{t+1}$  by even more, and so on, with  $\Delta p_{t+s+1} > \Delta p_{t+s}$  at any date  $s$ . End up with a path for  $\Delta p_{t+s}$  that is exploding to infinity at an exponential rate.
- ▶ There is no TVC because on prices, no money illusion.
- ▶ Taylor threat imposes a unique saddle-path equilibrium.
- ▶ Off equilibrium threats, sophisticated implementation.



## But three issues with it...third

Arguments for Wicksell and Taylor rule relied on log-linearizations. Even if only for approximation to make sense, focus on *locally bounded equilibrium*. Consistent to impose terminal condition.

- ▶ Assume away uncertainty,  $M_{t+1} = \beta$  and a constant inflation target  $\Pi^*$ , both for simplicity to study non-linear case.
- ▶ Equilibrium (Fisher) condition:

$$1 = \beta(1 + i_t)(1/\Pi_{t+1})$$

where  $\Pi_{t+1} = P_{t+1}/P_t$  is gross inflation.

- ▶ Taylor rule, with an extra constraint: nominal interest rates cannot go below zero (more on this soon):

$$1 + i_t = \max \left\{ \frac{\Pi^*}{\beta} \left( \frac{\Pi_t}{\Pi^*} \right)^\phi, 1 \right\}$$

# Global analysis and the ZLB

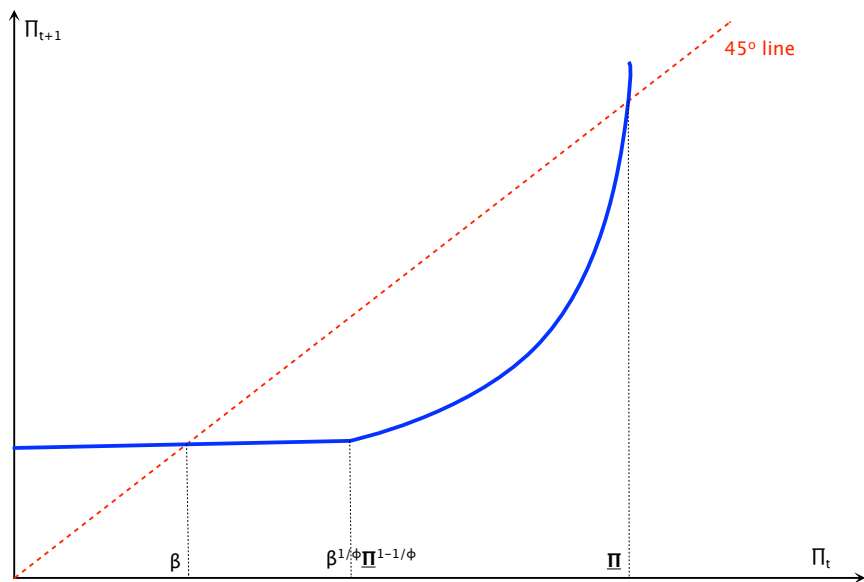
- ▶ Combining the two, get solution:

$$1 = \frac{\beta}{\Pi_{t+1}} \max \left\{ \frac{\Pi^*}{\beta} \left( \frac{\Pi_t}{\Pi^*} \right)^\phi, 1 \right\}.$$

Again a difference equation for inflation, non-linear now.

- ▶ Steady states? One is  $\Pi_t = \Pi^*$ , but another is  $\Pi_t = \beta$ , economy at the zero lower bound forever.
- ▶ Diagram in the next slide shows that:
  1.  $\Pi_t = \Pi^*$  is again saddle-path stable.
  2. Must again use a terminal condition to rule out explosions if  $\Pi_t > \Pi^*$ .
  3. But for  $\Pi_t < \Pi^*$ , converge to global stable solution:  $\Pi_t \rightarrow \beta$ . Deflation traps. How to rule them out?

## ZLB and the peril of Taylor rules



## Conclusion on interest rate rules

- ▶ What determines inflation? *Arbitrage. Central bank issues nominal liabilities, pricing them pins down the unit of account.*
- ▶ What is the more solid interest-rate rule? *Payment on reserves. Does not rely on linearizations, do not need to rule out explosions, smaller control errors.*
- ▶ What is the Taylor/Wisckell rule? *Have interest rates respond to inflation more than one-to-one (to price level positively). Pins down inflation because if threatens to explode it off equilibrium.*

Monetarist approach: choosing  
money

# The money demand equation

$$\frac{H_t}{C_t P_t} = e^{u_t} \left( \frac{I_t}{1 + I_t} \right)^{-\tilde{\eta}}$$

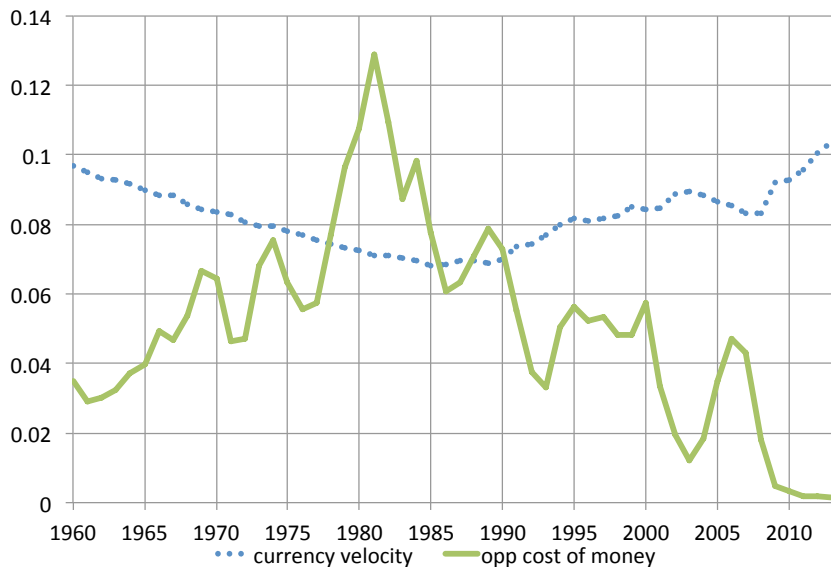
- ▶ There is some good, called “money”, which provides people some service in facilitating transactions. Peculiar, perhaps.
- ▶ Many “deep” theories of what is money, and what role it serves. Not true that need model of money to understand inflation. We have done fine so far.
- ▶ Long tradition in economics so lots of funny names attached to it. Left-hand side sometimes called “velocity” and money demand called the “quantity theory”.

## Four properties

$$\frac{H_t}{C_t P_t} = e^{u_t} \left( \frac{I_t}{1 + I_t} \right)^{-\tilde{\eta}}$$

1. Currency has two special properties: anonymous and pays zero interest. Private sector cannot short money so *zero lower bound* on interest rate on bonds:  $I_t \geq 0$ .
2. All attempts to estimate this equation have found it very difficult, unstable:  $u_t$  is volatile. So hard to pin down and measure  $H_t$ , sign of weakness of theories of what is money.
3. Income elasticity (really consumption): one to be consistent with BGP. When estimated, often get much lower numbers.
4. Price elasticity: opportunity cost of holding money instead of nominal bond is the foregone interest  $I_t$ . Elasticity  $\tilde{\eta}$  constant, in data seems to vary with nominal interest rates close to zero.

# Money demand in the United States?



Source: Hilscher, Reis, Raviv (2014)



## Microfoundations?

- ▶ Money gives utility and is complementary with consumption:

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t u(C_t, H_t/P_t) \right\} \text{ with } u_h(\cdot) \geq 0, u_{hh}(\cdot) \leq 0, u_{ch} \geq 0.$$

- ▶ Can't short money  $H_t \geq 0$ , hold it like an asset:

$$\begin{aligned} P_t C_t + B_{t+1} + P_t K_{t+1} + H_t &\leq \\ P_t(Y_t - T_t) + B_t(1 + I_{t-1}) + P_t K_t(1 + R_{t-1}) + H_{t-1}. \end{aligned}$$

- ▶ The first-order condition leads to the money demand equation:

$$\frac{u_h(\cdot)}{u_c(\cdot)} = \frac{I_t}{1 + I_t}.$$

Left-hand side is the MRS, right-hand side is the relative price.

- ▶ Following CES utility function leads to money demand:

$$u(C, H/P) = \left[ C_t^{1-1/\tilde{\eta}} + e^{u_t/\tilde{\eta}} (H_t/P_t)^{1-1/\tilde{\eta}} \right]^{\tilde{\eta}/(\tilde{\eta}-1)}.$$

## Fiscal and monetary policy

- ▶ Fiscal policy still uninteresting, exogenous  $G_t$ :

$$T_t + D_t = G_t$$

- ▶ Central bank issues  $H_t^S$ , currency. There are close substitutes to currency created by financial sector, often relying on currency. Market clearing condition is:

$$H_t = e^{v_t} H_t^S.$$

And  $v_t$  is both very volatile and trends (money multiplier.)

- ▶ Central bank balance sheet with currency as its only liability:

$$H_t^S = H_{t-1}^S + P_t D_t.$$

Policy is an exogenous choice for  $H_t^S$

# Equilibrium

- Nominal equilibrium:  $\{P_t, I_t\}_{t=0}^{\infty}$  such that:

$$(1 + I_t)^{-1} = \mathbb{E}_t \left[ M_{t+1} \left( \frac{P_t}{P_{t+1}} \right) \right]$$
$$\frac{H_t^S}{C_t P_t} = e^{u_t - v_t} \left( \frac{I_t}{1 + I_t} \right)^{-\tilde{\eta}}$$

and  $\{M_{t+1}, C_t\}_{t=0}^{\infty}$  exogenous from classical dichotomy.  $H_t^S$  is set by policy. Two equations in two variables, there is hope...

- Log-linearized version:

$$\dot{i}_t = r_t + \mathbb{E}_t \Delta p_{t+1},$$
$$h_t - p_t = c_t - \eta \dot{i}_t + u_t - v_t,$$

where  $\eta = \tilde{\eta}/I = \tilde{\eta}\beta/(\Pi - \beta)$ , and where  $h_t = \ln H_t^S / \bar{H}^S$ .

# Money supply rules

- Policy rule for money supply  $h_t$ .

$$h_t = p_t^* + \hat{c}_t - \eta(\hat{r}_{t+s} + \hat{p}_{t+1}^* - p_t^*) + \hat{u}_t - \hat{v}_t.$$

- Combining equations, iterating forward, and focusing on bounded solution (terminal condition now from TVC) get  $p_t = p_t^* + \varepsilon_t$  with error now:

$$\begin{aligned} \varepsilon_t = \frac{1}{1+\eta} \sum_{s=0}^{\infty} \left( \frac{\eta}{1+\eta} \right)^s \mathbb{E}_t[ & \hat{c}_{t+s} - c_{t+s} + \eta(\hat{r}_{t+s} - r_{t+s}) \\ & + \hat{u}_t - u_t - (\hat{v}_t - v_t) + p_{t+1+s}^* - \hat{p}_{t+1+s}^*]. \end{aligned}$$

The Cagan equation.

- The money demand condition then pins down  $i_t$ .

# Problems with “monetarist” approach to inflation

1.  $p_t$  is a purely forward-looking variable. Fits the data poorly, because predicts: (i) inflation less serially correlated than money growth, (ii) inflation more volatile than money growth.
2. Error is *very* large relative to interest-rate approach. Because  $u_t$  and  $v_t$  are really volatile (UK and US early 1980s). And because have large trends, with people using less currency and substitutes appearing all the time (Bitcoin, ApplePay).
3. Actually, central banks do not do this. They issue reserves and stand ready to exchange reserves for currency one-to-one, so hitting a target for  $h_t$  is actually not so easy.

# What is seignorage?

- ▶ From central bank budget constraint, dividend:

$$D_t = \frac{H_t^S - H_{t-1}^S}{P_t} \equiv S_t.$$

Seignorage arises because people are willing to hold a zero interest-rate asset, give real resources in exchange for it, but monetary authority prints it at zero cost.

- ▶ From market clearing in money market:

$$S_t = C_t \left[ e^{u_t - v_t} \left( \frac{l_t}{1 + l_t} \right)^{-\tilde{\eta}} - e^{u_{t-1} - v_{t-1}} \left( \frac{l_{t-1}}{1 + l_{t-1}} \right)^{-\tilde{\eta}} \frac{P_{t-1} C_{t-1}}{P_t C_t} \right]$$

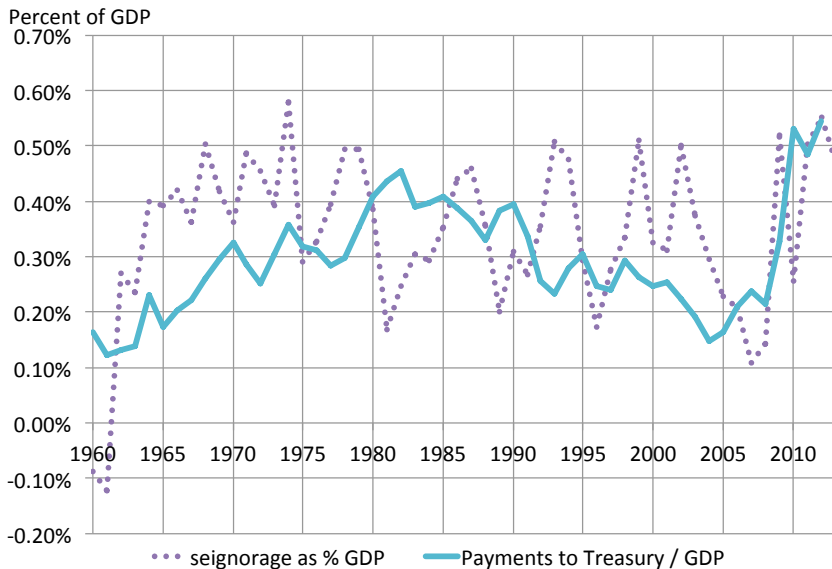
But then *only* inflation can generate seignorage.

- ▶ In steady state

$$S = C e^{u-v} \left( 1 - \frac{1}{\Pi} \right) \left( 1 - \frac{\beta}{\Pi} \right)^{-\tilde{\eta}}.$$

Note that this is bounded above by  $C e^{u-v}$ .

# Seigniorage in the United States



Source: Hilscher, Reis, Raviv (2014)

## Seignorage policy rule

- ▶ A log-linear approximation of seignorage function gives a first-order difference equation for prices:

$$\Delta p_t + \eta \mathbb{E}_{t-1} \Delta p_t - \eta \Pi \mathbb{E}_t \Delta p_{t+1} = (\Pi - 1) d_t + z_t$$

where  $z_t$  includes terms in  $c_t, u_t, v_t, r_t, c_{t-1}, u_{t-1}, v_{t-1}, r_{t-1}$ .

- ▶ Again can solve forward (long expressions). Error  $\varepsilon_t$  now depends on present and future  $z_t$  and  $d_t$ .
- ▶ Aside: if fiscal policy *refuses* to pay for its bills, chooses an *exogenous* path for  $T_t$ , then central bank does not control this rule, rather:

$$D_t = G_t - T_t \text{ is now } \textit{exogenous}.$$



# Unpleasant monetarist arithmetics

- ▶ Historically: all hyperinflations are preceded by big fiscal crises such that eventually government orders the central bank to pay the bills. Inflation is always and everywhere a fiscal phenomenon depend on  $d_t$ .
- ▶ But *terrible* model of controlling inflation:
  1. Large fluctuations with shifts in money demand and supply still dominating  $u_t, v_t$ , together with real interest rates and policy targets as before.
  2. Requires that central bank follows orders from fiscal authority,  $d_t$  likely very volatile.
  3. In non-linear case, seignorage function has a maximum. Rule may not be feasible if deficit is high enough.

## Conclusion on monetary rules

- ▶ What is money? *Deep question. But doesn't really make too much of a difference, as long as have a demand for it.*
- ▶ What is seignorage? *If money provides a service, then there is a revenue form providing it. But, given demand function, it can only be controlled by inflation. And it has an upper bound.*
- ▶ What is wrong with monetarism? *Nothing. But, without a good measure of money and a stable money demand, not a very good approach*

Gold standard approach: choosing  
pegs

# The price-index equation

$$p_t = \sum_{j=0}^J \omega_j p_t(j)$$

- ▶ Many consumption goods in the world, all with prices denominated in dollars. Indexed by  $j$ , with price index putting a weight  $\omega_j$  on each one.
- ▶ Weights sum to one is the important property, so still about the unit of account. Linearity in logs for simplicity.
- ▶ One approach to weights: cost of living, so expenditure necessary to get one unit of utility. Dynamic approach versus static approach.
- ▶ Another approach to weights: pure inflation, so corresponds to unit of account change.

## Fiscal, monetary, and pricing policy

- ▶ Fiscal policy sets  $T_t$  endogenously as before to pay for bills. Likewise with central bank, may even forget about it altogether  $D_t = 0$ .
- ▶ Policy is a *commodity peg*: determine that the price of a good, say good 0, is going to be set by the government in dollars.
- ▶ Can do it in respect to any good provided by the government or any other good. Can issue reserves, or currency, or set interest rates to be consistent with this. But can also just determine this will be the unit of account to pay taxes. People can denominate goods in whatever they want, but the government controls what a dollar is.

## Commodity standards

- ▶ Microfoundations: if  $u(C_t(0), \dots, C_t(J))$  in preferences and  $\sum_{j=0}^J P_t(j) C_t(j)$  in the budget constraint, then in endowment economy:

$$\frac{\partial u(.) / \partial C_t(j)}{\partial u(.) / \partial C_t(0)} = \frac{P_t(j)}{P_t(0)},$$

pins down  $p_t(j) - p_t(0) \equiv \rho_t(j)$ , depend on real endowments.

- ▶ Policy rule then:

$$p_t(0) = p_t^* + \sum_{j=1}^J \omega_j \hat{\rho}_t(j).$$

Need to estimate these relative prices and  $J$  is very large.

- ▶ Outcome is again  $p_t = p_t^* + \varepsilon_t$  and now:

$$\varepsilon_t = \sum_{j=1}^J \omega_j (\hat{\rho}_t(j) - \rho_t(j)).$$

# Problems and examples

Problems with commodity pegs:

1. Stability of  $\rho_t(j) = p_t(j) - p_t(0)$ . Typically very volatile.
2. Commodity standards often associated with having no discretion, with  $p_t^*$  deterministic, say constant growth. But don't really need to, could change every period what the peg is ("managed floats"). Confuses discussion of this strategy with setting of  $p_t^*$ , which I have kept separate so far.

Examples:

1. *Gold standard*: good that has a stable supply  $Y_t(0)$  and has little complementarity with other goods  $u(C_t(0), \dots, C_t(J)) = u^0(C_t(0)) + \tilde{u}(C_t(1), \dots, C_t(J))$ . Then  $\rho_t(j) = \log \tilde{u}_j(\cdot) - \log u^{0'}(Y_t(0))$ . Seems to minimize this volatility. But still large.

## Problems and examples

2. *Exchange rate peg*: good 0 is an aggregator of all foreign goods. The error is now, the relative price of the aggregate of foreign goods and domestic goods. This is the real exchange rate.
3. *Chilean CUF*: Instead of picking a good 0, rather pick a policy basket, so policy rule is now instead:

$$\sum_{j=0}^J \omega_j p_t(j) = p_t^*.$$

Then, the error now is:

$$\varepsilon_t = \sum_{j=0}^J (\hat{\omega}_j - \omega_j) p_t(j).$$



## Conclusion on commodity peg rules

- ▶ Why so prevalent in history? *Easier to implement. Do not need any markets.*
- ▶ Why quickly abandoned in most developed countries *Make it difficult to pursue target and come with very large policy errors.*

# Budget approach: choosing borrowing

# Integrated government budget constraint

$$\frac{\tilde{B}_t}{P_t} = \mathbb{E}_t \sum_{j=0}^{\infty} M_{t+1+j} (T_{t+j} - G_{t+j})$$

$\tilde{B}_t$  are the government nominal liabilities due at date  $t$ .

Micro-foundations, simple case:

1. Period resource constraint, for any  $t \geq 1$ .

$$\underbrace{V_{t+1} - (1 + I_{t-1})V_t}_{P_t D_t} + P_t T_t = P_t G_t.$$

Only government debt are the reserves by central bank, so  $\tilde{B}_t = (1 + I_{t-1})V_t$  for  $t \geq 1$ .

2. At date 0 instead:  $V_1 + P_0 T_0 = \tilde{B}_0 + P_0 G_0$  where  $\tilde{B}_0$  are nominal liabilities that started with.
3. No Ponzi schemes, no default.

# Monetary and fiscal policy

- ▶ Monetary policy: assumed away money, so  $S_t = 0$ . Central bank chooses  $V_t$ , so accepts the  $I_t$  in equilibrium that it faces in the market.
- ▶ Fiscal policy choice is  $\{T_t\}$ , So far, **Ricardian fiscal policy**: choose  $\{T_t\}$  to always ensure that government budget constraint will hold.
- ▶ Now assume that policy is non-Ricardian: fiscal authority chooses an exogenous path for  $\{T_{t+j}\}$ .

## Policy rule

- From date 0 constraint:

$$P_0 = \frac{\tilde{B}_0}{\sum_{j=0}^{\infty} \mathbb{E}_0 M_j (T_j - G_j)}.$$

Everything is exogenous on the right-hand side. Done!

- For other periods afterwards? If  $V_t > 0$ , then:

$$P_t \mathbb{E}_{t-1} \left( \frac{M_t P_{t-1}}{P_t} \right) = \frac{V_t}{\mathbb{E}_t \sum_{j=0}^{\infty} M_{t+1+j} (T_{t+j} - G_{t+j})}.$$

Difference equation for price level, with an initial condition.

- Policy rule for  $V_t$  ensures that hit  $P_t^*$ . Error  $\varepsilon_t$  depends on error in primary surplus and real interest rates.

## Fiscal theory of the price level

- ▶ Intuition: policy chooses how much nominal debt to issue. Budget constraint must hold, so the real value of that debt has to match the present value of real surpluses. Price level must adjust to make sure it it so. Implicitly, the central bank is doing a real default on its nominal obligations.
- ▶ Turning equation on its head: real value of debt must equal real present value of surpluses. Not as a constraint on what policy authorities can follow, but as an equilibrium condition to pin down price level.
- ▶ Reserves as stock: government debt is a share on future stream of fiscal surpluses. Price level is the (inverse) price of this share that adjusts to give the right value of the holders of the government debt.

# Problems

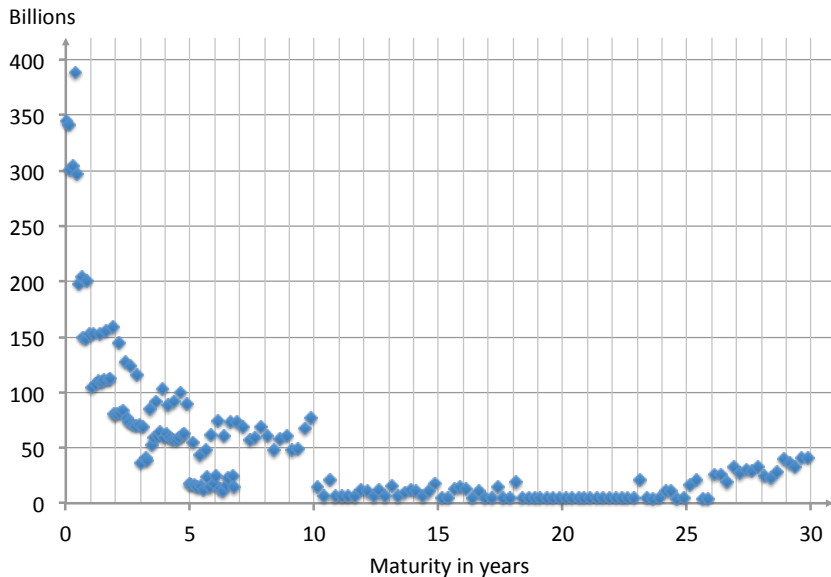
1. Imagine that the Treasury issues nominal and real bonds as well:  $\{B_t, K_t\}$ . Then condition becomes:

$$\frac{V_t + B_t}{P_t \mathbb{E}_{t-1} \left( \frac{M_t P_{t-1}}{P_t} \right)} = -(1+R_{t-1})K_t + \mathbb{E}_t \sum_{j=0}^{\infty} M_{t+1+j} (T_{t+j} - G_{t+j}).$$

It is joint exogenous path for  $\{V_t, B_t, K_t\}_{t=1}^{\infty}$  that pins down  $\{P_t\}_{t=1}^{\infty}$ . Relies on the right mix between real and nominal liabilities of Treasury and Fed (unlike QE in last few years).

2. Error in future fiscal surpluses is enormous. Predictions of run away inflation a few years ago because of large deficits.
3. Even measuring  $\tilde{B}_t$  is hard. How to value social security commitments? Are they real or nominal?
4. Countries default, even on nominal debt.
5. With maturity of debt, need volatile inflation.

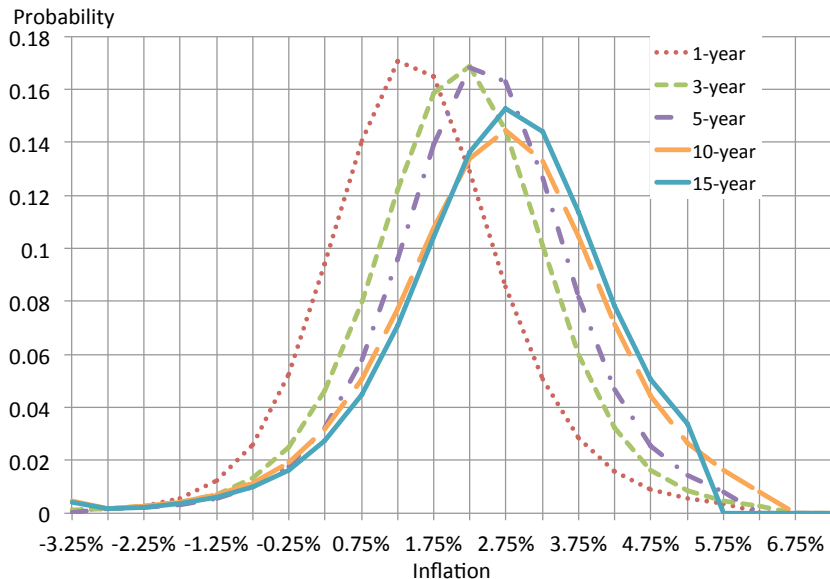
# Maturity of privately-held government debt in 2012



Source: Hilscher, Raviv, Reis (2014)



# Inflation expectations (cumulative) in 2012



Source: Hilscher, Raviv, Reis (2014)

## Conclusion on borrowing rules

- ▶ Why so controversial? *Because turns a constraint into an equilibrium condition.*
- ▶ Why so hard to empirically test? *Budget constraint must hold, question is how, what moves, and so many terms and policy variables in it.*
- ▶ Why difficult to implement? *Very hard to measure future fiscal surpluses or even current nominal liabilities of the government. Requires coordination with Treasury.*

# Inverted-VaR change in debt as a result of inflation

Risk-adjusted  
probability

0.60

0.50

0.40

0.30

0.20

0.10

0.00

0.00%

1.00%

2.00%

3.00%

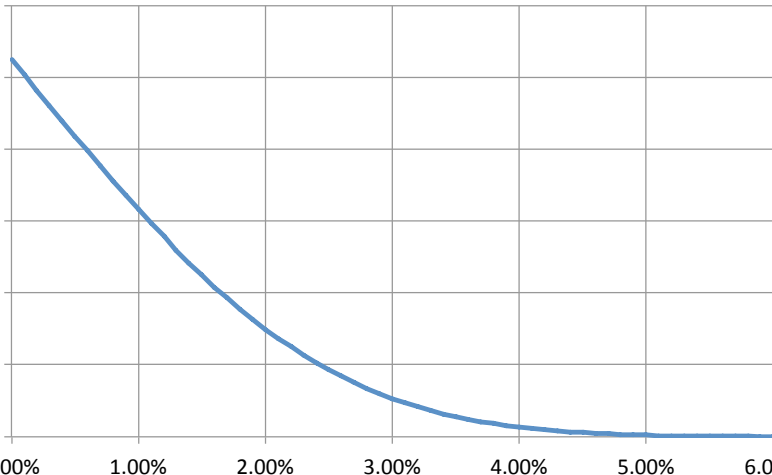
4.00%

5.00%

6.00%

Threshold fall in debt burden (% of GDP)

Source: Hilscher, Raviv, Reis (2014)



# Central bank independence

# One rule to rule them all

- ▶ Which is the right rule, right exogenous instrument?
  1. Payment on reserves:  $x_t$ ?
  2. Interest on nominal reserves:  $I_t^v$ ?
  3. Money supply,  $H_t$ ?
  4. Seignorage,  $S_t$ ?
  5. Commodity peg,  $P_t(0)$ ?
  6. Nominal reserves outstanding,  $V_t$ ?
- ▶ Crucially, can only use *one*.
  - ▶ Price level indeterminacy was an indeterminacy of degree 1.
  - ▶ Only one missing equation, one missing exogenous variable.
  - ▶ If do more than one, will be in trouble, there is no equilibrium.
- ▶ Once choose one rule, the other variables are pinned down endogenously.

# Which equation/approach is more important?

- ▶ Model with a central bank that issues indexed reserves, nominal reserves, and money, so full set of policy tools:

$$\{x_t, I_t^V, H_t, D_t, V_t, V_t^R\}.$$

- ▶ Private sector will:
  1. Holds nominal and real bonds;
  2. Arbitrages return differences;
  3. Derives utility from money;
  4. Pays taxes, does not allow Ponzi schemes;
  5. Buys many goods, domestic and foreign.
- ▶ So all the key equations will hold:
  1. Fisher equation;
  2. Money demand equation;
  3. Price index equation;
  4. Intertemporal budget constraint.
- ▶ Looked at one at a time, but can have them all at once.

## Policy coordination

- ▶ Role of fiscal policy crucial. Must always fully specify fiscal and monetary policy to determine equilibrium. Ricardian versus non-Ricardian fiscal policy limited the set of possible monetary policy rules.
- ▶ If  $\{T_t, B_t\}$  exogenous, then fiscal authority is the one pinning down the price level. So, no longer achieving  $P_t^*$ .
- ▶ Inflation is always and everywhere a monetary phenomenon or a fiscal phenomenon? Both and neither. The key question is who is active or passive. Who moves first? Who chooses exogenously, so the other has to endogenously accommodate?
- ▶ Central bank independence: can it act exogenously, actively pursue  $P_t^*$ , independent from fiscal authorities?

# The central bank balance sheet

$$V_{t+1} + H_t = (1 + I_t)V_t + H_{t-1} + P_t D_t + B_{t+1}^M - (1 + I_t)B_t^M + Q_t[Z_{t+1} - (1 - \delta)Z_t] - W_t Z_t.$$

- ▶ The central bank can:
  1. issue currency ( $H_t$ ),
  2. issue reserves that pay market nominal interest rate ( $V_{t+1}$ ),
  3. buy riskless nominal securities ( $B_{t+1}^M$ ),
  4. buy risky assets ( $Z_{t+1}$ ) for price  $Q_t$  that earn a stochastic payoff ( $W_{t+1}$ ) and depreciate by melting away at rate  $\delta$ ,
  5. pay a dividend to the government  $D_t$ .
  
- ▶ By arbitrage, the price of the risky asset is

$$Q_t = \mathbb{E}_t [M_{t+1} (W_{t+1} + (1 - \delta)Q_{t+1})].$$



# Central bank solvency and independence

- ▶ Central bank solvency: a central bank is insolvent if it has to go to the Treasury asking for funds. The Department of Transportation is always running at a loss, but does not matter. For central bank, solvency is really independence.
- ▶ Period solvency: if  $D_t > 0$  always. Rule solvency: if  $D_t$  follows a *rule* that is transparent.
- ▶ How does central bank go insolvent?
  1. It issues liabilities, reserves and currency, people may not want to hold them.
  2. There is no bankruptcy court, rather currency reform or hyperinflation.
  3. Avoid two fallacies: (i) accounting illusion, not about balance sheets or marking to market, about resource constraints. (ii) money illusion, seignorage has limits and I can also issue nominal bonds, but markets must clear.

## Solvency with old-style central banking

- ▶ Old-style central banking:  $V_{t+1} = 0$  no interest on excess reserves,  $Z_{t+1} = 0$ , only hold short-term government debt at relatively steady values  $B_t^M = B_{t+1}^M$ .

- ▶ Dividends paid therefore are:

$$D_t = S_t + \frac{I_t B^M}{P_t}$$

almost always positive.

- ▶ Central bank nominal capital is  $Cap_t = B_{t+1}^M - H_t$  so:

$$P_t D_t = I_t B_t^M - \Delta Cap_t.$$

Rule of Fed is that nominal capital should be kept roughly constant, this implies period-solvent.

# Fed's balance sheet, last few years

---

<i>December 31, 2008</i>			
Securities held outright		Federal Reserve notes	853.2
U.S. Treasury bills	18.4	Commercial bank reserves	860.0
U.S. Treasury notes and bonds	457.5	U.S. Treasury deposits	365.4
Agency debt	19.7	Reverse repurchase agreements	88.4
Repurchase agreements	80.0	Others	56.8
Direct loans	193.9		
Gold	11.0	Total liabilities	2,223.8
Foreign reserves	579.8		
Other assets	40.3	Capital	42.2
New asset categories			
Term Auction Facility (TAF)	450.2		
Commercial Paper Funding Facility (CPFF)	334.1		
Maiden Lane	73.9		
Total	2,265.9	Total	2,265.9

Source: Reis (2009)

# Credit policy during crisis

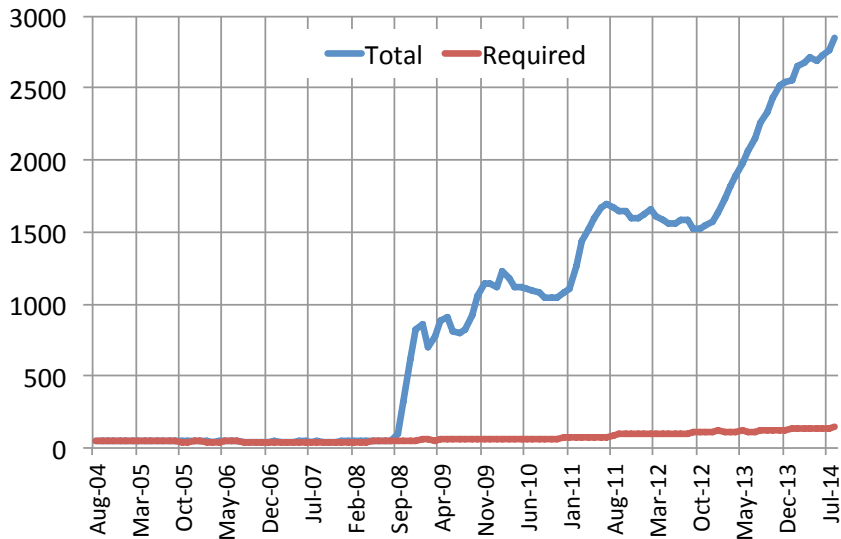
## United States:

1. TAF – credit auction to banks for 28, 84 days
2. TSLF (28d) and PDCF (overnight) – primary dealers
3. TALF – lend against collateral provided by ABSs on student, auto, credit card, and SBE loans
4. AMLF and MMLFF – Credit to money market funds
5. CPFF – Credit to firms directly by buying commercial paper as a backstop provider
6. Maiden Lane – taking in Bear Sterns and AIG assets

## Europe:

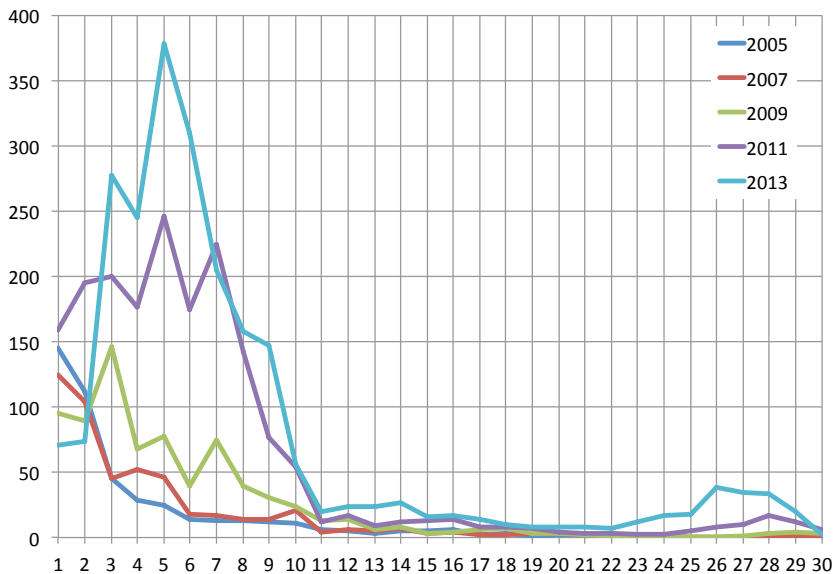
1. LTRO – credit to banks for up to 36 months.
2. SMP and OMT – purchase sovereign bonds in secondary markets.

## Fed's balance sheet now: liabilities



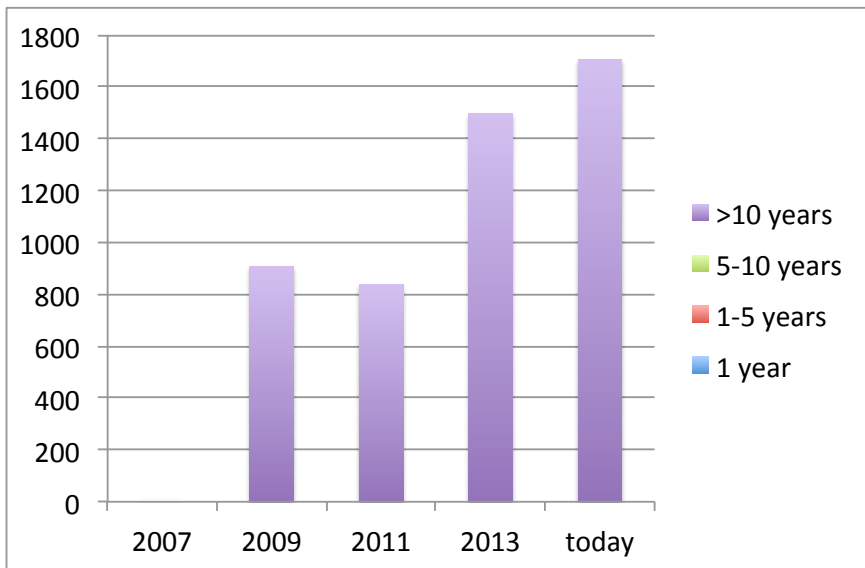
Source: FRED.

## Fed's balance sheet now: government bonds by maturity



Source: Hilscher, Raviv, Reis (2015)

## Fed's balance sheet now: MBS by maturity



Source: Reis (2014)

## Solvency with interest on reserves

- ▶ Simple case: no risky assets  $Z_t$  but pay interest on reserves.
- ▶ Rule that Fed follows for  $D_t$ : every period it pays its net income to the Treasury, which is:

$$P_t D_t = H_t - H_{t-1} + I_t B_t^M - I_t V_t.$$

- ▶ Then combining rule with resource constraint:

$$V_{t+1} - B_{t+1}^M = V_t - B_t^M = V_0 - B_0^M$$

Capital of central bank is constant, so always rule solvent.

- ▶ And dividends are again almost always positive:

$$D_t = S_t + I_t(B_{t+1}^M - V_{t+1})/P_t.$$



## Solvency with risky assets

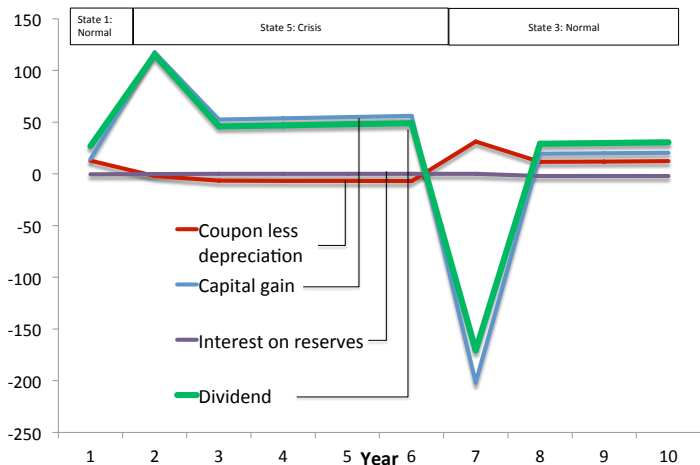
- ▶ Hall-Reis result 1: if pay net income every period, still capital of central bank is constant over time.
- ▶ Hall-Reis result 2: dividends can be negative:

$$D_t = S_t + R_t(Q_0 Z_0 - V_0) + (W_t - \delta Q_t - R_t Q_{t-1})Z_t + (Q_t - Q_{t-1})Z_t.$$

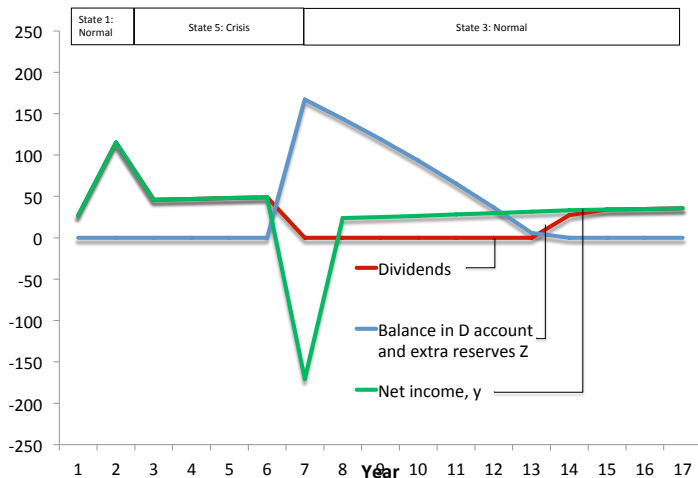
Because of losses in value of bonds, either if default, or capital loss because interest rates rise.

- ▶ Hall-Reis result 3: If negative dividends don't come with fiscal support, then reserves drift to infinity, central bank insolvent.
- ▶ Hall-Reis result 4: a deferred account reduces this risk.

# Simulations for the Fed: dividends



# Simulations for the Fed: deferred account



# Central Bank intertemporal solvency

- ▶ Iterate forward on budget constraint to derive:

$$\mathbb{E}_t \sum_{j=0}^{\infty} M_{t+j} D_{t+j} = \mathbb{E}_t \sum_{j=0}^{\infty} M_{t+j} S_{t+j} + (B_t^M - V_t)/P_t.$$

- ▶ Fiscal capacity of central bank equals the present value of seignorage plus its accounting capital (assets minus reserves).
- ▶ Three notes:
  1. TVC does not depend on properties of money. Money can be a bubble, excess reserves cannot.
  2. For US, Hilscher, Raviv, Reis (2015) estimate that PV seignorage is 15-20% of GDP, reserves are 14.7% of GDP.
  3. Del Negro and Sims (2015): self-fulfilling inflation scares.

# Conclusion

## Some parting fighting words

- ▶ *Need to understand money to understand inflation.* No, money is mostly irrelevant.
- ▶ *Inflation is always and everywhere a monetary phenomenon.* No, it is as much a fiscal phenomenon.
- ▶ *Supply and demand pins down prices.* No, price level is unit of account, arbitrage or budgets or indices as important as supply and demand.
- ▶ *A central bank can get a country out of trouble.* No, limits to seignorage as a fiscal resource, and fiscal backup or support are essential for any policy.

# References and readings

- Atkeson, Andrew, V. V. Chari and Patrick Kehoe (2010). "Sophisticated Monetary Policies." *Quarterly Journal of Economics*, 125, 47-89.
- Benhabib, Jess, Stephanie Schmitt-Grohe and Martin Uribe (2002). "Avoiding Liquidity Traps." *Journal of Political Economy*, 110, 535-563.
- Cochrane, John (2005). "Money as stock." *Journal of Monetary Economics*, 52, 501-528.
- Gali, Jordi (2008). *Monetary Policy, Inflation and the Business Cycle: An Introduction to the New Keynesian Framework*. Princeton University Press.
- Leeper, Eric (1991). "Equilibria under active and passive monetary and fiscal policies." *Journal of Monetary Economics*, 27, 129-147.
- Hall, Robert E. and Ricardo Reis (2013). "Maintaining Central-Bank Solvency under New-Style Central Banking." Columbia University manuscript.
- Hall, Robert E. and Ricardo Reis (2014). "Controlling inflation under new-style central banking." Columbia University manuscript.
- Hilscher, Jens, Alon Raviv and Ricardo Reis (2014). "Inflating Away the Public Debt? An Empirical Assessment", NBER working paper 20339.
- Hilscher, Jens, Alon Raviv and Ricardo Reis (2015). "The Market Value of a Central Bank" Columbia manuscript.
- Reis, Ricardo (2009) "Interpreting the Unconventional U.S. Monetary Policy of 2007-09," *Brookings Papers on Economic Activity*, 40, 119?165.
- Reis, Ricardo (2013). "Central Bank Design." *Journal of Economic Perspectives*, 27 (4), 17-44.
- Reis, Ricardo (2013). "The Mystique Surrounding the Central Bank's Balance Sheet, Applied to the European Crises." *American Economic Review*, 103, 135-140.
- Sargent, Thomas and Neil Wallace (1981). "Some unpleasant monetarist arithmetic." *Federal Reserve Bank of Minneapolis Quarterly Review*, Fall, 1-17.
- Sims, Christopher A. (2013). "Paper Money." *American Economic Review*, 103(2), 563-584.
- Walsh, Carl (2010). *Monetary Theory and Policy*, 3rd edition, MIT Press.
- Woodford, Michael (1994). "Monetary Policy and Price Level Determinacy in a Cash-in-Advance Economy." *Economic Theory*, 4, 345-380.
- Woodford, Michael (2000). "Fiscal Requirements for Price Stability." *Journal of Money Credit and Banking*, 33, 669-728.
- Woodford, Michael (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton University Press.
- Woodford, Michael (2008). "How Important is Money in the Conduct of Monetary Policy?" *Journal of Money, Credit and Banking*, 40(8), 1561-1598.