

# How does inflation work?

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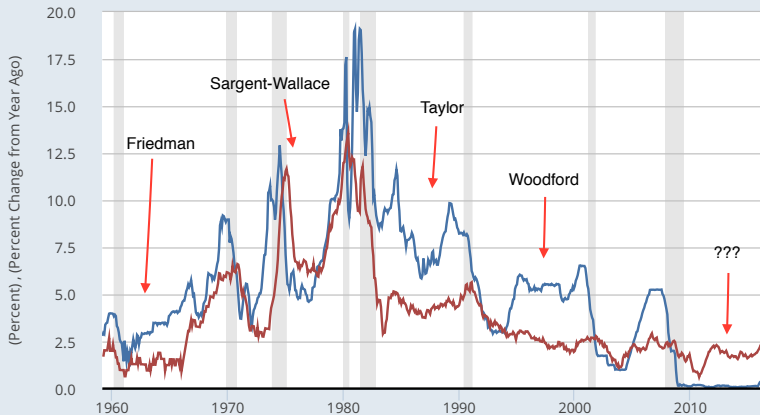
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# Our story

**FRED** 

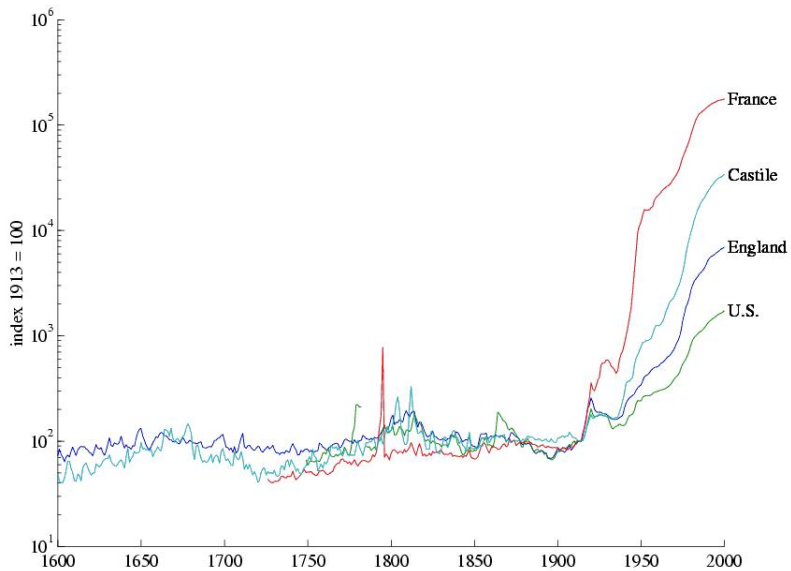
— Effective Federal Funds Rate

— Consumer Price Index for All Urban Consumers: All Items Less Food and Energy



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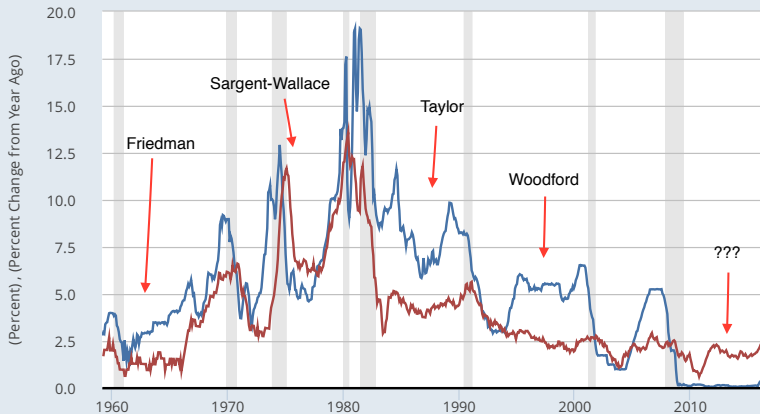
# History reminder



# Long history

- ▶ Gold to paper money and central banks
  - ▶ Inflation before there *were* central banks?
  - ▶ P: Metal coins, notes convertible to metal coins. Treasury, no Fed.
  - ▶ “Paper money” rapidly inflated away (Revolution, Civil War).
  - ▶ Late 1800s slow deflation.
  - ▶ Bryan: More inflation. (Plus ça change.) By using silver.
  - ▶ Gold standard gave long run price stability, but short run volatility.
- ▶ 1933 to 1968 Keynesianism
  - ▶ Monetary policy irrelevant. Fiscal policy fights recessions.
  - ▶ Prices “sticky,” “administered,” price controls, “jawboning,” union contracts, etc.
- ▶ Great power of central banks to set inflation, guide the macroeconomy is a recent view.
- ▶ Ideas have been radically different in the past. May be radically different in the future.
- ▶ Thesis: we are at once-in-a-generation rethinking of ideas.

— Effective Federal Funds Rate  
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## History 1960-now

- ▶ Rise of inflation 1960-1980. Bursts in booms/busts.
- ▶ Sudden end in 1984. Slow decline since.
- ▶ nominal rate = real rate + expected inflation  $i_t = r_t + E_t\pi_{t+1}$
- ▶ Rates largely below inflation 1970s, largely above 1980s-2008.
- ▶ Interest rates positively correlated with inflation. Do higher interest rates cause higher or lower inflation?
- ▶ Current long zero is unusual. More later.
- ▶ Why did inflation rise? Why did it stop so suddenly? Why is it trending down?

# Ideas

- ▶ Friedman. Monetarism.  $MV=PY$ .



## The American Economic Review

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Number 1

### THE ROLE OF MONETARY POLICY\*

*By* MILTON FRIEDMAN\*\*

There is wide agreement about the major goals of economic policy: high employment, stable prices, and rapid growth. There is less agreement that these goals are mutually compatible or, among those who regard them as incompatible, about the terms at which they can and should be substituted for one another. There is least agreement about the role that various instruments of policy can and should play in achieving the several goals.

My topic for tonight is the role of one such instrument—monetary policy. What can it contribute? And how should it be conducted to contribute the most? Opinion on these questions has fluctuated widely. In the first flush of enthusiasm about the newly created Federal Reserve System, many observers attributed the relative stability of the 1920s to the System's capacity for fine tuning—to apply an apt modern term. It came to be widely believed that a new era had arrived in which business cycles had been rendered obsolete by advances in monetary technology. This opinion was shared by economist and layman alike.



# Friedman Monetarism

What monetary policy can do

- ▶ Inflation source:  $MV=PY$
- ▶ M: Inventory demand to make transactions
- ▶ Monetary policy: More M, Less B. Making change. Who cares?  
Answer: M is special, less B is irrelevant
- ▶ *M policy can determine the price level.*
- ▶ Voluntary control of M can substitute for gold-standard discipline.
- ▶ Screw up by trying to 'fine tune.' Great depression.

# Friedman Monetarism

What monetary policy cannot do

- ▶ *M policy cannot permanently alter output or unemployment.*

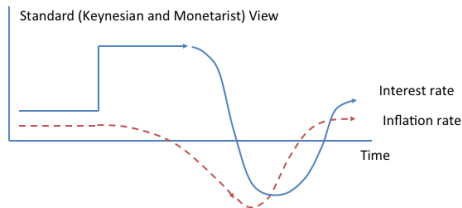
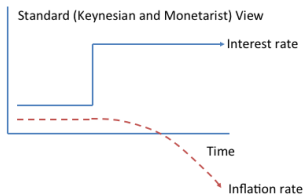
## **I. What Monetary Policy Cannot Do**

From the infinite world of negation, I have selected two limitations of monetary policy to discuss: (1) It cannot peg interest rates for more than very limited periods; (2) It cannot peg the rate of unemployment for more than very limited periods. I select these because the contrary

- ▶ Unemployment  $\leftarrow$  (inflation - expected inflation). Called home run! 70s stagflation.

# Friedman Monetarism

- ▶ *Interest rate targets are unstable*
- ▶ Fisher: interest rate = real rate + expected inflation.  $i_t = r_t + \pi_t^e$
- ▶  $i$  too low ( $r$ ,  $\pi$  shock or mistake)  $\rightarrow$  real rate declines  $\rightarrow$  “demand” increases  $\rightarrow$  output rises  $\rightarrow$  more inflation  $\rightarrow$  real rate declines more.
- ▶ Eventually, Fed must abandon peg, raise rates a lot. Called HR 2?



# Interest rate targets are unstable.

Model

$$i_t = r_t + \pi_t^e \quad \text{Fisher}$$

$$y_t = \kappa(\pi_t - \pi_t^e) \quad \text{Friedman-Phillips}$$

$$y_t = -a r_t \quad \text{IS}$$

Solve

$$r_t = -(\kappa/a)(\pi_t - \pi_t^e)$$

$$i_t = -(\kappa/a)(\pi_t - \pi_t^e) + \pi_t^e$$

$$i_t = -(\kappa/a)\pi_t + (1 + \kappa/a)\pi_t^e$$

Adaptive expectations:  $\pi_t^e = \pi_{t-1}$

$$\pi_t = -\frac{1}{\kappa/a} i_t + \frac{1 + \kappa/a}{\kappa/a} \pi_{t-1}$$

$i_t = i$  peg is unstable. Example

$$\pi_t = 2\pi_{t-1} = 1, 2, 4, 8, 16, 32, \dots$$

# Friedman Monetarism

## Friedman

- ▶ *Interest rate targets are unstable.*
- ▶ Control M instead.
- ▶  $M = \text{reserves} + \text{currency} + \text{bank accounts}.$

## Objections

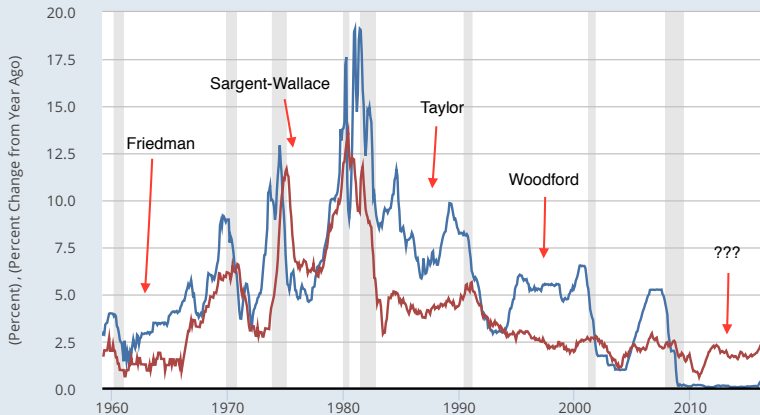
- ▶ Our Fed and all central banks follow interest rate targets, do not control M! OK 1968, but untenable for data, policy today.
- ▶ What's M? Rampant financial innovation undermines P, produces huge inflation?

# Taylor rule saves interest rate targets

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## Taylor and interest rate rules

- ▶ Taylor: Interest rate should vary more than 1-1 with inflation. This will *stabilize* the otherwise *unstable* economy.
- ▶ Recall interest rate = real rate + expected inflation.
- ▶ Was: Inflation rises 1% → → real rate declines → demand is higher → inflation goes up more. Unstable
- ▶ Now: Inflation rises 1% → interest rate rises more, 1.5% → real rate rises 0.5% → demand is lower → inflation goes down. Stable.
- ▶ Umbrella; <http://lewis500.github.io/macro/>.
- ▶ Implies, to raise inflation, temporarily lower rates.
- ▶ History: 1960s-1970s *reaction* was less than 1.0. 1980s-2000 reaction greater than 1.0 → “great moderation.”
- ▶ Why interest rates are positively correlated with inflation in the data, though higher rate lowers inflation.
- ▶ Fundamental source of inflation?  $MV=PY$  fades away, “active” interest rate alone sufficient to control inflation.

# Taylor rule stabilization

Model..

$$i_t = -(\kappa/a)\pi_t + (1 + \kappa/a)\pi_{t-1}$$

Add Taylor Rule  $i_t = \phi\pi_t$ ;  $\phi > 1$

$$\phi\pi_t = -(\kappa/a)\pi_t + (1 + \kappa/a)\pi_{t-1}$$

$$(\phi + \kappa/a)\pi_t = (1 + \kappa/a)\pi_{t-1}$$

$$\pi_t = \frac{1 + \kappa/a}{\phi + \kappa/a}\pi_{t-1}$$

$\phi > 1 \leftrightarrow$  stable. Example:

$$\pi_t = 0.5\pi_{t-1} = 1, 1/2, 1/4, 1/8, 1/16, 1/32, \dots$$

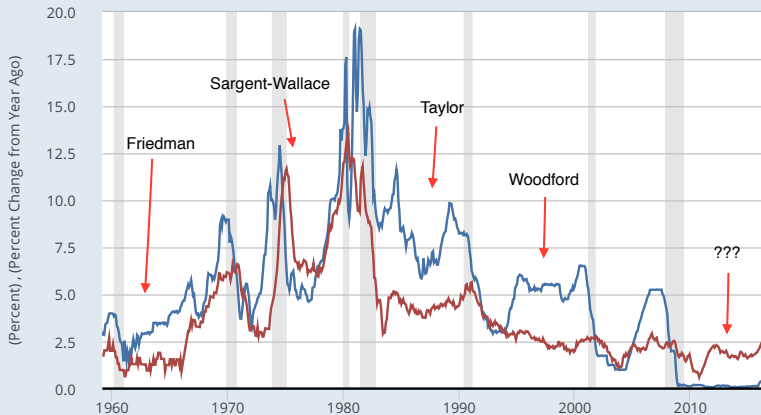


# Look for reaction to inflation greater than 1

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# Woodford, Lucas, Sargent-Wallace, New-Keynesians

- ▶ Objection: Adaptive expectations?
- ▶ Policy based on fooling people. Sooner or later they catch on. You can't *systematically* and *regularly* fool people.
- ▶ Expectations *in* the model should be expectations *of* the model.
- ▶ But  $\pi_t^e = E_t \pi_{t+1} \neq \pi_{t-1}$  changes everything!
- ▶  $i_t = r + E_t \pi_{t+1}$  Peg  $i_t$  determines  $E_t \pi_{t+1}$ . Stable!
- ▶ Story/intuition. Driving looking out front vs. back window.
- ▶ But *indeterminate*. (Sargent-Wallace)  $i_t$  *only* determines  $E_t \pi_{t+1}$ . Actual inflation can be anything (unpredictable).

# Rational expectations

Model...

$$i_t = -(\kappa/a)\pi_t + (1 + \kappa/a)\pi_t^e$$

Rational expectations:  $\pi_t^e = E_t\pi_{t+1} \neq \pi_{t-1}$

$$i_t = -(\kappa/a)\pi_t + (1 + \kappa/a)E_t\pi_{t+1}$$

$$E_t\pi_{t+1} = \frac{1}{1 + \kappa/a}i_t + \frac{\kappa/a}{1 + \kappa/a}\pi_t$$

- ▶ Friedman wrong! *Even a pure peg is stable on its own!*
- ▶ But we only nail down expected inflation, like coin is 50/50.
- ▶ Actual inflation can be anything, so long as unexpected. “Sunspots”  
“Multiple equilibria” “Indeterminacy.” (Sargent-Wallace)
- ▶ Woodford to the rescue...

# Woodford

Model with rational expectations

$$i_t = -(\kappa/a)\pi_t + (1 + \kappa/a) E_t \pi_{t+1}$$

Add Taylor rule to *this* model,

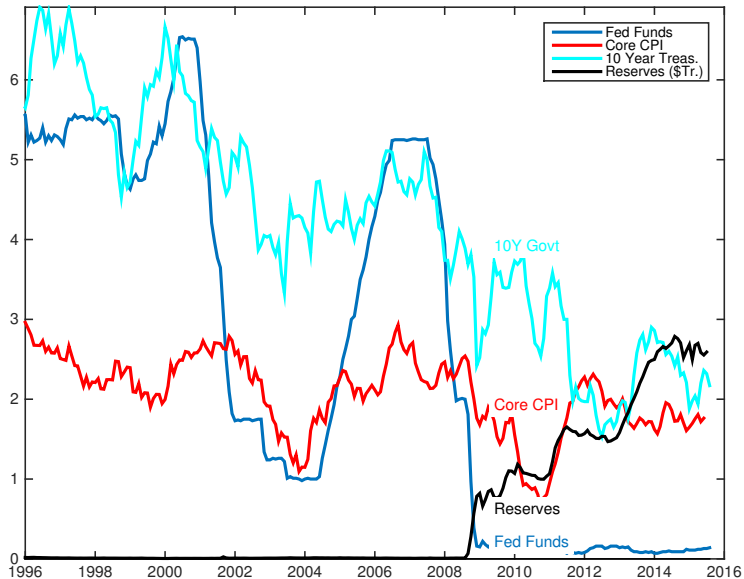
$$i_t = \phi \pi_t$$

and you get

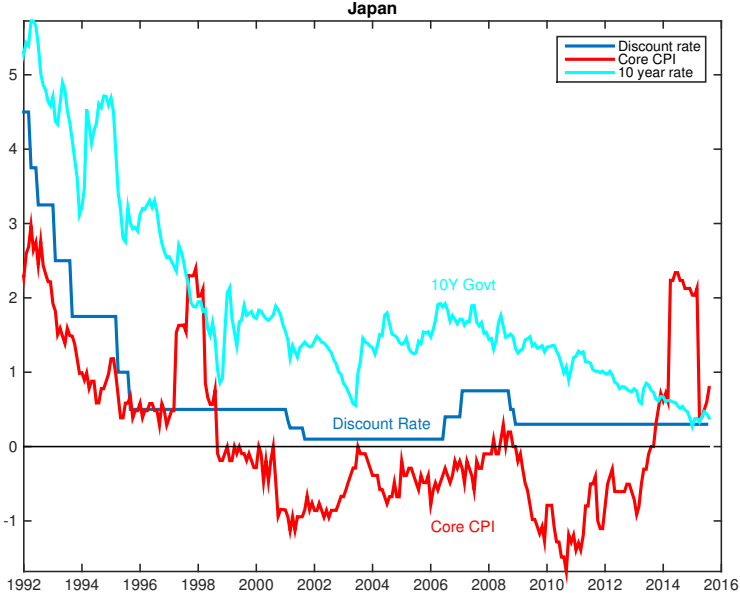
$$\begin{aligned}\phi \pi_t &= -(\kappa/a)\pi_t + (1 + \kappa/a) E_t \pi_{t+1} \\ [\phi + (\kappa/a)] \pi_t &= (1 + \kappa/a) E_t \pi_{t+1} \\ E_t \pi_{t+1} &= \frac{\phi + \kappa/a}{1 + \kappa/a} \pi_t.\end{aligned}$$

- ▶  $\phi > 1 \leftrightarrow$  inflation is unstable again... *unless*  $\pi_t = 0$ .
- ▶ Was: Taylor rule *stabilizes* an otherwise *unstable* world.
- ▶ Now: Taylor rule introduces *instability* into an otherwise *stable* world, so we will all jump to one of many possible equilibria.
- ▶ Fundamental P? Fed as DJ, equilibrium selection. Not M, S&D.
- ▶ Me: nutty but no need to criticize now ... The real world intrudes.

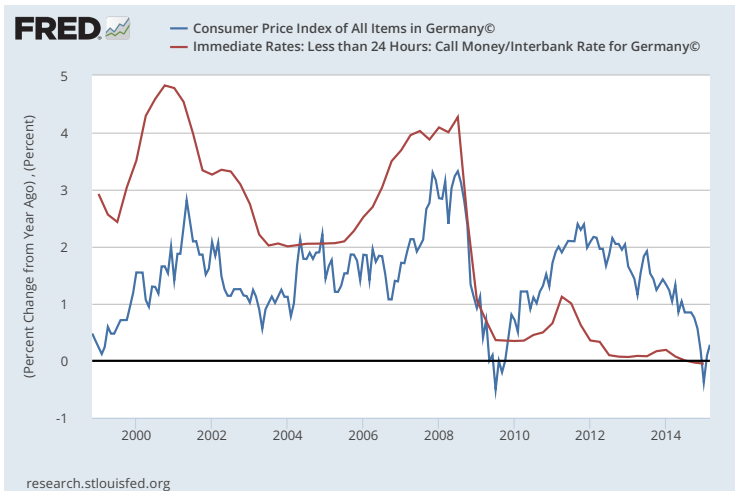
# Recent Experience—US



# Recent Experience – Japan



# Recent Experience – Europe

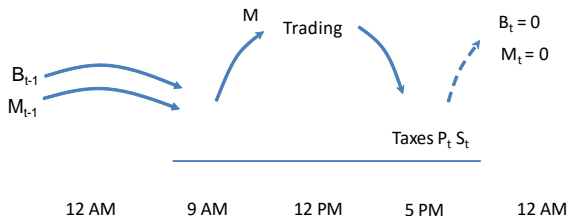


# The bomb that did not go off

- ▶ We hit zero bound,  $i$  stuck ( $\phi = 0$  in  $i = \phi\pi$ ). *Nothing happened!*
- ▶ Review:
  - ▶ Friedman, Keynesians, Policy world. Peg is *unstable*. "Deflation spiral" must ensue. Facts: peg can be stable!
  - ▶ Monetarists:  $MV=PY$ . Take  $M$  from \$50b to \$3,000b, hyperinflation must ensue. Facts:  $V = PY/M$ ! Bonds and money are perfect substitutes at  $i = 0$ .
  - ▶ New-Keynesians. Peg is stable, but "indeterminate." Should see more volatile inflation (& many other wild predictions).
- ▶ Need new theory!



# Fiscal Theory of the price level



AM: Redeem  $B_{t-1}$  for  $M$  (B promise to pay \$1).

PM: Government taxes  $P_t S_t$  and taxes must be paid in government money. Money/bonds have no value to consumer as wallpaper.

$$B_{t-1} + M_{t-1} = P_t S_t$$

$$\frac{B_{t-1} + M_{t-1}}{P_t} = S_t [= PV(\text{future } S)]$$

# The Fiscal Theory of The Price Level

$$\frac{B_{t-1} + M_{t-1}}{P_t} = S_t [= PV(\text{future } S)]$$

- ▶ Real value of government debt = present value of primary surpluses.
- ▶ Stocks: No. of shares  $\times$  price per share = pv of future dividends.
- ▶ “Aggregate demand.” “Tax theory of money.” “Backing”

## Doctrines

- ▶ Can determine  $P$  with no money (not “special”) at all. Solves “determinacy.”
- ▶ Open market operation (M vs. B) is irrelevant. (Good!)
- ▶ Money can pay interest (Good!)
- ▶ No need to control inside money, financial innovation (Good!)

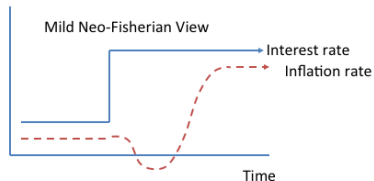
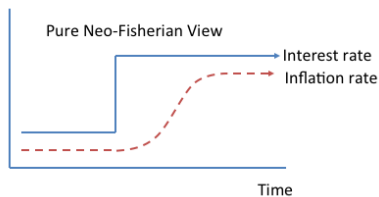
## Rate targets with FTPL

$$\frac{B_{t-1} + M_{t-1}}{P_{t-1}} E_{t-1} \left( \frac{P_{t-1}}{P_t} \right) = E_{t-1} S_t [= PV(\text{future } S)]$$
$$i_{t-1} = r + E_{t-1} \pi_t$$

- ▶ Gov't can target interest rates with no money. Set rate for bonds, come and get 'em. (What we do). Interest on reserves with no open market operations can work.
- ▶ Interest rate targets, including peg, determines expected inflation.
- ▶ Inflation is *stable* and *determinate* under a target/peg/zero. (So long as  $S$  is not a problem!)
- ▶ Nothing special about zero.
- ▶ Why no deflation? Deflation needs big taxes to pay a windfall to bondholders.

# The Neo-Fisherian question

- ▶ Facts:  $i = r + \pi^e$ .  $\pi$  seems to be following  $i$ . Peg is stable. Pedal misapplication? Will raising  $i$  raise  $\pi$ ?



## Effect of rate rise?

$$i_t = -(\kappa/a)\pi_t + (1 + \kappa/a) E_t \pi_{t+1}$$

FTPL says, with no fiscal news,  $\pi_{t+1} = E_t \pi_{t+1}$ . So,

$$(1 + \kappa/a) \pi_{t+1} = i_t + (\kappa/a)\pi_t$$

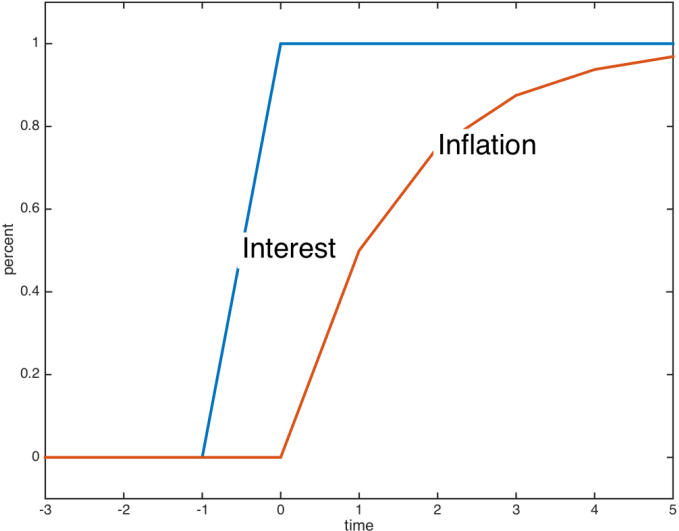
$$\pi_{t+1} = \frac{1}{1 + \kappa/a} i_t + \frac{\kappa/a}{1 + \kappa/a} \pi_t$$

$$\pi_{t+1} = \frac{1}{1 + \kappa/a} i_t + \frac{1}{(1 + \kappa/a)^2} i_{t-1} + \frac{\kappa/a}{1 + \kappa/a} \pi_{t-1}$$

$$\pi_{t+1} = \frac{1}{1 + \kappa/a} i_t + \frac{1}{(1 + \kappa/a)^2} i_{t-1} + \frac{1}{(1 + \kappa/a)^3} i_{t-2} + \dots$$

Model: raising interest rates *raises* inflation uniformly. True? (More realistic model?)

# Effect of rate rise?

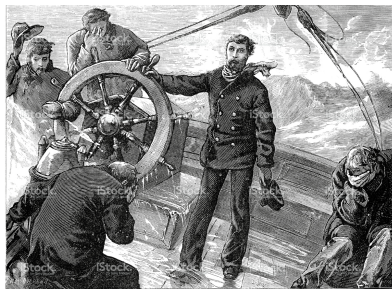


# Optimal quantity of money

The optimal quantity of money?



The optimal role for the Fed?



CAPTAIN LYON AND HIS CREW OFFERING PRAYERS FOR THEIR PRESERVATION.

# Optimal quantity of money and warning

## Optimal inflation/quantity of money?

- ▶ Friedman: Slight deflation  $i = 0$ ,  $\pi = -r$ . LOTS of money
- ▶ Why? Money is free. Don't starve the engine of oil.
- ▶ Past: Need  $i > 0$  for P control. FTPL, recent history:  $i = 0$ , huge reserves are fine.
- ▶ We have achieved the optimal quantity of money, and it is stable. Don't mess with it.



## Where's grumpy?



$$\frac{B_{t-1} + M_{t-1}}{P_t} = S_t [= PV(\text{future } S)]$$

- ▶ FTPL Warning: 100% debt/GDP ratio is dangerous! Higher rates could lead to unexpected and uncontrollable inflation.

## Review—what determines inflation?

- ▶ Gold Standard (not practical for US)
- ▶ Friedman:  $MV=PY$ , control  $M$ . Interest rate target is *unstable*.
- ▶ Taylor:  $i = \phi\pi$  rule,  $\phi > 1$  can render economy *stable* with  $i$  target.
- ▶ Sargent-Wallace, etc. With rational expectations,  $i$  peg is *stable* but *indeterminate*, multiple equilibrium.
- ▶ Woodford:  $i = \phi\pi$  rule,  $\phi > 1$  *destabilizes* for all but one equilibrium
- ▶ Facts. Zero bound,  $\phi = 0$ . QE  $M = \$3,000b$  and nothing happened. All theories blown out of water.
- ▶ FTPL. Money valued if gov't wil soak it up for tax payments. *Stable* and *determinate* with  $i$  peg, (with good fiscal policy!)
- ▶ Quiz: Match the equation to the theory

$$i = r + \pi^e$$

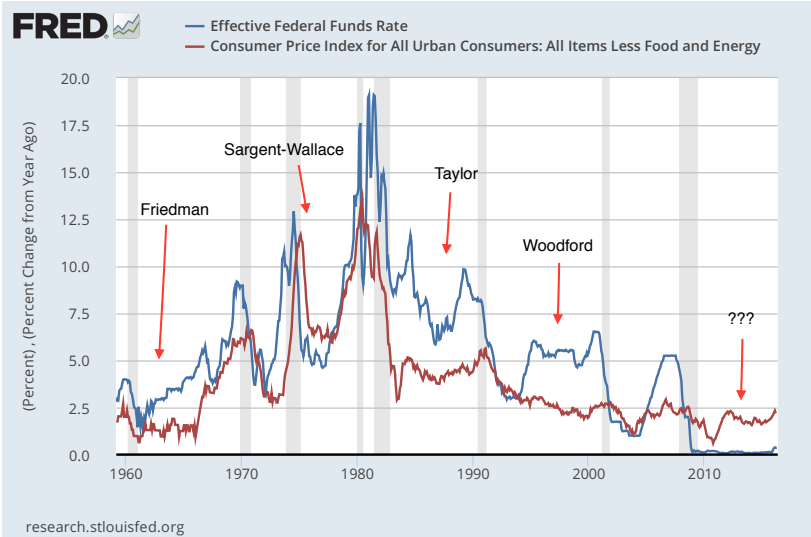
$$i = \phi\pi, \pi_t^e = \pi_{t-1}.$$

$$i = \phi\pi, \pi_t^e = E_t\pi_{t+1}.$$

$$\frac{B_{t-1} + M_{t-1}}{P_t} = EPV(S)$$

- ▶ and most of all, ...

# History

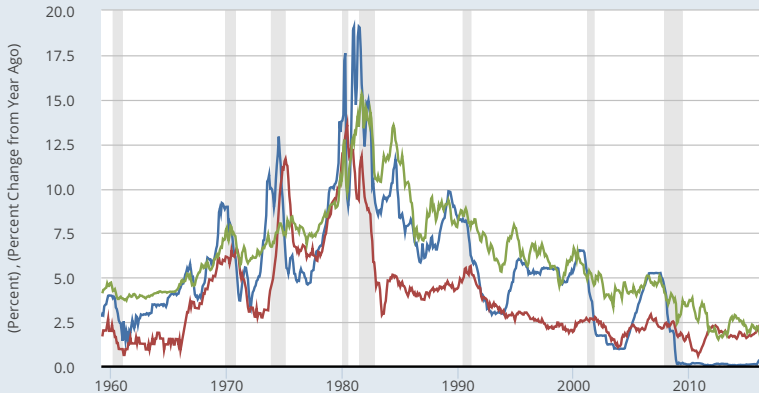


THE END  
Extra slides follow

# Interest rates and inflation, with long term rates

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- Effective Federal Funds Rate
- Consumer Price Index for All Urban Consumers: All Items Less Food and Energy
- 10-Year Treasury Constant Maturity Rate



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## Long term rates and expectations

- ▶ Nominal rate = real rate + expected inflation

$$i_t = r_t + E_t \pi_{t+1}$$

- ▶ Long term rate = average of expected future short rates (plus risk premium)

$$i_t^{(10)} = \frac{1}{10} \sum_{j=0}^9 E_t i_{t+j} + r.p.$$

- ▶ Long term rates reveal market expectations of inflation (+real rates, risk premium)
- ▶ Cyclical rate moves 1970-1980, 1990 - are expected to be temporary.
- ▶ 1970s inflation, 1980s disinflation was unexpected.
- ▶ (Divergence of 1984 reading. How did inflation stop so fast?)
- ▶ Rates largely below inflation 1970s, largely above 1980s-2008.
- ▶ Interest rates positively correlated with inflation. Do higher interest rates cause higher or lower inflation?

## Friedman on the Phillips curve

FRIEDMAN: MONETARY POLICY

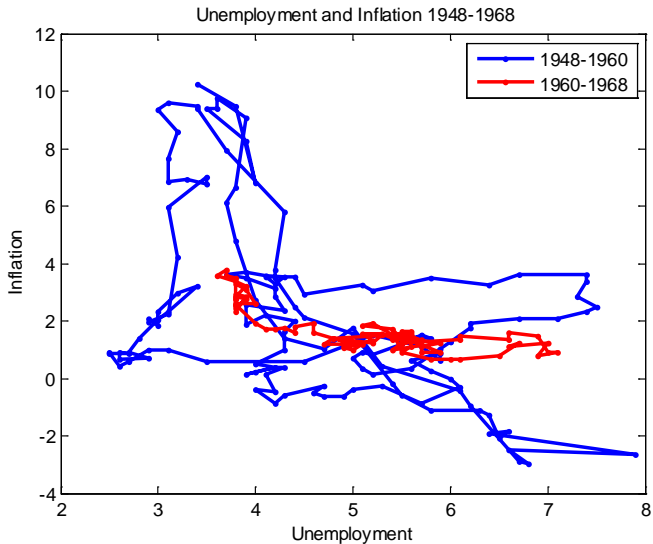
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these variations, it will set in train longer term effects that will make any monetary growth path it follows ultimately consistent with the rule of policy. The actual course of monetary growth will be analogous to a random walk, buffeted this way and that by the forces that produce temporary departures of the market rate from the natural rate.

To state this conclusion differently, there is always a temporary trade-off between inflation and unemployment; there is no permanent trade-off. The temporary trade-off comes not from inflation per se, but from unanticipated inflation, which generally means, from a rising rate of inflation. The widespread belief that there is a permanent trade-off is a sophisticated version of the confusion between “high” and “rising” that we all recognize in simpler forms. A rising rate of inflation may reduce unemployment, a high rate will not.

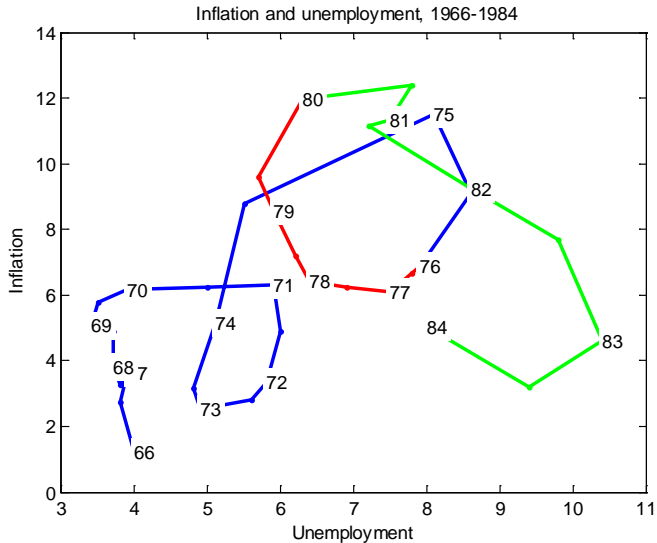
But how long, you will say, is “temporary”? For interest rates, we

# Early Phillips curve

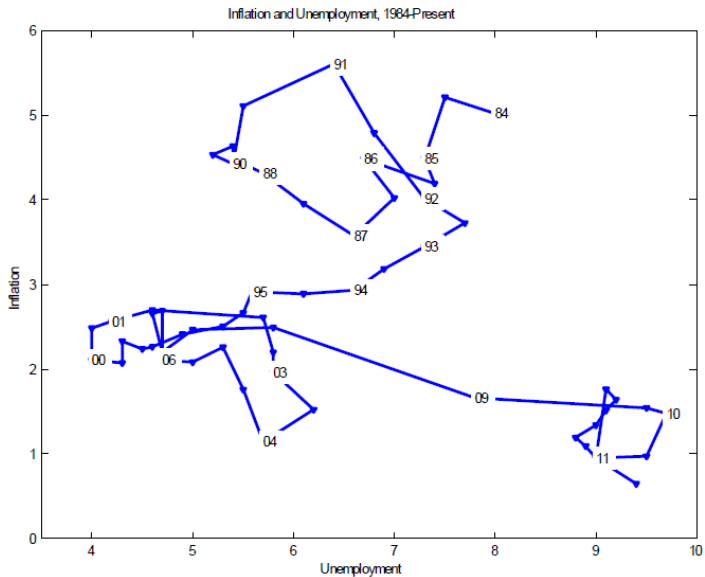




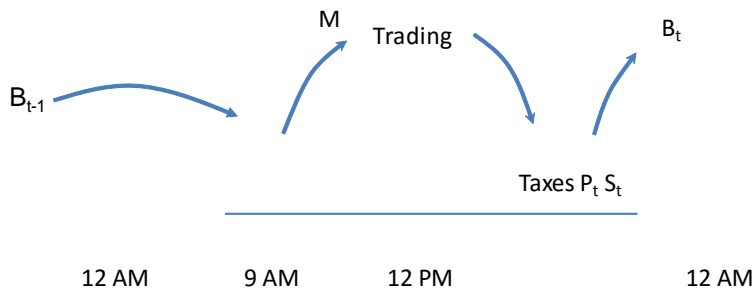
# Phillips curve 70s



# Current Phillips curve



# Intertemporal model



$$B_{t-1} = P_t s_t + Q_t B_t$$

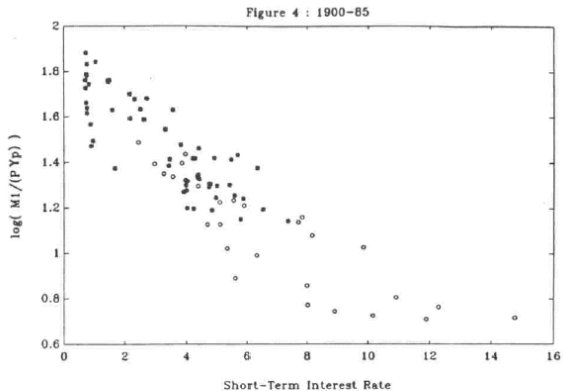
$$Q_t = E_t \left( \frac{1}{R} \frac{P_t}{P_{t+1}} \right) = \text{nominal bond price.}$$

$$\frac{B_{t-1}}{P_t} = s_t + E_t \left( \frac{1}{R} \frac{B_t}{P_{t+1}} \right)$$

$$\frac{B_{t-1}}{P_t} = E_t \sum_{j=0}^{\infty} \frac{1}{R^j} s_{t+j}$$

# Stability of money demand?

Lucas 1988:



\* - denotes observations from 1900 to 1957.

o - denotes observations from 1958 to 1985.

## Lucas' Nobel lecture

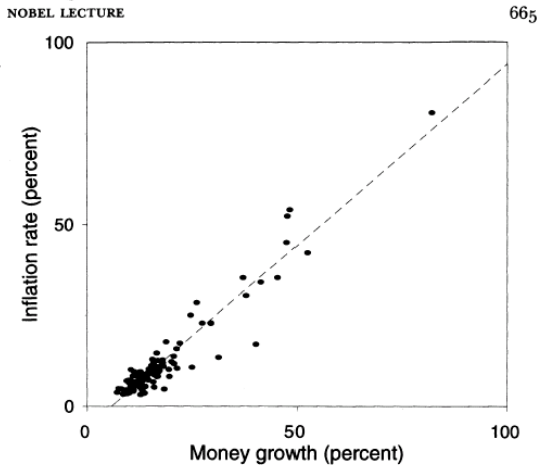


FIG. 1

But...  $P = MV/Y$ ? Or  $M = PY/V$ ? Driving BMW makes you rich?