Lecture 12: Inflation, Money Growth, and Interest Rates

See Barro Ch. 11

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Where are we? Taking stock

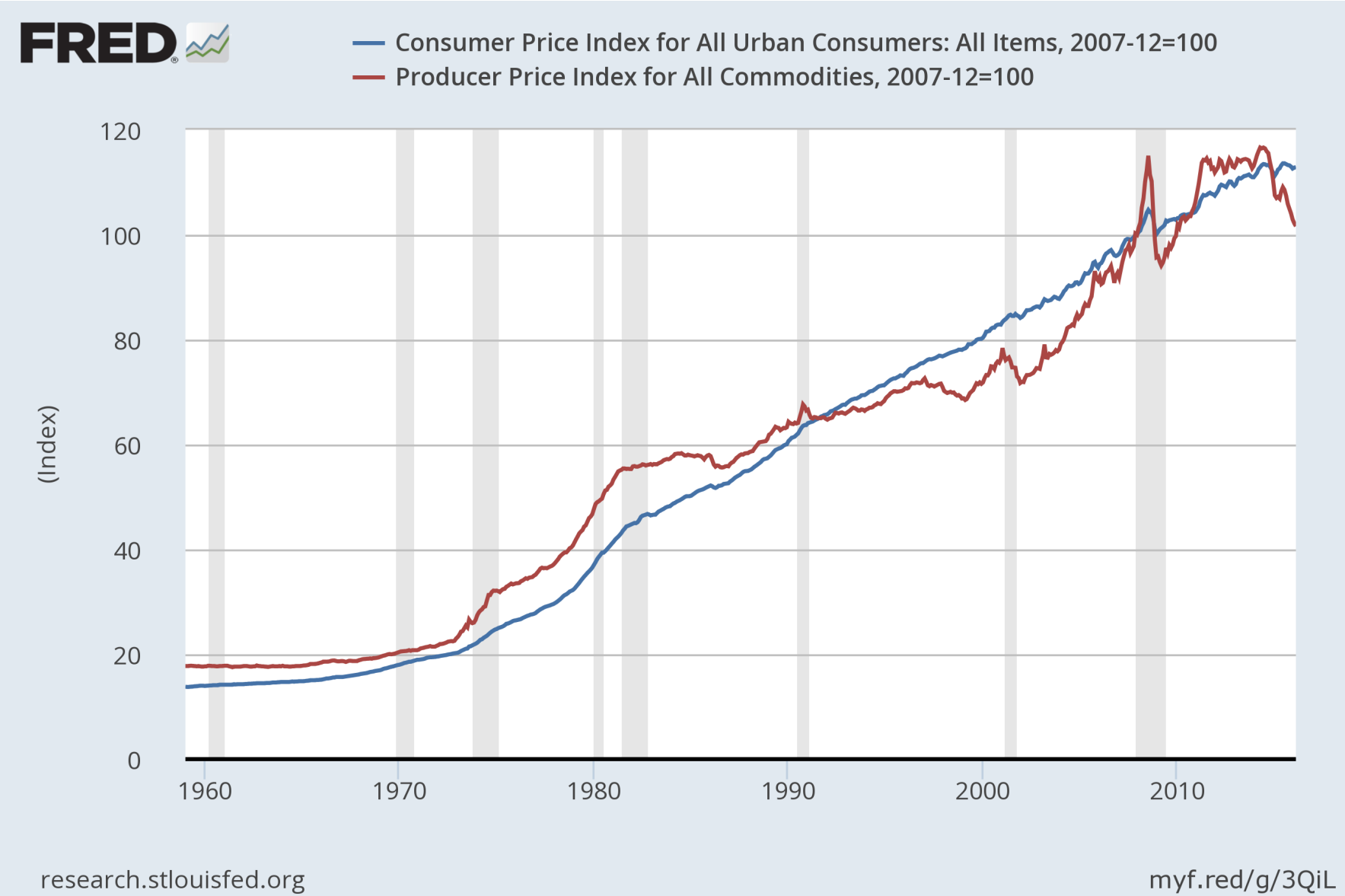
1. We just introduced money into our model.

2. Our big, fundamental result (that we can manipulate in various ways) is:
$$M^s = PL(Y, i)$$

3. Where M^s is money supply, P is the price level, Y is real income, and i is the real interest rate

4. But we don't just care about the price level: we care about inflation π, the change in the price level:

Price Index


FRED
Consumer Price Index for All Urban Consumers: All Items, 2007-12=100
Producer Price Index for All Commodities, 2007-12=100
120
100
80
60
40
20
0
(Index)
1960
1970
1980
1990
2000
2010
research.stlouisfed.org
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Definition of Inflation

- Net inflation π is the percentage change in the price level P

$$\pi_{t \to t+1} = \frac{P_{t+1} - P_t}{P_t}$$

- So if the price level goes from 1 to 1.05, the inflation rate is 0.05 (5%).

- Using our model, we can analyze four possible sources of inflation:

  1. M^s: changes in the money supply
  2. Y: changes in real income
  3. i: changes in the interest rate
  4. $L(\cdot, \cdot)$: other changes in the money demand function

- Which of these are reasonable to explain inflation?

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- How does an increase in real income effect inflation?

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- Increases in the money supply are a very good candidate to explain inflation
- Let's think about the evidence

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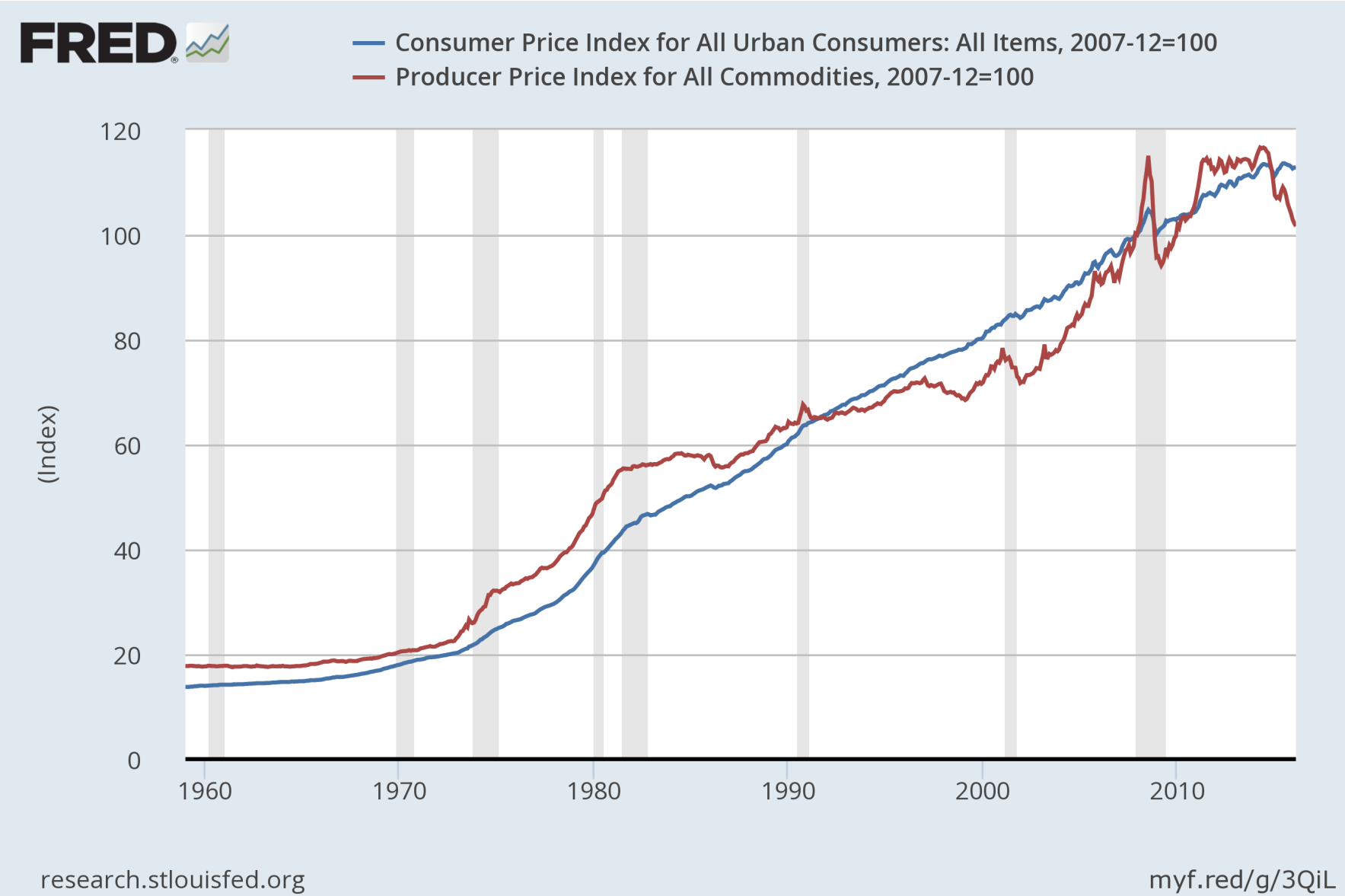
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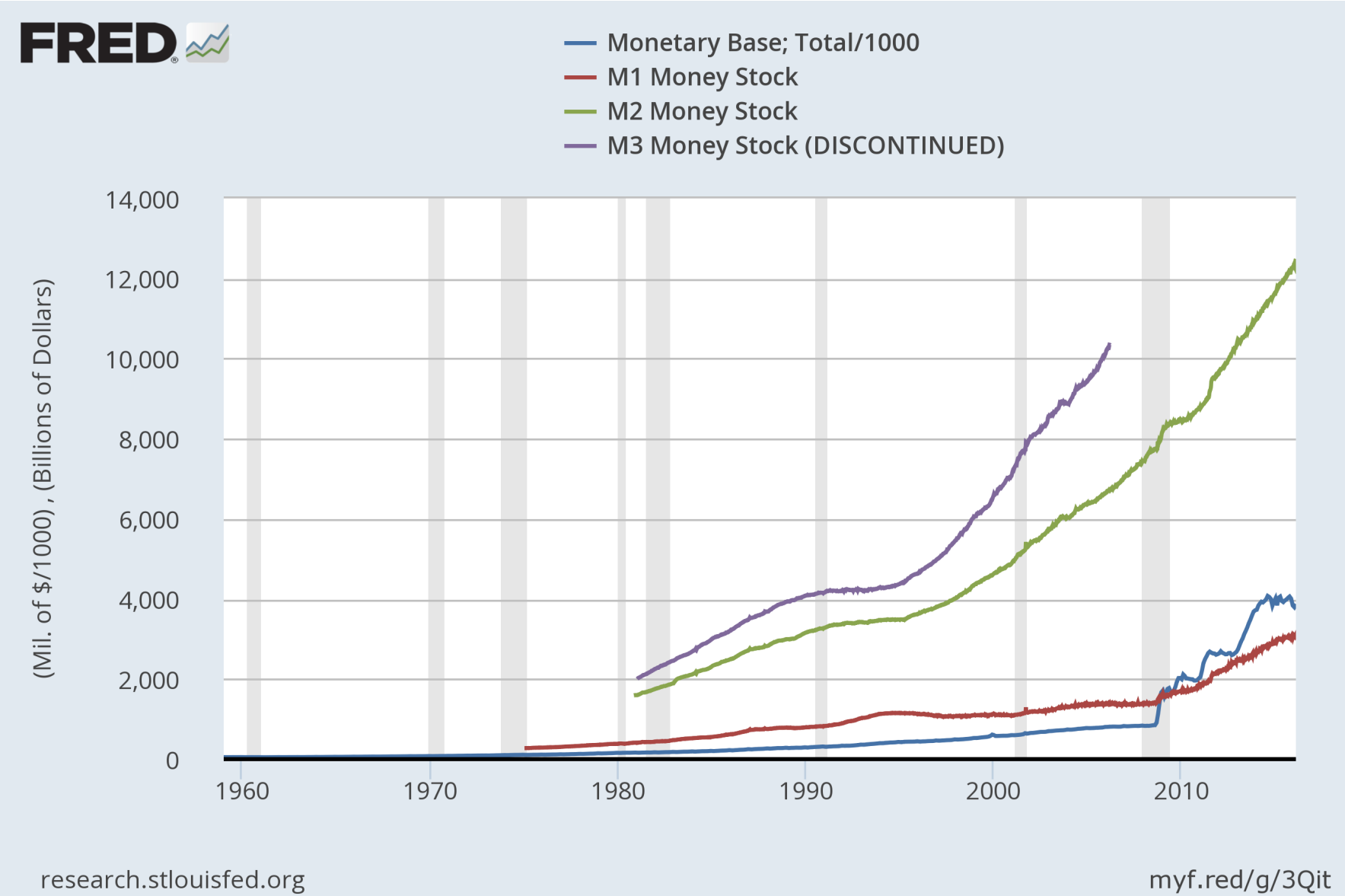
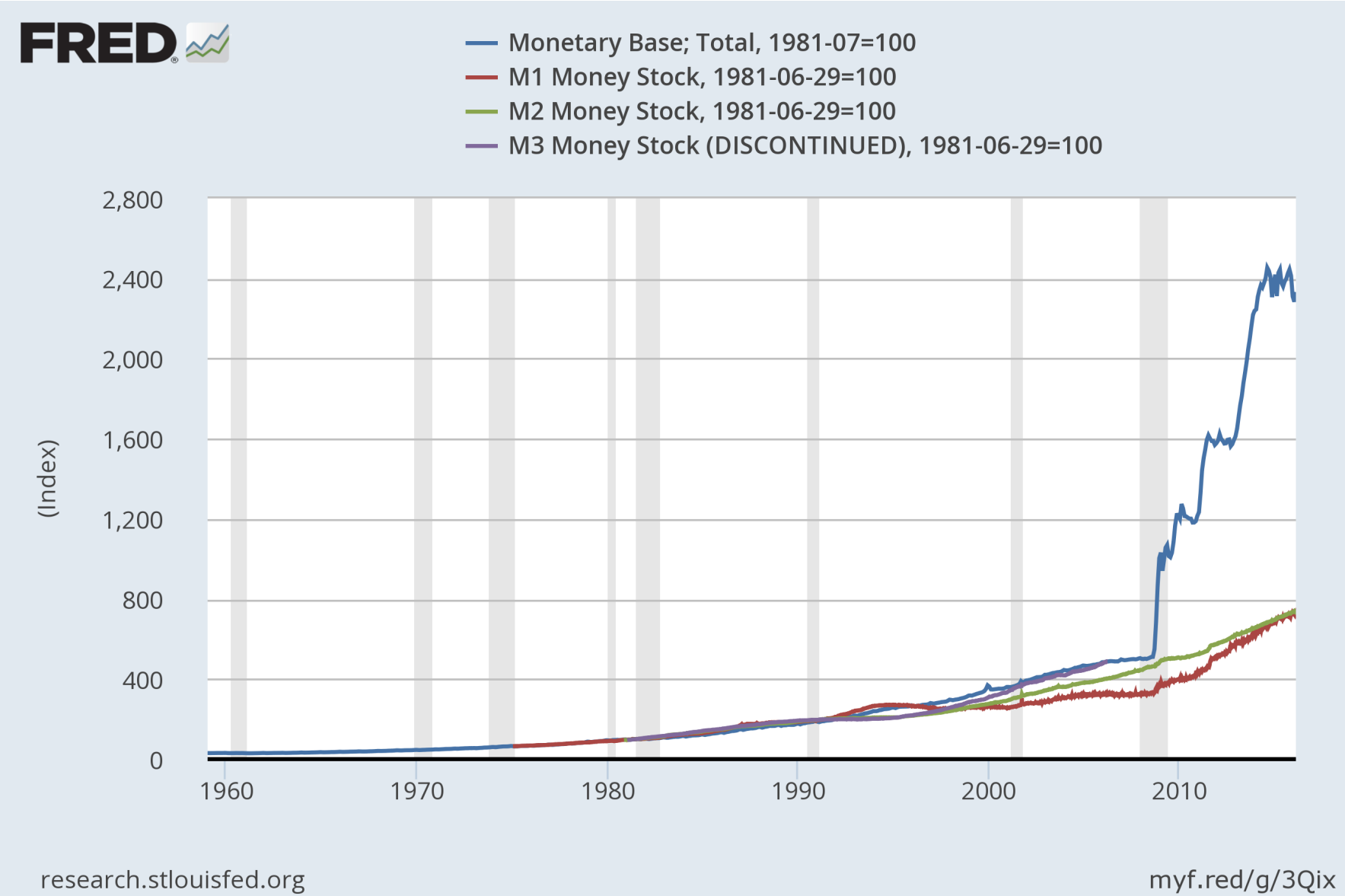
Money Supply



Money Supply-Indexed



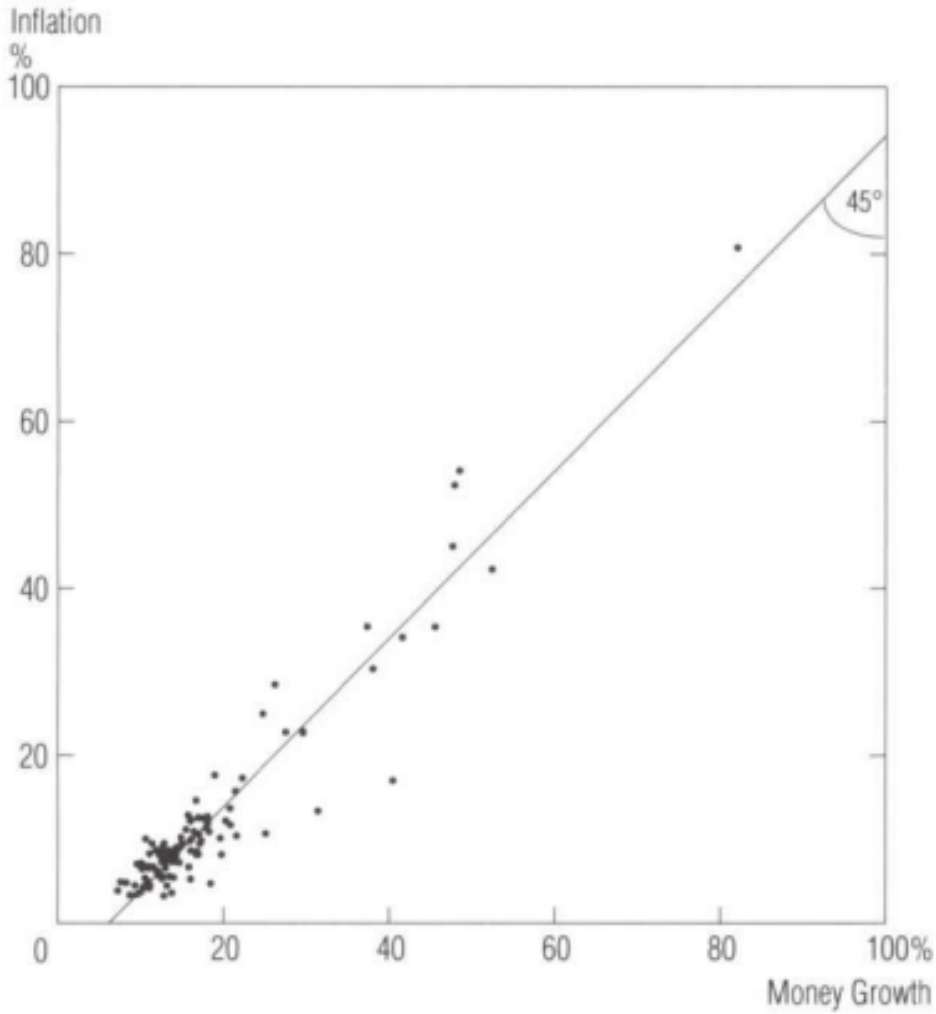
Can changes in money supply explain inflation?

- Take 30-year timespan for 110 countries
- Compare money growth with inflation
- What should this look like if this is all a money supply story?

Cross-Country Evidence

Money Growth and Inflation:
A High, Positive Correlation

Average Annual Rates of Growth in M2 and in Consumer Prices
During 1960–90 in 110 Countries



Source: International Monetary Fund

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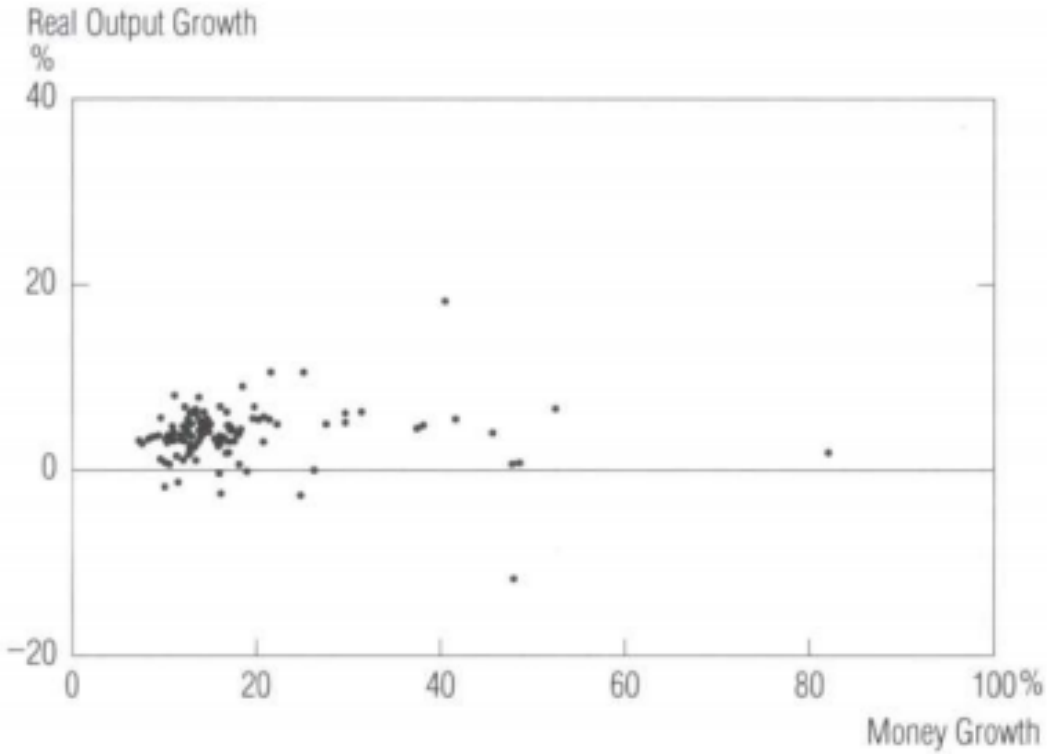
- Recall monetary neutrality: inflation doesn't impact real outcomes
- What should this look like?
- Let's check it out

Cross-Country Evidence

Money and Real Output Growth:
No Correlation in the Full Sample . . .

Average Annual Rates of Growth in M2
and in Nominal Gross Domestic Product, Deflated by Consumer Prices
During 1960–90 in 110 Countries

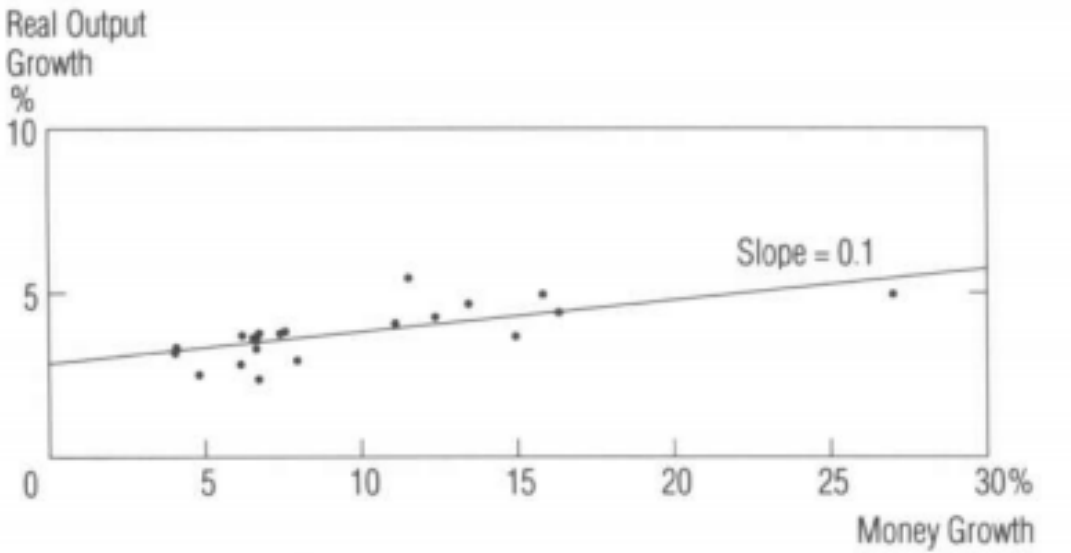


Source: International Monetary Fund

Cross-Country Evidence

. . . But a Positive Correlation in the OECD Subsample

Average Annual Rates of Growth in M0
and in Nominal Gross Domestic Product, Deflated by Consumer Prices
During 1960–90 in 21 Countries

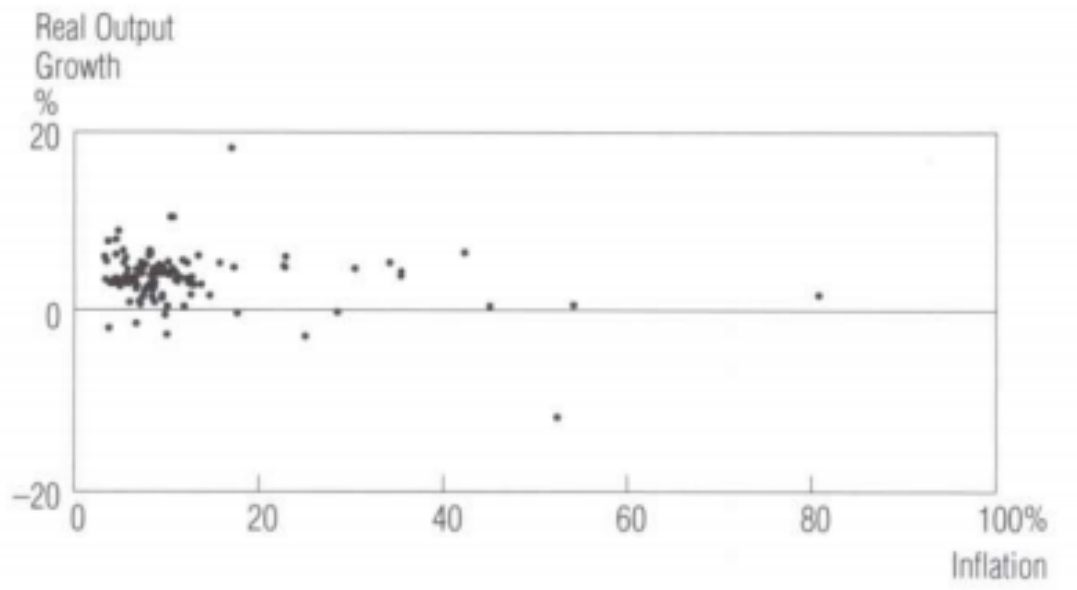


Source: International Monetary Fund

Cross-Country Evidence

Inflation and Real Output Growth: No Correlation

Average Annual Rates of Growth in Consumer Prices
and in Nominal Gross Domestic Product, Deflated by Consumer Prices
During 1960–90 in 110 Countries



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- We noted theoretically that inflation (and money supply) shouldn't be linked to real output growth
  - In the long run, they aren't.
- There remains some debate about the short run (we'll get to this: Ch. 15 and Ch. 16)

Inflation Expectations

- As we noted, the definition of inflation:

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- Therefore, we'll denote expected inflation as: $\pi^e_{t \to t+1}$.
- When households try to keep errors as small as possible and are able to avoid systematic errors, we call this rational expectations
- Rational expectations **does not** mean that people don't make mistakes!

Nominal and Real Interest Rates-I

- When I give up a dollar today, I don't care about how many dollars tomorrow I can get, I care about how many things I can buy. The *real* interest rate, not the *nominal*.
- Nominal contract: I give up \$1 today and get $1 + i$ dollars tomorrow.
- When I give up \$1 today I lose $\frac{1}{P_t}$ goods today and get $\frac{1+i}{P_2}$ tomorrow.
- Nominal interest rate is:

$$1 + i_t = \frac{\text{Dollars gained tomorrow}}{\text{Dollars lost today}}$$

- Real interest rate is:

$$1 + r_t = \frac{\text{Consumption goods gained tomorrow}}{\text{Consumption goods lost today}}$$

Nominal and Real Interest Rates-II

- Start with real interest rate and divide by $\frac{P_2}{P_1}$

$$
\begin{aligned}
1 + r_t &= \frac{\text{Consumption goods gained tomorrow}}{\text{Consumption goods lost today}} \\
&= \frac{\frac{\text{Dollars gained tomorrow}}{\text{Price per good tomorrow}}}{\frac{\text{Dollars lost today}}{\text{Price per good today}}} \\
&= \frac{\text{Dollars gained tomorrow}}{\text{Dollars lost today}} \frac{\text{Price per good today}}{\text{Price per good tomorrow}} \\
&= (1 + i_t)\frac{P_t}{P_{t+1}} \\
&= \frac{1 + i_t}{1 + \pi_t}
\end{aligned}
$$

Nominal and Real Interest Rates-III

- The real interest rate is the nominal interest rate divided by the inflation rate (all in gross terms)
- Example: Say the nominal interest rate is 10% and the inflation rate is 5%.
  - If I give up \$1 and the price is \$1/good, then tomorrow I get \$1.10 and the price is \$1.05/good. I can buy 1.0476 goods if I give up 1 good today.
  - Barro and people in general also like to use the approximation:

$$r_t = i_t - \pi_t$$

  - Barro derives it one way, an alternative is (recall $\log(1+\epsilon) \approx \epsilon$, for ϵ near zero):

$$(1 + r_t) = \frac{1 + i_t}{1 + \pi_t}$$

$$\log(1 + r_t) = \log\left(\frac{1 + i_t}{1 + \pi_t}\right)$$

$$\log(1 + r_t) = \log(1 + i_t) - \log(1 + \pi_t)$$

$$r_t \approx i_t - \pi_t$$

Nominal and Real Interest Rates-III

- Nominal interest rates are determined by:
  - People's impatience
  - People's taste for risk (we're largely ignoring this)
  - People's expectations about inflation
- So when we set the nominal interest rate, we set it equal to:

$$i_t = r_t^e + \pi_t^e$$

- How can we measure expected inflation?

Measuring Expected Inflation

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    - Con: Opinion surveys are worthless

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    - Con: People disagree about how to estimate
  - Use market data
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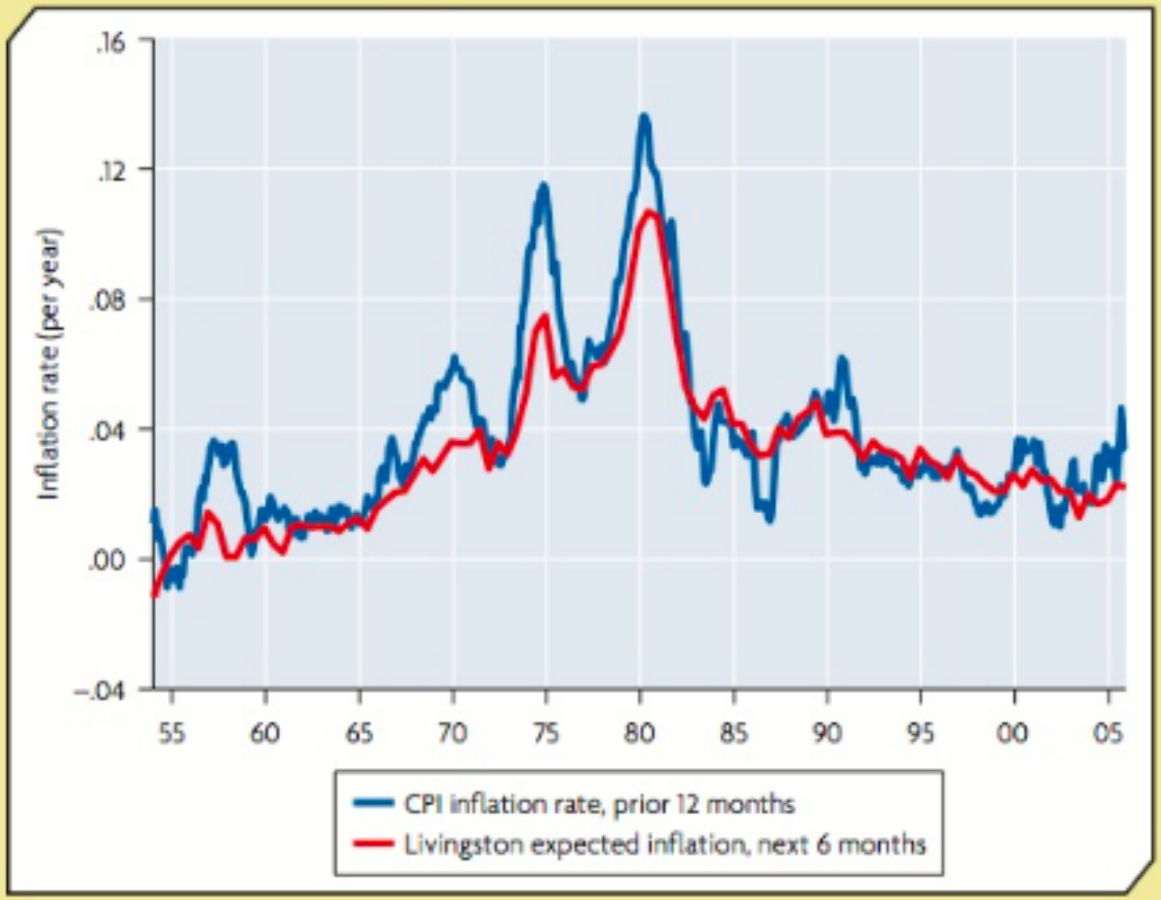
  - Ask people
    - Con: Opinion surveys are worthless
- Extra credit: can which one of these is just my opinion?

Measuring Expected Inflation with Surveys

Figure 11.2 *Actual and Expected Inflation Rates in the United States*



Measuring Expected Inflation with Surveys

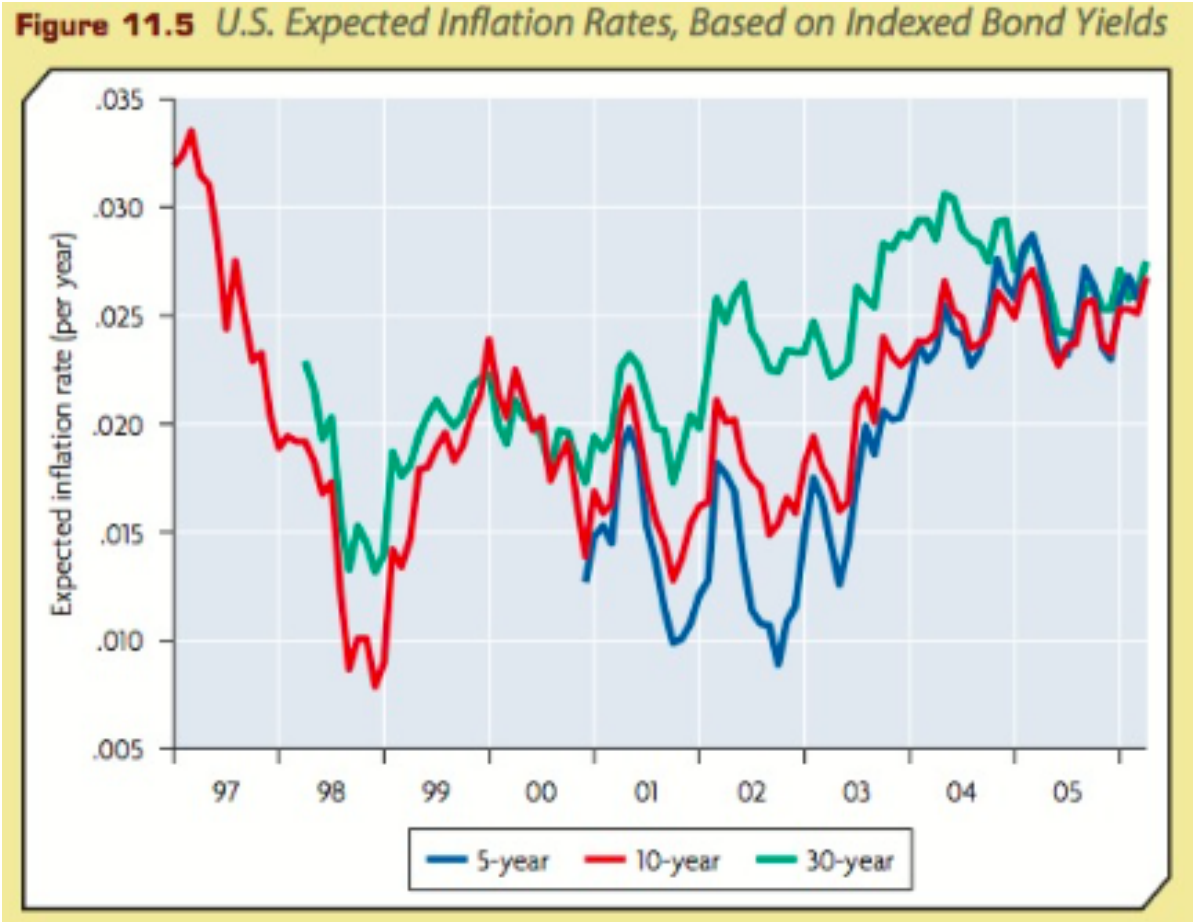
Figure 11.3 *Nominal and Expected Real Interest Rates in the United States*

Measuring Expected Inflation with Markets

Figure 11.4 *Real Interest Rates on U.S. Indexed Bonds*

Measuring Expected Inflation with Markets

Figure 11.5 *U.S. Expected Inflation Rates, Based on Indexed Bond Yields*



These match up fairly well with the surveys.

Putting Money into the Business Cycle I

- For the rest of this lecture we'll think about how *expected* inflation will change behavior
- Our story:
  - Money supply causes inflation
  - Government prints up money, drops from helicopter to the people
  - Everyone gets an equal share
  - Most importantly, it doesn't matter if you're working or not

Putting Money into the Business Cycle II

- Before, we had that:

$$i = \frac{R}{P}\kappa - \delta(\kappa)$$

- Now, we have that:

$$r = \frac{R}{P}\kappa - \delta(\kappa)$$

- The real interest rate is determined by real capital returns
- But money demand still depends on the nominal interest rate:

$$\frac{M^d}{P} = L(Y, i)$$

- When the inflation rate changes, the nominal interest rate ($i = r + \pi$) will change, so money demand will change
- Consequently prices will change
- But we've seen when prices change nothing real changes (monetary neutrality)

Putting Money into the Business Cycle III

- Okay, so nothing real is changing. What about interest rates? Let's assume for now that Y isn't changing. What about i?
- Recall that:

$$P_t = \frac{M_t^s}{L(Y_t, i_t)}$$

- If M^s grows at a constant rate μ, then P_t grows at the same constant rate: $\pi = \mu$.
- Then we can write down the nominal interest rate as:

$$i = r + \pi \Rightarrow i = r + \mu$$

- When r and μ are constant, then i is constant, so $L(Y, i)$ doesn't change.
- Therefore if we start out in equilibrium we stay in equilibrium, nothing (including real money demand) changes

Putting Money into the Business Cycle IV

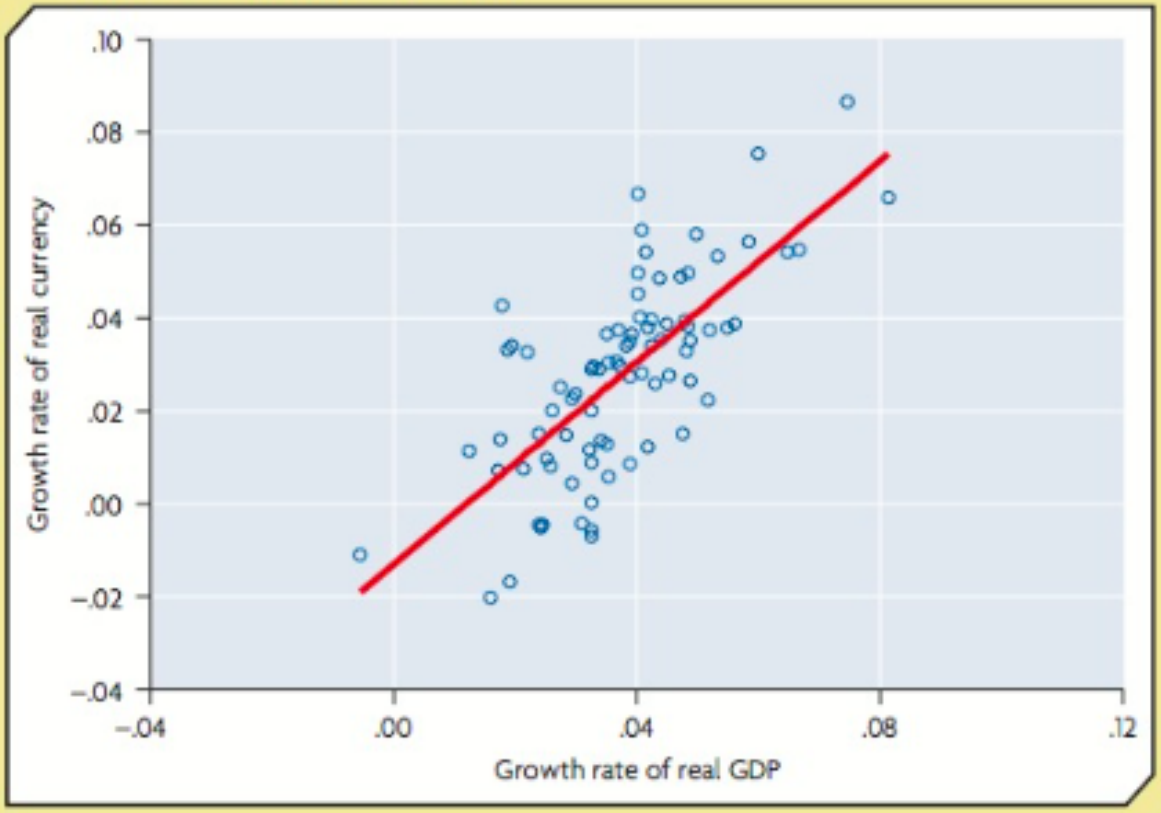
- What about a trend in the real demand for money?
- Let's say that $L(Y, i)$ increases at a rate γ while M grows at a rate μ.
- Then we can show that:

$$\pi = \mu - \gamma$$

- That is, inflation is equal to money growth minus whatever is taken out due to increased real demand for money.
- You could get this, for instance, if real GDP kept growing: then we'd see a growth in real money balances
- Let's see

Measuring Expected Inflation with Markets

Figure 11.8 *Growth Rate of Real Currency and Growth Rate of Real GDP for 82 Countries, 1960–2000*



Shift in the Growth Rate of Money

- Imagine since the beginning of time that the growth rate of M is μ. Then the inflation rate is π.
- Suddenly, the government changes the growth rate of μ to be μ'.
- Then the (long run) inflation rate will be π'.
- But prices will see a sudden jump: why?
- Two important equation:

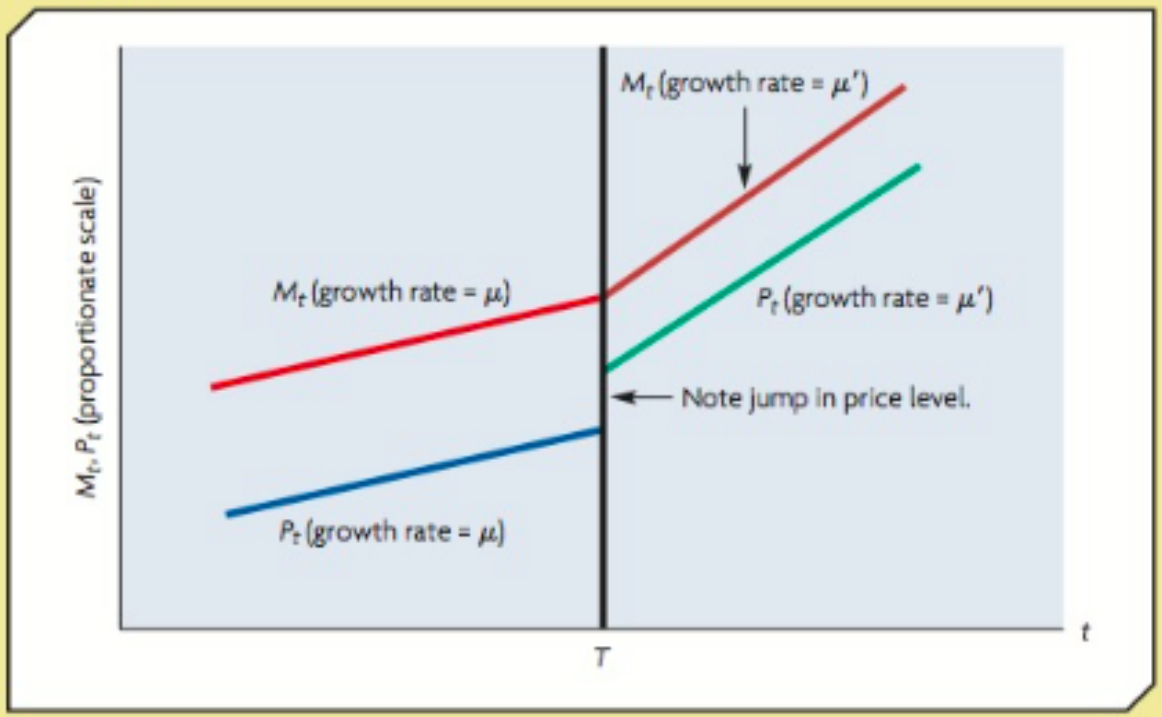
$$P_t = \frac{M^s}{L(Y, i)}$$

$$i = r + \mu$$

- When μ increases, i increases (permanently)
- When i increases, $L(Y, i)$ decreases, so the level of prices change.

Money Growth

Figure 11.9 *Effect of an Increase in the Money Growth Rate on the Price Level*



Shift in the Growth Rate of Money

- A shift in the money growth rate will cause a spike in prices (increase the intercept of prices over time, ceteris paribus) *and* an increase in the slope of prices over time.
- The slope is obvious: when the growth rate of M changes, the growth rate of P changes
- The price spike is less obvious, and comes from the fact that when the growth rate of P increases (π increases), the nominal interest rate i changes, which decreases money demand, raising the level of prices.
- It's one reason why a small expected change today can have a big impact on prices today! (and historically has)