Lecture 13: Interest Rates and Money Demand: The LM Curve

Macroeconomics (Quantitative)
Economics 101B

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Where Do We Stand

- Money market equilibrium / Aggregate demand:

$$\Delta \log M_t = \pi_t + \tilde{Y}_t - \tilde{Y}_{t-1}$$

- Price setting equation / Short-run aggregate supply:

$$\pi_t = \theta \tilde{Y}_{t-1}$$

- Okun‘s Law:

$$u_t - u^n = -\frac{1}{2}\tilde{Y}_t$$

Next Step

- Modernize our model of aggregate demand
- In medieval model, aggregate demand depends only on money holdings. Rather simplistic.
- Now we make demand depend on: Interest rates
- But before we do that, we should discuss interest rates and asset returns

Asset Returns

- If you purchase an asset, you expect to get a return
- How do we measure a return?
- Suppose you buy an asset at time t for $\$P_t$
- One period later you sell it for $\$P_{t+1}$
- What is the rate of return?
  - Gross return:

$$(1 + R_{t+1}) = \frac{P_{t+1}}{P_t}$$

  - Net return:

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

Interest Rate at the Bank

- Say you invest \$1 in a savings account at a bank that offers a 3% interest rate per year
- In one year's time you will have \$1.03
- Gross return:

$$\left(1 + R_{t+1}^{b}\right) = \frac{P_{t+1}}{P_t} = \frac{1.03}{1} = 1.03$$

- Net return:

$$R_{t+1}^{b} = \frac{P_{t+1} - P_t}{P_t} = \frac{1.03 - 1}{1} = 0.03 = 3\%$$

Returns over Many Periods

- What if you hold the asset for many periods?
- Gross return over two periods:

$$\frac{P_{t+2}}{P_t} = \frac{P_{t+2}}{P_{t+1}} \frac{P_{t+1}}{P_t}$$

  - Product of two successive one-period gross returns
  - Gross returns multiply over time (compounding)
- Money in the bank:
  - Two period return: $\left(1 + R^b\right)^2$
  - T-period return: $\left(1 + R^b\right)^T$

Compound Interest

- Suppose you had invested $100 in the stock market (S&P500) in January 1950 and held it until January 2025 reinvesting all dividends
- In January 2025, you would have $26,568
- This is a 7.72% compounded annual rate of return: $1.0772^{75} \approx 265$
- Simple interest: 75x$0.0772=$5.79
- Compound interest is $265-$6=$259

Power of Compound Interest

- In 1626, Peter Minuit is said to have purchased Manhattan Island from natives for 60 guilders
- 60 guilders said to be equivalent to $24
- Say natives had invested proceeds at 5% per year. How much would they have today?

$$\$24 \times (1 + 0.05)^{399} \cong \$6{,}800{,}000{,}000$$

(“only” $3 billion when I started teaching this course in 2008)

Interest Rates and Bond Prices

- Simple (zero-coupon) bond:
  - Promise to pay $1 one year from now
  - Price in the market today P_t
- **Yield to maturity**: Return you would get if you held bond to maturity. (Often called "yield" or "interest rate")
- What is the yield to maturity on our simple bond?

$$(1 + i_t) = \frac{1}{P_t}$$

- Bond prices and bond yield move in opposite directions!!

Nominal vs. Real Returns

- Nominal returns:
  - Returns measured in dollars
  - Not “corrected” for inflation
  - Dollar today buys less “stuff” than a dollar did 10 years ago
  - Might be interested in returns in terms of “stuff”
- Real returns:
  - Returns “corrected” for inflation
  - Prices of asset at different time deflated by overall price index for that time
  - Asset prices measured in “year 2020” dollars (for example)

Real Returns

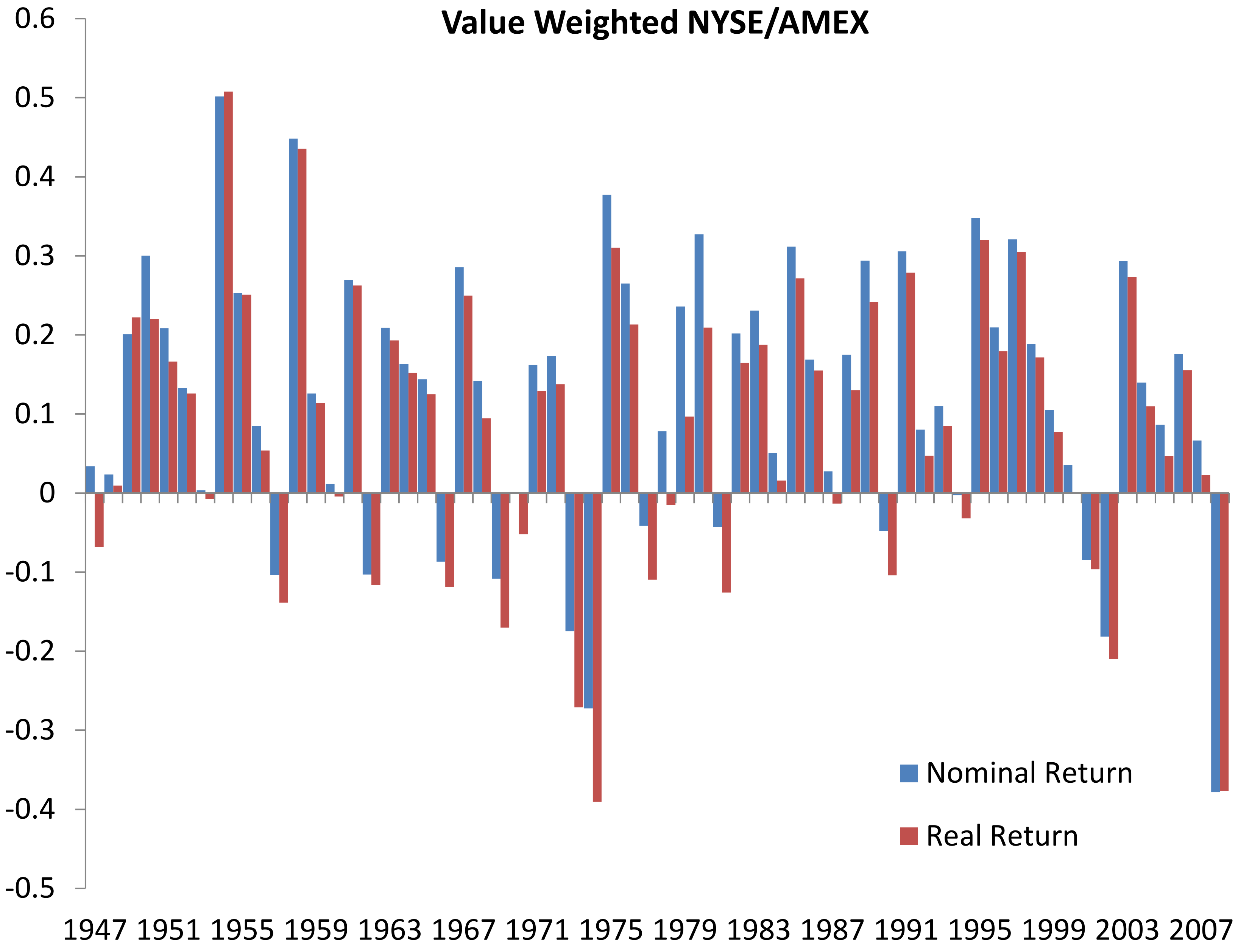
- Deflate asset prices by price index (say CPI):

$$\frac{P_t}{CPI_t} \qquad\qquad \frac{P_{t+1}}{CPI_{t+1}}$$

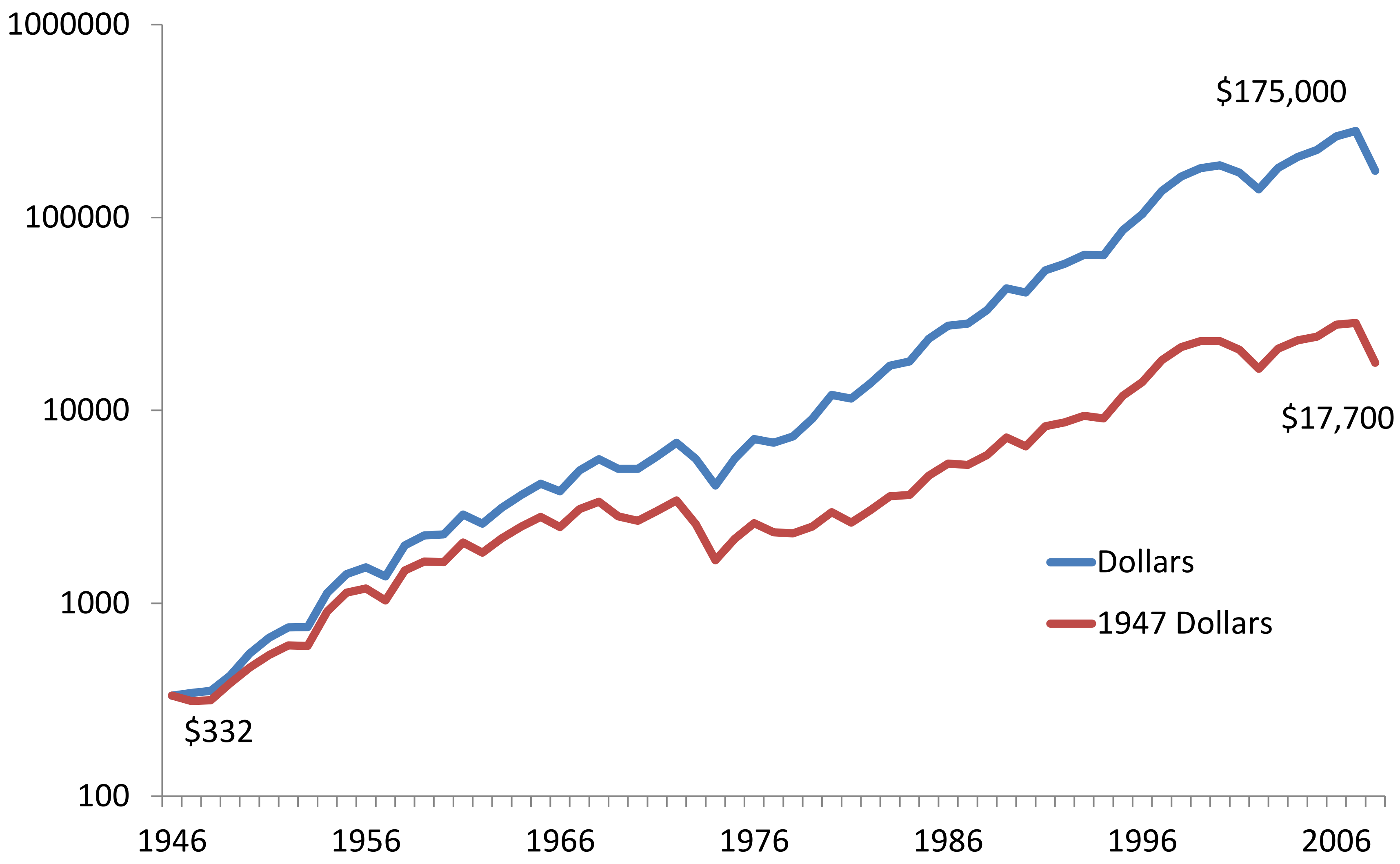
- Calculate (ex post) return using “real” prices:

$$1 + R_{t+1}^{r} = \frac{P_{t+1}/CPI_{t+1}}{P_t/CPI_t} = \frac{P_{t+1}/P_t}{CPI_{t+1}/CPI_t} = \frac{1 + R_{t+1}^{n}}{1 + \pi_{t+1}}$$

$$R_{t+1}^{r} \approx R_{t+1}^{n} - \pi_{t+1}$$


Value Weighted NYSE/AMEX
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1947 1951 1955 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003 2007
Nominal Return
Real Return

Value Weighted NYSE/AMEX



Fisher Equation

- Fisher equation:

$$R_t = i_t - E_t\pi_{t+1}$$

- Fisher equation is the definition of the ex ante real interest rate
- Ex ante real interest rate: Real interest rate people except at time t to prevail from time t to time $t+1$
  - π_{t+1} is not known until period $t+1$
- Ex post real interest rate: $R_{t+1}^{post} = i_t - \pi_{t+1}$
  - What real interest rate turned out to be between times t and $t+1$

Tricky Notation

$$R_t = i_t - E_t \pi_{t+1}$$

- i_t and R_t denote the nominal and ex ante real interest rates from time t and $t + 1$
- π_{t+1} denotes inflation between time t and $t + 1$
- Notice the difference in time subscripts!!!
- Time subscripts correspond to when variable is known

Expectations Formation

- How do people form expectations?
- **Assumption (Adaptive expectations):**
  Assume that people look at the past to form expectation:
  $$E_t \pi_{t+1} = \pi_t$$
- Alternative: Rational Expectations
  - People form “model consistent” expectations
  - Use all information available correctly
  - Make no systematic mistakes

Real Interest Rate

- Ex ante real interest rate

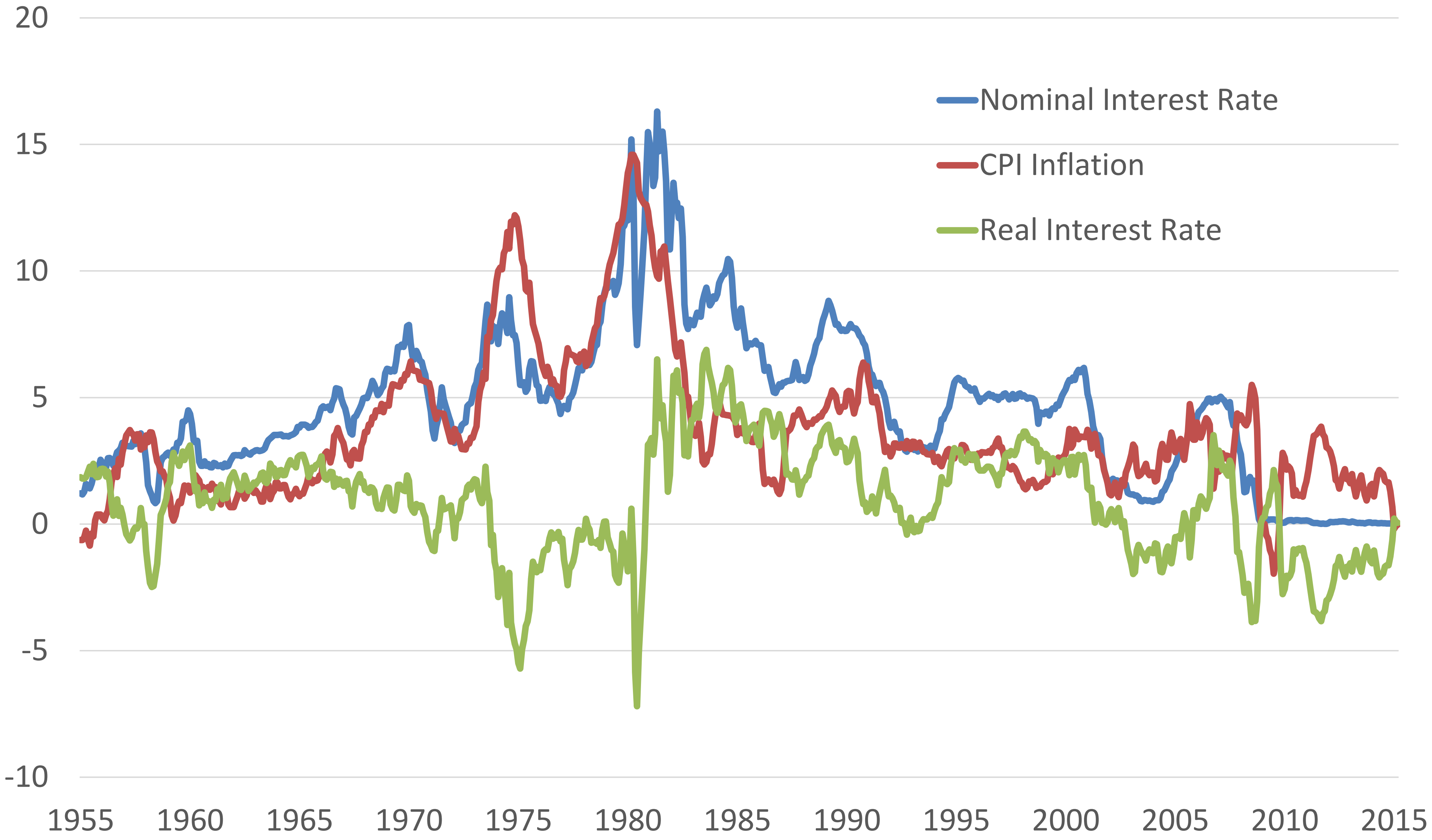
$$R_t = i_t - E_t\pi_{t+1}$$

- With adaptive expectations, this becomes

$$R_t = i_t - \pi_t$$

Real versus Nominal

- The difference between real and nominal is a crucial aspect of being reasonably informed about macro events
- Common to see people confused about this:
  - E.g.: “Interest rates have trended down for thirty years.
    Why hasn’t investment surged?”
  - Or: “We earned much higher returns in the 1970’s than now”


20
15
10
5
0
-5
-10
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Nominal Interest Rate
CPI Inflation
Real Interest Rate

Modernizing Money Demand

- In Medieval economy:
  - Gold coins only available asset
  - People had desired level “real money balances”:

$$M_t^d \bar{V} = P_t Y_t$$

- 19th and early 20th century:
  - Paper money and deposits become an important component of money supply

$$M = \frac{C/D + 1}{C/D + R/D} M_b = B_m M_b$$

Modernizing Money Demand

- People have access to other stores of value than money
- Face a trade-off between holding money and other stores of value such as real estate, stocks, bond, etc.
- What is the nature of this trade-off?
  - What are the benefits of holding money relative to other assets?
  - What are the costs of holding money relative to other assets?

Modernizing Money Demand

- Benefits of holding money:
  - Money is more "liquid"
  - I.e., more convenient for making payments
- Cost of holding money:
  - Money does not pay interest (or pays less interest)
  - Stocks, bonds, real estate have higher average returns than checking accounts

Modernizing Money Demand

- Consider the trade-off between bonds and money
- The nominal interest rate is the opportunity cost of holding money
- The higher is the nominal interest rate, the lower is demand for money
- We need to incorporate nominal interest rate into our model of money demand

Modernizing Money Demand

$$\log M_t + \log V_t = \log P_t + \log Y_t$$

- **New assumption:** The velocity of money is an increasing function of the nominal interest rate
$$\log V_t = \phi i_t - v_t$$
- Equivalently: money demand a decreasing function of the nominal interest rates
- Here v_t is a “money demand shock”, i.e., other factors that affect velocity (e.g., financial innovation (ATMs, credit cards))

Modern Money Demand

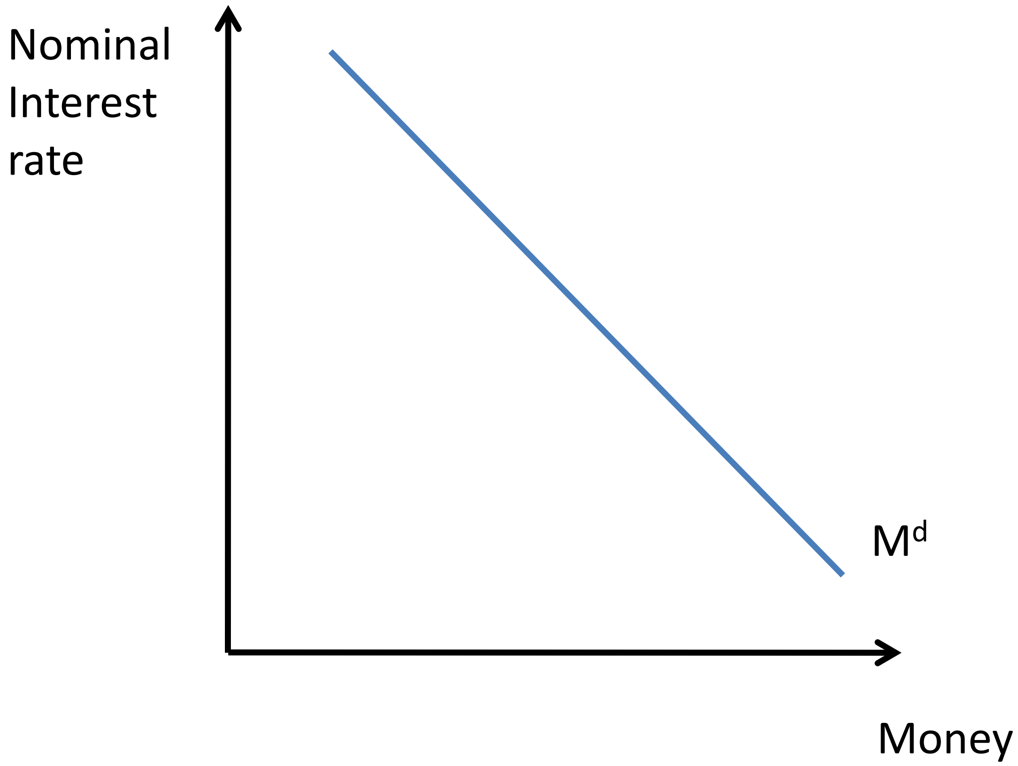
- This implies that money demand becomes:

$$\log M_t + \log V_t = \log P_t + \log Y_t$$

$$\log M_t + \phi i_t - v_t = \log P_t + \log Y_t$$

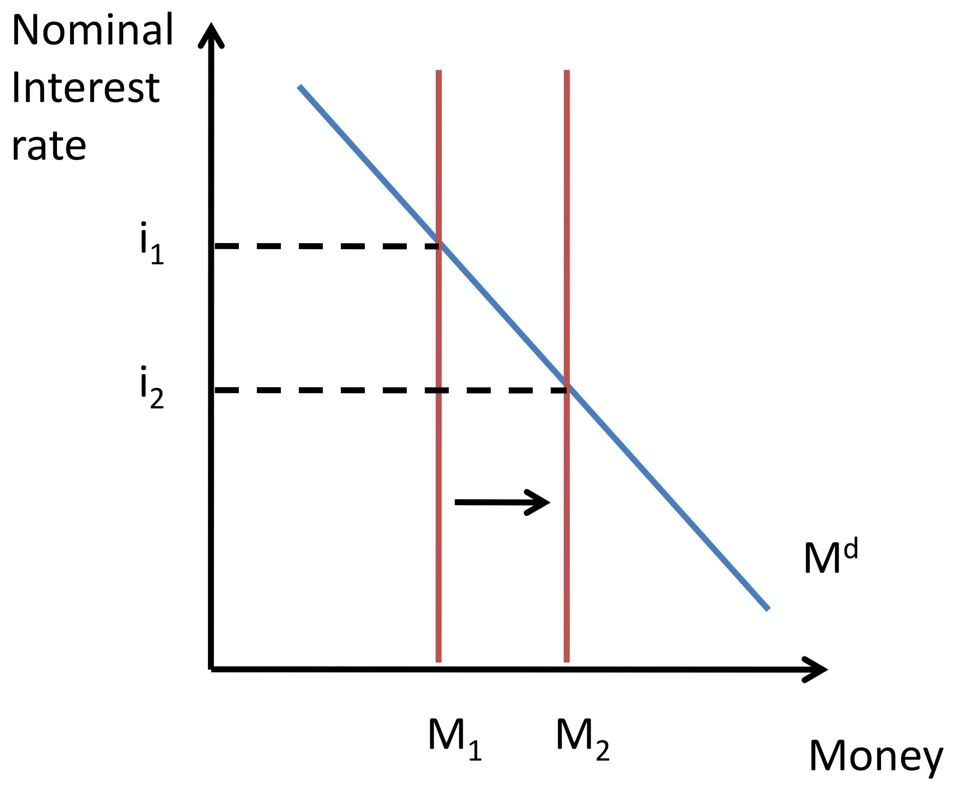
$$\log M_t - \log P_t = -\phi i_t + \log Y_t + v_t$$

- Downward-sloping function of nominal interest rates



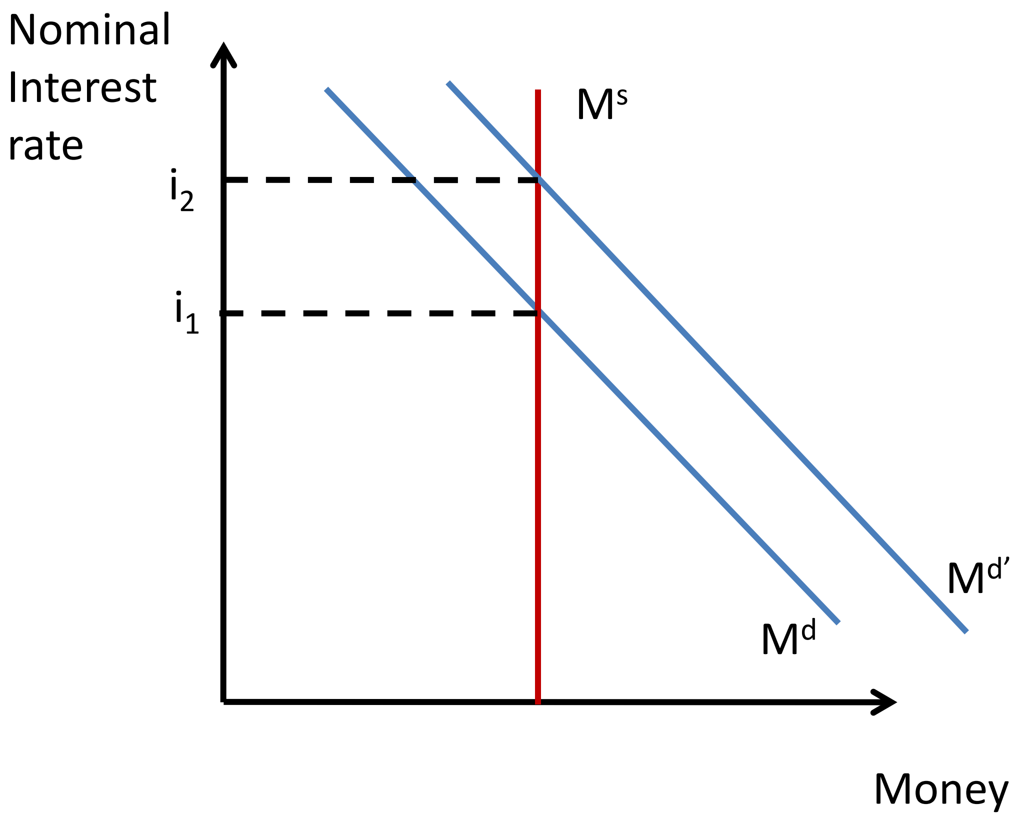
Money Supply

- Modern economy: Central bank can vary the money supply at will
- In particular: Central Bank can set money supply at each point in time to achieve any interest rate it desires
- Central bank can effectively control the nominal interest rate by varying money supply



Money Demand Shocks

- Money demand shocks shift the money demand curve
- Unless central bank offsets this, will affect interest rate
- In 19th century, interest rates would rise during harvest time due to increase in money demand
- No central bank to offset
- Money supply not "elastic"



Money Market Equilibrium

- We can now write money market equilibrium equation in terms of real interest rate by combining:

$$\log M_t - \log P_t = -\phi i_t + \log Y_t + v_t$$

$$R_t = i_t - \pi_t$$

- This yields:

$$\log M_t - \log P_t = -\phi(R_t + \pi_t) + \log Y_t + v_t$$

- Rearranging yields:

$$R_t \; = \phi^{-1} \log Y_t - \pi_t + \phi^{-1}(v_t - \log M_t + \log P_t)$$

LM Curve

$$R_t = \phi^{-1} \log Y_t - \pi_t + \phi^{-1}(v_t - \log M_t + \log P_t)$$

- We can plot this equation in (Y_t, R_t) space
- This curve is called the LM curve
- Notice that changes to both money demand (v_t) and money supply $(\log M_t)$ shift the LM curve