Monetary Economics and the Macroeconomy

Topic 1: Stylized Facts

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Inflation and Money Growth

- The functions of money
- Money and inflation
- Empirical evidence: Long-run relationships
- The Money Market in the long-run
- Long-run effects of money growth
- Short-run effects of money growth

Introduction

Reading:

- Romer (4th ed.) chapter 11.1.
- McCandless and Weber (1995), Federal Reserve Bank of Minneapolis Quarterly Review, Vol. 19, No. 3, pp. 211.

The Functions of Money

- The field of monetary economics investigates the relationship between real and nominal variables at the macro (aggregate) level
- Relationships between money, interest rates, inflation, output.
- We begin by asking what is special about money?
- The special functions that money perform make money special.
- We can identify three functions.

The Functions of Money

1. Medium of exchange, 2. Unit of account, 3. Store of value.

The Functions of Money

Medium of exchange:

- Money is used to pay for goods and services (alternative is barter economy).
- Use of money promotes economic efficiency by minimising time required to trade goods for goods (avoids barter).
- Avoids *double coincidence of wants* of traders
  - Without money, for trade to occur, person A must want what person B has and at the same time B must want what A has
  - With money, person A can sell their good to anyone who wants it and later use that money to buy whatever they want from someone else

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The Functions of Money

Unit of account:

- Money is used to measure value of goods and services in a common unit.
- Also promotes efficiency. How?
- In a barter economy the number of calculations required to exchange goods increases with the number of goods.

The Functions of Money

- Suppose only 3 goods. Then we need to know three prices to enable exchange.
- Move to 4 goods. Need 6 prices because there are six pairs of goods to compare.
- With the number of goods equal to N we will need to know $\frac{N(N-1)}{2}$ prices in a barter economy (formula that gives the possible pairs with N items).
- So in a supermarket with 10,000 items we will need to know about 500 million relative prices...impossible!
- Money improves efficiency as we only need to know 10.000 prices.

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Store of value:

- transfer purchasing power over time.
- Timing of income and expenditure differs. We normally do not spend income at the time we receive it.

Money not unique as a store of value: any asset might perform this function (durable household goods, art, jewelry, financial assets).

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Money

- Why is money better than these assets?
- Liquidity: speed at which money can be converted into a medium of exchange.
- By its own nature money is the most liquid of all assets since it is the medium of exchange, and other assets usually involve transaction costs to become liquid.

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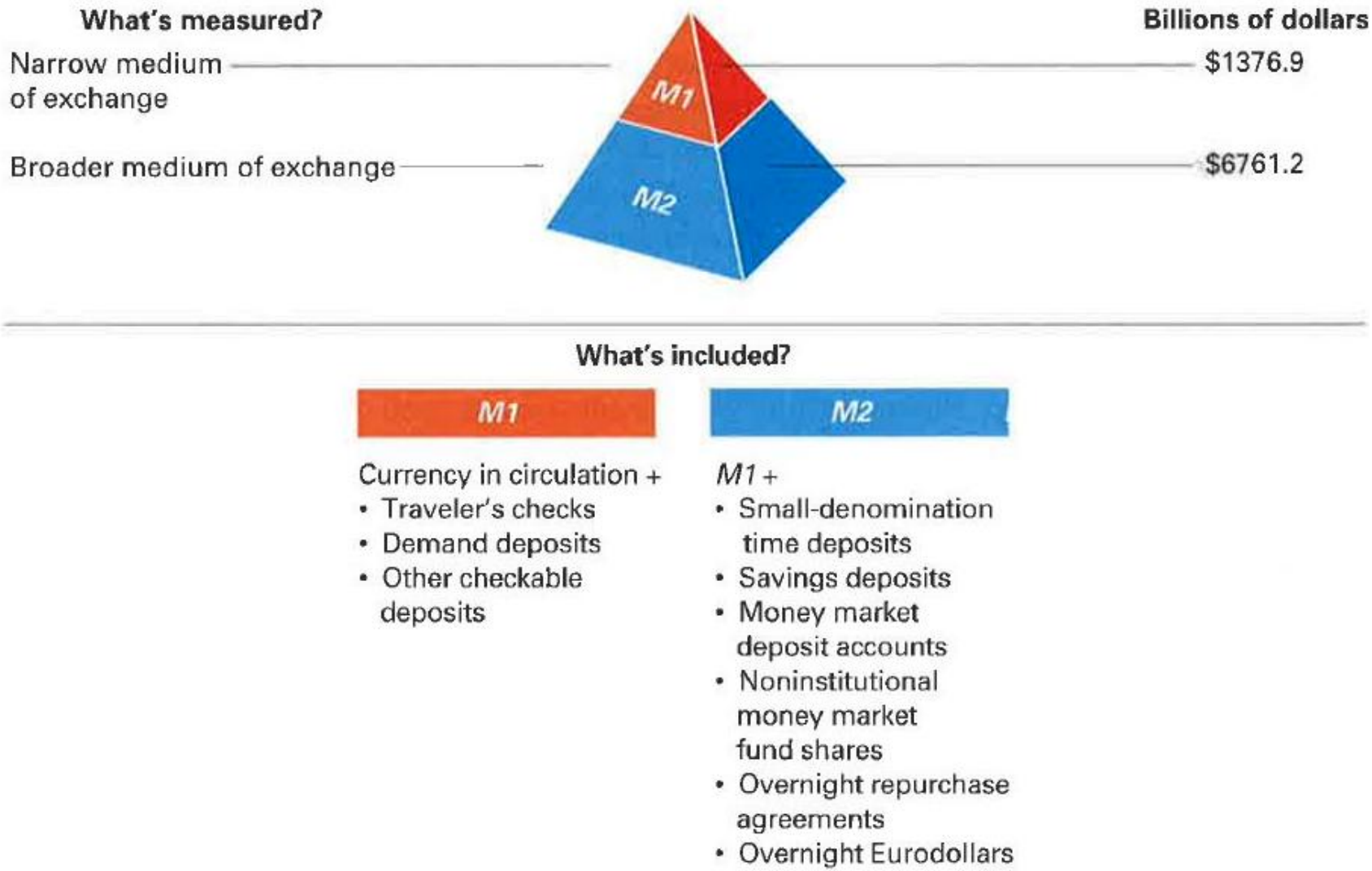
Money

How do we measure money?

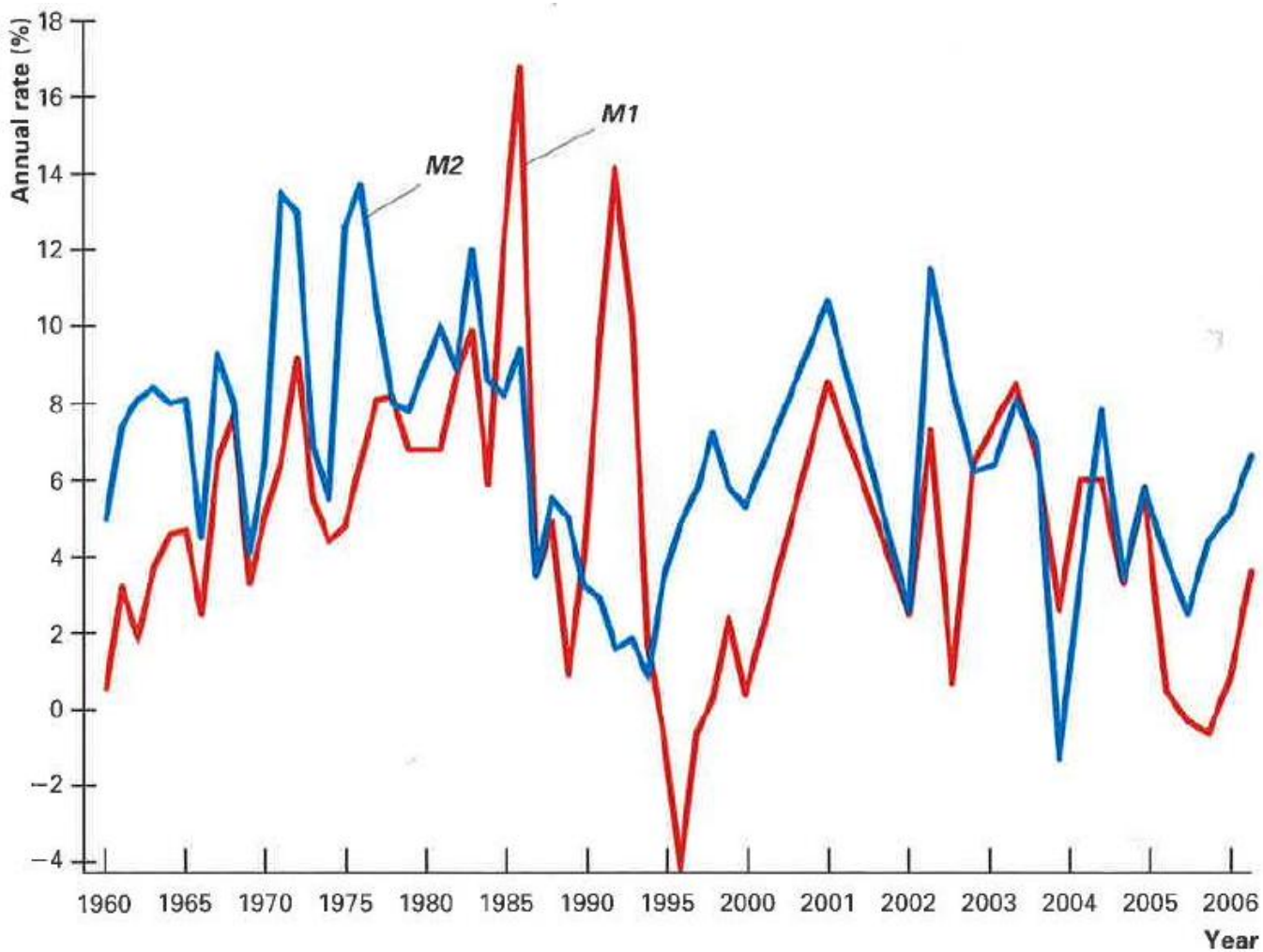
- In the Euro-Area and the UK:
- M1 = currency and overnight deposits.
- $\mathrm{M2} = \mathrm{M1}+$ time deposits (redeemable with a 3 month notice and with a maturity up to 2 years).
- Definitions differ slightly from the ones used in the US.

Figure: Monetary aggregates (US definitions)



Monetary Aggregates: M1 and M2

Growth rates of M1 and M2 in the US. M1 and M2 move together broadly over long periods of time, but their growth rates diverge during some periods.



Money and Inflation

- How is the value of money measured in terms of goods? By the inverse of the price level.
- The usefulness of money as a store of value depends on the price level.
- Suppose that all prices double overnight. Then the value of money is halved because it can only buy half the goods.
- Inflation: Rise in the general level of prices of goods and services in an economy over a period of time.
- Measuring inflation in practice: in the UK we rely on the Consumer Price Index (CPI). The main index used to infer inflation can differ across countries!

Inflation

- Inflation thus erodes the value of money as a way to store purchasing power.
- Costs of inflation:
  - When inflation increases people cut down on money balances, hence they visit the bank more often (shoe leather costs)
  - Firms need to alter price lists, slot machines and menus (menu costs)
  - Inflation redistributes wealth from
  - lenders to borrowers (inflation erodes debt)
  - the elderly to the young (pensions are typically fixed incomes that decline with inflation).
  - the private to the public sector (tax brackets do not keep up with inflation)
- Further hidden costs of inflation:
  - When inflation is not anticipated, firms find it harder to plan investment and this reduces economic growth.
  - People mistakenly negotiate on the basis of nominal variables known as money illusion.

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Inflation

- Hyperinflation (or extreme inflation) in Austria, Germany, Poland, Hungary after WWI with inflation rates at around $1,000\%$ a month meant that the quantity of money needed to purchase basic items became excessive and money eventually worthless $\Rightarrow$ barter economy.
- When inflation gets above about 50 per cent per month it is regarded as hyper-inflation
- To meet the reparation payments to the allies after WWI Germany printed money.
- The following slides illustrate the German hyperinflation 1922-1923.

1921

- 1 Mark - Would buy 1/2 Dozen Eggs or a pound of flour. Bread is 1.20 Mark a loaf.
- No hyperinflation as yet, but the 1 Mark note, called a "State Loan Currency Note", was not backed by reserves or hard assets and was therefore a convenient source of revenue for the government.

Early 1922

- 10,000 Mark which would buy over 250 Pounds of Meat. Bread is 3.50 Mark a loaf.
- Although the highest denomination of circulating currency ever issued by the German government, it would soon become small change.

May 1923

- 500,000 Mark which would buy about 40 pounds of meat. Bread is 1200 Mark a loaf.
- French and Belgian forces take over the industrial Ruhr valley, people start to carry large stacks of notes because money is losing value.

July 1923

- 10 Million Marks buys 12 Pounds of Meat. Bread is 100,000 Mark a loaf.
- In order to save printing cost and produce the currency faster, the note was printed on only one side.

October 1923

- 1 Billion Marks buys 3/4 pound of Meat. Bread costs 670 Million Mark per loaf.
- German National Railroad, firms and towns had already begun to issue their own currency as the government was unable to print money fast enough. The Government printed larger notes. Prices rise by the hour.

November 1923

- 100 Billion Marks would buy 3 pounds of meat. Bread is 3 billion Mark a loaf rising to 80 billion by 15 November.
- Notes are now practically worthless and riots occur due to inflation. Citizens attempt to hold wealth in real assets e.g. land, gold etc.

End of the Hyperinflation

- On November 15 a new currency, the *Rentenmark* was introduced, backed by everything real that the government owned.
- One new *Rentenmark* was equal to One Trillion Marks.
- Prices stabilized under the new currency, however the wealth of most of the nation's citizens had been destroyed.
- People got used to using coins again!

Notorious Hyperinflations

Country	Dates	Avg. Inflation (% per month)	Real Money (end/start)
Austria	Oct. 1921-Aug. 1922	47.1	0.35
Germany	Aug. 1922-Nov. 1923	322	0.030
Greece	Nov. 1943-Nov. 1944	365	0.007
Hungary	Mar. 1923-Feb. 1924	46.0	0.39
Hungary	Aug. 1945-Jul. 1946	19,800	0.003
Poland	Jan. 1923-Jan. 1924	81.1	0.34
Russia	Dec. 1921-Jan. 1924	57.0	0.27

A Model of the Money Market

- Inflation is an increase in the average price of goods and services in terms of money.
- It is easiest to think of money as high-powered money, i.e. currency and reserves (M1 or M2).
  Thus, to understand inflation we will examine the market for money. Keynes postulated that money demand depends on income and the nominal interest rate:
- Demand for real money balances $L(i, Y)$ depends negatively on the nominal interest rate, i ($L_i < 0$).
  $\hookrightarrow$ High-powered money pays no nominal interest, the opportunity cost of holding it is the nominal interest rate.
- Demand for real money balances $L(i, Y)$ depends positively on real income (output), Y ($L_Y > 0$).
  $\hookrightarrow$ Demand for real balances increases in output as higher output implies a higher volume of transactions.

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A Model of the Money Market

- In equilibrium, money supply equals money demand:

$$\frac{M}{P} = L(i, Y), \quad L_i < 0, \quad L_Y > 0$$

with M is the money stock and P is the price level. Then the price level is given by

$$P = \frac{M}{L(i, Y)} \tag{1}$$

- **Fisher Identity**: The real interest rate is defined as the difference between the nominal interest rate, i, and expected inflation, π^e.

$$r \equiv i - \pi^e \Leftrightarrow i \equiv r + \pi^e. \tag{2}$$

A Model of the Money Market

Combining (1) and the Fisher Identity:

$$P = \frac{M}{L(r + \pi^e, Y)} \tag{3}$$

This indicates that inflation can change due to several reasons. The price level can rise if

- Money supply increases
- Nominal interest rate increases (due to increases in r or π^e)
- Output decreases
- Money demand decreases (for given i and Y)

Empirical Evidence and the Money Market Model

What affects inflation in the long run?

- Expected inflation (π^e) reflects inflation itself
- Variation in the real interest rate is limited and persistent changes unlikely
- Long term decreases in output are unlikely
- Money demand does typically not drop persistently
- Money supply (M) can change in the long run.

In the long run, only money supply can lead to movements in inflation.

Empirical Evidence and the Money Market Model

Money growth is important for determining inflation because

- It affects prices more directly than the other variables in equation (3). Money supply can grow persistently at almost any rate (large negative during deflations, large positive during hyperinflations)
- Empirically money growth has a much higher volatility than the other variables in equation (3)

Empirical Evidence

We now turn to examine some data on money, prices and output.

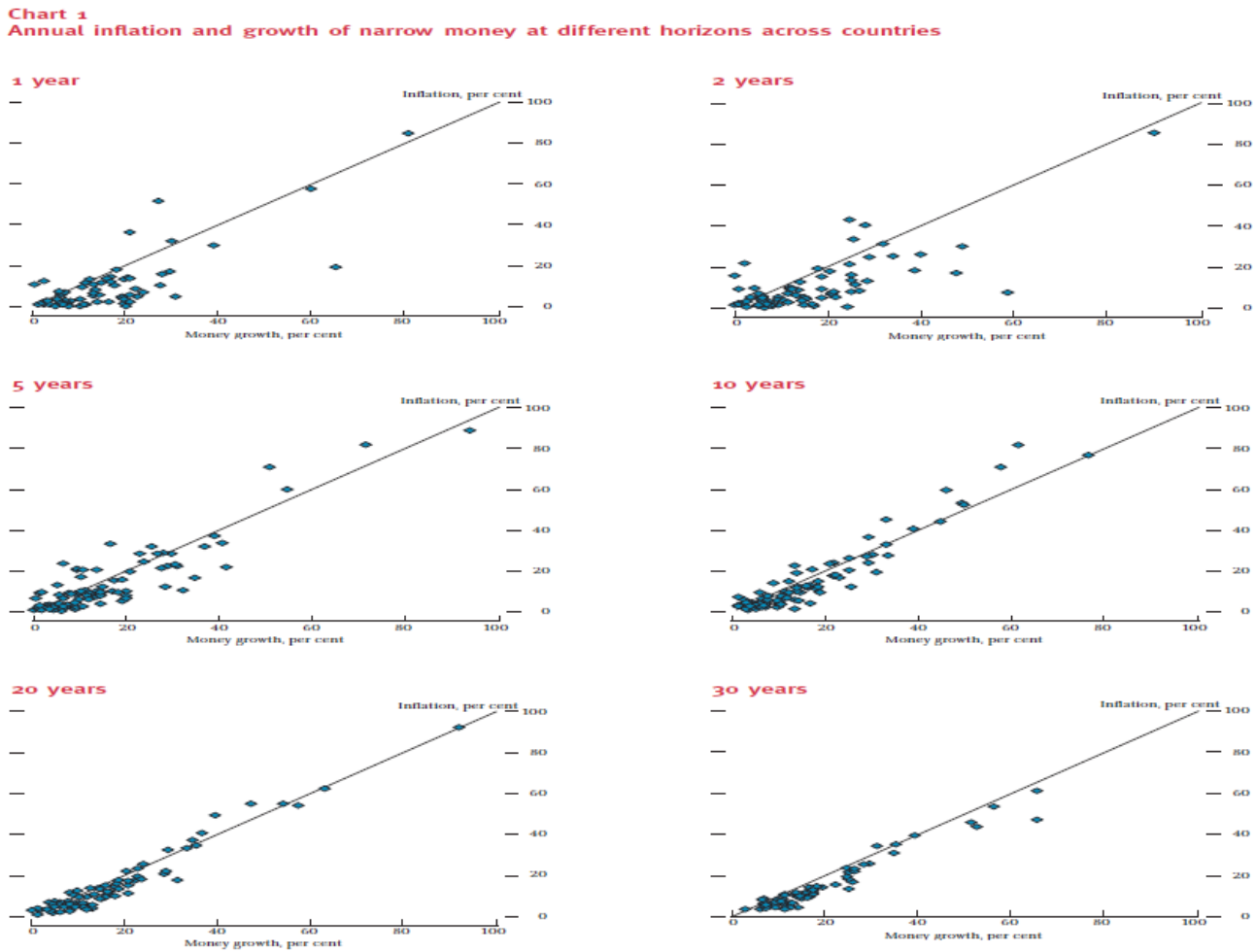
Goal: summary of long-run monetary relationships

McCandless and Weber (1995)

- They examine data covering a 30 year period from 110 countries using various definitions of money.
- Examine average rates of inflation, output growth, and the growth rates of various measures of money.
- By examining these over a long period of time and for many different countries relationships are unlikely to be dependent on unique, country specific events.

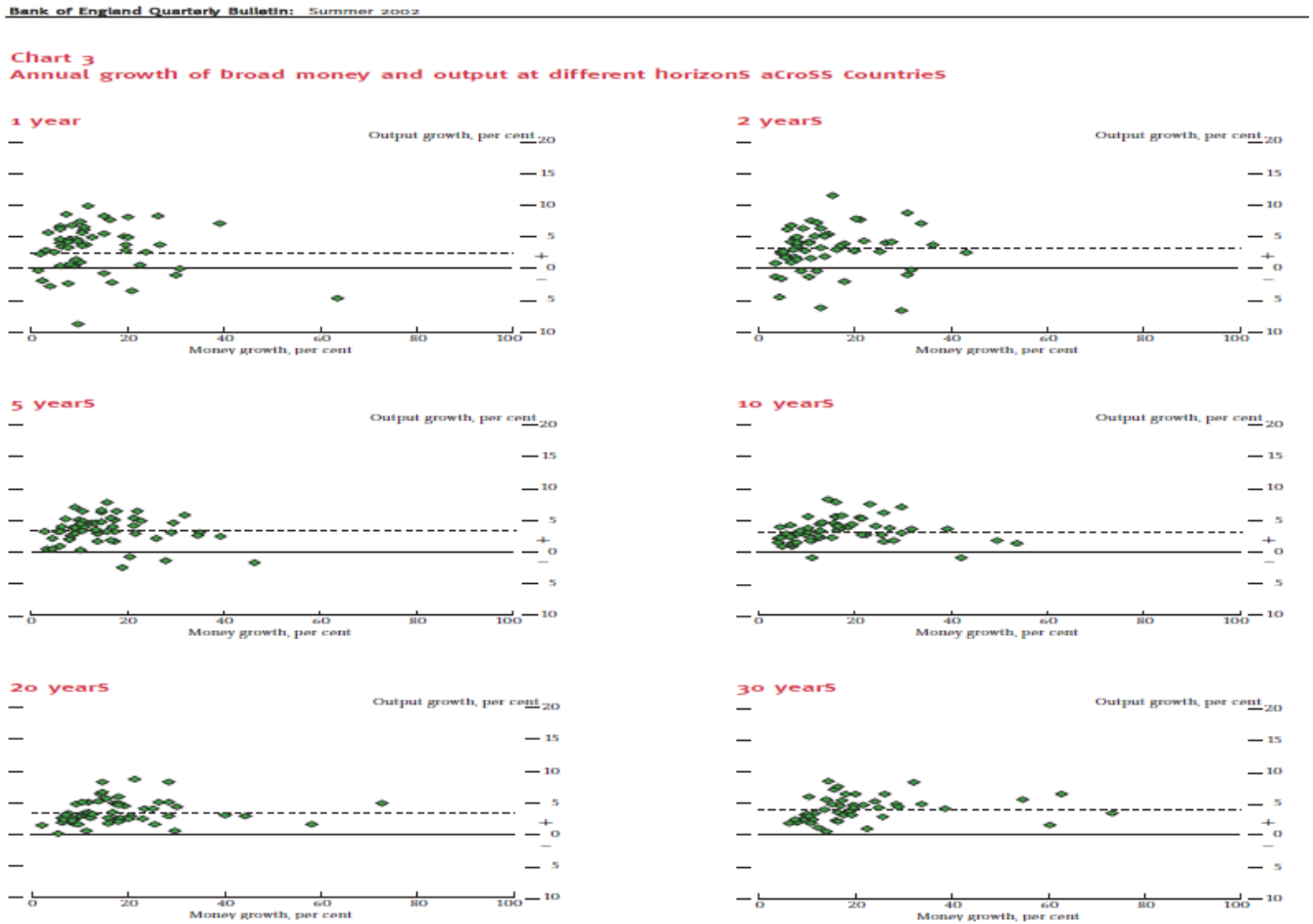
Correlations b/w Money and Inflation

Annual inflation and growth of narrow money at different horizons across countries



Correlations b/w Money and Real Output

Annual growth of money and real output at different horizons across countries



Inflation and Money Growth in the Long-Run

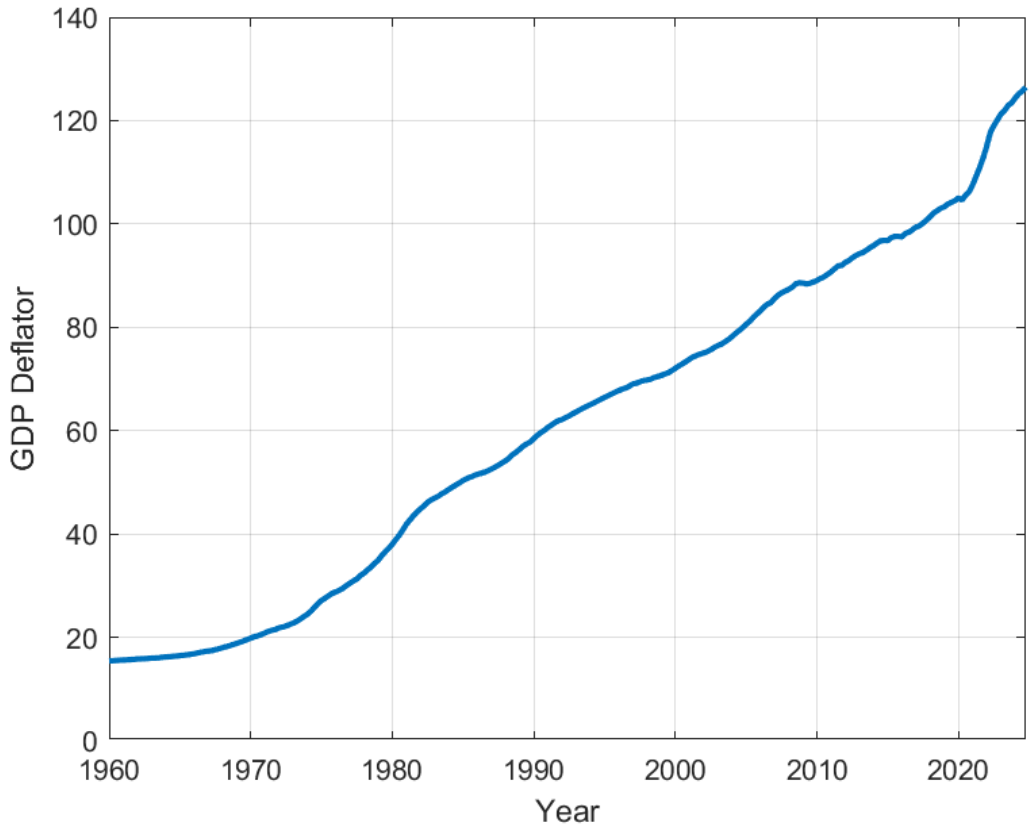
- Note from the charts that the correlation between money growth and inflation is higher the longer the time horizon.
- Countries with faster growth rates of money experience higher inflation.
- Over the 30 -year horizon the correlation between the growth of narrow money and real output growth was -0.09 and between broad money growth and output was -0.08 .

Time Series Evidence for U.S.

- So far we have seen empirical evidence based on cross-country data
- Let's look at evidence on the correlations b/w money growth, inflation and output for the U.S. economy, over a long time horizon (from 1960 to 2024)

GDP Deflator

- GDP Deflator for U.S., time period: 1960-2024
- Quarterly data

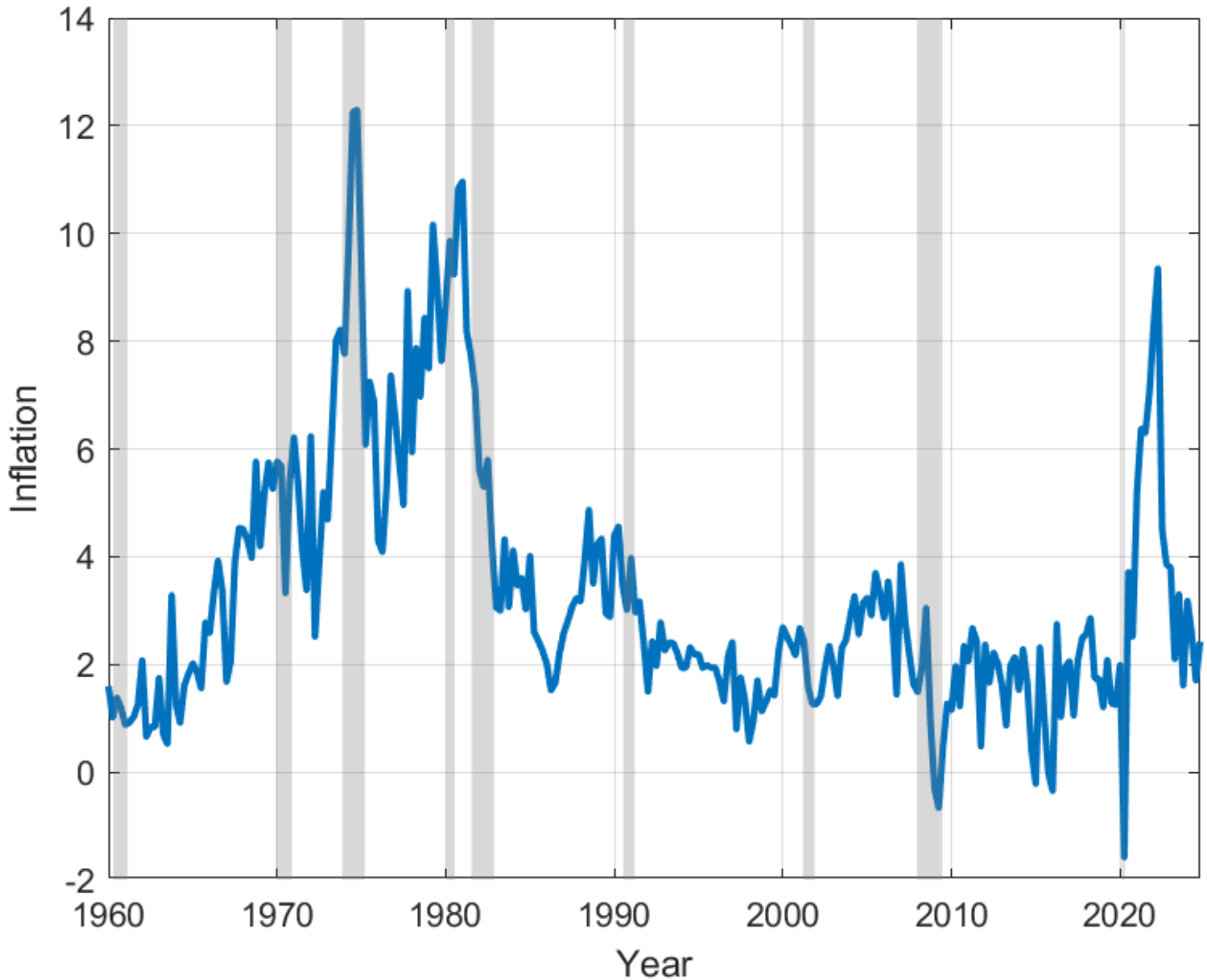


GDP Deflator

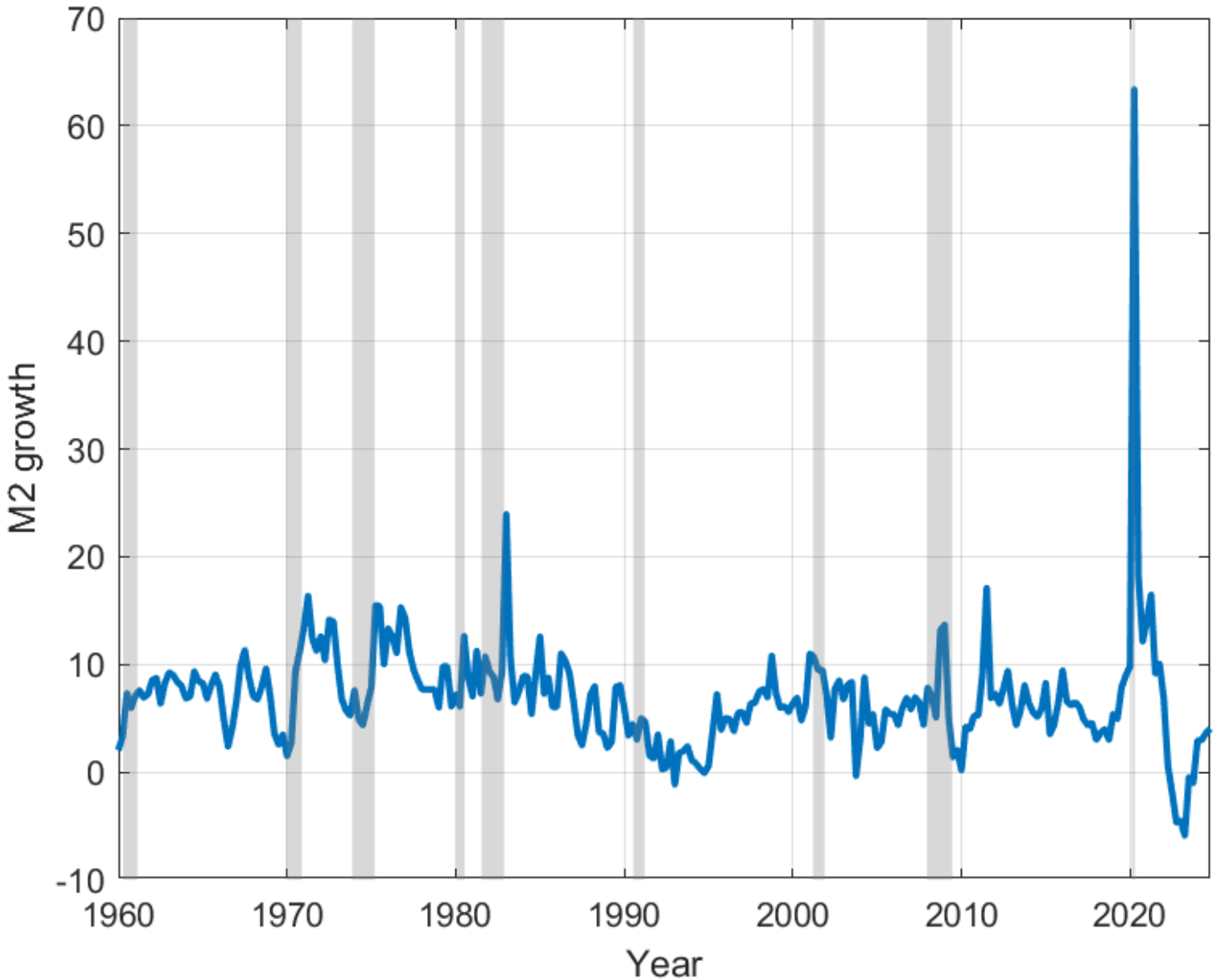
- How do we measure inflation?
- Quarterly growth rate of GDP deflator, annualized

$$\pi_t = \left(\frac{GDPDEF_t}{GDPDEF_{t-1}} \right)^4 - 1$$

Inflation: Growth Rate of Prices

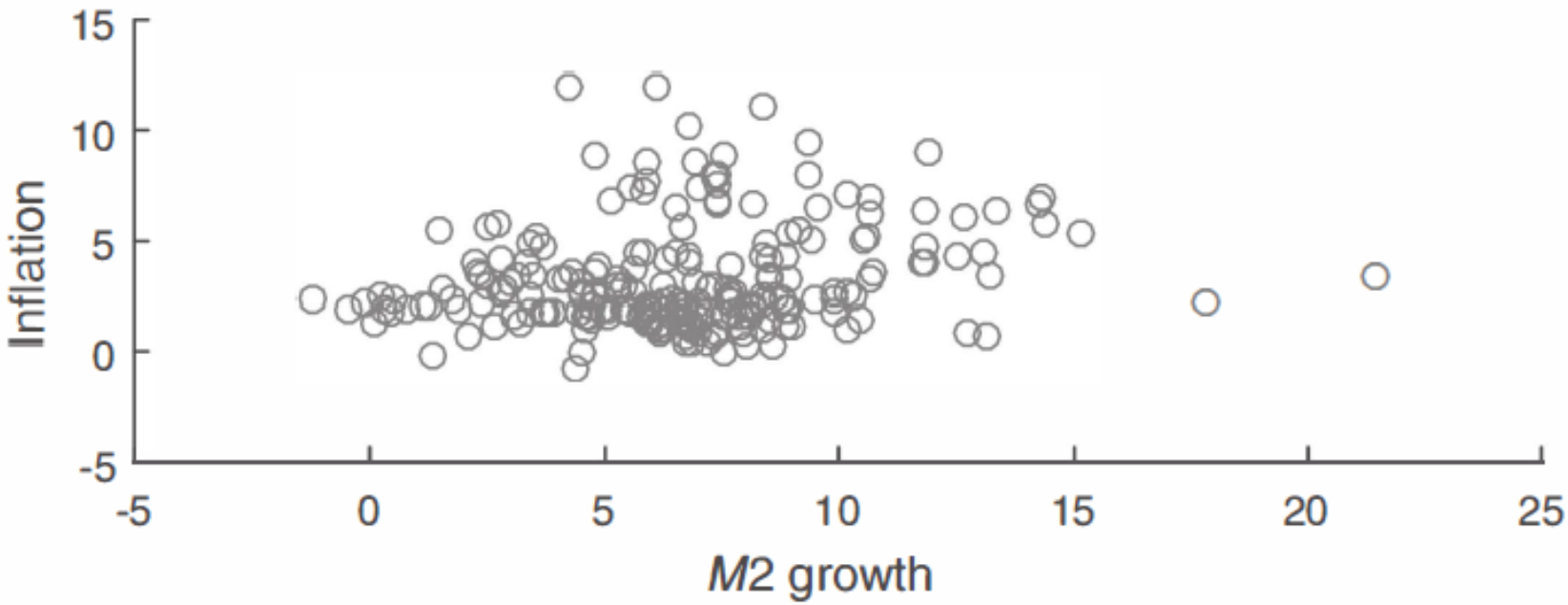


M2 Growth


70
60
50
40
30
20
10
0
-10
M2 growth
1960
1970
1980
1990
2000
2010
2020
Year

M2 Growth and Inflation

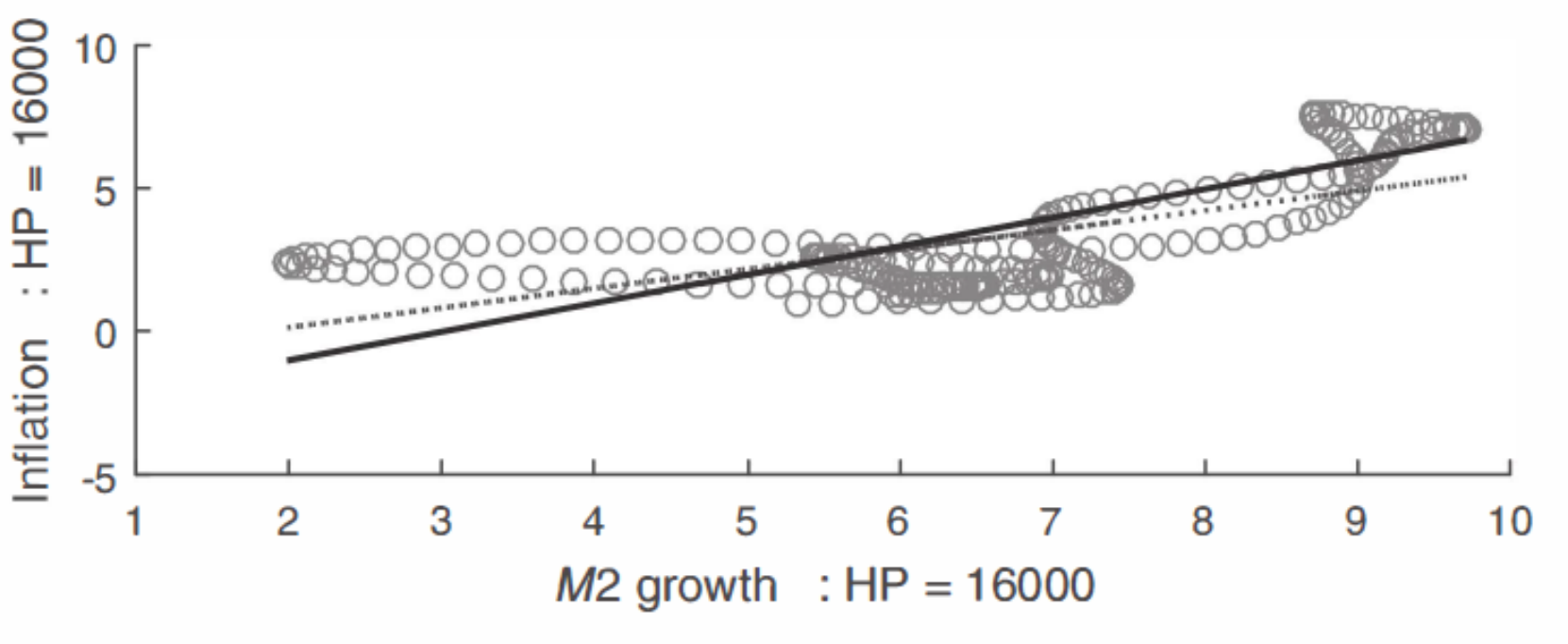
Scatter plot of money growth, measured by the quarterly growth rate of M2 and the quarterly inflation rate, measured by the GDP price deflator (after removing Covid data points)



Weak relationship b/w money growth and inflation; the contemporaneous correlation between the two is 0.21

M2 Growth

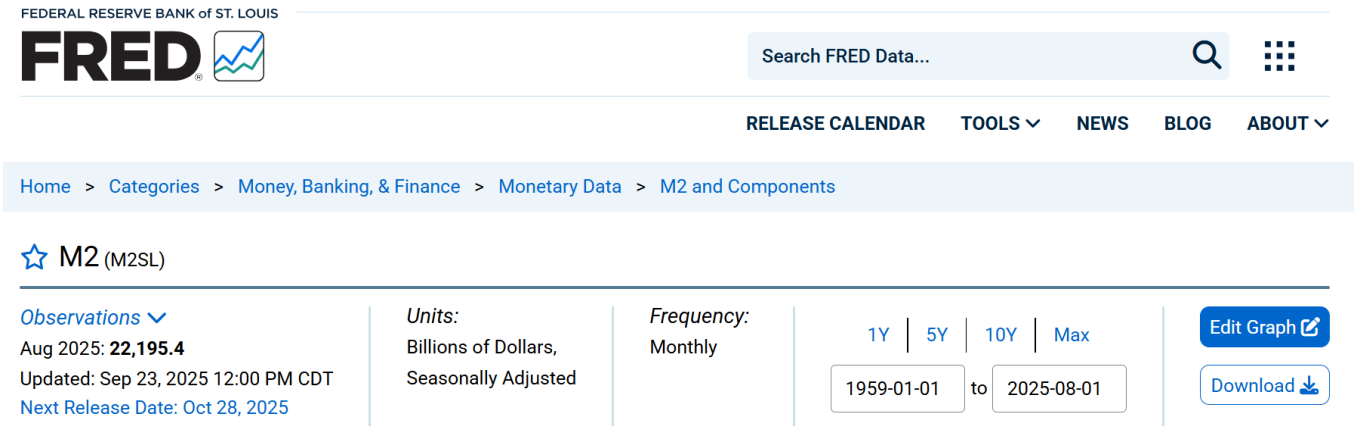
Remove short-run fluctuations using the HP-filter. Solid line: 45 degree line, Dotted line: fitted regression line.



Very positive relationship for the filtered data! The contemporaneous correlation is 0.66

Replication Exercise

- Try to reproduce the previous figures on your own
- Download data on GDP price deflator and M2 from FRED database



- Can automatize the downloading process with the Matlab function `getFredData.m` written by R.Kirkby, available here

Example Matlab Code

```
clear,clc,close all

frequency = 'q';
StartDate='1960-01-01';
EndDate='2024-12-31';

% Inflation
aux = getFredData('GDPDEF', StartDate, EndDate, 'pca',
     frequency);
inflation = aux.Data;

% M2 growth rate
aux = getFredData('M2SL', StartDate, EndDate, 'pca',
    frequency);
M2_growth = aux.Data;

figure
scatter(M2_growth,inflation)
```

Inflation and Money Growth in the Long-Run

Two robust conclusions:

(i) correlation between inflation and the growth rate of money supply is nearly one.

(ii) there is no evidence of a long run correlation between either inflation or money growth and the growth rate of real output.

Conclusion (i) is taken as support of the **Quantity Theory of Money**: A change in the growth rate of money seems to induce in the long run an approximately equal change in the inflation rate and hence in the price level.

Digression: Quantity Theory of Money

- One of the oldest monetary theories
  - Developed originally by prominent thinkers and economists including John Locke, David Hume, and Alfred Marshall
  - Restated by Milton Friedman in the 1950s, becoming a cornerstone of monetarist doctrine

$$\underbrace{M_t \times V_t}_{\text{money} \times \text{velocity}} = \underbrace{P_t \times Y_t}_{\text{nominal output}} \qquad \text{(QTM)}$$

- This is uncontroversial: an accounting identity that defines V_t as the ratio of nominal GDP to the money supply. Not very useful!
- If the velocity of money V_t is constant, the key question is whether **changes in money** translate fully into **changes in prices**, or whether they also affect real output Y_t.

Quantity Theory of Money

- Monetary policy shock: $\Delta m_t = \log M_t - \log M_{t-1}$

$$M_t V = P_t Y_t \quad \Rightarrow \quad \Delta m_t = \Delta p_t + \Delta y_t$$

- Effect on output Y_t depends on what happens to aggregate price P_t
  - if prices are flexible, P_t adjusts immediately, no real effect on Y_t
  - if prices are sticky, P_t adjusts sluggishly, real effect on Y_t
- Empirical evidence:
  - Long-run relationships b/w inflation, money growth, interest rates and real output
  - Short-run analysis: Are monetary shocks important for business cycles?

Inflation and Money Growth in the Long-Run

However caution needed in interpreting the correlations in (i).

- The high correlation between inflation and money growth does not necessarily imply causation from money to inflation.
- An alternative interpretation is that other factors generate inflation and central banks allow the growth rate of money to adjust.
- However, most economists believe that there is a causal relation between inflation and the growth rate of money. Thus Friedman's (1963) famous quote about inflation: "Inflation is always and everywhere a monetary phenomenon"

Inflation and Money Growth in the Long-Run

Does (ii) mean that money does not matter for the real economy in the long-run?

- Some economists argue that it does not: regressions of inflation or output growth on monetary growth usually prove insignificant or unstable.
- These are however reduced-form equations that are difficult to interpret.
  $\Rightarrow$ Conclusions about the impact of money on the real economy in the long-run are highly dubious.

Neutrality of Money

- Recall the empirical evidence: Almost zero correlation of output and inflation.
- Important assumption of our analysis is that money supply does not affect real output and the real interest rate.

This is based on an important concept in monetary economics called the neutrality of money.

- According to this, a change in the quantity of money results in a proportional change in the general level of prices.
- Relative prices and real economic variables remain un-affected by this change

$\Rightarrow$ The quantity of money simply determines the price level

Given the neutrality of money, why should we study monetary economics?

Neutrality of Money

- In other words, does it make a difference if and how money is controlled in the economy?
- Money is just a "veil" over the real sector.
- This proposition is also known as the **classical dichotomy** (Modigliani, Patinkin).
- It dictates that real variables are determined independently of the money supply process.

Short-Run Effects of Money Growth

- However, carefully examining the data from several countries and time periods reveals that money and monetary policy has real effects - at least in the short run.
- The data clearly indicate there are good reasons to study monetary economics.
- Short run changes in money have effects on real output, interest rates, unemployment and inflation.

Short-run Non-Neutrality: Estimating the Effects of Monetary Policy

- What happens when the central bank raises interest rates and/or contracts money supply?
- Raising interest rates is also called tightening monetary policy.
- The aim of tightening monetary policy is to decrease inflation and "cool" the economy.
- So raising interest rates decreases inflation and decreases output.
- Does it? What is the evidence?

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Short-run Non-Neutrality: Estimating the Effects of Monetary Policy

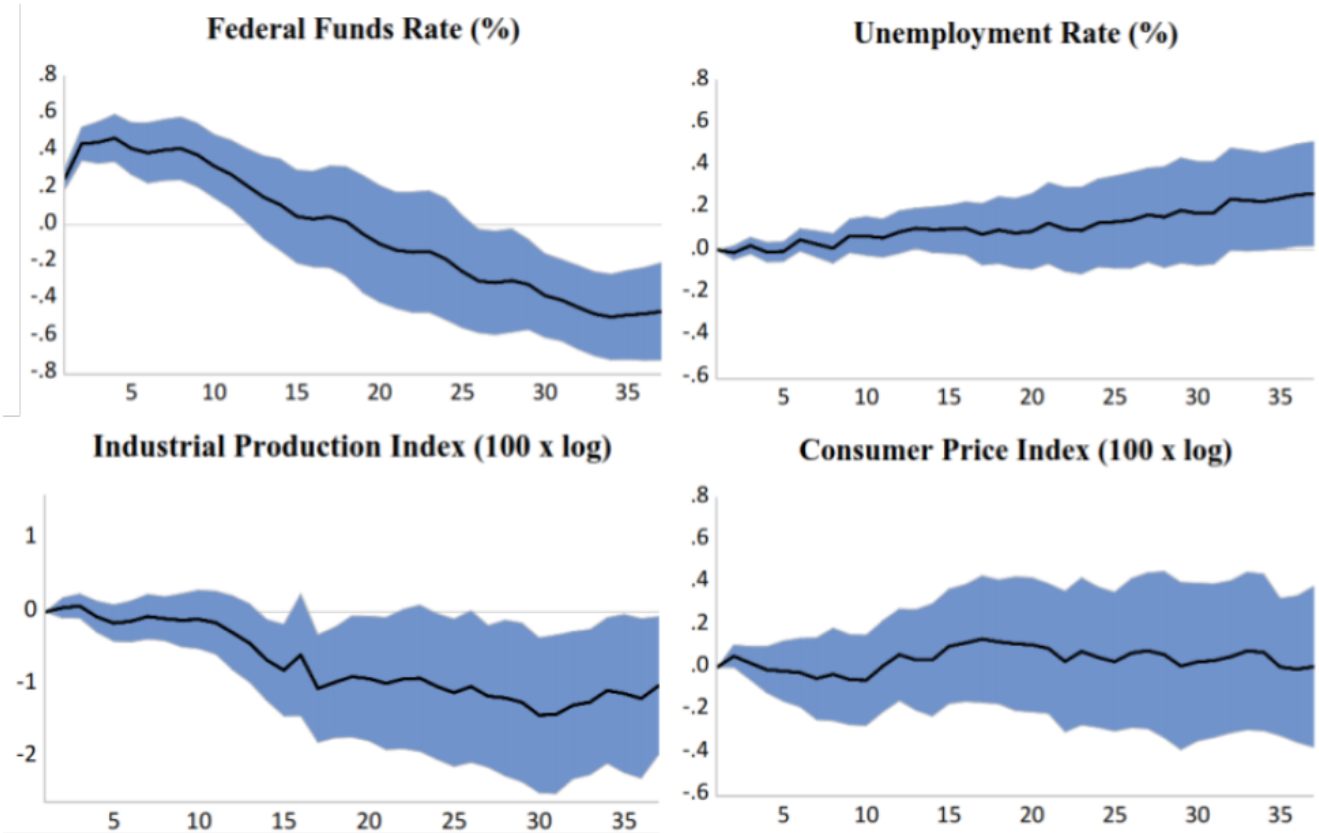
- We want to measure how the economy reacts to an interest rate rise.
- The most common approach is to look at impulse response functions to an interest rate rise.
- These summarize how output, employment, and inflation react following an interest rate rise.
- Two-steps to doing this:
  1. Measure 'monetary policy shocks'.
  2. Estimate the impulse response functions using local projection

  (Other method: SVARS.)

Short-run Non-Neutrality: Estimating the Effects of Monetary Policy

- Current approaches to measure 'monetary policy shocks': high-frequency, narrative (natural language processing)
- E.g., high-frequency: the change in the market interest rate of 3-month Treasury bills on the within two-hours before and after a monetary policy announcement.
- Note: We cannot use the actual monetary policy announcement of the change in the policy interest rate because it is likely at least partially expected (so not a shock).
- Use local-projection to estimate impulse response functions.

IRFS to a monetary tightening (positive shock to Fed Funds Rate)



Notes: Monthly US data from 1982 to 2016. Federal Funds Rate is the interest rate set by the US Federal Reserve. Industrial Production is used as is roughly GDP, but is available monthly while GDP is only quarterly. (Arouba & Dreschel, Identifying Monetary Policy Shocks: A Natural Language Approach).

Short-run Non-Neutrality: Estimating the Effects of Monetary Policy

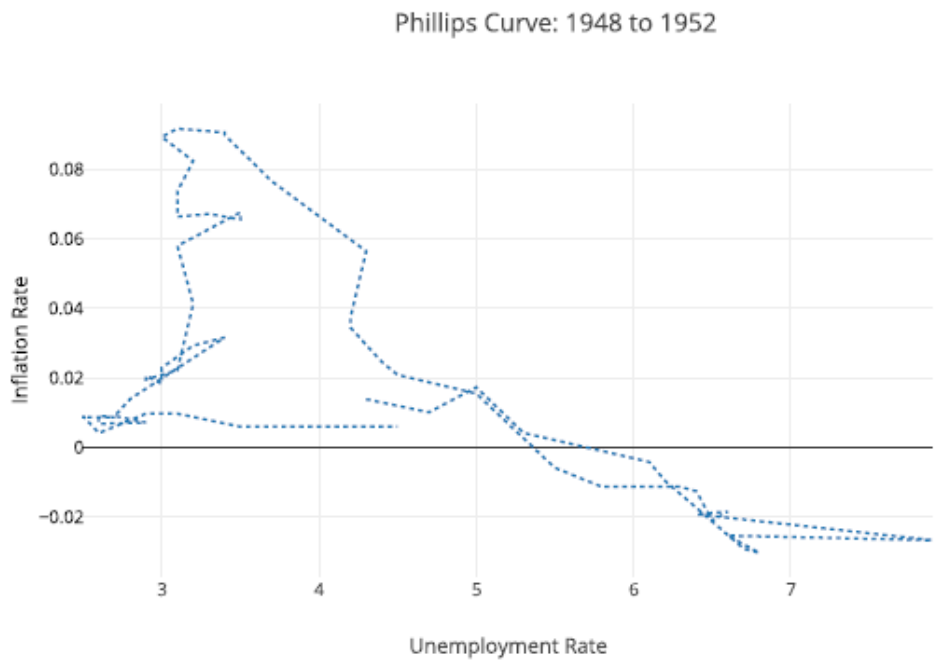
- So the evidence seems generally supportive of the standard view:
- When the central bank increases the interest rate...
- ...output and employment are decreased...
- ...inflation is decreased...
- ...and all of these reactions happen with some lag, last some time.

Short-run Non-Neutrality: Estimating the Effects of Monetary Policy

- Obviously the particular identification scheme used for graph I showed was rather arbitrary.
- Much work has been done with other specifications, identification schemes, etc.
- These general lessons - tightening monetary policy decreases output, employment, and inflation, with lags - seem pretty robust.

The (Old) Phillips Curve

- The Phillips curve plots inflation (vertical axis) against unemployment (horizontal axis)
- It shows a negative correlation between inflation and unemployment



Monthly US data on CPI inflation and Unemployment rate for the period 1948 to 1952.

Misuse of the Phillips Curve

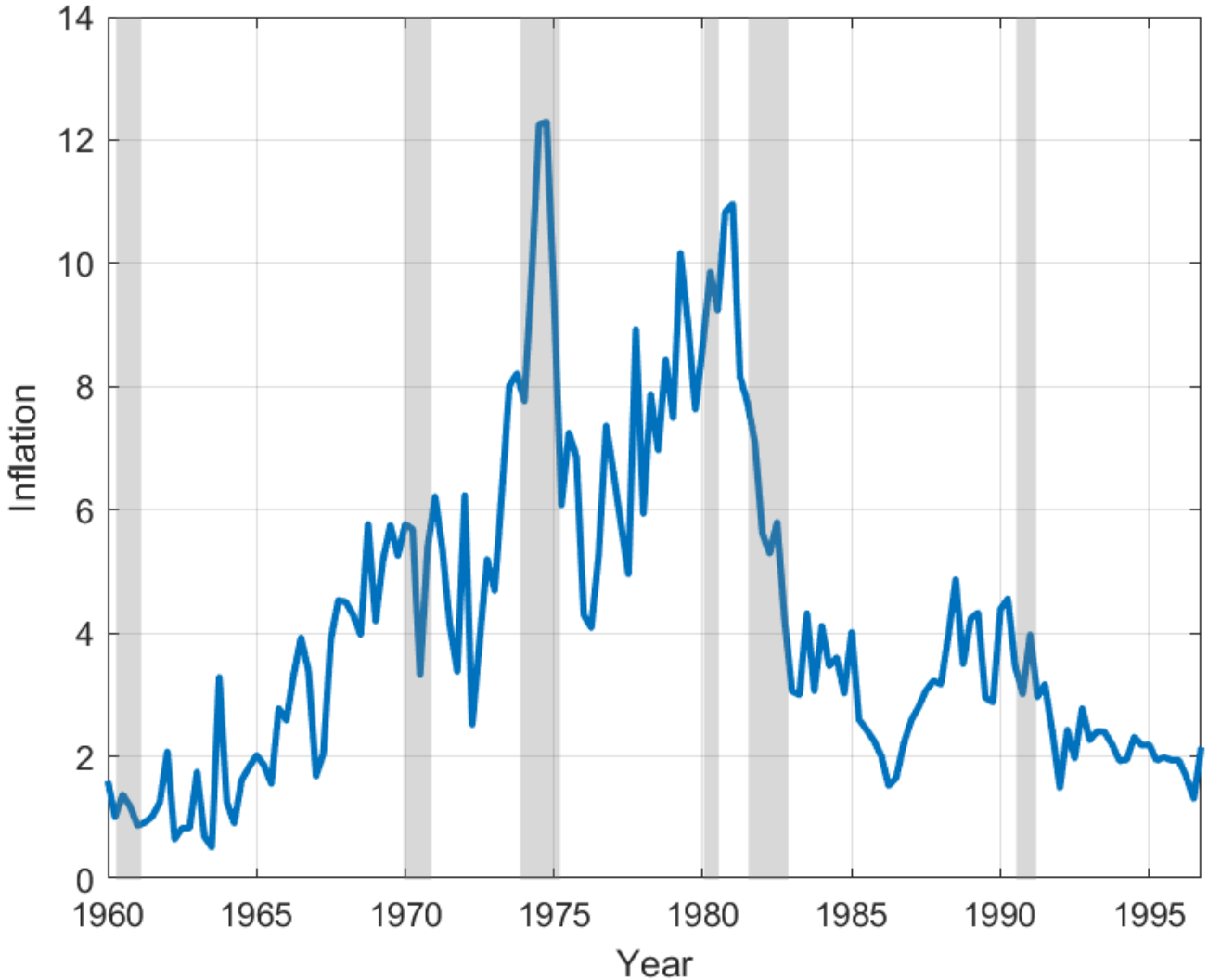
- People interpreted the Phillips curve as a structural relationship between inflation and unemployment, eg.

$$\text{unemployment} - \bar{u} = -\phi(\text{ inflation} - \bar{\pi})$$

- So if we print more money (more inflation) we should get less unemployment. Right?
- This was tried in the US (and many other countries) in the 1960s and 70s...

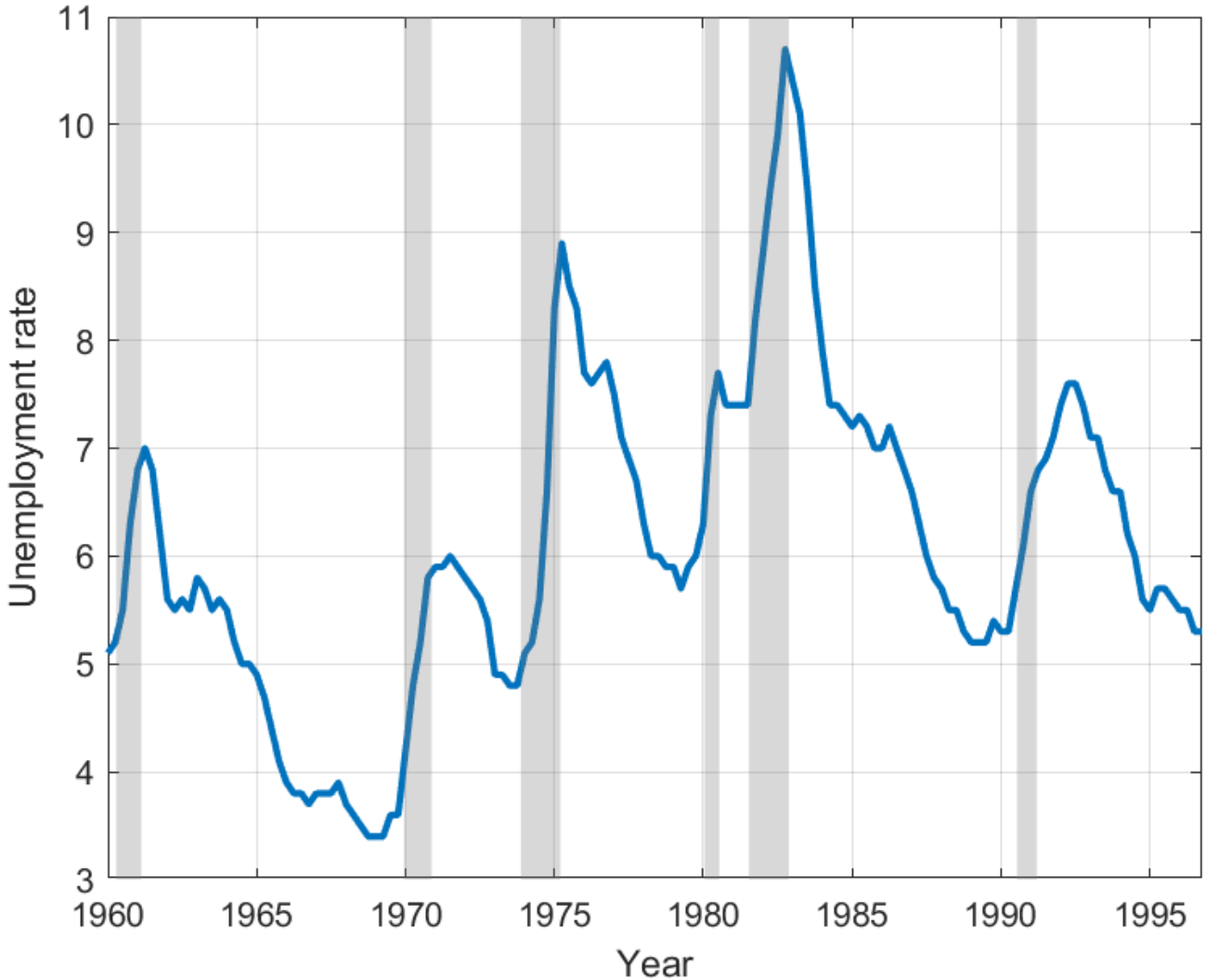
Misuse of the Phillips Curve

- ...the result was the great inflation...



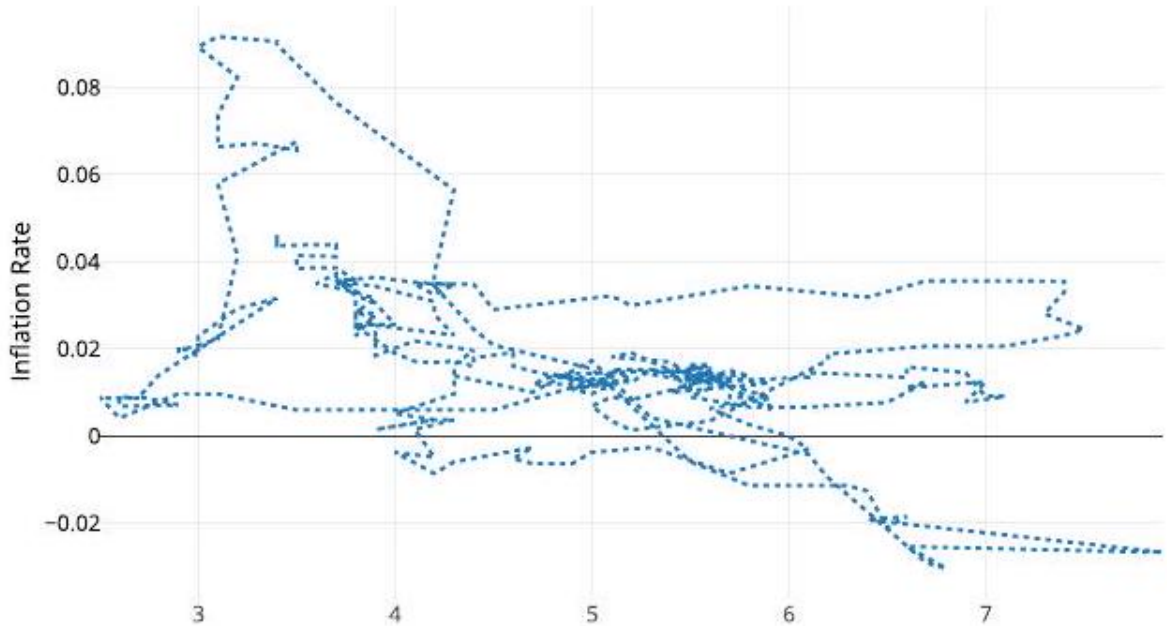
Misuse of the Phillips Curve

- ...and no less unemployment than before...



Phillips Curve: The Outcome

- Not a good outcome!
- In the late 1960s Milton Friedman and Edmund Phelps had both criticized the (old) Phillips Curve on the ground that if one tried to exploit it the relationship would break down.
- This is exactly what happened.



Notes: Monthly US data on CPI inflation and Unemployment rate for the period 1948 to 1967.

Phillips Curve: A Lesson on the importance of Expectations

- Provides a lesson in mistaking correlation for a structural relationship.
- Shows the importance of expectations.
- Expectations change over time.
- So this is something dynamic and stochastic!

New-Keynesian Phillips Curve

- This insight is formalized in a Phillips Curve with expectations.

$$\pi_t = \mathbb{E}_t \left[\pi_{t+1}\right] - \phi \left(u_t - \bar{u}\right)$$

- If $\mathbb{E}_t \left[\pi_{t+1}\right]$ is constant (like $\bar{\pi}$ was), we would get the old (short-run) Phillips Curve.
- But if $\mathbb{E}_t \left[\pi_{t+1}\right]$ moves, this will be like shifting the short-run Phillips Curve up and down.
- Friedman and Phelps can be understood as saying that if you try and permanently stimulate the economy with higher inflation this just increases $\mathbb{E}_t \left[\pi_{t+1}\right]$. The result will be higher inflation, without a corresponding decrease in unemployment.

Summary and Next Class

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  - Countries cannot become richer by printing more money!
- Money has real effects in the short-run: an increase in money supply or a reduction in the nominal interest rate is generally followed by an increase in economic activity
- Philips curve (inverse relatioship between inflation and unemployment) is not "stable", and expectations about future inflation do matter
- Next class: Introduce a micro-founded monetary model and examine implications

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