Identification in macroeconomics

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Some of the main questions in macroeconomics are

1. What causes business cycle fluctuations?
2. How does monetary or fiscal policy influence the economy?
3. Why do some countries grow faster than others?

The answers to these questions are often

1. Unknown
2. Difficult to find

A major complication in finding answers is **identification**

- As in any empirical field

Identification means whether or not the unknown parameter value can be deduced from the observed data

- Consistent estimators may exist under number of assumptions, i.e. central limit theorem etc.

Why do we need an identified model?

- Necessary condition for the existence of consistent estimators
- i.e. when sample size increases, the estimator will converge, probabilistically, to parameters unknown value

For a general definition of identification, let P be the true distribution of observed data X which can be modeled by

$$\mathbf{P} = \{P_\theta : \theta \in \Theta\} \tag{1}$$

Assuming that

$$P \in \mathbf{P} = \{P_\theta : \theta \in \Theta\} \tag{2}$$

or that there is a correctly specified model with parameters $\theta \in \Theta$ such that $P \in \mathbf{P}$. Of course we are interested in θ

Suppose that we know for a fact that

$$P \in \mathbf{P} \tag{3}$$

This means that there is

$$\theta \in \Theta \tag{4}$$

for

$$P_\theta \in \mathbf{P} \tag{5}$$

One problem however is that we cannot distinguish

$$\theta \in \Theta \tag{6}$$

from

$$\theta^* \in \Theta \tag{7}$$

i.e. from our knowledge about P we can only say that

$$\theta \in \Theta_0(P) = \{\theta \in \Theta : P_\theta = P\} \tag{8}$$

Given $\theta \in \Theta_0(P)$, $\Theta_0(P)$ is the identified set

- So θ is identified if $\Theta_0(P)$ is a singleton for all $P \in \mathbf{P}$

$\mathbf{P}$ should be interpreted as a structural model for the distribution of observed data X

Two remaining questions

1. Why bother with a structural model?
2. How can a model be identified?

From P we can calculate all kinds of interesting statistics

- Predictors, conditional probabilities, etc.

Although these statistics provide useful insights about the data, it tells us little about the mechanisms generating the data

- Hence the need for a structural model

In the identified model the structure of the data $\mathbf{P}$ is given by unknown value $\theta \in \Theta$

- A central question is what we can learn from θ, under certain conditions, from observed distribution P

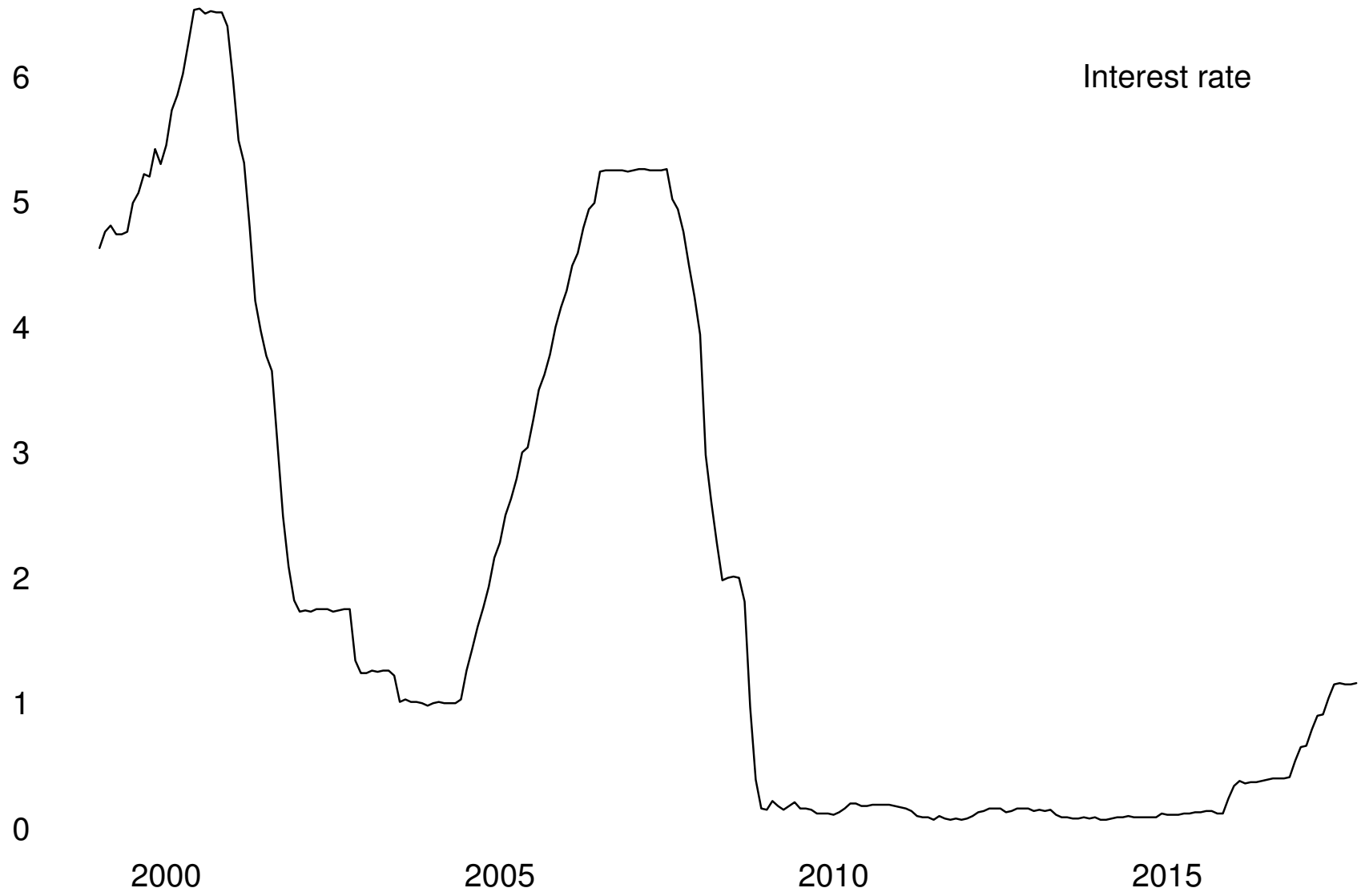
So how can a model be identified? This can be achieved through

1. Through variation
2. Through 'natural experiments'

Let's consider a practical example: FED interest rates

- In 2008 the FED lowered the rates in a reaction to the financial crisis (later Great Recession)
- Lowering interest rates should encourage spending; stimulate economic activity

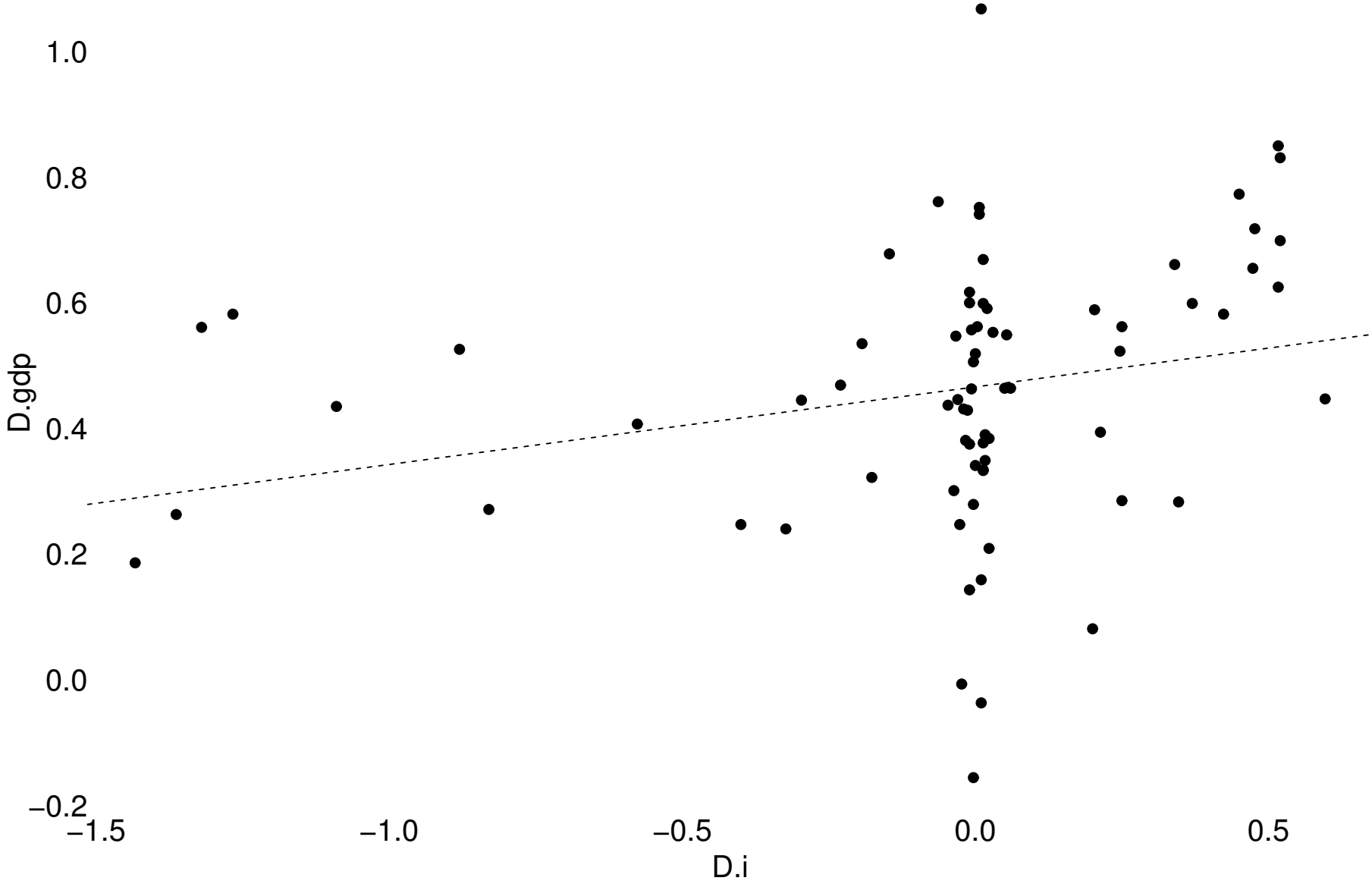
Interest rate change are a source of variation in monetary policy: can be used in a model


Interest rate
6
5
4
3
2
1
0
2000
2005
2010
2015

Estimate effect of interest rate on economic output using following model

$$\Delta GDP_t = \alpha + \beta \Delta i_t + \epsilon_t \tag{9}$$

Fit model to data using OLS; possible estimate $\beta > 0$


1.0
0.8
0.6
0.4
0.2
0.0
−0.2
D.gdp
−1.5
−1.0
−0.5
0.0
0.5
D.i

Based on regression results we could conclude that reduction in interest rate correlates/causes decrease in output

- i.e. lowering the interest rate will harm the economy

Sticking to evidence-based policy, the implication would be to increase the interest rate in order to stimulate economic activity

Naturally the FED does not change interest rates randomly

- They change due to some factor(s) affecting the economy
- Around 2008 think of falling house prices and their effect on bank balance sheets

This means that interest rates are endogenous and that other factors confound the effect of change in monetary policy

- i.e. the regression does not capture the **isolated** effect of the interest rate

Therefore dynamics play an important role in macroeconomic research and this entails two important challenges

1. Difficult to identify exogenous variation in macroeconomic policy
2. Natural experiment that can be identified are rarely those required to answer questions we're interested in.

This results into an external validity problem.

Some other important issues include

1. Dynamic nature of monetary and fiscal policy make it high dimensional; can have effect on both short and long run
2. Effects of fiscal shocks depends on monetary policy (constrained by zero lower bound) and tax policy response
3. Effect of policy depends on the economy
4. Degree to which a policy is a surprise affects when and how strongly an economy reacts

Therefore, macroeconomic research tends to be structural in nature

- Different from other empirical economic research which seeks to identify causal effects

Applied macroeconomics heavily uses statistical methods and therefore relies on the use of **moments**

- Moments characterise the statistical distribution and are most commonly taken around the mean
- e.g. mean, variance, etc.

We can distinguish between **identified** and **unidentified** moments

1. Unidentified: Simple statistics such as means, variances, and correlations
2. Identified: Statistics derived from empirical strategies or causal effect estimates

Identified moments are designed to help uncover causal effects (micro) or responses to structural shocks (macro).

1. Micro moments are constructed using microeconomic data on behaviour of individuals and firms
2. Macro moments use aggregated data to identify equilibrium outcomes; informative about what type of world we live in

Important to know is whether these moments actually correspond to structural parameters.

In some cases moment do correspond to structural parameters

- e.g. labour supply elasticity in labour economics

In other cases they don't

- e.g. marginal propensity to consumer (following transitory fiscal rebate); estimate of regional fiscal multiplier

When an identified moment does not correspond to a structural parameter, a theoretical framework is needed to go from identified moment to macroeconomic question of interest.

Finally we have to consider data and the unit-of-analysis; in general a model can be identified at

1. Aggregate level; focusing on single country
2. Cross-sectional level; e.g. across countries or within country

Cross-sectional identification is a fairly recent development

- Due to improvements in data collection
- Cross-sectional identification brings additional estimation challenges

Majority of studies are based on U.S. economy

1. Largest economy in the world
2. Technological leader
3. Best data availability

NB- Recall issue of external validity

Let's look at a number of examples of applied macro papers focusing on two important questions

1. The effect of fiscal stimulus
2. The non-neutrality of monetary policy

Concerning the effect of fiscal stimulus there are two approaches

1. Evidence coming from wars
2. Evidence coming from VARs

We will discuss VARs (Vector Autoregression) in more detail than you could wish for - or desire - in future lectures. For now, note that a VAR model can be written as

$$Y_t = A_1 y_{t-1} + e_t \tag{10}$$

$$Y_t = \begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} \tag{11}$$

$$A_1 = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \tag{12}$$

$$e_t = \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix} \tag{13}$$

There is a lot of interest in the effect of fiscal stimulus packages, specifically following the 2008-09 recession. Ideally, increased government purchases should have an expenditure multiplier (> 1)

- Packages can also include tax reductions

However, there is little to no empirical evidence for a response of real GDP to changes in government purchases or taxes

- A complication is that there is no basis for identification, isolating the effect of these changes on economic activity

Barro & Redlick (2011) use for identification changes in US defence spending

- These changes are associated with buildups and aftermaths of wars
- Approach can help distinguish between temporary and permanent chances in defence spending


US military expenditures
in billion USD
700
600
500
400
300
200
100
0
1920
1940
1960
1980
2000

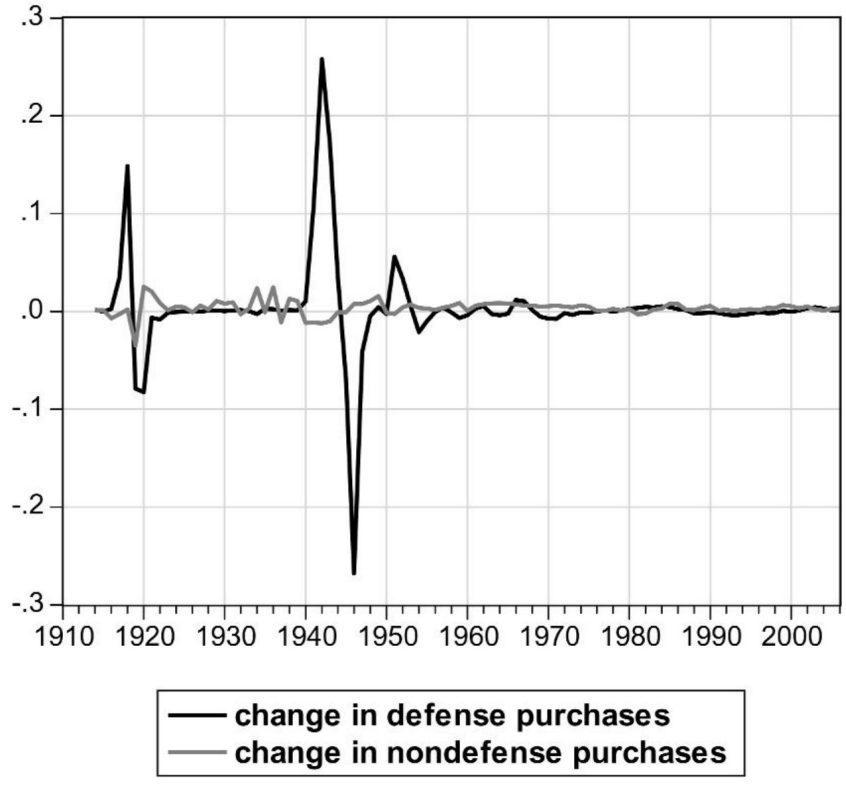


FIGURE I

Changes in Defense and Nondefense Government Purchases, 1914–2006
(expressed as ratios to the previous year's GDP)

The figure shows the change in per capita real government purchases (nominal purchases divided by the GDP deflator), expressed as a ratio to the prior year's per capita real GDP. The black graph is for defense purchases, and the gray graph is for nondefense purchases by all levels of government. The data on government purchases since 1929 are from Bureau of Economic Analysis and, before that, from Kendrick (1961). The GDP data are described in the online appendix.

Barro & Redlick, 2011

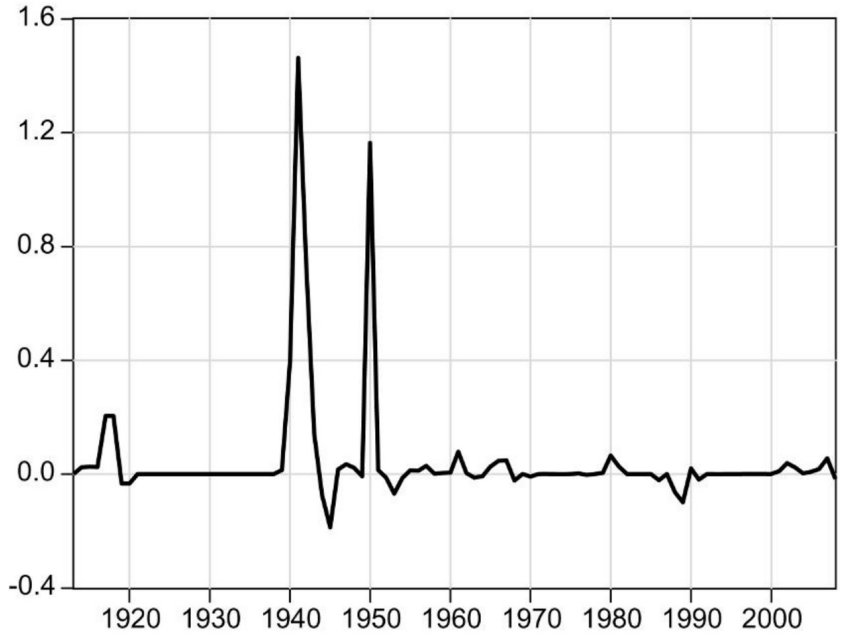


FIGURE II
Defense News Variable, 1913–2008

From 1939 to 2008, the variable is the annual counterpart of Ramey's (2011, Table II) measure of the present value of expected future nominal defense spending, expressed as a ratio to the prior year's nominal GDP. Values from 1913 to 1938 are rough estimates, described in Section III of the text. We use the defense news variable to measure $(g_t^* - g_{(t-1)}^*)/y_{t-1}$ in equation (1).

Barro & Redlick, 2011

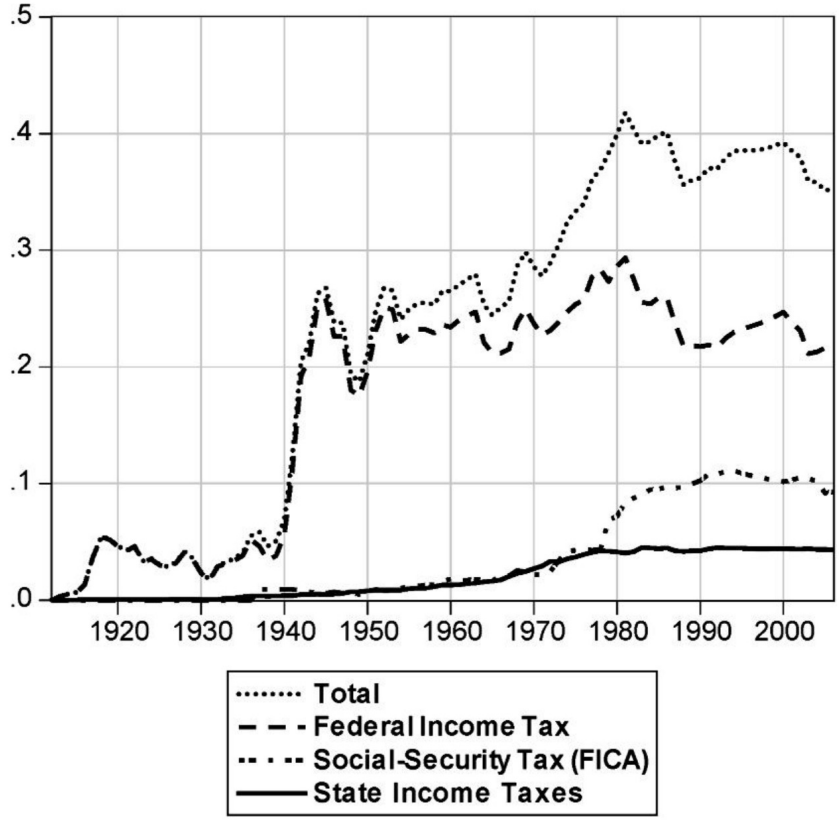


FIGURE III
Average Marginal Income Tax Rates, 1912–2006

The graph with large dashes is for the federal individual income tax, the graph with smaller dashes is for the Social Security payroll tax (FICA), and the solid graph is for state income taxes. The top graph is the total average marginal income tax rate. The data are from Table I.

Barro & Redlick, 2011

TABLE IV
Predicted Effects from Defense Spending on Components of GDP

	Predicted effect on:				
Increase in:	GDP	Consumption	Investment	Nondefense government purchases	Net exports
g: defense	+	−	−	−	−
g: defense news*	+	−	+	−	+

Notes. The table considers in the left-most column increases in current defense spending, g, or in news about future defense spending, $g*$. The five columns to the right show the signs of the predicted changes in GDP and its four components: private consumption, gross private domestic investment, nondefense government purchases, and net exports. The effects on nondefense government purchases follow if we view these purchases as primarily consumption, rather than investment. In our empirical application, we identify consumption with personal consumer expenditure on nondurables and services, and we consider consumer expenditure on durables as a form of investment.

Barro & Redlick, 2011

Barro & Redlick find that the estimated multiplier for temporary defence spending is

1. 0.4-0.5 contemporaneously (i.e. at year t)
2. 0.6-0.7 over two years

Magnitude of tax multiplier is 1.1; balanced budget-multiplier for defence spending is negative.

The non-neutrality of monetary policy is a contested area in macroeconomic research. Nakamura & Steinsson (2017) highlight three prominent pieces of evidence for non-neutrality

1. Poor FED policy decisions prior to Great Depression, making things worse
2. The Volcker disflation
3. Break in volatility of US real exchange rate

These pieces of evidence provide a useful insight into the preferred empirical methods

- Two cases are exclusively based on historical events
- One is example of identification based on discontinuity

Not appearing in this list: VARs

In general there are four prevalent approaches in identifying the effect of monetary policy

1. Large shocks
2. Narrative record to identify shocks
3. Discontinuity-based identification
4. 'Controlling' for confounding factors, i.e. VAR methods

In empirical science the gold standard is of course the controlled experiment

- Which for macro has become the holy grail as it is hard. if not impossible, to implement looking at monetary policy

Therefore, a fruitful approach is to look for large shocks or 'natural experiments'

- i.e. situations where policy changes are relatively large to potential confounding factors that cannot be accounted for
- These changes are few and far between

Concerning natural experiments, Friedman & Schwartz (1963) argue that there were three policy actions by the FED during the interbellum that were

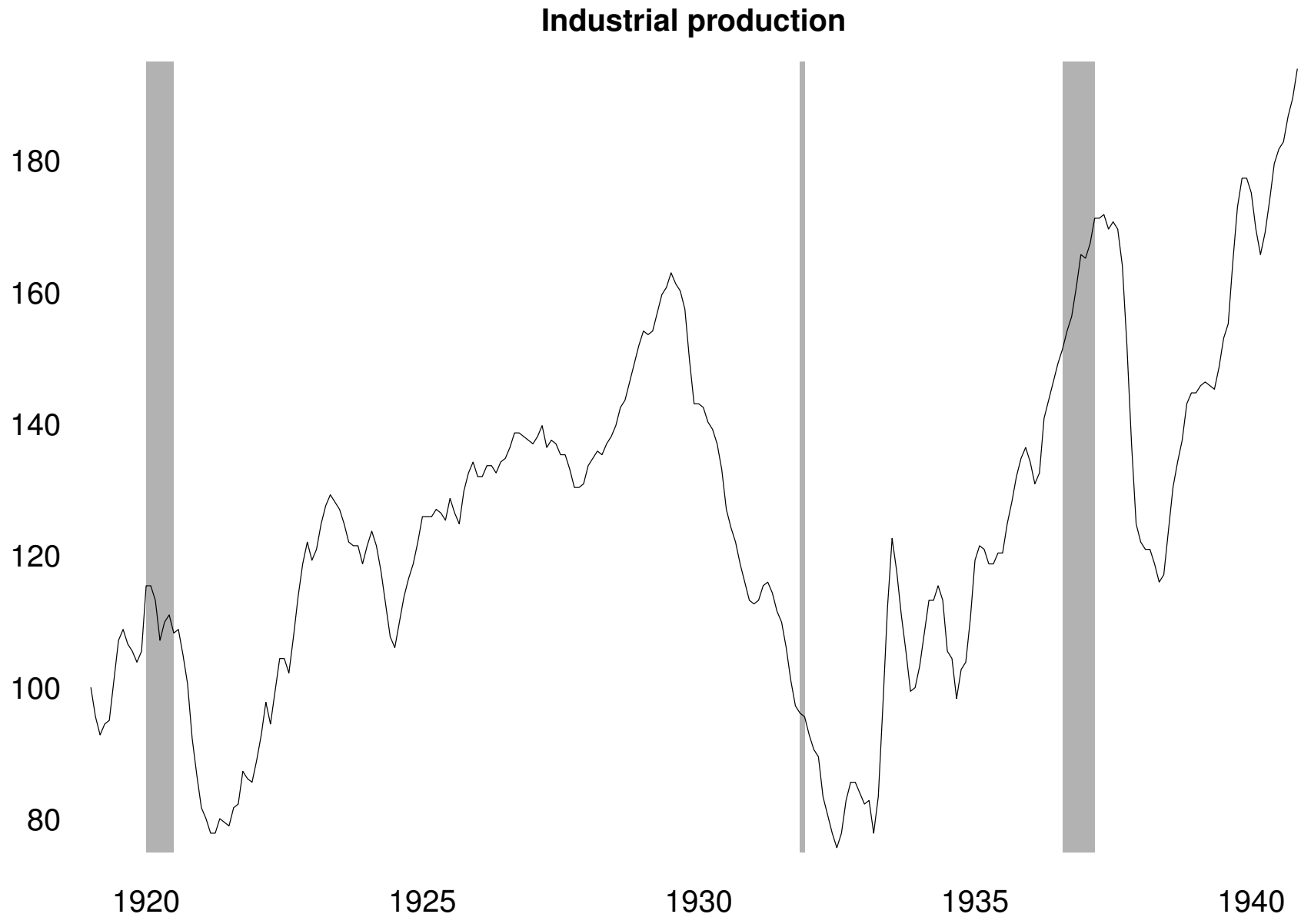
1. 'of major magnitude'
2. 'cannot be regarded as necessary or inevitable economic consequences of contemporary changes in money income and prices'

They argue that

> *the results are so consistent and sharp as to leave little doubt about their interpretation*

The dates of these policy events are

- January-June 1920
- October 1931
- July 1936 - January 1937


Industrial production
180
160
140
120
100
80
1920
1925
1930
1935
1940

These policy mistakes that Friedman & Schwartz identified, what were these exactly? Let's look at the decision made in October 1931

- Raise in discount rate from from 1.5% to 3.5%
- This was a response to speculative attacks on the US dollar following Britain leaving the gold standard

FED tightened policy at a time that industrial production was decreasing rapidly; this might seem like clear monetary shock.

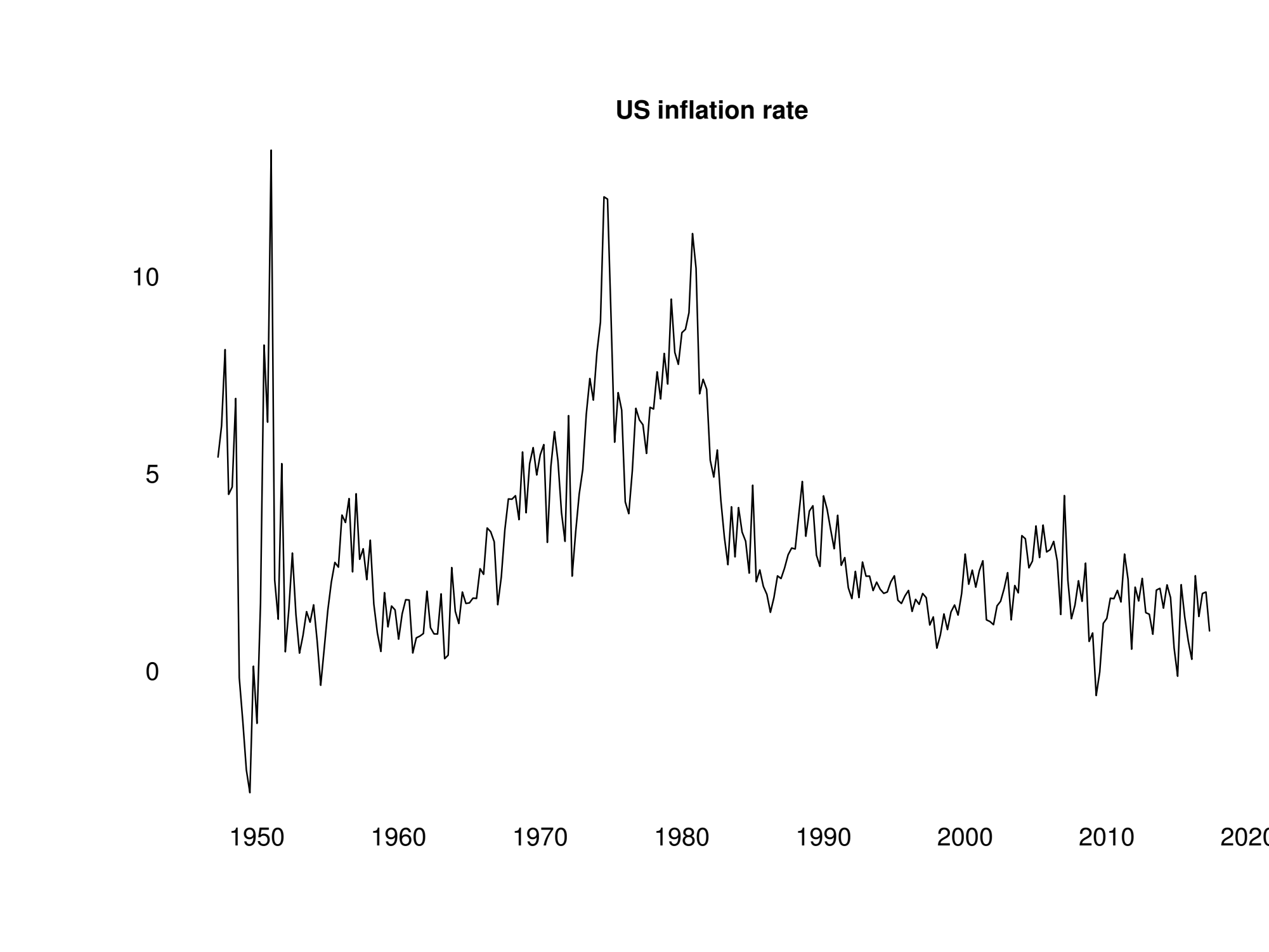
- Subsequent fall in industrial production, between October 1931- March 1933, not much different from preceding period
- Unclear how much of decrease can be attributed to policy shock

During the period July 1937-January 1937 two things happened

1. FED announced doubling the reserve requirements (fully implemented May 1937)
2. Treasury engaged in sterilisation of gold inflows

Before this period there was a rapid rise in industrialisation but it was followed by a rapid decrease of 33%

- 1937 recession might therefore be caused by slowdown in money creation due to policy actions
- Other factors at play though: tighter fiscal policy, constraints of gold standard


US inflation rate
10
5
0
1950
1960
1970
1980
1990
2000
2010
2020

The Great Inflation of the 1970s followed a period of relatively stable and low inflation

- Stable period after end of Korean War in 1953, inflation started to rise in the 1960s
- During 1970s inflation was high and volatile, often in double digits

During this period monetary policy was characterised by 'stop-go'

- Tight when the public was concerned about inflation, loose when public was concerned about unemployment

Volcker disflation followed after Volcker was appointed as chairman of the Federal Reserve Board in August 1979

- November 1980 Volcker broke with this modus operandi and targeted deliberate disinflation

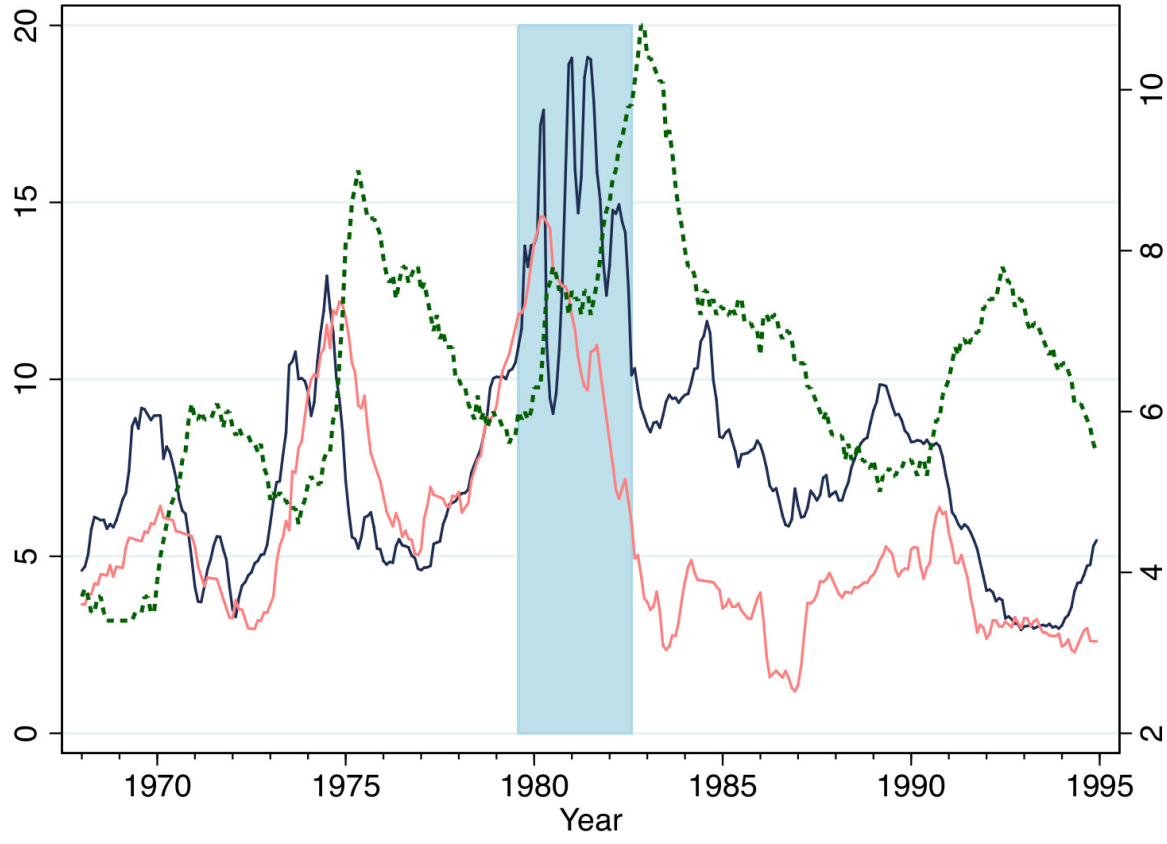
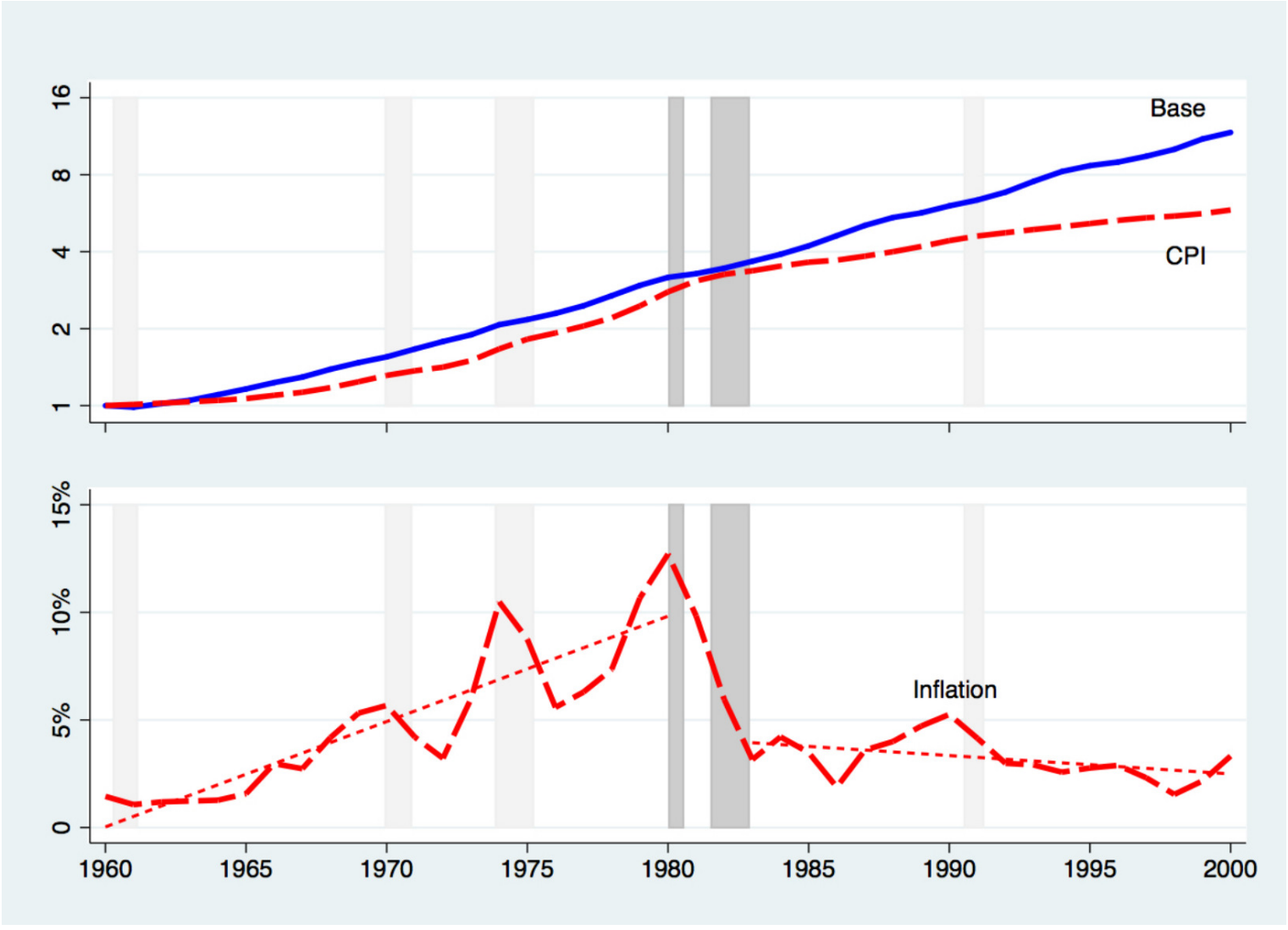


Figure 2: Federal Funds Rate, Inflation, and Unemployment from 1965 to 1995

Note: The figure plots the federal funds rate (solid blue, left axis), the 12-month inflation rate (solid pink, left axis), and the unemployment rate (dashed green, right axis). Volcker disinflation period shaded in blue (August 1979 to August 1982).

Nakamura & Steinsson (2017)


16
8
4
2
1
Base
CPI
15%
10%
5%
0
Inflation
1960
1965
1970
1975
1980
1985
1990
1995
2000

Romer (2016)

During the 1980s output seemed indeed to respond to monetary policy, but there are other factors

1. Oil shocks in 1979/1980
2. Credit controls in 1980
3. Tax cuts in 1981-82

Volcker episode is consistent with non-neutrality of monetary policy, but not concerning idea that policy affects output with long and variable lags.

- Indeed output reacted largely synchronised with FED actions

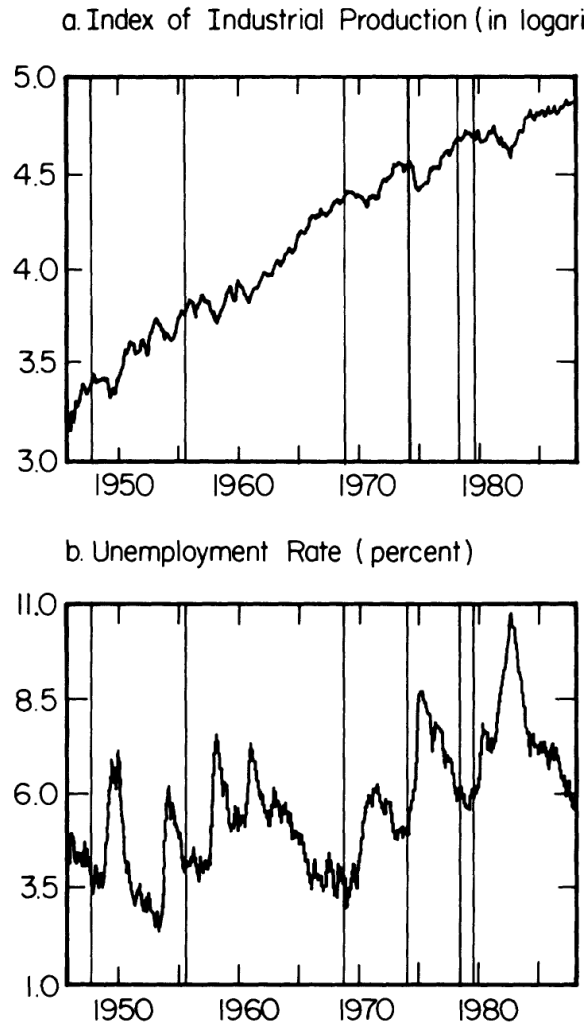
Romer & Romer (1989) use the narrative record to search for natural experiments

- Based on Federal Reserve records, identifying attempts to exert contractionary influence on the economy to reduce inflation
- There are 6 Romer-Romer dates

Their work is based on the paper by Friedmand & Schwartz (1963) earlier mentioned

- Indeed the title is 'Does monetary policy matter? A new test in the spirit of Friedman and Schwartz'

Figure 1 ECONOMIC ACTIVITY AND MONETARY SHOCKS.



Notes: Vertical lines are drawn at the dates of monetary shocks. The actual dates are October 1947, September 1955, December 1968, April 1974, August 1978, and October 1979. The sources of the data are described in the text. The data have been seasonally adjusted by a regression on monthly dummy variables.

Romer & Romer (1989)

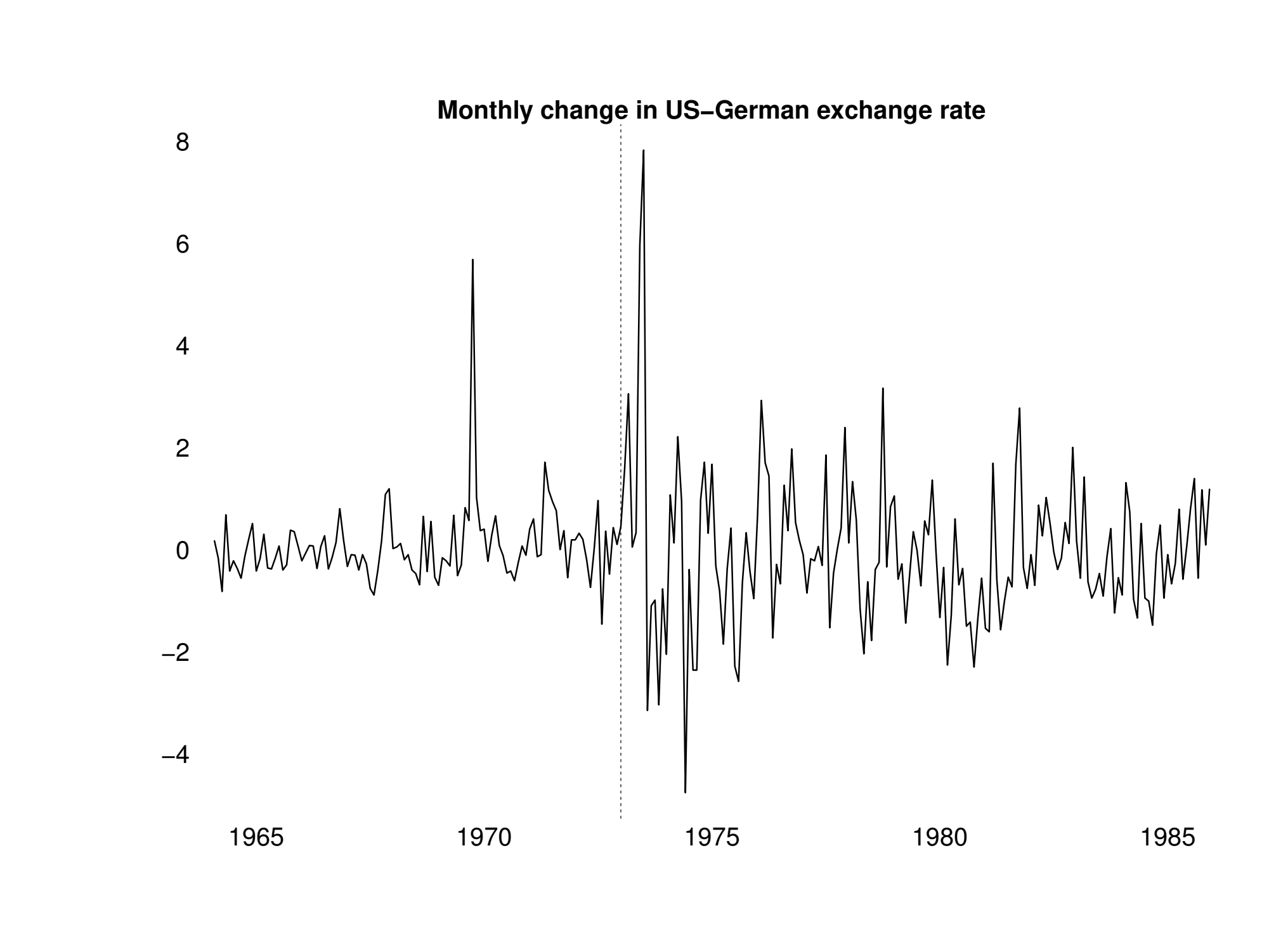
There are a number of shortcomings associated with this approach

1. Unclear how narrative record is selected; risk of reverse-engineering
2. Few data points; some other factor might be correlated with monetary shock, e.g. oil shocks
3. Shock are endogenous because they might be predictable; hard to establish though

Finally there is the approach using **discontinuity-based** identification

- Quasi-experimental based on using some event as an intervention allowing for comparison of pre- and post situation
- The identifying assumption made is that other factors affecting the exchange rate do not change discontinuously

Seminal paper on monetary policy is Mussa (1986) using a change in exchange rate regime


Monthly change in US–German exchange rate
8
6
4
2
0
−2
−4
1965
1970
1975
1980
1985

Under Bretton-Woods system exchange rates were fixed

- Made US dollar reserve currency, other currencies were to be maintained within 1% band
- System broke down in February 1973; Japan and EEC countries let their currency float
- Breakdown caused large increase in volatility of US exchange rate

Mussa (1986) associated the breakdown of the system, the result of change in monetary policy, with increase in real exchange rate

- Note that switching exchange rate regime from fixed to flexible is strictly monetary action
- If monetary policy is neutral, this change should have no impact on real variables such as real exchange rate

Instead, Mussa found a more than fourfold increase in the standard deviation