Evidence on money and economic activity

Lecture 10

Readings

- Mishkin, chapter 23, 9th edition
- G. McCandless and W. Weber, “Some Monetary Facts,” FRBN *Quarterly Review* 19, 2005

Plan

- Look at evidence on the behavior of:
  - Prices
  - Monetary aggregates and interest rates
  - Output
- Issues:
  - Neutrality of money
  - Real effects of money (non-neutrality of money)
  - Short-run versus long-run

Long-run relationships

- Question: is money neutral in the long run? Answer: yes
- McCandless and Weber (1995): what do they do?
  - 110 countries, 30 years (1960-1990)
  - Statistical long-run correlations across countries of
    1. inflation and money growth rate
    2. real GDP growth and money growth rate
    3. inflation and real GDP growth
  - Use three definitions of a country's money supply (M0, M1 and M2) and two subsamples of countries (21 OECD countries, 14 Latin American countries)

Long-run relationships, cont.

- McCandless and Weber (1995): what do they obtain?

1. Growth rates of money supply and the general price level are highly correlated for all three money definitions, for the full sample of countries, and for both subsamples

2. The growth rates of money and real output are not correlated, except for a subsample of countries in the OECD, where these growth rates are positively correlated

3. The rate of inflation and the growth rate of real output are essentially uncorrelated

Money growth and inflation in the long run

Table 1

Correlation Coefficients for Money Growth and Inflation*

Based on Data From 1960 to 1990

Sample	Coefficient for Each Definition of Money		
	M0	M1	M2
All 110 Countries	.925	.958	.950
Subsamples			
21 OECD Countries	.894	.940	.958
14 Latin American Countries	.973	.992	.993

*Inflation is defined as changes in a measure of consumer prices.

Source of basic data: International Monetary Fund

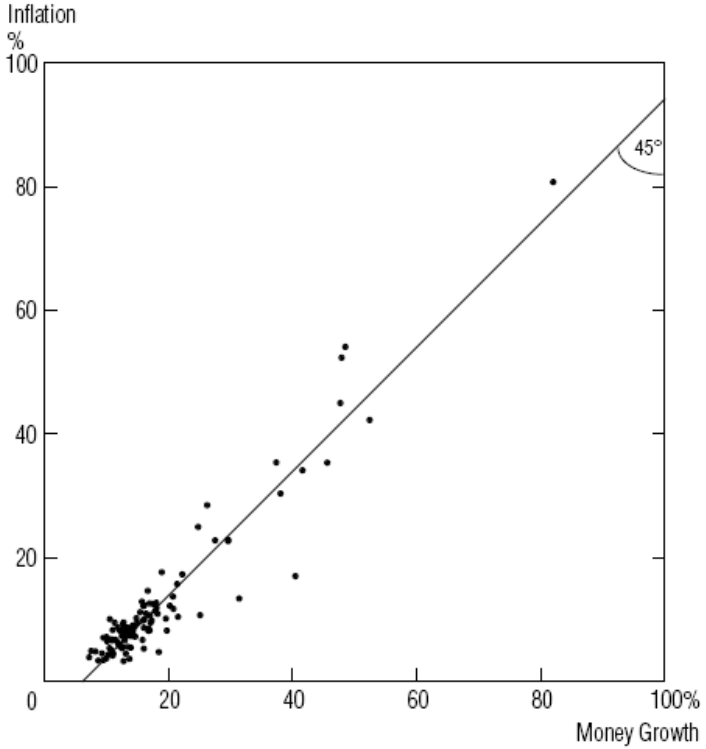
- Very high correlation, almost unity
- True across subsamples of countries
- Correlation slightly higher for M1 and M2

Money growth and inflation in the long run, cont.

Chart 1

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

- Very high correlation
- Individual countries observations lie on the 45 degree line: slope of relationship close to unity
- Consistent with quantitative theory of money:

$M \times V = P \times Y$

$\Delta \log M + \Delta \log V = \Delta \log P + \Delta \log Y$

$m + v = \pi + y$

$\pi = m - y + v$

Money growth and inflation in the long run, cont.

- Correlation does not have any implications for causality. That is, correlation does not necessarily imply that money causes inflation. Two issues:

1. Reverse causality

   It may be that correlation is due to inflation causing money, with money being endogenous

   Consider a single country where the CB follows a feedback monetary policy rule where the growth rate of money is determined by the inflation rate $\rightarrow$ we would observe perfect correlation between money and inflation for that country

   McCandless and Weber use a large set of countries in the hope that correlation will be free of policy rule influences

2. Outside driving factor

   An outside factor could be the driving force behind two variables that move together

- Yet, while correlations are not direct evidence of causality, they support causal hypotheses that yield predictions consistent with the correlations

Money growth and inflation in the long run: conclusions

- Main result:

  Tight relation between money growth and inflation in the long run

- One important conclusion:

  Any theoretical model not consistent with a one-to-one long-run relationship between money and inflation should be questioned

But what about the short run?

Money growth and real output growth

Table 3

Correlation Coefficients for Money Growth and Real Output Growth*

Based on Data From 1960 to 1990

Sample	Coefficient for Each Definition of Money M0	M1	M2
All 110 Countries	–.027	–.050	–.014
Subsamples			
21 OECD Countries	.707	.511	.518
14 Latin American Countries	–.171	–.239	–.243

*Real output growth is calculated by subtracting changes in a measure of consumer prices from changes in nominal gross domestic product.

Source of basic data: International Monetary Fund

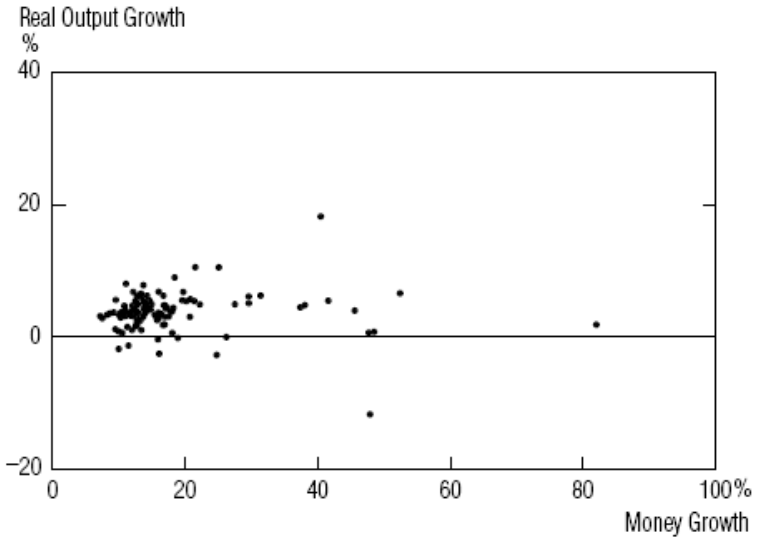
- Correlation not statistically different from zero at any reasonable significance level for the full sample
- Result consistent with long-run monetary neutrality

Money growth and real output growth, cont.

Chart 2

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

- Lack of any relationship in the full sample also clear from the scatter plot of money growth and real output growth
- Result consistent with monetary long-run neutrality

Money growth and real output growth, cont.

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Correlation Coefficients for Money Growth and Real Output Growth*

Based on Data From 1960 to 1990

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*Real output growth is calculated by subtracting changes in a measure of consumer prices from changes in nominal gross domestic product.

Source of basic data: International Monetary Fund

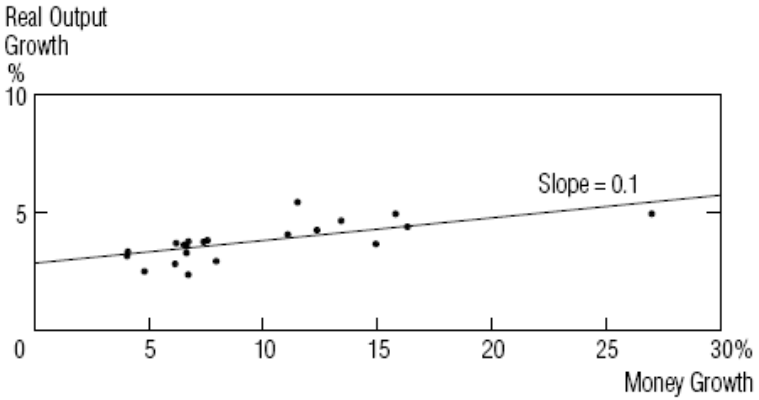
- Correlation not statistically different from zero at any reasonable significance level also for Latin American subsample
- However for the OECD subsample there is a positive and relatively high correlation
- Note: Correlation coefficient indicates direction and strength of a linear relation (increases in money growth are associated with increases in real output growth) but not its magnitude (whether increases in money growth are associated with increases in real output that are large or small)

Money growth and real output growth, cont.

Chart 3

. . . 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

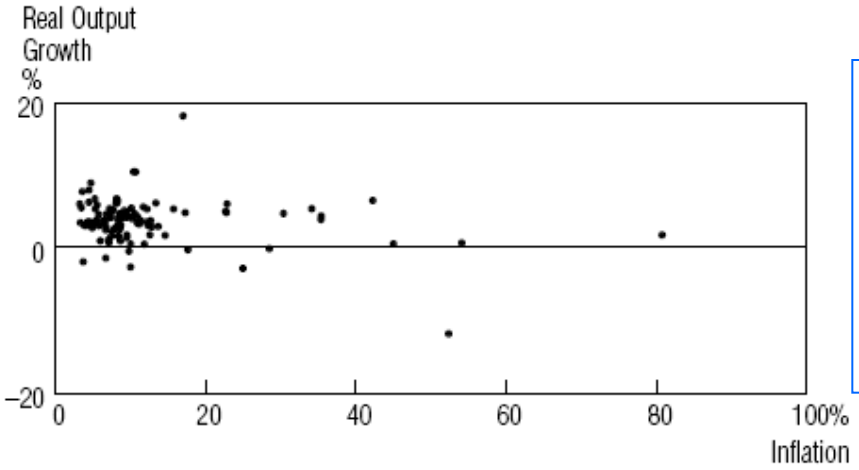
- To obtain an idea of the magnitude of the relation for OECD countries regress real output growth on money growth for OECD countries and measure the slope of the regression line: obtain 0.1 for three definitions of money
- Recall results do not imply causality

Inflation and real output growth

Chart 4

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



Source: International Monetary Fund

- Essentially no correlation
- Robust across subsamples
- Consistent with long run monetary neutrality

Money growth/inflation and output in the long run: conclusions

- Main result:

  Almost no correlation between money growth and output growth and between inflation and output growth in the long-run

- One important conclusion:

  Any theoretical model not consistent with long-run monetary neutrality should be questioned

But what about the short run?

Evidence on the effects of money in the short run

- Main question:

  How important is money to economic fluctuations, i.e., to short-run movements in real economic activity?

- Look at three pieces of evidence:
  - Early Keynesian evidence based on structural model evidence
  - Early monetarist evidence based on reduced- form evidence
  - Recent state of the art evidence based on Vector Auto Regressions (VARs)

Types of empirical evidence

- Two main types of empirical evidence:
  - Structural model evidence: Examines whether one variable affects another by using data to build a model that explains the channels through which the variable affects the other
  - Reduced-form evidence: Examines whether one variable has an effect on another variable simply by looking directly at the relationship between the two variables

- Example: does drinking coffee leads to heart diseases?
  - Structural model evidence involve developing a model that analyzes data on how coffee is metabolized by the human body, how it affects the operation of the heart, and how its effects on the heart lead to heart attacks
  - Reduced form evidence would involve directly looking at whether coffee drinkers tend to experience heart attacks more frequently than non coffee drinkers

Types of empirical evidence, cont.

- Example: does monetary policy affects economic activity?
  - Structural model evidence involve developing a model of the transmission mechanisms of monetary policy and look at specific channels of monetary influence

    For example consider the following transmission mechanism: a change in money supply affects interest rates, which in turn affect investment spending , which in turn affects aggregate spending, which in turn affects aggregate output
  - Reduced-form evidence would involve directly looking at whether movements in money are linked to movements in real economic activity treating the economy as a black box whose workings cannot be seen

    For example look at the statistical correlation between money and output

Advantages and disadvantages

- Structural model evidence
  - Possible to gather more evidence → more confidence on the direction of causation
  - More accurate predictions
  - Understand how institutional changes affect the link
  - Only as good as the model it is based on
- Reduced form evidence
  - No restrictions imposed on the way monetary policy affects the economy
  - Correlation does not necessarily imply causation (reverse causation, outside driving factor)

Early Keynesian evidence

- Mainly looked at structural model evidence
- Concluded that money is not very important to economic fluctuations
- Transmission mechanism considered: monetary expansion → i ↓ → I ↑ → Y ↑
- Three pieces of structural model evidence
  - Low interest rates during the Great Depression indicated expansionary monetary policy but had no effect on the economy
  - Empirical studies found no linkage between movement in nominal interest rates and investment spending
  - Surveys of business people confirmed that investment in physical capital was not based on market interest rates

Objections to early Keynesian evidence

- Friedman and Schwartz publish “A Monetary History of the United States, 1867-1960” (1963) showing that monetary policy was actually contractionary during the Great Depression
- Many different interest rates (high interest rates on lower grade bonds)
- During deflation, low nominal interest rates do not necessarily indicate expansionary policy
- Weak link between nominal interest rates and investment spending does not rule out a strong link between real interest rates and investment spending
- Interest-rate effects are only one of many channels

Real and nominal interest rates

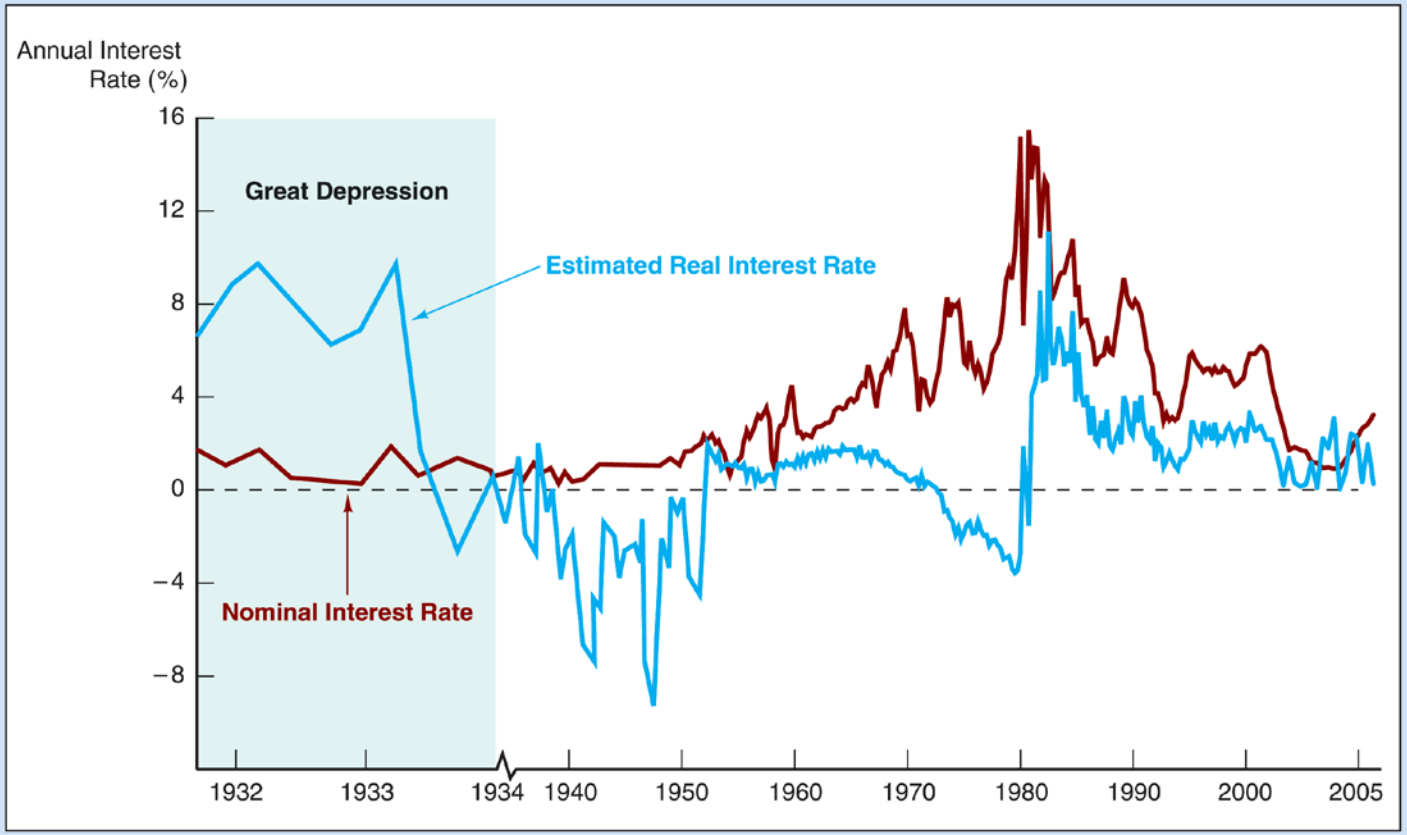


FIGURE 1 **Real and Nominal Interest Rates on Three-Month Treasury Bills, 1931–2005**

Sources: Nominal rates from www.federalreserve.gov/releases/h15/update/. The real rate is constructed using the procedure outlined in Frederic S. Mishkin, "The Real Interest Rate: An Empirical Investigation," *Carnegie-Rochester Conference Series on Public Policy* 15 (1981): 151–200. This involves estimating expected inflation as a function of past interest rates, inflation, and time trends and then subtracting the expected inflation measure from the nominal interest rate.

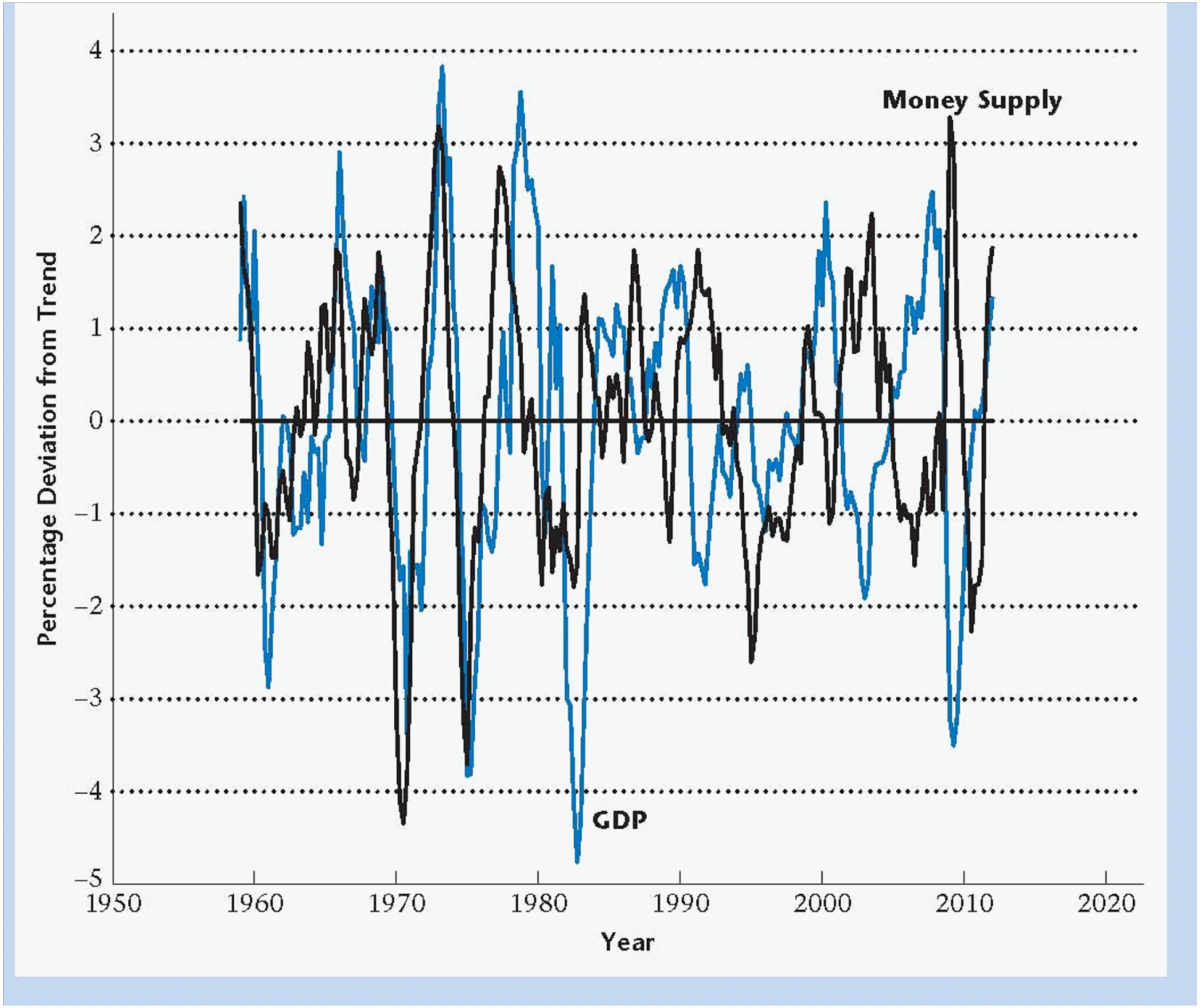
Early monetarist evidence

- Mainly looked at reduced-form evidence
  - Timing evidence
  - Statistical evidence
  - Historical evidence
- Promoted the case for a strong effect of money on economic activity

Timing evidence

- Timing evidence: looks at whether movements in one variable typically occur after another
- Based on the principle stated in Latin as *post hoc ergo propter hoc*, "after this, therefore because of this", that is, since that event followed this one, that event must have been caused by this one
- Friedman and Schwartz in “Money and Business Cycles” (1963):
  - Found that in every business cycle on nearly a century money growth rate always declined before output did, with a lead time that could vary from a few months to more than two years
  - Concluded that money growth causes business cycle fluctuations but its effects operate with long and variable lags

Timing evidence, cont.



Objection to timing evidence

- Post hoc, ergo propter hoc
  - Principle valid only if first event is an exogenous event
    (economic events versus controlled experiments in chemistry or physics)
  - Reduced form nature leads to possible reverse causation (lag may be a lead) or outside factor

Historical evidence

- Historical (narrative) evidence: looks at specific economic episodes that appear to be exogenous events
- These events are almost like controlled experiments so that the principle *post hoc, ergo propter hoc* is far more likely to be valid
- Friedman and Schwartz (1963) document several episodes in which the change in the money supply was an exogenous event, and was then soon followed by a change in the business cycle

Historical evidence, cont.

- Example:
  - Increase in reserve requirements in 1936-1937 that led to a sharp decline in money supply and was then followed by the very severe recession of 1937-1938
  - Increase implemented because the Fed wanted to improve its control of monetary policy
  - Not implemented in response to economic conditions
  - Rule out reverse causation
  - Also difficult to think about an outside factor that could have driven the Fed decision and at the same time have directly affected output
- Historical evidence very strong evidence that monetary policy does have an impact on output

Identifying the effects of monetary policy

- Money and interest rate are endogenous variables, partly determined by
  - endogenous response of the banking sector to economic shocks
  - endogenous response of monetary policy actions themselves (for example policy rule where money or interest rates respond to the state of the economy)

  → cannot tell causality

- Need to identify the exogenous part of money/interest rates (monetary policy shocks)

- Vector Auto Regression (VAR)

Vector Auto Regression (VAR)

- A Vector Auto Regression (VAR) is an econometric model used to capture the evolution and the interdependence between variables over time (multiple time series)

- All variables in a VAR are treated symmetrically by including for each variable an equation explaining its evolution based on its own lags and the lags of all other variables in the model

- Example: VAR in real output *y* and the instrument of monetary policy *x* (money supply or interest rate)

$$y_t = \vartheta x_t + \vartheta_{y,1} x_{t-1} + \vartheta_{y,2} x_{t-2} + \varphi_{y,1} y_{t-1} + \varphi_{y,2} y_{t-2} + e_{yt}$$
$$x_t = \varphi y_t + \varphi_{x,1} y_{t-1} + \varphi_{x,2} y_{t-2} + \vartheta_{x,1} x_{t-1} + \vartheta_{x,2} x_{t-2} + e_{xt}$$

where e_{yt} and e_{xt} are uncorrelated error terms (called structural shocks to y and x)

Interpretation of shocks: examples

- Monetary policy shock:
  - Exogenous shocks to the preferences of the monetary authority, perhaps due to random shifts in the relative weight given to output and inflation
  - These shifts could reflect shocks to the preferences of the members of the Federal Open Market Committee (FOMC), or to the weights by which their views are aggregated
- Output shock:

  Demand shock, such as a random shift in consumer preferences toward certain products
- Inflation shock:

  Supply shock, such as an oil price shock

Structural VAR

- Structural VAR $\rightarrow$ its structure is well suited to represent the underlying economic relationships between variables
- Two features of the structural form are important in this respect:
  - structural shocks driving dynamics of variables are independent
  - each variable has a contemporaneous impact on other variables

Reduced-form VAR

- In its structural form the VAR cannot be estimated using standard OLS techniques because of the endogeneity problem (y_t depends on x_t which in turn depends on y_t and vice versa)

- Substitute out x_t in the expression for y_t and y_t in the expression for x_t, rearrange and obtain

$$y_t = \beta_{y,1} x_{t-1} + \beta_{y,2} x_{t-2} + \alpha_{y,1} y_{t-1} + \alpha_{y,2} y_{t-2} + u_{yt}$$
$$x_t = \alpha_{x,1} y_{t-1} + \alpha_{x,2} y_{t-2} + \beta_{x,1} x_{t-1} + \beta_{x,2} x_{t-2} + u_{xt}$$

where the error terms u_{yt} and u_{xt} are composite of the structural shocks as follows

$$u_{yt} = \frac{1}{1-\vartheta\varphi}\left[e_{yt} + \vartheta e_{xt}\right]$$
$$u_{xt} = \frac{1}{1-\vartheta\varphi}\left[\varphi e_{yt} + e_{xt}\right]$$

- Reduced-form VAR, no endogeneity problem

- Run OLS and estimate coefficients α and β, and obtain the VAR residuals u

VAR residuals

- VAR residuals (u_{yt} and u_{xt}) are linear combinations of the primitive, structural shocks (output shock e_{yt} and monetary policy shock e_{xt})

$$u_{yt} = \frac{1}{1-\vartheta\varphi}\left[e_{yt} + \vartheta e_{xt}\right]$$

$$u_{xt} = \frac{1}{1-\vartheta\varphi}\left[\varphi e_{yt} + e_{xt}\right]$$

- We are interested in estimating the response of output y_t to monetary policy shock e_{xt}

Identification of e_{xt}

- We can observe u_{yt} and u_{xt} as regression residuals
- We cannot observe e_{yt} and e_{xt}
- Need to recover e_{xt} from u_{yt} and u_{xt}
- Common assumption: recursiveness assumption

Identification of e_{xt}, cont.

- Example 1: ψ=0

$$u_{xt} = e_{xt} \qquad u_{yt} = e_{yt} + \vartheta e_{xt}$$

Economic meaning: Monetary policy does not respond to contemporaneous output shock (for example, due to availability of data)

- Example 2: ϑ=0

$$u_{yt} = e_{yt} \qquad u_{xt} = \varphi e_{yt} + e_{xt}$$

Can estimate ψ by running OLS

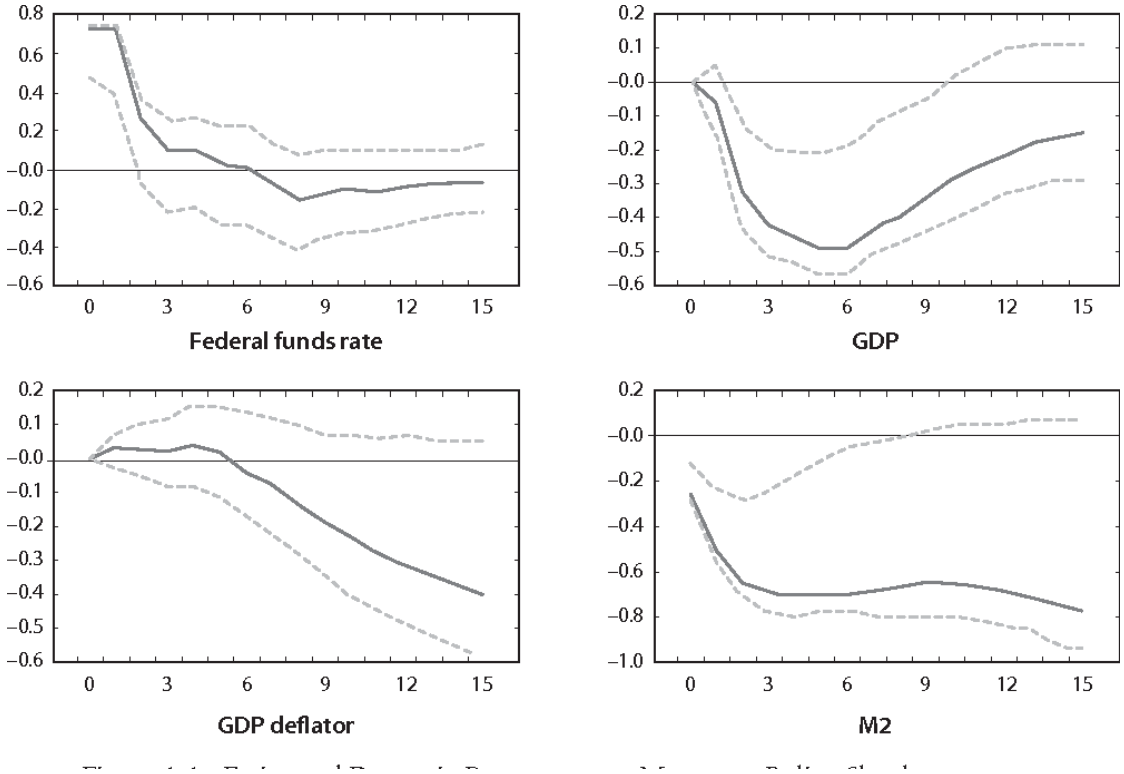
Economic meaning: Output does not respond to policy contemporaneously (for example, due to decision lags)

Estimate VAR

- Estimate VAR
- Under example 1, monetary policy shock is $e_{xt} = u_{xt}$
- Simulate the VAR model and calculate the “impulse response function” of output to a monetary policy shock
- This way we can see the dynamic effects of a monetary policy shock on output

Empirical effects of an increase in the Federal Funds rate

Source: Christiano, Eichenbaum and Evans (1999). "Monetary Policy Shocks: What Have we Learned and to What End?"



- Slow adjustment of output and prices
- Short run non neutrality of money

Empirical effects of an increase in the Federal Funds rate

Source: Christiano, Eichenbaum and Evans (1997). "The Effects of Monetary Policy Shocks: Evidence form the Flow of Funds"