Monetary Economics

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Lecture I

Empirical Evidence on Money, Prices and Output

”Motto”

”This tension between two incompatible ideas–that changes in money are neutral unit changes and that they induce movements in employment and production in the same direction–has been at the center of monetary theory at least since Hume wrote his essays Of Money and Of Interest (1752)”

(Robert Lucas in his Nobel Lecture, 1995)

Outline

- Some Basic Correlations
  - Long–Run Relationships
  - Short–Run Relationships
- Estimating the Effect of Money on Output
  - The Evidence of Friedman and Schwarz
  - The VAR Approach
  - The Evidence of Romer and Romer
- Summary

Why Empirical Evidence?

- basic "facts" about both the long–run and short–run relationships can serve as benchmarks for judging theoretical models and practical policy

- reviewing the empirical evidence provides an opportunity to discuss the approaches economists have taken to estimate the effects of money and **monetary policy** on real economic activity

Long–Run Relationships

- a nice summary is provided by McCandless and Weber (1995) (among many others)
  - the used data cover a 30-year period from 110 countries using several definitions of money
  - inflation rate and output growth
  - hence, provided evidence is unlikely to depend on country-specific events

- first general conclusion
  - the correlation between the inflation and the money supply growth rate is almost 1
  - it varies between 0.92 and 0.96 depending on the money supply definition that is used
  - this is often taken to suport the basic idea of the **quantity theory of money**: *a change in the growth rate of money induces an equal change in the rate of inflation*

- however
  - this high correlation says in fact nothing about the **causality**

- if the country followed policy under which the money-supply growth rates were exogenously determined then the correlation could be taken as evidence that money growth causes inflation
- an alternative possibility is that other factors generate inflation and central bank allow the money-supply to adjust
- both are consistent with the one-to-one relationship between the inflation and the money-supply growth

- second general conclusion
  - there is no correlation between either inflation or money growth and the growth rate of real output
  - this conclusion is, however, not as robust as the preceeding one
  - for example
    * for OECD countries subsample there is positive correlation between real output growth and money growth
    * Kormendi and Meguire (1984) find no long-run relationship between the money and output growth using the sample of 50 countries
    * Barro (1995, 1996) reports on negative correlation between the inflation and output growth

- thus, there is somewhat greater uncertainty once the output is concerned
- but the general consensus is well summarized by the Taylor (1996) proposition: *about which there is now little disagreement, ... that there is no long-run trade-off between the rate of inflation and the rate of unemployment*

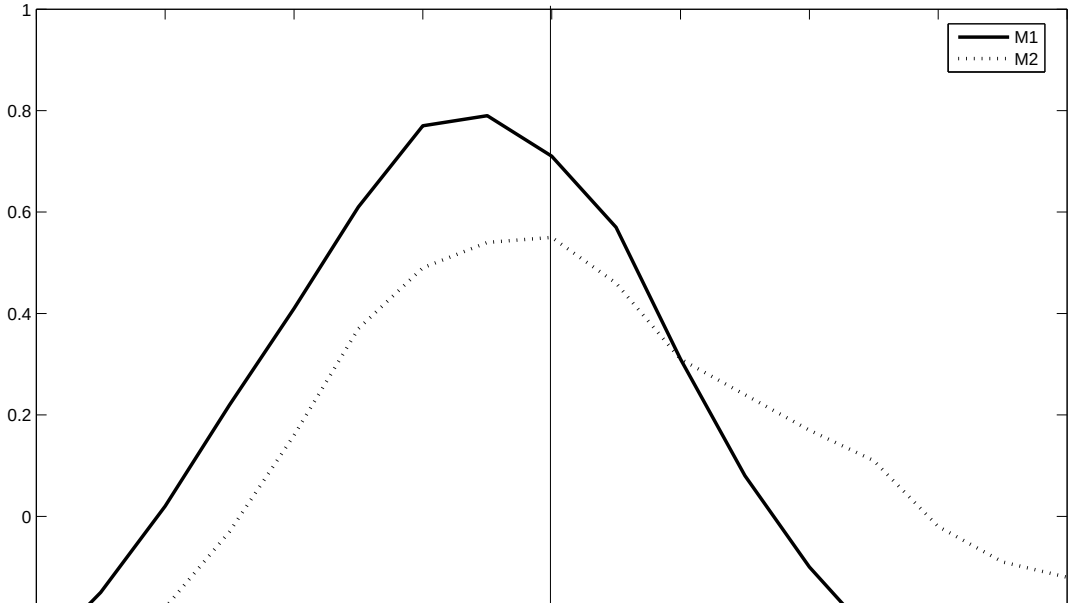
- interest rates, inflation and money ...
  - according to the Fisher equation the nominal interest rates equal the real return plus the expected inflation
  - if the real return is independent of inflation, then nominal rates should be positively related to expected inflation
  - and to the money growth
  - Monnet and Weber (2001) examine the period 1961-1998 for a sample of 31 countries
    * they find a correlation of 0.87 between money growth and long-term interest rates
    * however, for developed countries the correlation is smaller, i.e. 0.7

Short–Run Relationships

- is of main concern for this course in monetary policy
- our interest arises because of a need to understand how *(if at all)* monetary policy affects the behavior of the macroeconomy over time periods of quarters
- what, however, extremely complicates any inference from the correlations is the problem of endogenity
- short-run correlations among money, output and inflation reflect actually both
  - the way in which private agents respond to economic disturbances including the monetary policy
  - and the way the monetary policy authority responds to the same disturbances
- for this very reasons the short-run correlations are likely to vary
  - across countries as different central banks implement policy in different ways
  - and across time as the sources of economic disturbaces vary by themselfs

- next Figure shows (using the Czech data) correlations between the log of detrended real GDP and monetary aggregates (log and detrended)

Money and Output correlations

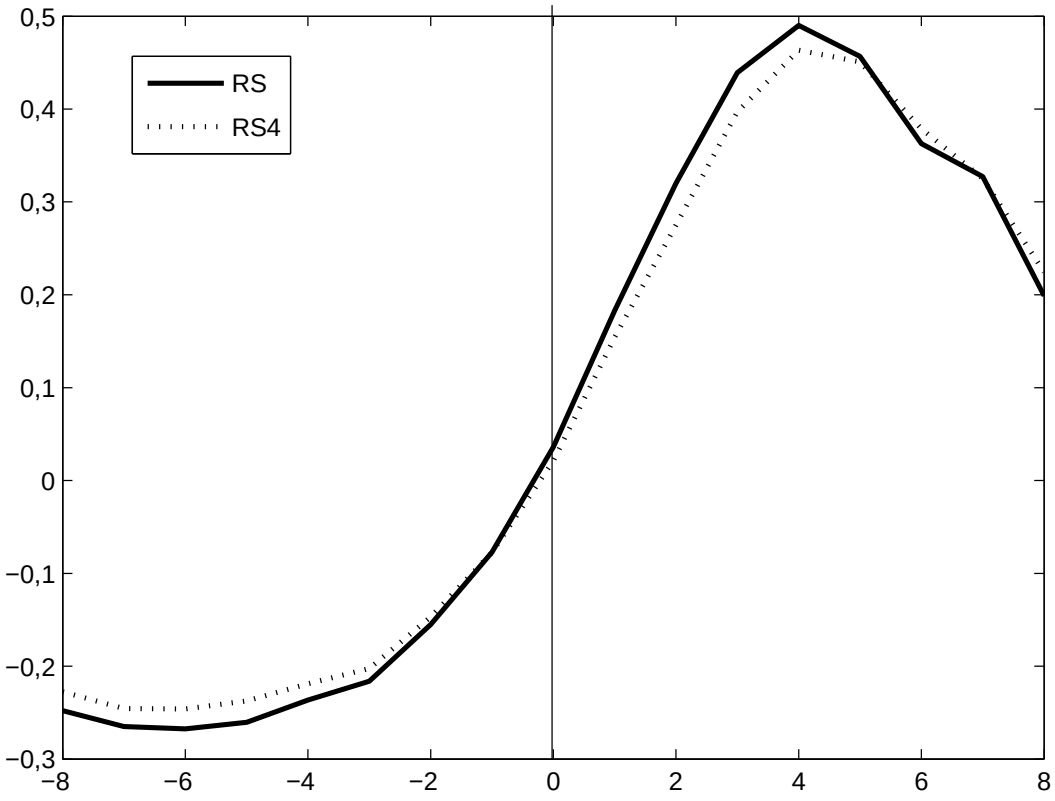

M1
M2
1
0.8
0.6
0.4
0.2
0

- the Figure plots the correlation between the real GDP_t and M_{t+j} against j where M represent monetary aggregates $M1$ and $M2$

- as the Figure shows
  - the correlation change as one moves from $M1$ to $M2$
  - the relatively narrow measure $M1$ is highly positively correlated at lags but seems to be negatively correlated at leads
  - this can be interpreted in a way that *high GDP tends to be proceeded by high values of* $M1$ *but followed by low values* which indicates that *movements in money lead movements in output (no doubts this timing played an important role in Friedman and Schwarz's classic and highly influential Monetary History of the United States*
  - in contrast the broad measure $M2$ is positively correlated at both leads and lags
  - this arise from the endogenous nature of an aggregate such as $M2$ covering not just the *money* hold by private agents but also their *savings*
  - anyway, the pattern of both correlograms is relatively similar

- next Figure shows (again using the Czech data) correlations between the GDP (again detrended) and interest rates

Interest Rate and Output correlations

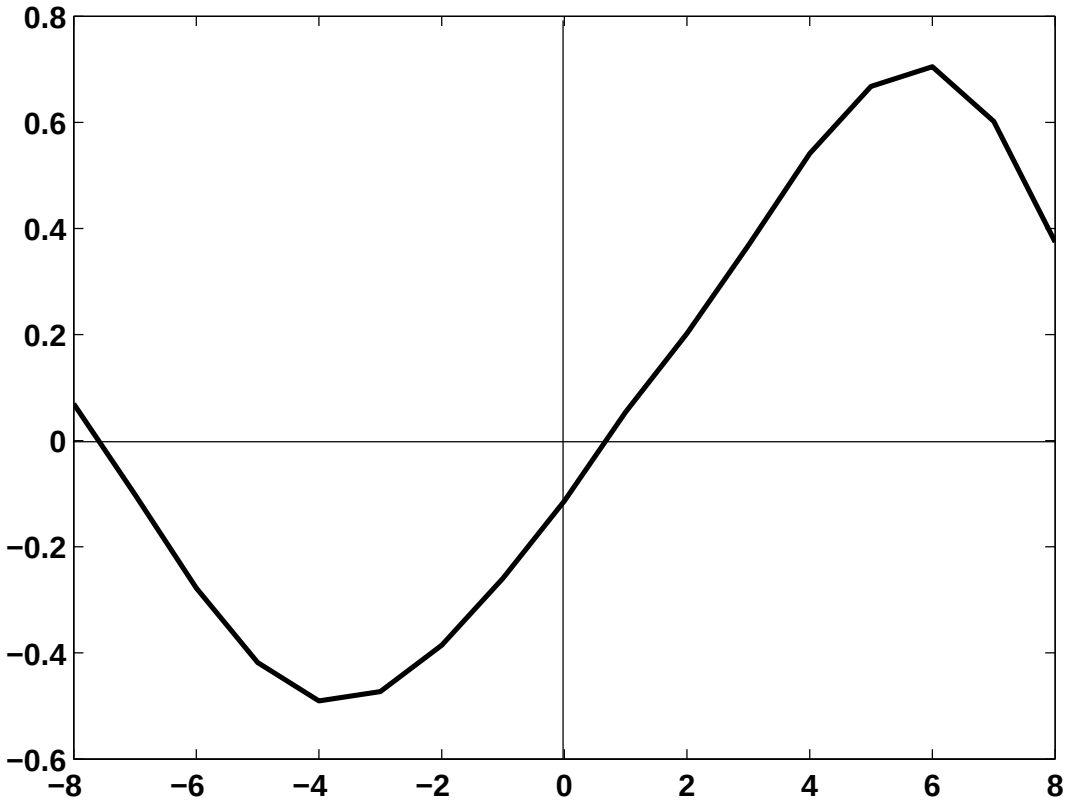

RS
RS4
0,5
0,4
0,3
0,2
0,1
0
−0,1
−0,2
−0,3
−8
−6
−4
−2
0
2
4
6
8

- the Figure plots the correlation between the real GDP_t and R_{t+j} against j where R represent $3M$ and $1Y$ interest rates RS and $RS4$

- possible remarks
  - both interest rates series display similar correlation
  - *low* interest tend to lead *high* output
  - while a *rise* in output tends to be followed by *higher* interest rates

- however, to make things more complicated see the next Figure

Inflation and Output correlations


0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−8
−6
−4
−2
0
2
4
6
8

- the Figure plots (using Czech data) the correlation between the real detrended GDP_t and detrended $GDPdeflator_{t+j}$ against j and shows
  - that, contemporaneously and at lags, the GDP deflator tends to be below trend when output is above trend
  - and that incerases in real output tend to be followed by increases in prices

- using the latter observations Kydland and Prescott (1990) have argued
  - that the negative contemporaneous correlation between the output and prices suggests that supply shocks must be responsible for business cycle fluctuations *(using US data this evidence would be more striking)*
  - and that demand shocks *(means monetary policy)* do not play an important role

- having all this evidence in mind the challenge remaining for us is to discuss the degree to which the data reveal causal relationships, relationships that can be used for a practical conduct of monetary policy

Estimating the Effect of Money on Output

- almost all economists accept that from the long-run perspective the effects of money fall entirely on prices with no impact on real variables

- however, from the short-run perspective there is crucial disagreement

- though most economists believe that monetary disturbances have an important real effects there still exist a lot of them who do not

- over time there has been several influential studies estimating the impact of monetary policy that reflected the developments in time-series econometrics and economic modelling

- we review some of them

The Evidence of Friedman and Schwarz

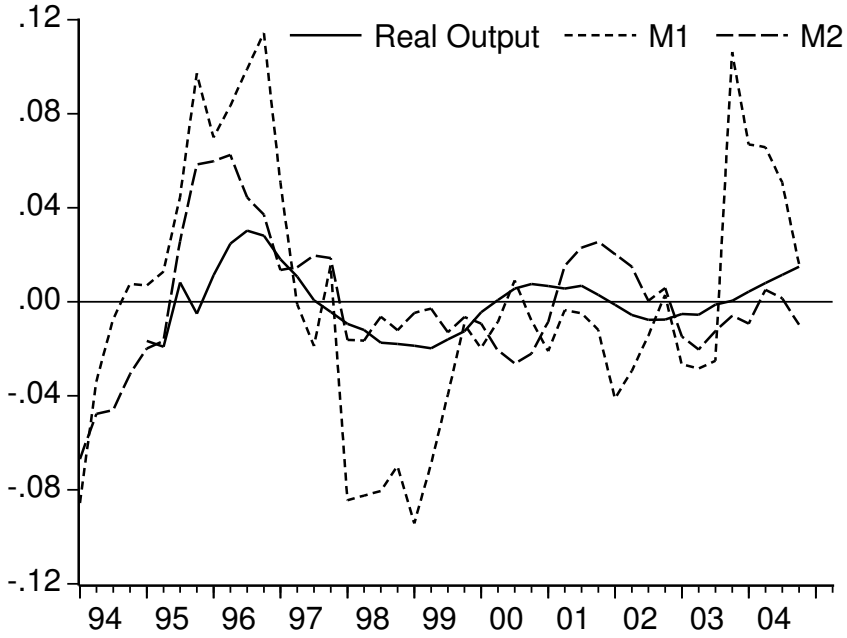
- Friedman and Schwarz's classic study probably still represents the most influential empirical evidence bringing the story that money does matter for business cycle fluctuations

- their evidence (almost 100 years of US data) relied heavily on patterns of timing - the causal interpretation in which money *causes* output fluctuation is supported by systematic evidence that money growth changes lead changes in real economic activity

- facing the evidence Friedman and Schwarz conclude *(Monetary History of the United States, pp.676)*:
  - *changes in the behavior of the money stock have been closely associated with changes in economic activity, money income, and prices*
  - *the interrelation between monetary and economic change has been highly stable*
  - *monetary changes have often had an independent origin; they have not been simply a reflection of changes in economic activity*

- next Figure plots the detrended money and real output using the Czech data

Money and Output


Real Output
M1
M2
.12
.08
.04
.00
-.04
-.08
-.12
94
95
96
97
98
99
00
01
02
03
04

- taking $M1$ as a monetary policy measure the conclusion that money leads the business cycle fluctuations seems to be quite plausible

- however, using especially the US post 1970 data the Friedman and Schwarz's evidence has been heavily criticized

- clearly, evidence based on timing patterns and simple correlations may not indicate the *true* causal role of money

- since the central bank and the banking sector respond to economic developments, movements in the monetary aggregates are not exogenous

- the latter is strenghtened by the fact that practicaly central banks implement monetary policy by controlling the short-term market interest rates

- then the money stock will be affected by both policy actions that change interest rates and by developments in the economy not related to policy actions

- if the money stock is used to measure monetary policy, the observed relationship may reflect the impact

of output on money and not the impact of money and monetary policy on output

- Tobin (1970) was the first who modeled formally the idea that the positive correlation between money and output could, in fact, reflect the opposite – *output might be causing money*

- a more modern treatment of this idea is provided by King and Plosser (1982) who shows that the *inside money* component of the monetary aggregate $M1$ is more highly correlated with output than is *outside money*

- King and Plosser interperet this as evidence that much of the money (means $M1$ or $M2$) and output correlation arises from the endogenous response of the banking sector to economic disturbances that are not related to monetary policy actions

- however, at this very stage it is worth to mention that
  - whereas Tobin(1970) arguments went against the use of money as a monetary policy measure
  - hence, in Tobin view money did not matter but monetary policy definitely did, i.e. money was just not the right monetary policy measure

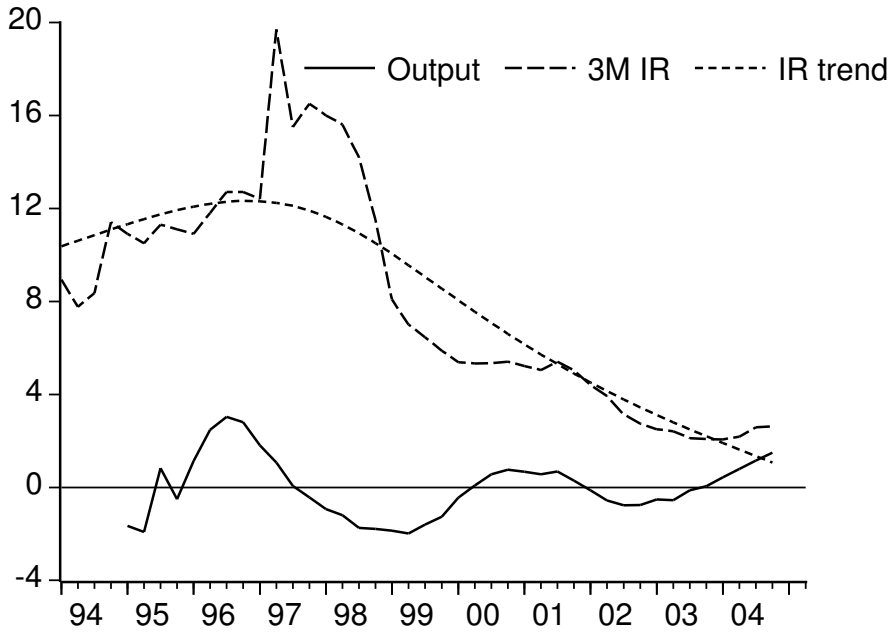
  - King and Plosser(1982) attacked the role of monetary policy for the business fluctuations in general
  - thus, in King a Plosser view money was the right monetary policy measure and as money did not matter so did not monetary policy

- as was mentioned above, the endogeneity problem is likely to be severe if central bank implements its policy employing the short-term interest rates

- changes in the money stock will then be endogenous and can be hardly interpreted as representing policy actions

- next Figure shows the behavior of 3M interest rate and detrended output

Interest Rate and Output


Output
3M IR
IR trend
20
16
12
8
4
0
-4
94
95
96
97
98
99
00
01
02
03
04

- we can iterpret the plotted evidence that interest rate have typically increased above its trend prior to economic downturns

- however, this evidence that monetary policy has caused cyclical fluctuations can not be simply infered from the Figure; the movements in interest rate may simply reflect the CNB's response to the state of economy

- although simple plots and correlations are suggestive, they can not be decisive

- consequently, the time-series analysis has been used since the beginning of 1960s

- one of the earliest time-series econometric attempts to estimate the impact of money was Friedman and Meiselman (1963)
  - their objective was to test the relative importance of monetary and fiscal policy for the output determination
  - they estimated following equation

$$y_t^n \equiv y_t + p_t = y_0^n + \sum_{i=0} a_i A_{t-i} + \sum_{i=0} b_i m_{t-i} + \sum_{i=0} h_i z_{t-i} + u_t$$

where y^n denotes the log of nominal income, A is a measure of autonomous expenditures, and m is a monetary aggregate; z represents other relevant variables

  - and reported finding of a much more stable and significant relationship between output and money than between output and their measure of autonomous expenditures

- the use of similar equations for policy analysis was promoted by a number of economists, especially at the Federal Reserve Bank of St. Louis, so regression of nominal income on money are often called *St. Louis equations*

- Andersen and Jordon (1968) work is worth to mention among others

- as usuall in economics the use of this type of equation generated critical response
  - arising debate emphasized *misspecification* of the equation if the m was endogenous
  - to ilustrate the point assume that the central bank is able to manipulate the money supply to offset almost perfectly all the shocks
  - in this case the y^n would simply reflect the random errors the central bank failed to offset

- and as a result m and y^n might be completely uncorrelated
- moreover, if policy is able to respond to shocks u_t, m_t and u_t will be correlated and an OLS estimation of money on output will be inconsistent
- then the resulting estimate will depend on the manner in which policy has induced a correlation between m_t and u_t

- before we move further there is one key aspect worth to mention regarding the *St. Louis equations* type of econometrics; **the Lucas critique**
  - suppose a question whether St. Louis type regression can be simply used for policy purposes, that is, whether regression of this form can be used to policy design
  - if it can, then the rest fo this course would be really unnecessary, so the answer is NO
  - and Lucas critique is one reason for it
  - Lucas (1976) argues that empirical relationships are unlikely to be invariant to changes in policy regimes, i.e. that estimated coefficents do vary depending on the used monetary policy framework
  - as a consequence, a relationship estimated using the past data is of no use once the monetary

policy starts to behave in a different way and only relatioship that is *policy invariant* is reliable

- the lesson from Lucas critique is that we can not design policy without a theory of how money affects the economy

The VAR Approach

- the VAR means *vector autoregression* and it is nowadays the most used empirical tool for estimating the effect of monetary policy on the economy

- the use of VARs was pioneered by Sims(1972, 1980)

- summary of the VAR literature can be found in Christiano, Eichenbaum and Evans (1999)

- what is the VAR?
  - suppose bivariate system in which y_t is the natural log of real output at time t and x_t is the measure of monetary policy stance such as money stock or market short-term interest rate
  - then the VAR system can be written as

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{pmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{pmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} \quad (1)$$

  - this system is easily estimated using the OLS estimator and represents a system of correlations among variables that are included
  - then the system could be hit by the *shock*, which can be a monetary policy shock and the responses could be calculated

- unfortunately, the estimated u_{yt} and u_{xt} innovations do not represent the "*true*" independently distributed shocks to output and monetary policy and are rather linear combinations of them

$$\begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} = \begin{pmatrix} 1 & \theta \\ \phi & 1 \end{pmatrix} \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \tag{2}$$

- so it is not as easy to proceed as the knowledge of matricies

$$\begin{pmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{pmatrix}, \begin{pmatrix} 1 & \theta \\ \phi & 1 \end{pmatrix}, \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix}^T \tag{3}$$

  is necessary while only the first one is directly known

- to identify the latter two additional restriction must be added

- two basic identification approaches are used
  - first one uses the *contemporaneous* zero restrictions whereas the second one the *long-run* zero restricitons
  - following the first approach (contemporaneous zero restrictions) we simply assume that the monetary policy does influence output only with a lag, so the restriciton $\theta = 0$ is sufficient to *identify* the whole system

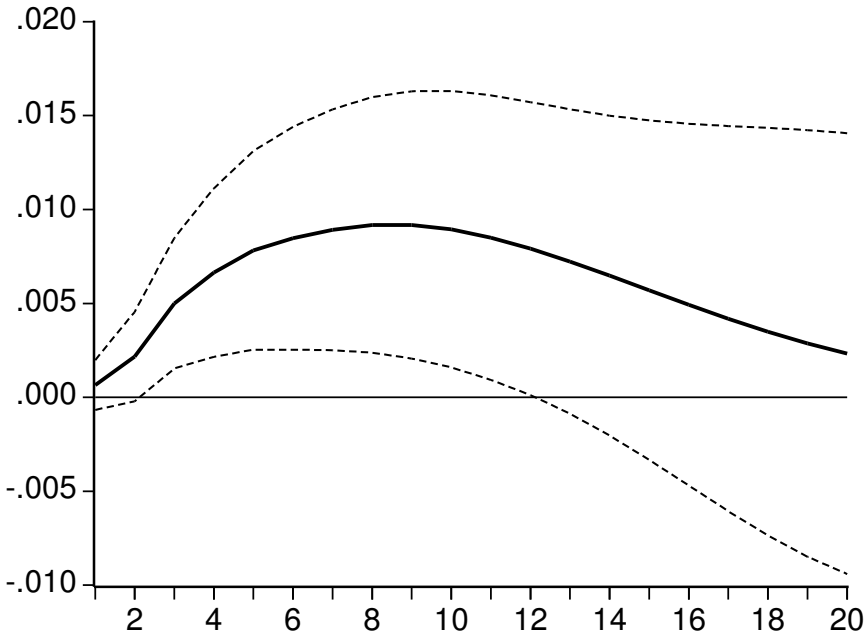
  - alternatively, we can assume that the monetary policy does not respond contemporaneously to the output shocks, i.e. the restriction is $\phi = 0$
  - *for more detailed analysis visit the seminar*

- Sims(1972) originaly used bivariate system where $M1$ was treated as a measure of monetary policy and policy shocks we identified assuming that $\phi = 0$

- this corresponds to the assumption that the monetary policy is predetermined and that policy innovations are exogenous

- an atempt to replicate the Sims(1972) work using the Czech data brings the following results

Sims (1972) VAR and Czech data


.020
.015
.010
.005
.000
-.005
-.010
2
4
6
8
10
12
14
16
18
20

- the figure shows that an expansinary policy shock is followed by an incerase in output that reaches its peak after roughly two years

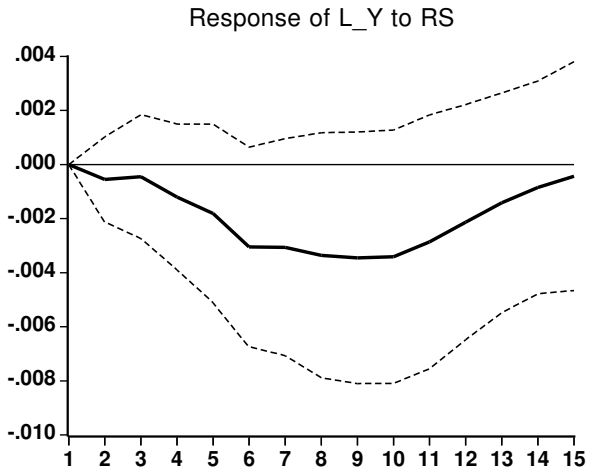
- this result is quite similar to those for developed countries

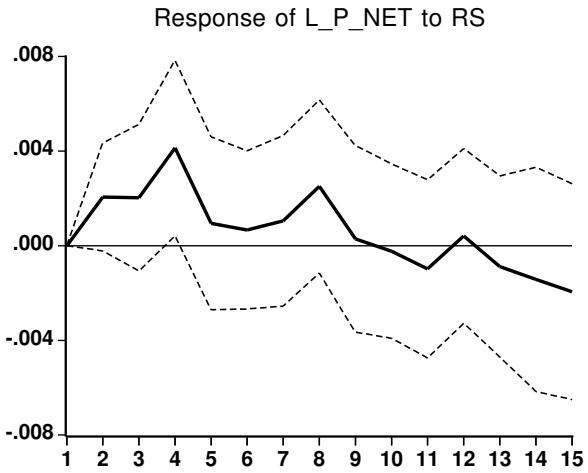
- Sims (1972) original VAR model has been extended substantialy over the time

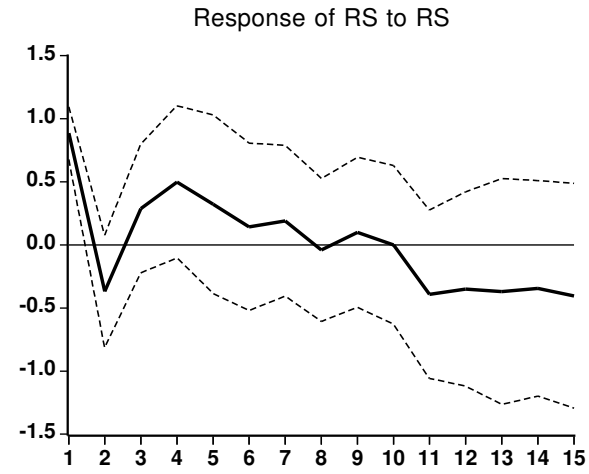
- a *common* VAR model looks as follows
  - ouptut and prices as economy variables
  - money stock measure and interest rate as policy measures
  - exchange rate and commodity prices to capture the openess of the economy and avoid the *price puzzle*, i.e. the counterintuitive reaction of prices to a policy shock

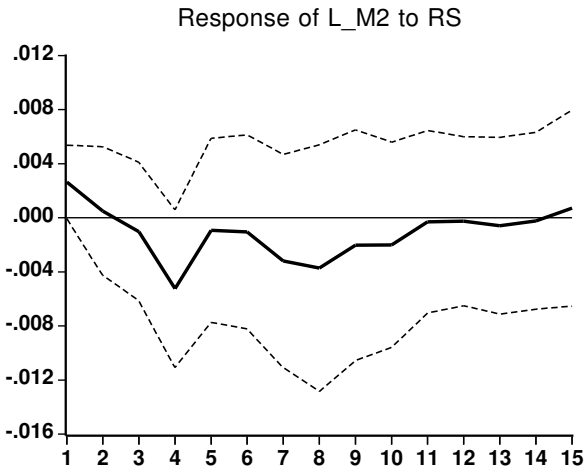
- next figure shows the result for the VAR model estimated using Czech data (Arnostova and Hurnik (2005))

Arnostova and Hurnik VAR model (2005)


Response of L_Y to RS
.004
.002
.000
-.002
-.004
-.006
-.008
-.010
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15


Response of L_P_NET to RS
.008
.004
.000
-.004
-.008
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15


Response of RS to RS
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15


Response of L_M2 to RS
.012
.008
.004
.000
-.004
-.008
-.012
-.016
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

- the results
  - are standard in respect to the output response
  - however, significant price puzzle is present
- as everything in economics also the VARs have been criticized on several grounds
  - first and as you can see, some of the responses do not accord with most economists' priors
  - second, the residuals from the VAR regressions that are used to represent exogenous policy shocks often bear little resemblance to standard interpretations of past policy actions
  - third, the VAR models cover the policy shocks only and say nothing about the systematic policy and the response of the economy to it

The Evidence of Romer and Romer: the "narrative" approach

- *narrative* approach develops a measure of the stance of monetary policy from direct examination of the policy record

- this approach was taken by Romer and Romer (1989) paper: *Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwarz*

- Romer and Romer used the Fed's "Record of Policy Actions" and minutes of FOMC meetings to identify episodes in which policy was designed to reduce inflation

- for US they found six different months during the postwar period that saw such contractionary shifts in Fed policy: October 1947, September 1955, December 1968, April 1974, August 1978, and October 1979

- Romer and Romer argue that their approach provides a better measure of the net stance of policy and helps to solve the endogeneity problem
  - it enables to distinguish between the *intention* of the monetary policy to disinflate (or inflate) and the policy *response*

- *"... our discussion of particular episodes makes it clear that our central concern has been with the intentions rather than the actions of the Federal reserve. We do this because the same actions can occur both independently of the real economy and in response to real events"* (Romer and Romer, 1989, pp.21)

- and they conclude
  - *a shift to anti–inflationary policy led, on average, to an ultimate reduction in industrial production of 12 percent and an ultimate rise in the unemployment rate of two percentage points*
  - *the maximum depressing effect ... occurs after roughly two and half years ... the real effects of demand disturbances appear to be highly persistent* (Romer and Romer, 1989, pp.36)

- Romer and Romer extended further the analysis in their (2003) paper: *A New Measure of Monetary Shocks: Derivation and Implications*

Summary

- the consensus from the empirical literature on the *long-run relationship* between money, prices and output is clear
  - money growth and inflation essentially display a correlation of 1
  - the correlation between the money growth (or inflation) and real output is probabbly close to 0
  - although it may be slightly positive at low inflation rates and negative at high rates
- the consensus from the empirical literature on the *short-run effects* of money is that
  - monetary policy shocks produce hump-shaped movements in real output
  - output response reaches its peak after a lag of several quarters (two or three years) and then dies out
  - the exact manner in which policy is measured is critical
- there is less consensus on the role played by the systematic feedback responses of monetary policy
- nevertheless, the latter is in fact a major theme of all the comming lectures