Advanced Monetary Economics

Lecture 8

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What we have learned so far

- Monetary policy sets the short-term nominal interest rate (or the money supply).
- Changes in the short-term nominal interest rate (or money supply) lead to changes in the mid- and long-term interest rate via the yield curve.
- Changes in interest rates (or money supply) effect the economy through different transmission mechanisms.
- One of these channels is the interest-rate channel.

Aim of this class

- In the following lectures we study theoretical models for money supply and the interest-rate channel.

- We want to use the model to answer the question: what is the effect of monetary policy on the economy?

- Starting point: How to model the household and firm sector under the assumption of flexible prices.

- Now: How to model monetary policy and determine its effects on the economy.

1 Monetary policy

- What does monetary policy? It sets the short-run interest rate:

$$i_t = \rho + \phi\pi_t + \nu_t$$

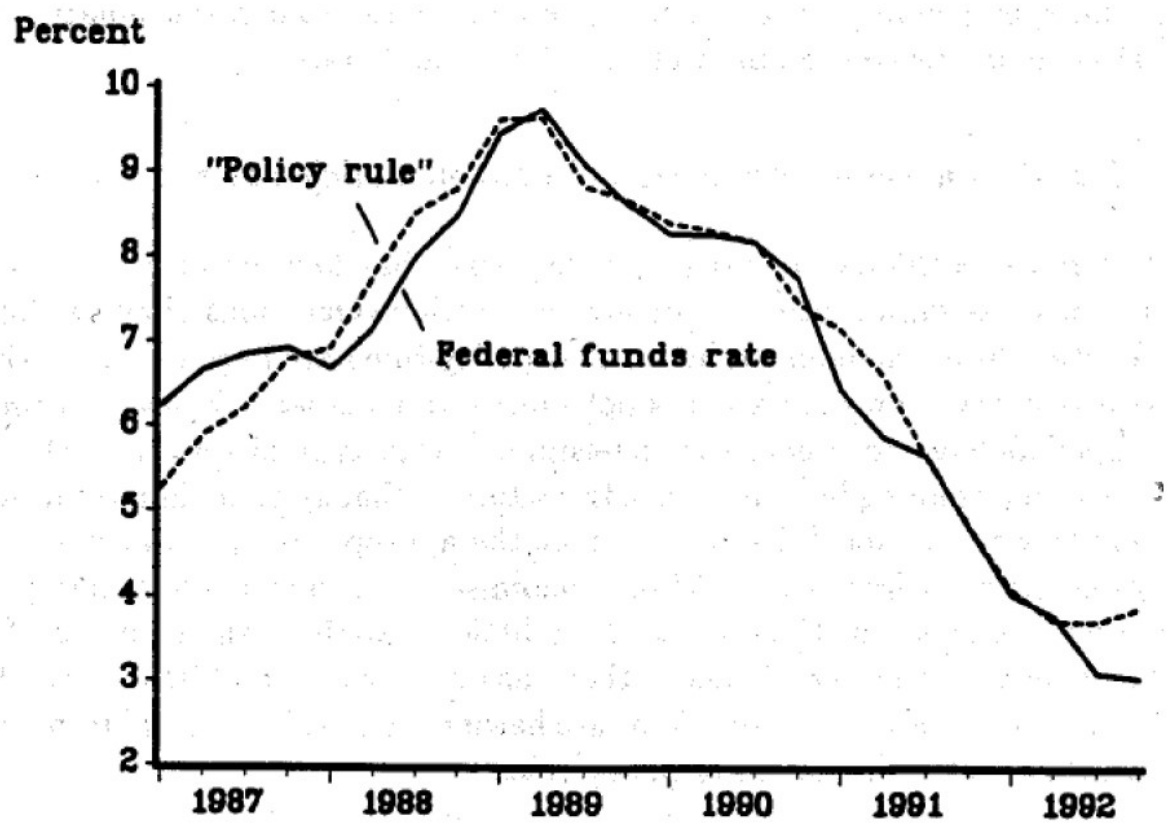
- Systematic component: $\rho + \phi\pi_t$

- ν_t is an exogenous variation – the monetary policy shock.

- This rule is named a Taylor rule, after John Taylor (1993). He showed that the behavior of the Federal funds rate (i_t) is described well by a simple rule, which prescribes adjustment in i_t in response to inflation (π_t) and the output gap (y_t):

$$i_t = 0.04 + 1.5(\pi_t - 0.02) + 0.5y_t.$$

- Policy rule and Federal funds rate



- Reminder: The real part of the economy contains 3 endogenous variable y_t, n_t, r_t, 3 equations and one exogenous variable a_t.

$$
\begin{aligned}
\sigma y_t + \varphi n_t &= a_t - \alpha n_t + \log(1-\alpha) \\
y_t &= E_t[y_{t+1}] - \frac{1}{\sigma}(r_t + \rho) \\
y_t &= a_t + (1-\alpha) n_t.
\end{aligned}
$$

- To the system of equations, we add monetary policy.

- We add two new variables: the nominal interest rate i_t and inflation π_t.

- We add two new equations: a Taylor rule and a definition of the real interest rate.

- We add one new shock: the monetary policy shock ν_t.

- This yields the classical monetary model

$$
\begin{aligned}
\sigma y_t + \varphi n_t &= a_t - \alpha n_t + \log(1-\alpha) \\
y_t &= E_t[y_{t+1}] - \frac{1}{\sigma}(r_t + \rho) \\
y_t &= a_t + (1-\alpha) n_t \\
i_t &= \rho + \phi \pi_t + \nu_t \\
r_t &= i_t - E_t \pi_{t+1}
\end{aligned}
$$

- Endogenous variables: output y_t, hours worked n_t, the real interest rate r_t, inflation π_t and the nominal interest rate i_t.

- Exogenous variables: technology a_t and monetary policy shock ν_t.

2 Solution of the model

- **Endogenous variables:** The solution of the model is a solution for the endogenous variables.

- Endogenous variables are variables, which are determined in the model – loosely speaking you have an equation for the variable.

- We collect our endogenous variables in one vector x_t:

$$x_t = \begin{bmatrix} y_t \\ n_t \\ r_t \\ \pi_t \\ i_t \end{bmatrix}.$$

- **Exogenous variables:** They are determined 'outside' the model.

- They can be random realizations from a probability distribution.

- In this model the exogenous variables are:

  1. Monetary policy shock ν_t
  2. Technology shock a_t

- We collect the exogenous variables in a vector ε_t:

$$\varepsilon_t = \begin{bmatrix} a_t \\ \nu_t \end{bmatrix}.$$

- **Solution of the model:** We want to find a solution for the endogenous variables x_t

$$x_t = F x_{t-1} + G \varepsilon_t$$

  as a function of

- their past realizations to capture dynamics x_{t-1}
- the exogenous variables ε_t to study the effects of technology and policy innovations
- the parameters of the model (these determine the values in the matrices F and G)

- Dynare solves for the matrices F and G.

- **Uniqueness of the solution:** The solution to the system might not be unique - there can be many sequences for x_t consistent with the equilibrium conditions.

- Monetary policy can determine uniqueness (only one sequence x_t) using the systematic component of the interest-rate rule:

$$i_t = \rho + \phi\pi_t + \nu_t.$$

- If $\phi > 1$ the solution is unique.

- In other words: the central bank should respond more than one-for-one to changes in inflation.

3 The effects of monetary policy

3.1 Impulse response functions

- Impulse response functions represent the response of the endogenous variables x_t to an impulse in one exogenous variable ε_t.

- The responses are changes of the endogenous variables.

- In our case, we are considering responses to two stochastic sources (impulses):

  1. monetary policy shock ν_t
  2. technology shock a_t

- As an example, we compute the impulse response functions to the following model:

$$x_t = F x_{t-1} + G \varepsilon_t$$

with

$$\varepsilon_t \sim \mathcal{N}\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \mathbf{\Sigma}_\varepsilon \right)$$

and

$$x_t = [\pi_t, y_t]'.$$

- Typically, we have that $\mathbf{\Sigma}_\varepsilon$ has only non-zero entries on the main diagonal. There is no correlation between the shocks.

- Let us assume numbers and calculate the impulse response functions.

- The complete F

$$F = \begin{bmatrix} 0.9 & -0.1 \\ 0.5 & 0.3 \end{bmatrix}$$

- The complete G

$$G = \begin{bmatrix} 1.2 & -0.1 \\ -0.5 & 0.7 \end{bmatrix}$$

- The complete $\mathbf{\Sigma}_\varepsilon$

$$\mathbf{\Sigma}_\varepsilon = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}$$

- We assume: $v_1 = 1, a_1 = 0, \pi_0 = 0, y_0 = 0$.

- Period 1: $\pi_1 = 0.9\pi_0 - 0.1y_0 + 1.2v_1 = 1.2$.

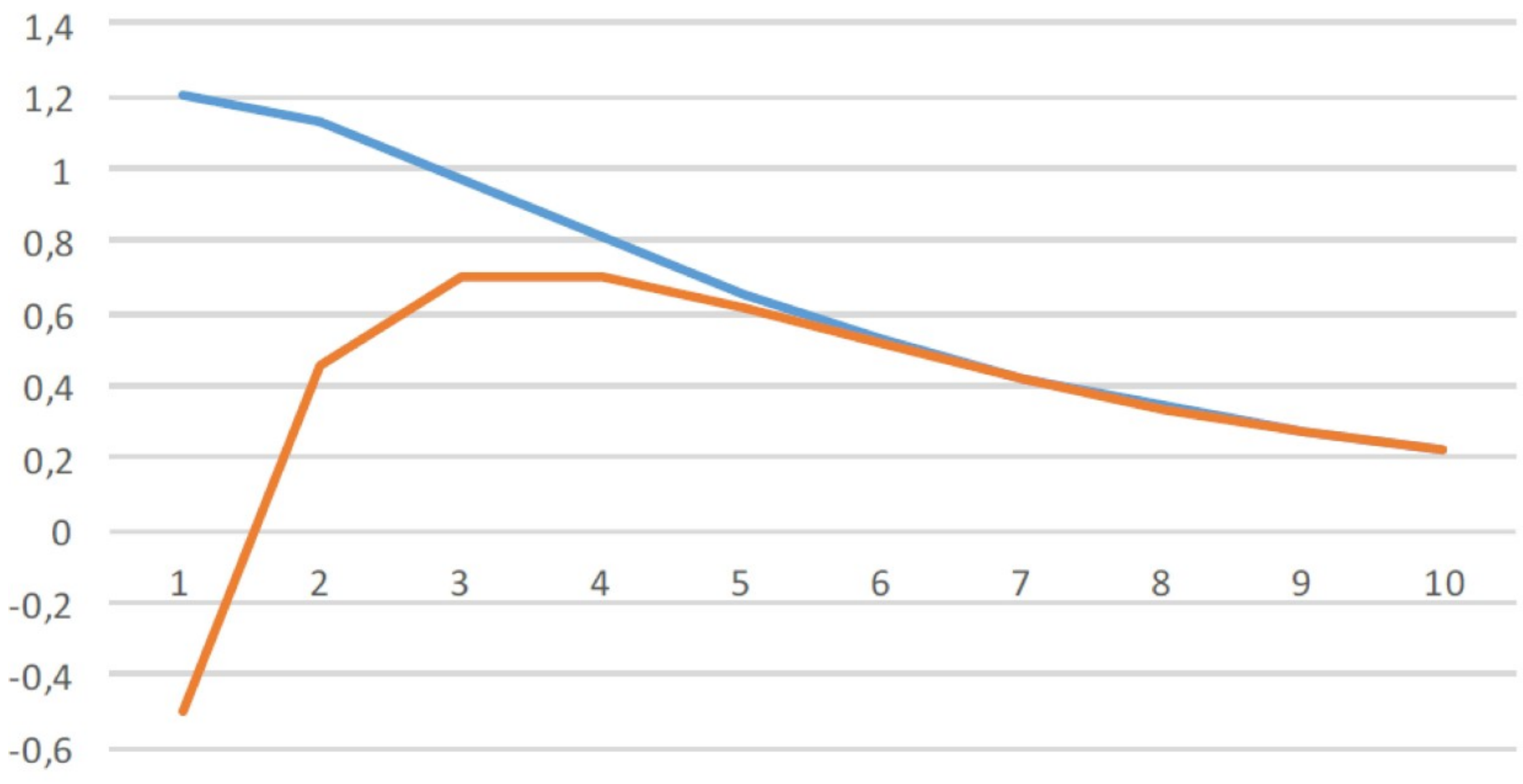
- Period 1: $y_1 = 0.5\pi_0 + 0.3y_0 - 0.5v_1 = -0.5$.

- Period 2: $\pi_2 = 0.9\pi_1 - 0.1y_1 = 1.13$.

- Period 2: $y_2 = 0.5\pi_0 + 0.3y_1 = 0.45$.

- and so on...

- Graphical representation of responses of π_t (blue line) and y_t (orange line) for $t = 10$ periods



- You have learned how to compute an impulse response function by hand.

- Fortunately, this is not necessary every time.

- Dynare computes the impulse response functions for you.

3.2 Calibration of the parameters

- Parameters in the model determine the behavior of households, firms and monetary policy, e.g.:
  - how important are future periods,
  - how sensitive is the labor supply to a change in wages,
  - how much does the nominal interest rate change after a change in inflation

- We have to pick numbers to quantify the behavior.

- from labor demand $1 - \alpha = \frac{(W/P)N}{Y} = 3/4 \rightarrow \alpha = 1/4$: average labor income share in quarterly data

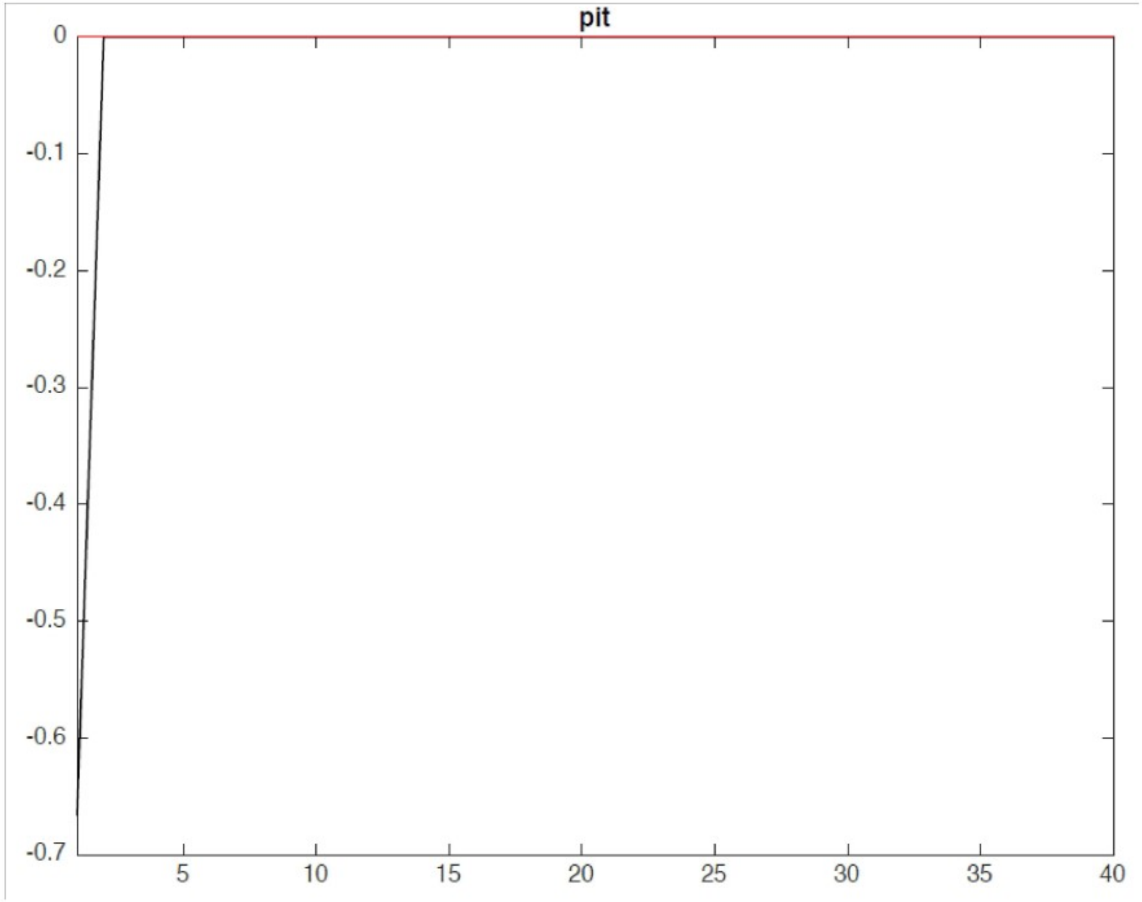
- from estimates: $\sigma \in [0.5, 5] \rightarrow \sigma = 1$ (log utility)

- from estimates: $\varphi^{-1} \in [0, 0.5] \rightarrow \varphi = 5$, usually set to hit $N = 1/3$ (average share of time for labor)

- from annual average real interest rate: $\beta = \exp(-i)\,; i = 0.0404/4 \rightarrow \beta = 0.99$. Note that inflation is zero in this equilibrium.

- from estimates and the Taylor principle: $\phi = 1.5$.

- Impulse response functions of our model



- In the classical monetary model with flexible prices classical dichotomy holds!

- After a surprise increase in monetary policy (i.e. the nominal interest rate): Inflation decreases $\longrightarrow$ real interest rates do not change.

- The real economy is not affected.

Summary

- Our question today and the following lectures: what is the effect of monetary policy?

- Classical monetary model without price stickiness or money demand: classical dichotomy $\longrightarrow$ monetary policy does not effect the real part of the economy.

- Let's model money demand or sticky prices in the following lectures.