

6. The New Keynesian Model

6.1 The Baseline Model

Basic Concepts of the New Keynesian Model

Markets are imperfect:

- Price and wage adjustments: contract duration, adjustment costs, imperfect expectations
- Market structure: monopolistic competition / mark up of prices above marginal cost
- Capital markets: credit restrictions
- Information asymmetries / information costs

Methodology

- Microeconomic foundation
- Intertemporal optimization
- Rational expectations
- From this: stochastic dynamic equilibrium models



Analogy to the RBC-theory, sometimes even called
„New neoclassical synthesis“

Results

- Market imperfections are quantitatively important!
- Even small rigidities on the micro level can have big effects on the macro level.
- Monetary impulses have effects on the business cycle.
- Monetary policy is probably more relevant for the business cycle than technology shocks (However, not every economist would agree here!).
- In the long run, there hold the same conditions as in the RBC model. In particular, monetary shocks are neutral with respect to the real economy in the long run.

Most Important Assumptions of the Baseline Model

1. Monopolistic competition at the commodity markets.
Mark up of prices above marginal cost for firms, welfare maximizing output level will not be reached.
2. Rigidities in the price setting behaviour of the firms.
Firms are not able or do not want to adjust prices immediately after shocks (nominal rigidity).

These assumptions lead to the result that monetary policy has real effects in the short run (and even in the medium term).

Empirical Evidence for Price Rigidities: Studies on the Micro Level

- Empirically: prices adjust slowly (for example ECB Inflation Persistence Network www.ecb.int/home/html/researcher_ipn.en.html).
- On average, 15 % of the firms change their prices in the euro area per month. The average duration is about 13 months.
- In the USA, prices seem to change more frequently. About 25 % of the companies change their prices per month (duration: 7 month).

	Unprocessed Food	Energy (Oil Products)	Industrial Goods	Services	Overall
Euro Zone	28.3	78.0	9.2	5.6	15.1
USA	47.7	74.1	22.4	15.0	24.8

Source: Dhyne et al. (2005)

Modeling Price Rigidities: The Calvo Model (See also Section „Incomplete Nominal Adjustment“)

- Staggered price adjustment (Calvo, 1983): at every point in time a company adjusts its prices with a probability of $1-\theta$ („lottery“).
- Time of adjustment is independent of the behaviour of the other companies, independent of the point of time of the last price change and independent of the difference between the price of the previous period and the profit maximizing price.
- On the macro level: in each period a share of $1-\theta$ of the prices remains unchanged, while the other θ prices are adjusted. The aggregated price level follows approximately the differential equation

$$p_t = \theta p_{t-1} + (1 - \theta) p_t^*$$

- Where p_t^* is the price, which is optimal in period t . Because of the assumption of identical firms and identical demand structures this price is equal for all firms.

New Keynesian Baseline Model

- Gali (2008) “Monetary Policy, Inflation, and the Business cycle”, Princeton University Press.
- Central model equations – similar to the RBC-Model – are defined as deviations from the steady state:

1. a macroeconomic demand curve, which depends on the real interest rate (IS curve):

$$x_t = \frac{1}{\sigma} (i_t - E_t[\pi_{t+1}] - r_t^n) + E_t[x_{t+1}]$$

2. a Phillips curve:

$$\pi_t = \beta E_t[\pi_{t+1}] + \kappa x_t + u_t$$

3. a monetary policy rule:

$$i_t = \varphi_\pi \pi_t + \varphi_x x_t + v_t$$

1. IS Curve

$$x_t = \frac{1}{\sigma} (i_t - E_t[\pi_{t+1}] - r_t^n) + E_t[x_{t+1}]$$

- The IS curve reflects the utility maximizing consumption and saving decision of the households (Euler equation).
- It describes the output gap x_t , defined as the percent deviation of the macroeconomic production from the “natural” (steady state) output level, as function
 - of the deviation of the expected real interest rate $i_t - E_t[\pi_{t+1}]$ from the „natural“ real interest rate r_t^n ,
 - and of the expected future output gap $E_t[x_{t+1}]$.

σ : measure for the level of the absolute risk aversion.

$1/\sigma$: intertemporal elasticity of substitution.

2. Phillips Curve

- New Keynesian Phillips curve:

$$\pi_t = \beta E_t[\pi_{t+1}] + \kappa x_t + u_t$$

- The inflation rate is determined by
 - the inflation expectations $E_t[\pi_{t+1}]$: firms, that can change their prices in period t , take into account expected future price changes, as they possibly are not allowed to adjust next period (and thereafter),
 - the output gap x_t : measure of demand nad/or marginal cost,
 - the supply shock u_t : e.g. an oil price shock.

3. Monetary Policy Rule (1)

- In the past: money stock targeting (Bundesbank, LM curve).
- Today: inflation targeting / inflation expectations targeting (ECB: medium term inflation target close to but below 2 %).
- Central bank (CB) aims at controlling the real interest rate.
- In reality, the CB can only control the short-term nominal interest rate (overnight money market rate – unless the money market is in turmoil), but it can control the real interest rates indirectly as long as it is able to anticipate the effects of its policy on the inflation rate.
- Formalized by using the Taylor rule (central bank reaction function)

$$i_t = \varphi_\pi \pi_t + \varphi_x x_t + v_t \quad .$$

3. Monetary Policy Rule (2)

$$i_t = \varphi_\pi \pi_t + \varphi_x x_t + v_t$$

- The central bank reacts to
 - deviations of the inflation rate π_t from the steady state, which corresponds to the inflation target of the central bank,
 - Deviations of production from steady state (=output gap x_t), as such a situation leads to price adjustments away from the inflation target.
- In addition, there exists an unsystematic interest rate setting behaviour of the central bank (cannot be explained by variables): monetary policy shock v_t .
- Possible reasons for monetary policy shocks:
 - mistakes of the central bank (e.g. when estimating the output gap),
 - internal differences in opinion (monetary hawks vs. monetary doves, e.g. Weber vs. Trichet),
 - extraordinary circumstances (e.g. oil price shocks, financial crises),
 - better informed than the public.

6.2 Solution of a New Keynesian Model Using Dynare

Dynare Code (1)

```
File Edit Text Cell Tools Debug Desktop Window Help
[Icons] Stack: Base
1 // New Keynesian Model
2
3 // Define variables
4 var x pi i r rbar ybar y n c wp mcr mu v a g;
5 varexo ev ea eg;
6
7 // Define model parameters
8 parameters rho v rho a rho g sigma phi beta theta lambda kappa gamma_pi gamma_x epsilon mue;
9 rho_v = 0.5;
10 rho_a = 0.9;
11 rho_g = 0.9;
12 sigma = 1;
13 phi = 1;
14 beta = 0.99;
15 theta = 0.01;
16 lambda = (1-theta)*(1-beta*theta)/theta;
17 kappa = lambda*(sigma+phi);
18 gamma_pi = 1.5;
19 gamma_x = 0.5/4;
20 epsilon = 6;
21 mue = log(epsilon/(epsilon-1));
22
```

Calibration →

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Dynare Code (2)

```

File Edit Text Cell Tools Debug Desktop Window Help
[Icons] Stack: Base
22
23 // Define model equations
24 // Budget constraints  $w*1+(r+1-\delta)*k(-1)=c+t+k$ ; are neglected, as the model is collinear;
25  $x = -(1/\sigma)*(i-\pi(+1)-\bar{r}) + x(+1);$  // New Keynesian IS curve
26  $\pi = \beta\pi(+1) + \kappa x;$  //New Keynesian Phillips curve
27  $i = \gamma_{\pi}\pi + \gamma_x x + v;$  //interest rate rule
28  $r = i - \pi(+1);$  //real rate
29  $\bar{r} = -\sigma*((1+\phi)/(\phi+\sigma))*(1-\rho_a)*a + \sigma*(\phi/(\phi+\sigma))*(1-\rho_g)*g;$  //natural real rate
30  $\bar{y} = ((1+\phi)/(\phi+\sigma))*a + (\sigma/(\phi+\sigma))*g;$  //flex price (natural) output
31  $y = x + \bar{y};$  //sticky price output
32  $y = n + a;$  //production function
33  $y = c + g;$  //goods market clearing
34  $w\pi = \phi*n + \sigma*c;$  //substitution between consumption and labor
35  $mcr = w\pi - a;$  //real marginal costs
36  $\mu = a - w\pi;$  //distortion
37  $v = \rho_v*v(-1)+e_v;$  //monetary policy shock
38  $g = \rho_g*g(-1)+e_g;$  //government shock
39  $a = \rho_a*a(-1)+e_a;$  //technology shock
40 end;
41
42 // Variances of the shocks
43 shocks;
44 var  $e_v = 0.0625;$ 
45 var  $e_g = 0.5;$ 
46 var  $e_a = 1;$ 
47 end;
48
49 check;

```

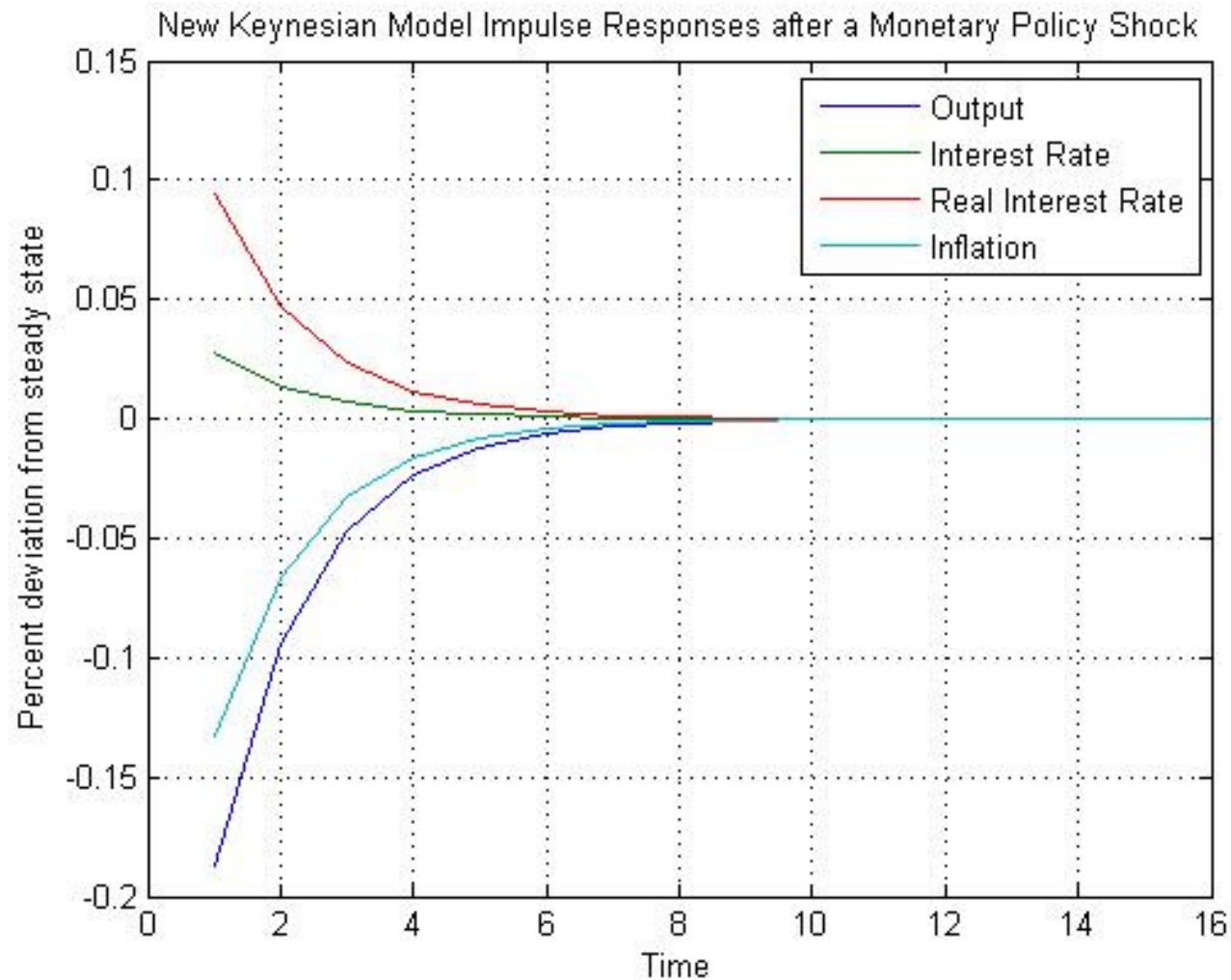
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Dynare Code (3)

```
File Edit Text Cell Tools Debug Desktop Window Help
[Icons] Stack: Base
50
51 // Impulse response functions and simulation of the moments
52 stoch_simul(irf=16,periods=5000,order=1,nograph);
53 T=0:15;
54
55 // Impulse responses after a monetary policy shock
56 IAF1=[y_ev i_ev r_ev pi_ev ];
57 figure;
58 plot(IAF1);
59 grid on;
60 xlabel('Time');
61 ylabel('Percent deviation from steady state','FontSize',10);
62 title('New Keynesian Model Impulse Responses after a Monetary Policy Shock','FontSize',10);
63 legend('Output','Interest Rate','Real Interest Rate','Inflation');
64
65
66 // Impulse responses after a government spending shock
67 IAF1=[y_eg i_eg r_eg pi_eg ];
68 figure;
69 plot(IAF1);
70 grid on;
71 xlabel('Time');
72 ylabel('Percent deviation from steady state','FontSize',10);
73 title('New Keynesian Model Impulse Responses after Government Spending Shock','FontSize',10);
74 legend('Output','Interest Rate','Real Interest Rate','Inflation');
75
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```

(1) Impulse Response Functions after a Contractionary Monetary Policy Shock

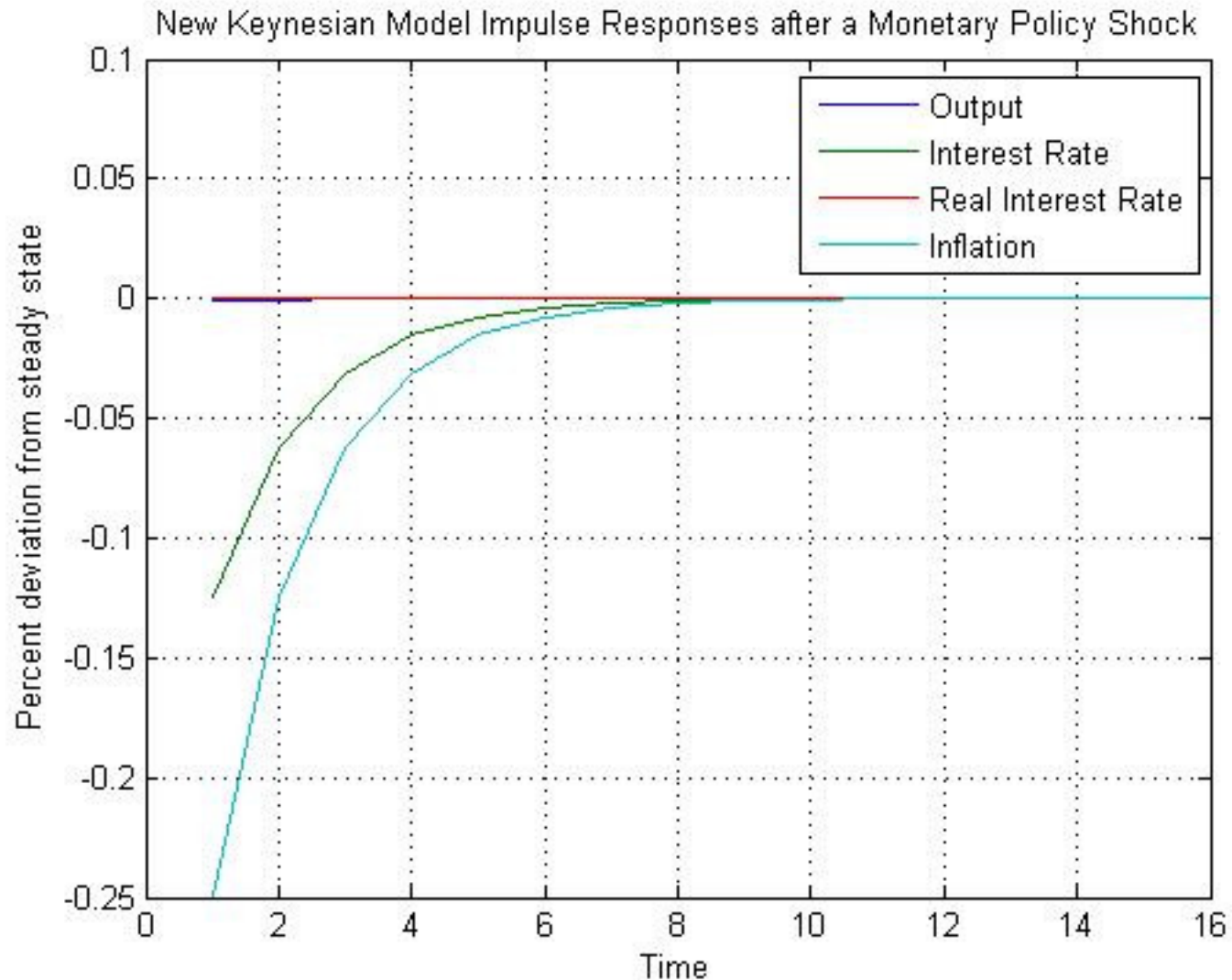
Impulse Response Functions for the Model with Price Rigidities ($\theta=0.66$) (1)



Impulse Response Functions for the Model with Price Rigidities ($\theta=0.66$) (2)

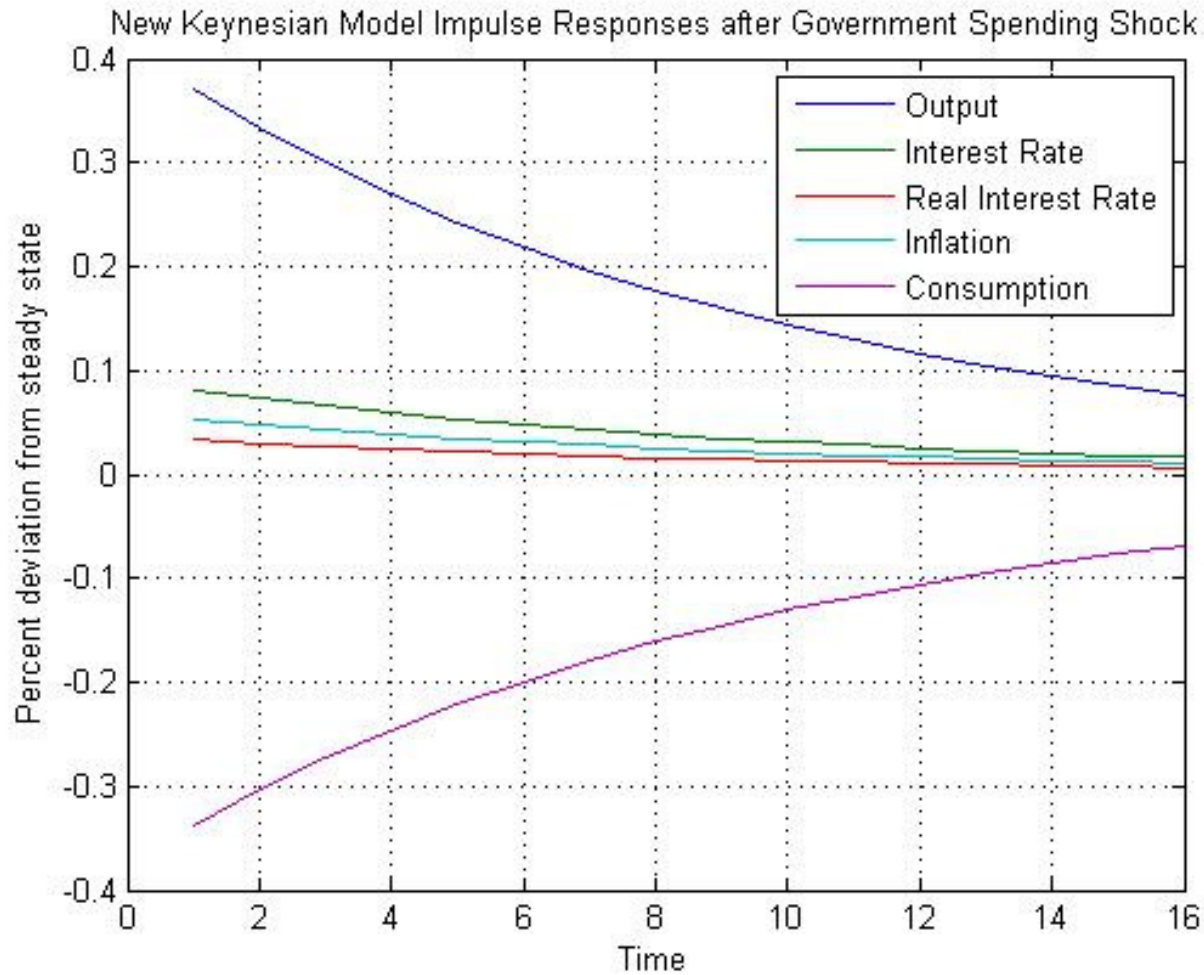
- In the first place, the restrictive monetary policy shock has some positive direct effect on the level of the interest rate.
- As there exist price rigidities, the increase in the interest rate concurrently shifts up the real interest rate, thereby decreasing demand and consequently decreasing the level of output of the economy.
- The decline in the level of output puts pressure on the price level. Inflation decreases over time (see Phillips curve).
- As inflation decreases and affects the policy decisions of the central bank contemporarily (see Taylor rule), there is some negative feedback effect on the interest rate. However: This negative feedback effect does not offset the concurrent increasing effect of the restrictive monetary policy shock.

Impulse Response Functions for the Model without Price Rigidities ($\theta=0.01$)



(2) Impulse Response Functions after a Positive Government Expenditure Shock

Impulse Response Functions for the Model with Price Rigidities ($\theta=0.66$) (1)



Impulse Response Functions for the Model with Price Rigidities ($\theta=0.66$) (2)

- Although a positive government spending shock decreases private demand (see RBC model, Section 4.3), overall demand (private and public demand) will increase.
- Given prices, the firms are able to satisfy this additional demand and widen output. This leads to a positive output gap. The stronger the nominal rigidities, the larger the output gap.
- Nonetheless, from the firms point of view, it is optimal to react to the higher demand by raising prices (if allowed). This leads to an upward shift in the level of inflation (see Phillips curve).
- The central bank realizes the increase in the output gap and the rising inflation and tries to eliminate some of the additional demand induced. The result is a higher interest rate (see Taylor rule).

Impulse Response Functions for the Model without Price Rigidities ($\theta=0.01$)

