Monetary Policy

(Advanced Monetary Economics)

ECON 4325

Nina Larsson Midthjell - Lecture 7 - 11 March 2016

Outline

- Equilibrium Dynamics in the NKM (Gali ch.3 4.1. Section 3.4.2 can be dropped)
  - Introducing an interest rate rule for monetary policy
  - What are the effects of shocks under an interest rate rule?
  - Learning a new method: The method of undetermined coefficients

- Monetary Policy in the NKM (Gali ch.4.1 and 4.2)
  - The choice of households and firms in the basic NKM
  - The efficient allocation
  - Inefficiencies in the basic New Keynesian Model
    - Monopolistic competition
    - Sticky prices x 2!
  - What is optimal monetary policy within this framework?

The step from equation (1)* to equation (1), i.e. including the steady state level of output, was added in the 2015 version of the book, as a clarification.

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy 1/9

- Note: Section 3.4.2 in Galí, discussing equilibrium under exogenous money supply will <u>not</u> be considered in the course.

- We will now analyze equilibrium dynamics given the following rule for monetary policy:

$$i_t = \rho + \phi_\pi \pi_t + \phi_y \hat{y}_t + v_t, \qquad \phi_\pi, \phi_y > 0 \qquad (1)^*$$

where $\hat{y}_t = y_t - y$, and $y =$ the steady state value of output.

- Equation (1) can be rewritten in terms of the output gap:

$$i_t = \rho + \phi_\pi \pi_t + \phi_y \tilde{y}_t + \phi_y \hat{y}_t^n + v_t, \quad \phi_\pi, \phi_y > 0 \qquad (1)$$

where $\hat{y}_t^n = y_t^n - y$, i.e. the deviation between the natural level of output and the steady state level of output

Including the steady state level of output, y, was added in the 2015 version of the book as a clarification.

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy 2/9

- What is the difference between $\hat{y}_t = y_t - y$ and $\hat{y}_t^n = y_t^n - y$ and $\tilde{y}_t = y_t - y_t^n$?

- Interpretation of equation (1): $i_t = \rho + \phi_\pi \pi_t + \phi_y \tilde{y}_t + \phi_y \hat{y}_t^n + v_t$,

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy 3/9

- Together with the NKPC and the DIS, we now have the three key equations (the equilibrium equations) of the NKM:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa \tilde{y}_t \qquad (2) \qquad (25)$$

$$\tilde{y}_t = E_t\{\tilde{y}_{t+1}\} - \frac{1}{\sigma}\left(\underbrace{i_t - E_t\{\pi_{t+1}\}}_{r_t} - r_t^{natural} \right) \qquad (3) \qquad (28)$$

$$i_t = \rho + \phi_\pi \pi_t + \phi_y \tilde{y}_t + \phi_y \hat{y}_t^n + v_t, \qquad (1)$$

- We combine them into a system of difference equations to study how they interact.

- How to proceed:

1. First we insert for eq. (2) in eq. (1) and then in equation (3)
2. Then we solve for the output gap
3. Inserting for the output gap into the NKPC yields a solution for inflation

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy 4/9

- Give it a go!

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy 5/9

- Give it a go!

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy 6/9

- Give it a go!

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy

- Solutions for output gap and inflation when defining $\hat{r}_t^n \equiv r_t^{natural} -: \rho$

$$(4) \quad \tilde{y}_t = \frac{\sigma}{\sigma + \phi_y + \phi_\pi \kappa} E_t\{\tilde{y}_{t+1}\} + \frac{1 - \beta\phi_\pi}{\sigma + \phi_y + \phi_\pi \kappa} E_t\{\pi_{t+1}\} + \frac{1}{\sigma + \phi_y + \phi_\pi \kappa}\left(\hat{r}_t^n - \phi_y \hat{y}_t^n - v_t\right)$$

$$(5) \quad \pi_t = \frac{\sigma\kappa}{\sigma + \phi_y + \phi_\pi \kappa} E_t\{\tilde{y}_{t+1}\} + \frac{\kappa + \beta(\sigma + \phi_y)}{\sigma + \phi_y + \phi_\pi \kappa} E_t\{\pi_{t+1}\} + \frac{\kappa}{\sigma + \phi_y + \phi_\pi \kappa}\left(\hat{r}_t^n - \phi_y \hat{y}_t^n - v_t\right)$$

This can be written as the following system of difference equations:

$$\Rightarrow \begin{bmatrix} \tilde{y}_t \\ \pi_t \end{bmatrix} = \underbrace{\Gamma \begin{bmatrix} \sigma & 1 - \beta\phi_\pi \\ \sigma\kappa & \kappa + \beta(\sigma + \phi_y) \end{bmatrix}}_{\mathrm{A}_T} \begin{bmatrix} E_t\{\tilde{y}_{t+1}\} \\ E_t\{\pi_{t+1}\} \end{bmatrix} + \underbrace{\Gamma \begin{bmatrix} 1 \\ \kappa \end{bmatrix}}_{\mathrm{B}_T} \left[\underbrace{\hat{r}_t^n - \hat{y}_t^n - v_t}_{u_t} \right] \qquad (6)$$

where: $\Gamma = \dfrac{1}{\sigma + \phi_y + \phi_\pi \kappa}$

The solution for u(t) follows from the solution for the natural interest rate from equation (27) at lecture 5, which is the same as the one found at lecture 3, and from the definitions below.

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy 8/9

- Interpretation of equation (6):

$$\begin{bmatrix} \tilde{y}_t \\ \pi_t \end{bmatrix} = \mathrm{A}_T \begin{bmatrix} E_t\{\tilde{y}_{t+1}\} \\ E_t\{\pi_{t+1}\} \end{bmatrix} + \mathrm{B}_T \left[\hat{r}_t^{natural} - \phi_y \hat{y}_t^n - v_t \right] = \mathrm{A}_T \begin{bmatrix} E_t\{\tilde{y}_{t+1}\} \\ E_t\{\pi_{t+1}\} \end{bmatrix} + \mathrm{B}_T u_t$$

- Note that: $$u_t \equiv \hat{r}_t^{natural} - \phi_y \hat{y}_t^n - v_t = -\psi_{ya}\left(\phi_y + \sigma(1-\rho_a)\right)a_t + (1-\rho_z)z_t - v_t \qquad (7)$$

- How to find u_t ?

- Recall that $y_t^{natural} = \psi_{ya} a_t + \xi_y^n$ as discussed at lecture 5 (slide 25) is the deviation from steady state.

- Redefining level natural output yields: $y_t^n = y^* + \psi_{ya} a_t + \xi_y^n$, where $y = y^* + \xi_y^n < y^*$ is the reachable steady state given the state of the economy $(\mu \neq 0, \alpha \neq 0)$.

- Given this information, inserting from the natural interest rate and the natural output level in equation (7) yields the solution for u_t .

Equilibrium Dynamics in the NKM

Introducing an interest rate rule for monetary policy 9/9

$$u_t \equiv \hat{r}_t^{natural} - \phi_y \hat{y}_t^n - v_t = -\psi_{ya}\left(\phi_y + \sigma(1-\rho_a)\right)a_t + (1-\rho_z)z_t - v_t \qquad (7)$$

- 3 shock possibilities in this model (however, we could easily have extended to more shocks and will do so later at the seminars)
  - A technology shock
  - A discount rate (preference) shock
  - A monetary policy shock

Will eq. (6) have a unique solution?

$$\begin{bmatrix} \tilde{y}_t \\ \pi_t \end{bmatrix} = \mathrm{A}_T \begin{bmatrix} E_t\{\tilde{y}_{t+1}\} \\ E_t\{\pi_{t+1}\} \end{bmatrix} + \mathrm{B}_T\left[\hat{r}_t^{natural} - \phi_y \hat{y}_t^n - v_t\right] = \mathrm{A}_T \begin{bmatrix} E_t\{\tilde{y}_{t+1}\} \\ E_t\{\pi_{t+1}\} \end{bmatrix} + \mathrm{B}_T u_t \qquad (6)$$

- Yes, if both eigenvalues of A_T lie within the unit circle (Blanchard-Kahn conditions).
- Necessary condition for uniqueness: $\kappa(\phi_\pi - 1) + (1-\beta)\phi_y > 0$ (8)

- Equation (6) represents the solution to the model, describing equilibrium dynamics under the interest rule presented in equation (1).

- How to find the eigenvalues? We will answer that question at seminar 3 (see exercise)

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Equilibrium Dynamics in the NKM

What are the effects of shocks under an interest rate rule? 1/14

Effects of a monetary policy shock

- Let's assume that the monetary policy shock follows an AR(1) process equal to:

$$v_t = \rho_v v_{t-1} + u_t^v, \qquad 0 \le \rho_v < 1 \qquad \text{and} \qquad E_t\{u_t^v\} = 0$$

Interpretation:

- Since the evolution of the natural interest rate and natural output is independent of monetary policy we can assume $\hat{r}_t^{natural} = \hat{y}_t^n = 0$ when we consider a monetary policy shock (no shocks in preferences and technology)

Effects of a monetary policy shock

- The intuition behind a monetary policy shock:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa \tilde{y}_t \qquad (2)$$

$$\tilde{y}_t = E_t\{\tilde{y}_{t+1}\} - \frac{1}{\sigma}\left(\underbrace{i_t - E_t\{\pi_{t+1}\}}_{r_t} - r_t^{natural} \right) \qquad (3)$$

$$i_t = \rho + \phi_\pi \pi_t + \phi_y \tilde{y}_t + \phi_y \hat{y}_t^n + v_t, \qquad (1)$$

- We have an idea what's going on, but because of the expectation terms, we can't really tell for sure.
  - Have to make a guess!
  - Method of undetermined coefficients – A five step method

Effects of a monetary policy shock

- Introducing method of undetermined coefficients – a 5 step method!

Step 1

Guess how endogenous variables and expectations of future endogenous variables are related to state variables and shocks

When we assume $\hat{r}_t^{natural} = \hat{y}_t^n = 0$, there are no state variables left in the equation system (6), only the shock variable v_t. The guesses are:

$$\tilde{y}_t = \psi_{yv} v_t$$

$$\pi_t = \psi_{\pi v} v_t$$

$$E_t\{\tilde{y}_{t+1}\} = \psi_{yv} E_t\{v_{t+1}\} = \psi_{yv} \rho_v v_t$$

$$E_t\{\pi_{t+1}\} = \psi_{\pi v} E_t\{v_{t+1}\} = \psi_{\pi v} \rho_v v_t$$

Effects of a monetary policy shock

- Introducing method of undetermined coefficients – a 5 step method!

Step 2

Insert for the guesses in the equations

In order not to get lost in calculation we will here use the NKPC as in equation (2) and the DIS equation as in equation (3), inserted for the nominal interest rate (eq.1). Inserting for the guesses yields:

$$\psi_{\pi v} v_t = \beta \psi_{\pi v} \rho_v v_t + \kappa \psi_{yv} v_t \qquad (2')$$

$$\psi_{yv} v_t = \psi_{yv} \rho_v v_t - \frac{1}{\sigma}\left(\phi_\pi \psi_{\pi v} v_t + \phi_y \psi_{yv} v_t + v_t - \psi_{\pi v} \rho_v v_t\right) \qquad (3')$$

Effects of a monetary policy shock

- Introducing method of undetermined coefficients – a 5 step method!

Step 3

Collect all coefficients related to each state/shock variable in different equations, considering coefficients only.

In this example: Only one such variable, so step 3 is to consider the two equations we found on the previous slide, only not including the v's:

$$\psi_{\pi v} = \beta\psi_{\pi v}\rho_v + \kappa\psi_{yv} \qquad (2'')$$

$$\psi_{yv} = \psi_{yv}\rho_v - \frac{1}{\sigma}\left(\phi_\pi\psi_{\pi v} + \phi_y\psi_{yv} + 1 - \psi_{\pi v}\rho_v\right) \qquad (3'')$$

Effects of a monetary policy shock

- Introducing method of undetermined coefficients – a 5 step method!

Step 4

Solve the equation system for the unknown coefficients!

Solving eq. (2'') for $\psi_{\pi v}$ yields:

$$\psi_{\pi v} - \beta \psi_{\pi v} \rho_v = \kappa \psi_{yv} \Rightarrow \psi_{\pi v} = \frac{\kappa}{1-\beta\rho_v}\psi_{yv}$$

Inserting into equation (3'') and solving for ψ_{yv} yields:

$$\psi_{yv} = -\left(\underbrace{\frac{1}{(1-\beta\rho_v)[\sigma(1-\rho_v)+\phi_y]+\kappa[\phi_\pi - \rho_v]}}_{\Lambda_v} \right)(1-\beta\rho_v) = -\Lambda_v(1-\beta\rho_v)$$

Effects of a monetary policy shock

- Introducing method of undetermined coefficients – a 5 step method!

Step 4 con't

Solve the equation system for the unknown coefficients!

Inserting back for ψ_{yv} in the solution for $\psi_{\pi v}$ yields: $\psi_{\pi v} = -\frac{\kappa}{1-\beta\rho_v}\Lambda_v(1-\beta\rho_v) = -\kappa\Lambda_v$

Step 5

Inserting for the undetermined coefficients in the guess

$$\tilde{y}_t = \psi_{yv} v_t = -(1-\beta\rho_v)\Lambda_v v_t \qquad (9)$$

$$\pi_t = \psi_{\pi v} v_t = -\kappa\Lambda_v v_t \qquad (10)$$

Effects of a monetary policy shock

- Can be shown that, as long as the system has a unique solution, then $\Lambda_v > 0$
- Interpreting

$$\tilde{y}_t = \psi_{yv} v_t = -(1-\beta\rho_v)\Lambda_v v_t \qquad (9)$$

$$\pi_t = \psi_{\pi v} v_t = -\kappa\Lambda_v v_t \qquad (10)$$

Effects of a monetary policy shock

- Inserting in equation (1), to interpret the effect on the nominal interest rate from the shock:

$$i_t = \rho + v_t\left[1 - \phi_\pi \kappa \Lambda_v - \phi_y (1 - \beta \rho_v) \Lambda_v\right]$$

- Interpretation:

Equilibrium Dynamics in the NKM

The effects of a monetary policy shock under an interest rate rule

Effects of a monetary policy shock

Interpretation:

THE BASIC NEW KEYNESIAN MODEL 69

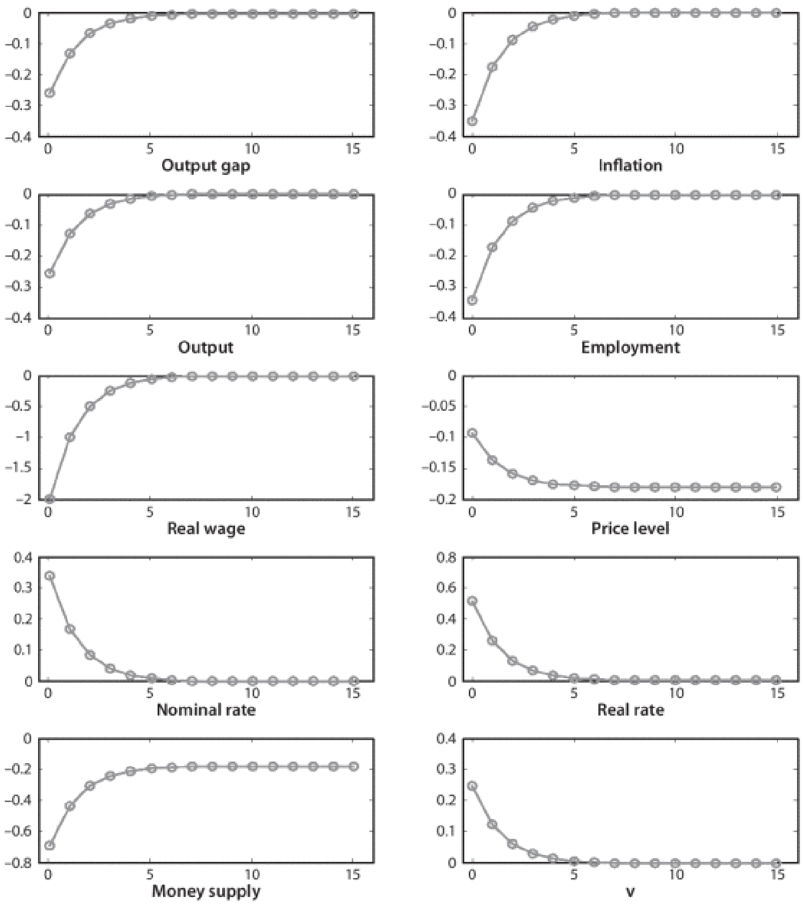

Figure 3.1. Dynamic Responses to a Monetary Policy Shock: Interest Rate Rule.

Gali (2015)

Added in the 2015 edition.

Effects of a discount rate shock

Home assignment: Solve for the effects of a discount rate shock, using the interest rate rule presented in equation (1), when you know that:

1. The discount rate shock follows the AR(1) process: $z_t = \rho_z z_{t-1} + \varepsilon_t^z, \quad 0 \leq \rho_z < 1 \quad E_t\{\varepsilon_t^z\} = 0$
2. Preferences enter the key equations through the natural interest rate.
3. We may assume $v_t = a_t = 0$
4. Solve for inflation and output gap and interpret how inflation, output gap and the nominal interest rate responds to a shock in the discount rate

NB: The book page covering the discount rate shock in the 2015-edition of the book will be distributed at the lecture for those of you who have the 2008-edition of the book.

Added in the 2015 edition.

Equilibrium Dynamics in the NKM

The effects of a discount rate shock under an interest rate rule

<u>Effects of a discount rate shock</u>

Interpretation:

70 CHAPTER 3

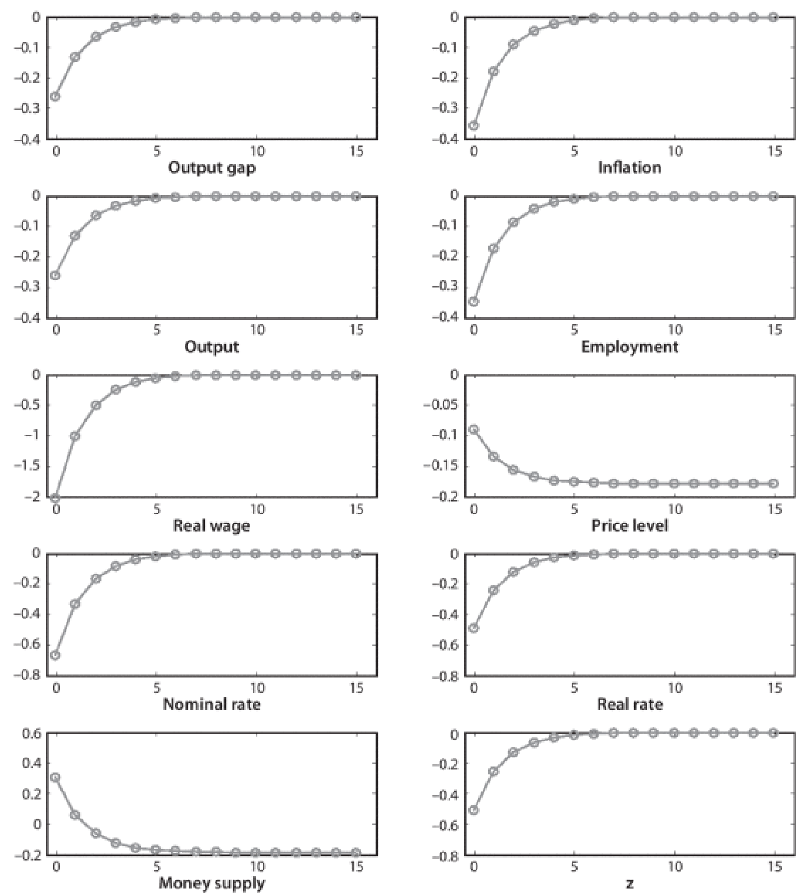

Figure 3.2. Dynamic Responses to a Discount Rate Shock: Interest Rate Rule.

Gali (2015)

Equilibrium Dynamics in the NKM

The effects of a technology shock under an interest rate rule

Effects of a technology shock

Home assignment: Solve for the effects of a technology shock, using the rule presented in equation (1), when you know that:

1. Technology follows the AR(1) process: $a_t = \rho_a a_{t-1} + u_t^a, \quad 0 \le \rho_a < 1 \quad E_t\{u_t^a\} = 0$
2. Technology enters the key equations through the natural interest rate and the natural level of output.
3. The following is true: $E_t\{\Delta a_{t+1}\} = E_t\{a_{t+1}\} - E_t\{a_t\} = E_t\{a_{t+1}\} - a_t$
4. We may assume $v_t = z_t = 0$
5. Solve for inflation and output gap and interpret how inflation, output gap and the nominal interest rate responds to a shock in technology

NB: The book pages covering the technology shock in the 2015-edition of the book will be distributed at the lecture for those of you who have the 2008-edition of the book.

Effects of a technology shock

Interpretation:

THE BASIC NEW KEYNESIAN MODEL 73

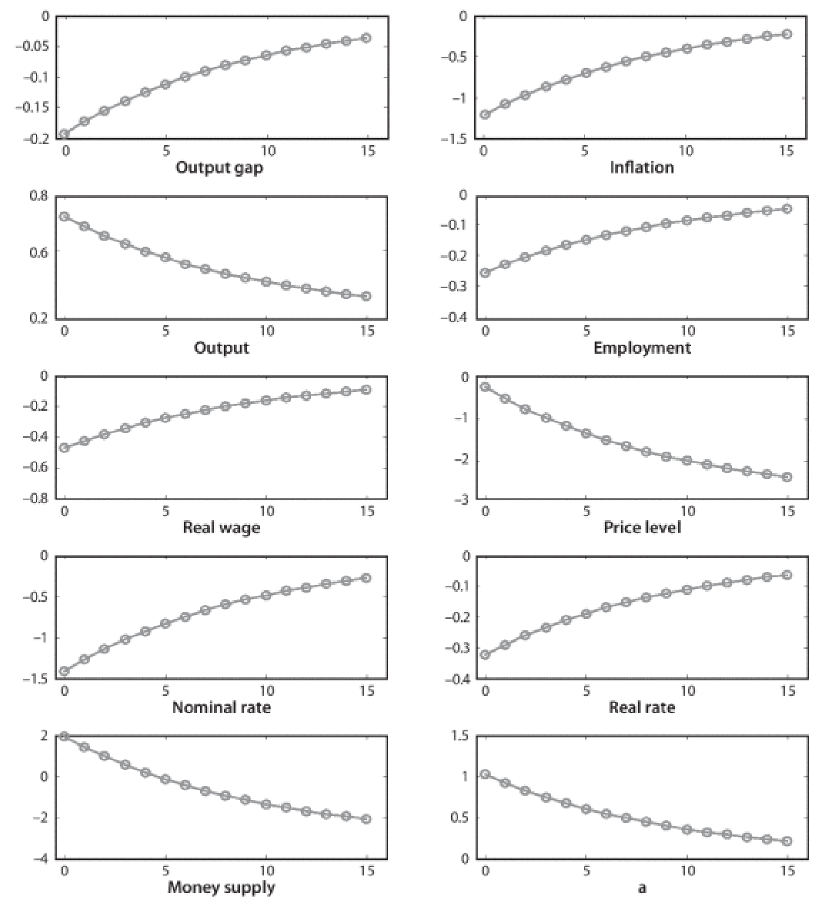

Figure 3.3. Dynamic Responses to a Technology Shock: Interest Rate Rule.

Gali (2015)

Parameter values used above

- The following parameter values are chosen to discuss the effects of shocks in ch.3 in the 2015-edition of the book (and on the slides above):

$\beta = 0.99$	Implies a steady state real return on financial assets of close to 4 %
$\sigma = 1$	Implies log utility
$\varphi = 5$	Commonly chosen value for the inverse of the Frisch elasticity of labor supply (used to be 1)
$1-\alpha = 3/4$	Commonly chosen value for the output elasticity of labor (used to be 2/3)
$\varepsilon = 9$	Commonly chosen value for demand elasticity (used to be 6)
$\theta = 3/4$	Only 1/4 of the firms change prices in every period (used to be 1/3)
$\phi_\pi = 1.5$	Consistent with the *Taylor principle*
$\phi_y = 0.5/4$	Not much weight put on the output gap (Greenspan)
$\rho_v = 0.5$	Implies a stationary, moderately persistent monetary policy shock
$\rho_z = 0.5$	Implies a stationary, moderately persistent discount rate shock
$\rho_a = 0.9$	Implies a stationary, very persistent technology shock

What have we learned so far and where to go next?

- We have so far in the course calculated our way through the NK model in order to say something about how **inflation** and the **output gap** will respond to shocks in the economy

- We also discussed briefly how the nominal interest rate will react to changes in inflation and the output gap, following a monetary policy rule.

- The responses depend crucially on parameter values.

- An important step in the construction of a credible NK model : Try to find credible values for each of the ***parameters*** and use it to **calibrate** the model
  - How to do this?

- The next step is also to choose **optimal** ***coefficient*** values, i.e. an optimal interest rate rule. We will start on this today, and continue with this at lectures 8 and 9.

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Monetary Policy in the NKM
The choice of households and firms in the NKM 1/3

- **Households:**
  - Complete financial markets. Perfectly competitive labor markets.

- **Monopolistically competitive firms:**
  - Production function with labor as the only input
  - Firms set their price. Prices are sticky.

- **General Equilibrium**
  - A so-called DSGE model

Monetary Policy in the NKM

The choice of households and firms in the NKM 2/3

The household maximization problem:

- Maximize discounted expected utility: $E_t \sum_{k=0}^{\infty} \beta^k U(C_{t+k}, N_{t+k}; Z_{t+k})$ (11)

where:
$$C_t \equiv \left(\int_0^1 (C_t(i))^{1-\frac{1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (12)$$

- Period budget constraint: $\int_0^1 P_t(i) C_t(i) di + Q_t B_t \leq B_{t-1} + W_t N_t + D_t$ (13)

- Solvency constraint like before (lecture 3)

Monetary Policy in the NKM

The choice of households and firms in the NKM 3/3

- Firms choose prices, output and labor input to maximize:

$$\underset{P_t^*}{Max} \sum_{k=0}^{\infty} \theta^k E_t \left\{ \Lambda_{t,t+k} \left(\frac{1}{P_{t+k}} \right) \left(P_t^* Y_{t+k|t} - W_{t+k} N_{t+k|t} \right) \right\} \qquad (14)$$

subject to:

$$Y_{t+k|t} = \left(\frac{P_t^*}{P_{t+k}} \right)^{-\varepsilon} Y_{t+k}\,, \qquad (15)$$

$$Y_{t+k|t} = A_{t+k} N_{t+k|t}{}^{1-\alpha} \qquad (16)$$

For each firm i:

$$P_{t+k+1}(i) = \begin{cases} P_{t+k+1}^*(i) & \text{with probability} \quad (1-\theta) \\ P_{t+k}(i) & \text{with probability} \quad \theta \end{cases} \qquad (17)$$

$$\Lambda_{t,t+k} \equiv \beta^k \frac{U_{c,t+k}}{U_{c,t}}$$

Monetary Policy in the NKM
The efficient allocation

- A social planner solves the model in order to find the Pareto optimal solution – he maximizes welfare.
  - This is the efficient allocation

- The equilibrium prices that yield the social planner's solution is the desired competitive equilibrium in the model (i.e. the **first-best** solution).

- The social planner maximizes the (representative) household's welfare:

$$\max U(C_t, N_t; Z_t) \tag{18}$$

subject to:

$$C_t = \left(\int_0^1 C_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}} \tag{19}$$

$$C_t(i) \leq A_t N_t(i)^{1-\alpha} \quad \forall i \in [0,1] \tag{20}$$

$$N_t = \int_0^1 N_t(i)\, di. \tag{21}$$

Monetary Policy in the NKM

The efficient allocation

2/2

- The social planner's problem implies the following optimality conditions:

$$\boxed{\begin{aligned} C_t(i) &= C_t \ \forall i \in [0,1] \\ N_t(i) &= N_t \ \forall i \in [0,1] \end{aligned}}$$

(22)

(23)

Price dispersion leads to a welfare loss!

= Consume the same amount of every good, which implies that the use of labor is equal across firms.

- In addition we have:

$$\boxed{-\frac{U_N(C_t, N_t)}{U_C(C_t, N_t)} = (1-\alpha)\frac{Y_t}{N_t}.} \quad (24)$$

- $MRS = MRT$
- LHS: Marginal cost (in units of consumption goods) of increasing the use of labor in production.
- RHS: Marginal increase in production of increasing the use of labor in production.

Equation 24 is found by solving the max problem with respect to consumption and labor supply, subject to equation (20)

(Try this yourself)

Monetary Policy in the NKM
Inefficiencies in the New Keynesian Model
Monopolistic competition – An inefficiency *unrelated to* sticky prices! 1/2

- Recall the frictionless mark-up (derived on slide 36, lecture 4): $$\mathrm{M} = \frac{\varepsilon}{\varepsilon - 1} \qquad (25)$$
  - Exists due to market inefficiency: Each firm is endowed with some market power because of monopolistic competition (How is this related to the Barro Gordon model from lecture 2?)
- Assume fully flexible prices for now (in order to isolate the mon.comp inefficiency)

Since all firms face the same prod.function they all choose the same optimal price

- Recall from optimal price-setting under flexible prices with monopolistic competition, (derived on slide 34-38, lecture 4):

$$P_t^*(i) = \mathrm{M}\,\psi_t(i) = \mathrm{M}\frac{W_t}{MPN_t(i)} \Rightarrow P_t^* = \mathrm{M}\frac{W_t}{MPN_t} \qquad (26)$$

- Hence: $$-\frac{\partial U / \partial N_t}{\partial U / \partial C_t} = \frac{W_t}{P_t^*} = \frac{MPN_t}{\mathrm{M}} < MPN_t \qquad (27)$$

Welfare loss! Working and consuming more would have increased welfare!

- Interpretation:

Monetary Policy in the NKM
Inefficiencies in the New Keynesian Model
Monopolistic competition – An inefficiency *unrelated to* sticky prices! 2/2

- How to deal with this inefficiency? Know that boosting inflation doesn't work…

- Let us assume that the fiscal authorities pay an **employment subsidy** to firms per unit of labor.

- If we assume that the rate at which the cost of employment is subsidized equals τ, then the cost for the firm per worker equals: $(1-\tau)W_t$

- In that case the firm's optimality condition is: $$P_t^* = \mathrm{M}\frac{(1-\tau)W_t}{MPN_t} \qquad (28)$$

- Given this solution for the firm, combining the HH and firm optimality conditions yields:

$$\frac{-\partial U/\partial N_t}{\partial U/\partial C_t} = \frac{W_t}{P_t^*} = \frac{MPN_t}{(1-\tau)\mathrm{M}} = MPN_t \qquad (29) \qquad \text{iff} \qquad (1-\tau)\mathrm{M} = 1 \Rightarrow \tau = \frac{1}{\varepsilon}$$

Monetary Policy in the NKM

Inefficiencies in the New Keynesian Model

Sticky prices

- In the following, we assume $\tau = \frac{1}{\varepsilon}$ to isolate the role of sticky prices.
- **Sticky prices lead to two types of inefficiency in the NKM:**
  1. Fluctuations in the mark-up over average costs
  2. Relative price distortions
- Recall equation 18, slide 19, lecture 5: $$\pi_t = \beta E_t\{\pi_{t+1}\} + \underbrace{\frac{(1-\theta)(1-\beta\theta)}{\theta}\Theta}_{\lambda}\hat{mc}_t$$

- Firms set prices as a function of a weighted average of current and future marginal cost deviations from ss,
  - Hence, inflation in period t is determined by current and future fluctuations in average real marginal costs around steady state.

- If average real marginal costs in period t increases, then a fraction $(1-\theta)$ of the firms will increase their price and face a lower demand.

- Recall the cost of higher prices for the firm: Higher prices = Lower demand = Lower production = Higher MPN (due to DRTS) = Lower marginal costs and dampens the initial increase = Dampens the optimal increase in prices

Monetary Policy in the NKM

Inefficiencies in the New Keynesian Model

Sticky prices

2/3

Fluctuations in the mark-up over average costs

Since firms no longer change prices at the same time, the economy's average mark-up will vary over time in response to shocks, and will be different from the frictionless mark-up.
Recall from lecture 4 the real average marginal costs: MC_t

What is the economy's average mark-up?
$$P_t = \mathrm{M}_t \frac{W_t}{MPN_t} \Rightarrow \mathrm{M}_t = \frac{P_t}{\frac{W_t}{MPN_t}} = \frac{1}{MC_t} \qquad (30)$$

Introducing the subsidy to employment costs and assuming $\tau = \frac{1}{\varepsilon}$ in order not to have monopolistic distortion yields:

$$\mathrm{M}_t = \frac{P_t}{(1-\tau)\frac{W_t}{MPN_t}} = \frac{\mathrm{M}}{MC_t} \Rightarrow \frac{\mathrm{M}_t}{\mathrm{M}} = \frac{1}{MC_t} \qquad (31)$$

Since we have corrected for the frictionless markup, we should then have $\mathrm{M} = \mathrm{M}_t$ and $\frac{1}{MC} = 1$ in st.state (see slide 10, lecture 5)

Given this solution for the firm, combining the HH and firm optimality conditions yields:

$$-\frac{\partial U / \partial N_t}{\partial U / \partial C_t} = \frac{W_t}{P_t} = MPN_t \frac{\mathrm{M}}{\mathrm{M}_t} \underset{<}{\overset{>}{=}} MPN_t \qquad (32)$$

, with equality only if: $\frac{\mathrm{M}}{\mathrm{M}_t} = 1 \Rightarrow \mathrm{M} = \mathrm{M}_t$

Interpretation:

Possible welfare loss!

Relative price distortions

Due to staggered price setting (not all firms change their price in a given period), we will have $P_t(i) \neq P_t(j)$ for any pair of goods (i, j) whose prices are not adjusted in the same period. From the demand function for goods we can write $\frac{C_t(i)}{C_t(j)} = \left(\frac{P_t(i)}{P_t(j)}\right)^{-\epsilon}$, and therefore different quantities are produced and consumed; and, as a result, $N_t(i) \neq N_t(j)$.

Recall: The efficient allocation requires that all quantities produced and consumed are equalized (i.e. prices and marginal costs must also be equalized)

Mark-ups should be identical across firms and goods at all times, in addition to be constant and equal to the frictionless mark-up on average

Outline

- Equilibrium Dynamics in the NKM (Gali ch.3 4.1)
  - Introducing an interest rate rule for monetary policy
  - What are the effects of shocks under an interest rate rule?
  - Learning a new method: The method of undetermined coefficients

- Monetary Policy in the NKM (Gali ch.4.1 and 4.2)
  - The choice of households and firms in the basic NKM
  - The efficient allocation
  - Inefficiencies in the basic New Keynesian Model
    - Monopolistic competition
    - Sticky prices x 2!
  - What is optimal monetary policy within this framework?

Monetary Policy in the NKM

What is optimal monetary policy within this framework? 1/3

- Optimal monetary policy is the kind of policy that realizes the efficient allocation
  - A policy that eliminates the inefficiencies!
- If we assume the following:

Correction of the market power inefficiency is done by the fiscal authorities

No inherited relative price distortions

- Then the efficient allocation can be obtained by stabilizing marginal costs at a level consistent with the firm's desired markup, given the prices in place.
- If all firms know this policy <u>and it is a credible policy</u> , then no firms will have incentives to change their prices in any period!

Monetary Policy in the NKM

What is optimal monetary policy within this framework? 2/3

- What will then the inflation be in every period? $P_t^* = P_{t-1} = P_t = P_{t-2}$
  - No relative price distortion
- If marginal costs are stabilized and constant, then: $\dfrac{\mathrm{M}}{\mathrm{M}_t} = 1 \Rightarrow \mathrm{M} = \mathrm{M}_t$
- Have we then ensured the efficient allocation?

- What does the optimal policy require?
  - Recall eq. 24 from lecture 5 (slide 27), describing what drives the mark-up:

$$\mu_t - \mu = -\left(\sigma + \frac{\varphi+\alpha}{1-\alpha}\right)\underbrace{\left(y_t - y_t^{natural}\right)}_{outputgap} = -\left(\sigma + \frac{\varphi+\alpha}{1-\alpha}\right)\tilde{y}_t$$

Monetary Policy in the NKM

What is optimal monetary policy within this framework? 3/3

- With constant mark ups under the optimal policy the output gap is then closed at all times:

$$\mu_t - \mu = 0 \Rightarrow \tilde{y}_t = 0$$

The divine coincidence

- It is also optimal to keep the same price in every period hence (and through the NKPC): $\pi_t = 0$

- The DIS-equation: $$\tilde{y}_t = E_t\{\tilde{y}_{t+1}\} - \frac{1}{\sigma}\left(\underbrace{i_t - E_t\{\pi_{t+1}\}}_{r_t} - r_t^{natural}\right) = 0 \qquad (33)$$

- Hence, the optimal policy that eliminates all inefficiencies and lead us right to the efficient allocation requires that the equilibrium nominal interest rate must be so that

$$r_t = i_t - E_t\{\pi_{t+1}\} = r_t^{natural}$$

- Next week: look at some **interest rate rules** that are consistent with this equilibrium outcome

The next two lectures:

Optimal Monetary Policy in the NKM

- Gali chapters 4.3 and 4.4.1 (ch. 4.4.2 can be dropped)
- Clarida, Galì & Gertler (2000)
- Clarida, Galì & Gertler (1999)

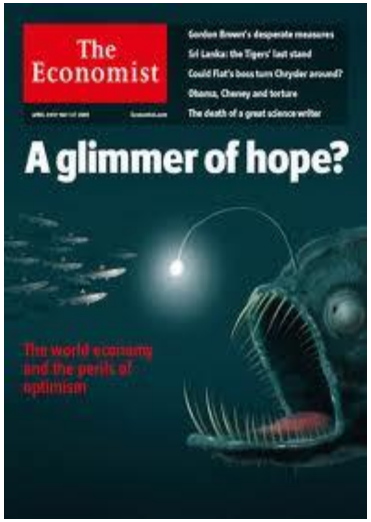
At lecture 8 and 9, we will again introduce discretion (recall lecture 2) and study how optimal policy is conducted with a re-optimizing central bank minimizing a loss function within a New Keynesian system and how this may be welfare-enhancing compared to using a simple interest rate rule and further more, how some commitment may be *even more* welfare-enhancing.

Lecture 8 on 18 March - then Easter break

- then **lecture 9 at 1 April**

- Seminar exercise 3 (for next week's seminars) is on the web

Half way there!



What is left?

18.03	Lecture 8	*Optimal Policy in the New Keynesian Model*	Clarida, Galí and Gertler (1999)	Nina Larsson Midthjell
25.03	No lecture			
01.04	Lecture 9	*Optimal Policy in the New Keynesian Model*	Clarida, Galí and Gertler (1999)	Nina Larsson Midthjell
08.04	Lecture 10	*Markov Switching in the New Keynesian Model*	Davig and Leeper (2007)	Nina Larsson Midthjell
15.04	Lecture 11	*Monetary Policy in Norway*	The Norges Bank Monetary Policy Report (1/2016), The Norges Bank Watch report (2016)	Nina Larsson Midthjell
22.04	Lecture 12	*Financial Stability in Norway*	The Norges Bank Financial Stability Report (2015)	Henrik Borchgrevink (Norges Bank)
29.04	Lecture 13	*Topical Lecture: Forward Guidance*	CEPR ebook on Forward Guidance (2013)	Nina Larsson Midthjell

- **Seminar 3** (16-18 March) and **Seminar 4** (6-8 April) : The NKM
- **Seminar 5** (27-29 April): Related to Financial Stability
- **Seminar 6** (4-6 May): Related to the exam
- **Exam**: 24 May at 2:30 pm (3 hours)

Monetary Policy

(Advanced Monetary Economics)

ECON 4325