INSTITUTE FOR
CAPACITY DEVELOPMENT

Workshop 2 – The Basic New-Keynesian Model

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Course on Monetary and Fiscal Policy Analysis with DSGE Models (JV25.29)

Learning Objectives

- Learn how to solve the basic three-equation NK model using Dynare
- Play around with some policy parameters
- Include new variables and modify equations in the model

The Three-Equation NK Model

1) The Aggregate Supply (AS) or New-Keynesian Phillips Curve (NKPC)

$$\pi_t = \beta \mathbb{E}_t\{\pi_{t+1}\} + \kappa \tilde{y}_t + u_t$$

2) The Aggregate Demand (AD) or Dynamic IS Equation (DISE)

$$\tilde{y}_t = \mathbb{E}_t \tilde{y}_{t+1} - \frac{1}{\sigma}\left(i_t - \mathbb{E}_t\{\pi_{t+1}\} - r_t^n\right)$$

with $r_t^n = \rho - (1-\rho_a)\psi_{ya}^n a_t + (1-\rho_z) z_t$ and $\rho \equiv -\log(\beta)$

3) A Taylor rule

$$i_t = \rho + \phi_\pi \pi_t + \phi_y \tilde{y}_t + v_t$$

- Stochastic processes for $s_t = \{v_t, a_t, z_t, u_t\}$

$$s_t = \rho_s s_{t-1} + \varepsilon_t^s, \quad \rho_s \in (0,1), \quad \varepsilon_t^s \sim N(0, \sigma_s^2)$$

The Three-Equation Model

- Other equations
  - Output gap: $\tilde{y}_t = y_t - y_t^n$
  - Natural output: $y_t^n = \psi_{ya}^n a_t + \psi_y^n$
  - Actual output: $y_t = a_t + (1-\alpha)n_t$
  - Real interest rate: $r_t = i_t - \mathbb{E}_t\{\pi_{t+1}\}$
  - Money demand: $m_t - p_t = y_t - \eta i_t$

where $\psi_{ya}^n \equiv \frac{1+\varphi}{\sigma(1-\alpha)+\varphi+\alpha}$ and $\psi_y^n \equiv -\frac{(1-\alpha)(\mu-\log(1-\alpha))}{\sigma(1-\alpha)+\varphi+\alpha}$

Housekeeping

- Endogenous variables: $\tilde{y}_t$, y_t, y_t^n, π_t, n_t, i_t, r_t, m_t, r_t^n, a_t, v_t, z_t, u_t
- Exogenous variables: ε_t^s with variances σ_s^2 for $s_t = v_t, a_t, z_t, u_t$
- Parameters: β, σ, φ, α, ε, θ, η, ϕ_π, ϕ_y, ρ_v, ρ_a, ρ_z, ρ_u, μ, ρ
- Composite parameters: κ, λ, Θ, ψ_{ya}^n, ψ_y^n

Housekeeping

- The model is already log-linearized: variables are already expressed as log deviations from their steady state

- The model frequency is quarterly

- The nominal interest rate i_t, real interest rate r_t, and inflation π_t are also on quarterly basis
  - The code in Dynare introduces i_t- ρ instead of i_t

- To express the inflation rate and interest rate on annual basis, multiply them by 4

Calibration

Parameter	Value	Target
β	0.99	Real annual financial return = 4%
σ	1	Log utility
φ	5	Frisch labor elasticity ($1/\varphi$) = 0.2
α	1/4	Data
ε	9	Steady-state markup =12.5%
θ	3/4	Average price duration $\frac{1}{1-\theta}$= 4 quarters
η	3.77	Regress log(M2) on 3-month T-bill rate
ϕ_π	1.5	Mimic FFR during Greenspan era
ϕ_y	0.5/4	Mimic FFR during Greenspan era
ρ_v, ρ_z, ρ_u	0.5	
ρ_a	0.9	

Simulation

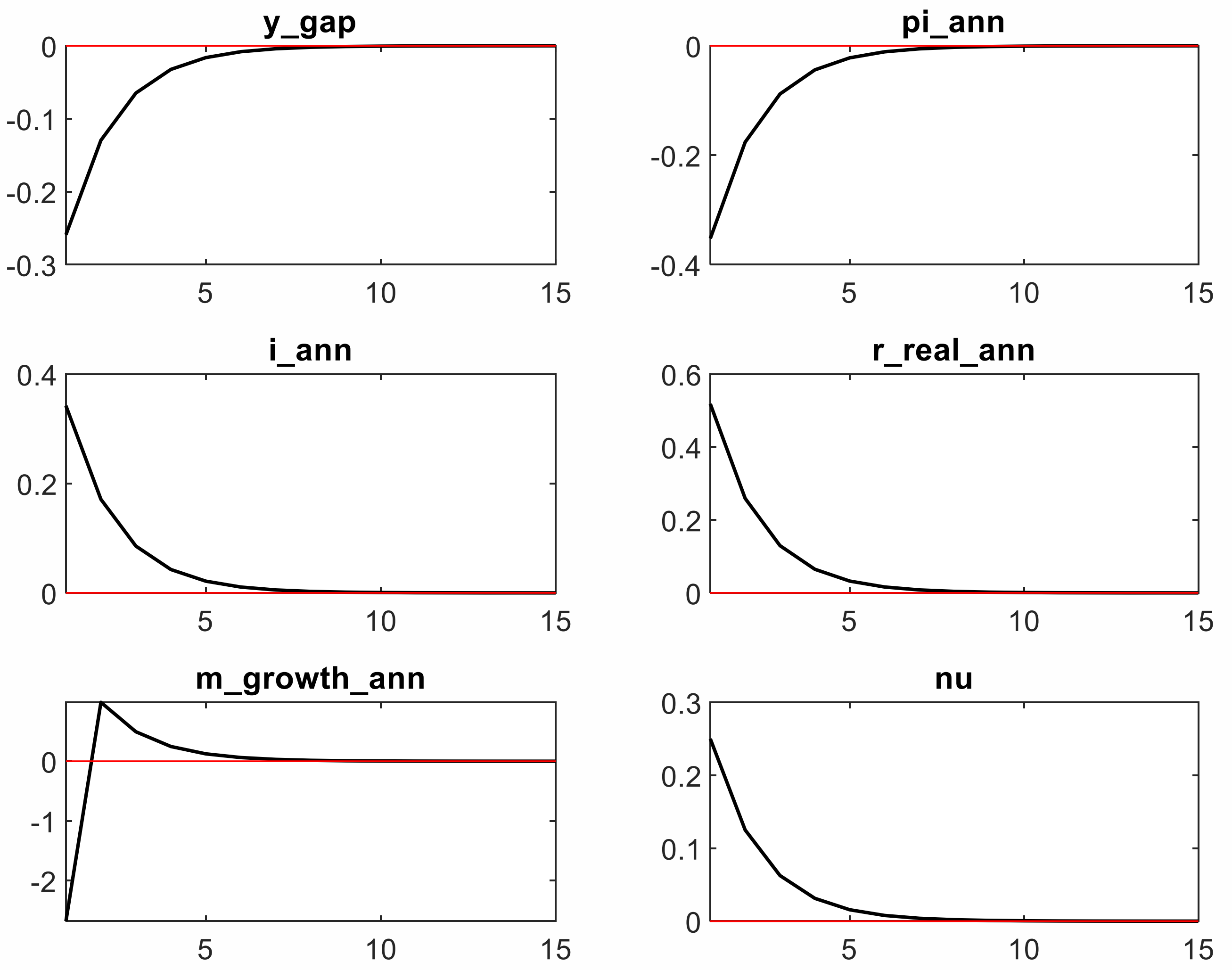
- The model is solved and simulated using the stoch simul command
- Options for stoch simul

Options	Meaning	Default
period	# of periods used simulations	0
nocorr	don't print the correlation matrix	PRINT
drop	# points dropped at beginning of simul.	100
irf	# periods for IRFs	40
order = [1,2,3]	Order of Taylor approximation	1

- To execute the code, type "dynare nkm_Gali.mod" in the MATLAB command window

The Effects of a Monetary Policy Shock (Taylor Rule)

Baseline



Exercises

Exercise 1: Explain the transmission mechanism of a monetary policy shock in the basic new-Keynesian model

The Effects of a Monetary Policy Shock $v \uparrow$

Monetary tightening $v \uparrow$

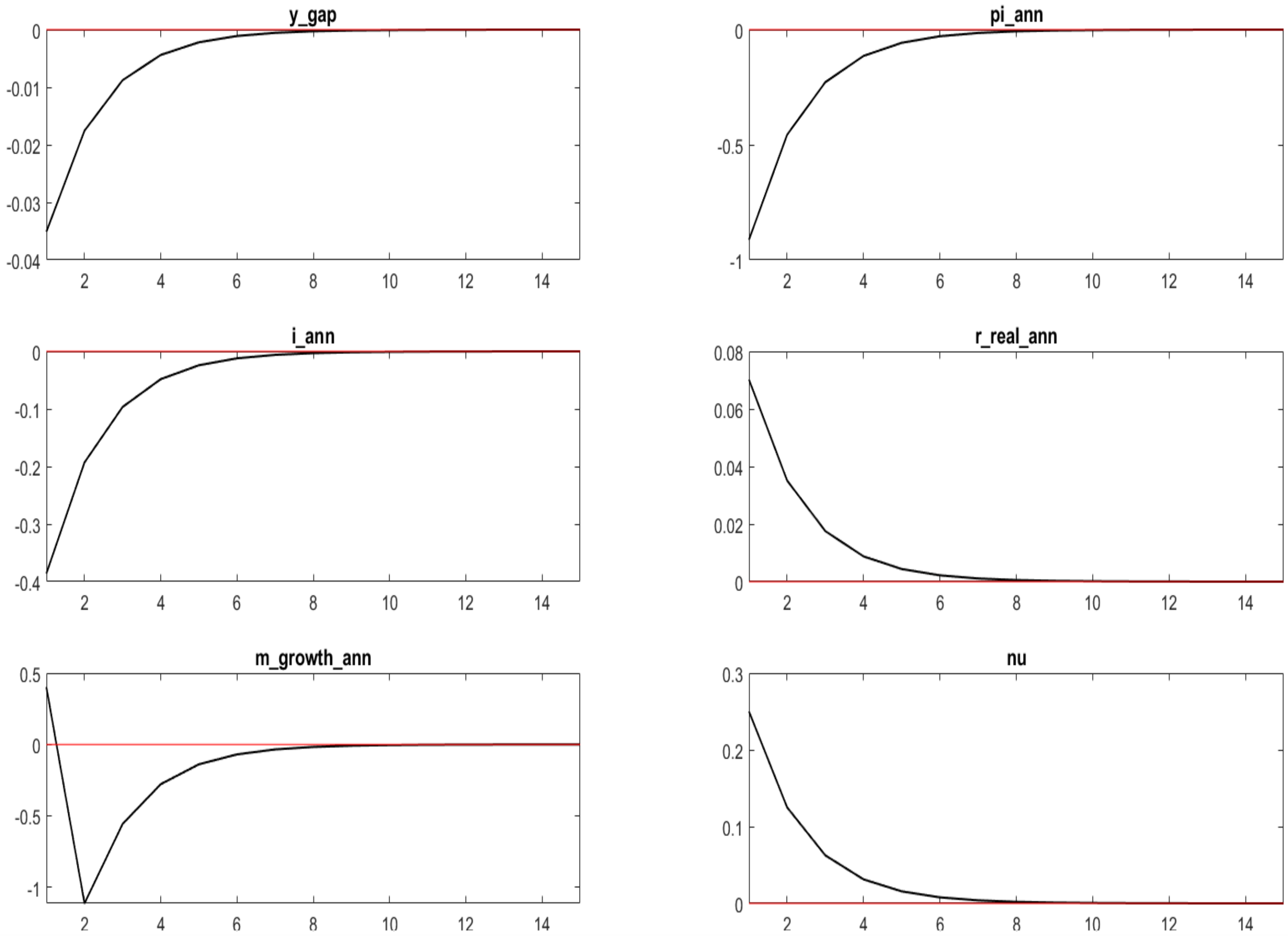
- Output gap $\downarrow$, inflation $\downarrow$, nominal and real interest rate $\uparrow$ $(r_t = i_t - \mathbb{E}_t\{\pi_{t+1}\})$
- Transmission: $v \uparrow \xRightarrow{\text{Taylor Rule}} i_t \uparrow \xRightarrow{\text{DISE}} \tilde{y}_t \downarrow \xRightarrow{\text{NKPC}} \pi_t \downarrow$
- Qualitatively consistent with VAR evidence
- Matching the quantitative features of empirical IRFs requires enriching the basic NK model in several dimensions

Sensitivity Analysis

Exercise 2: Under a Taylor rule, change the price-stickiness parameter θ from 3/4 (benchmark) to 0.3. What happens and why?

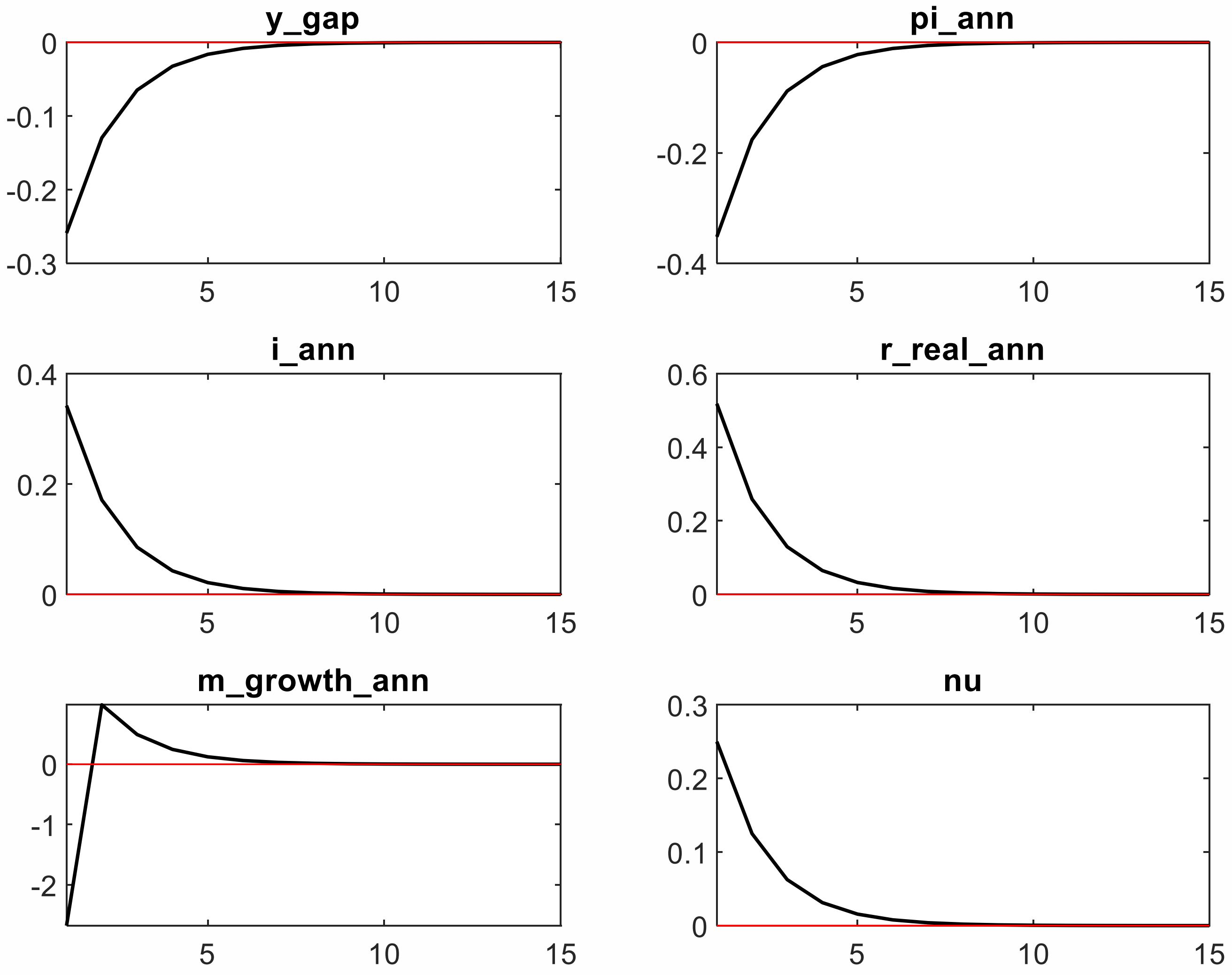
The Effects of a Monetary Policy Shock (Taylor Rule)

Lowering the price-stickiness parameter θ to 0.3



The Effects of a Monetary Policy Shock (Taylor Rule)

Baseline



Playing Around with the Taylor Rule

Exercise 3: Change the response parameter ϕ_π from 1.5 to 0.8. What happens?

- You will get indeterminacy. The Blanchard-Kahn condition is not satisfied!

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EIGENVALUES:
         Modulus              Real          Imaginary

               0                 0                  0
               0                 0                  0
             0.5               0.5                  0
             0.5               0.5                  0
             0.5               0.5                  0
             0.9               0.9                  0
          0.9151            0.9151                  0
           1.393             1.393                  0


There are 1 eigenvalue(s) larger than 1 in modulus
for 2 forward-looking variable(s)

The rank condition ISN'T verified!
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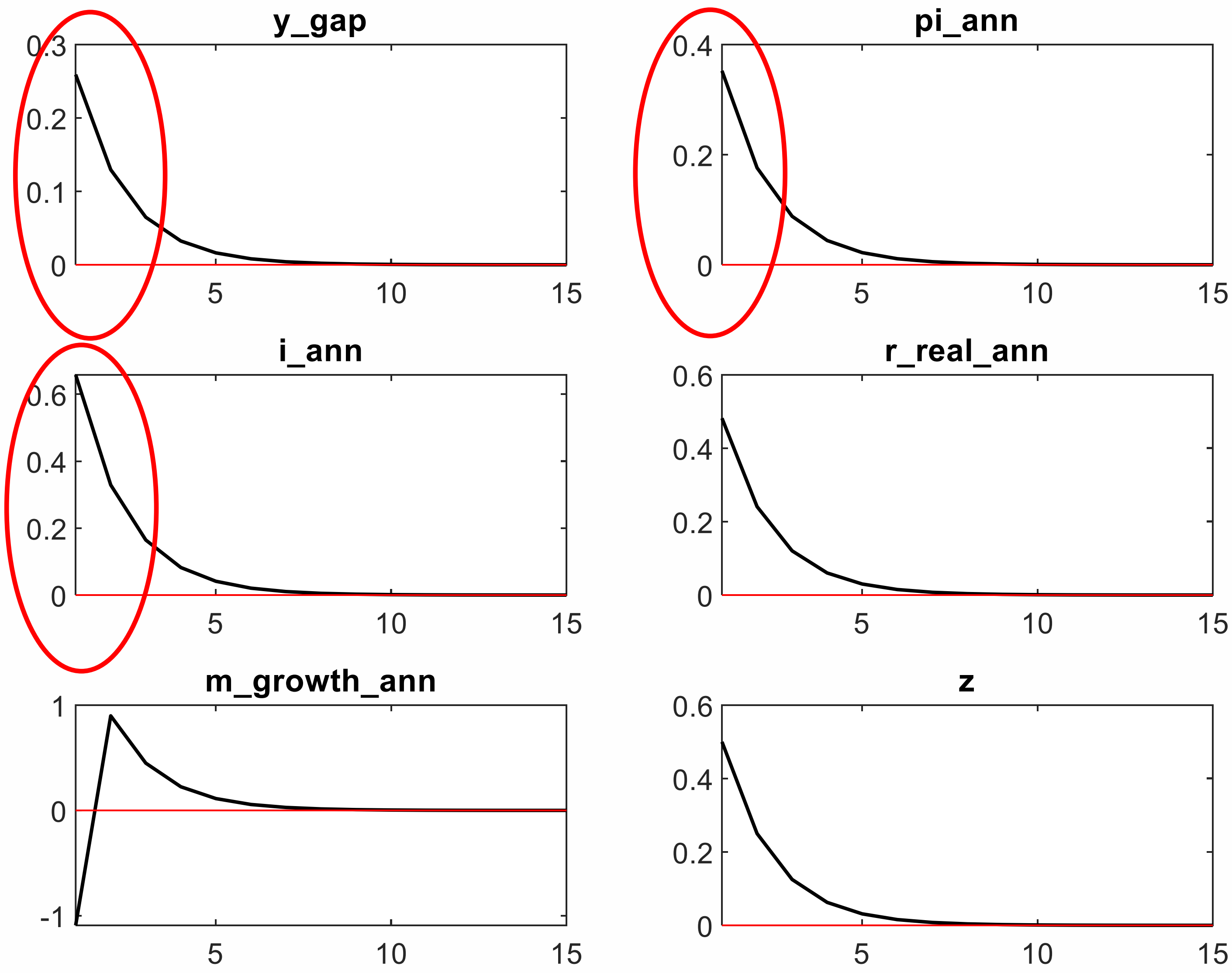
- Taylor principle in the canonical NK model: a 1% rise inflation should be met by a greater than 1% rise in the nominal interest rate

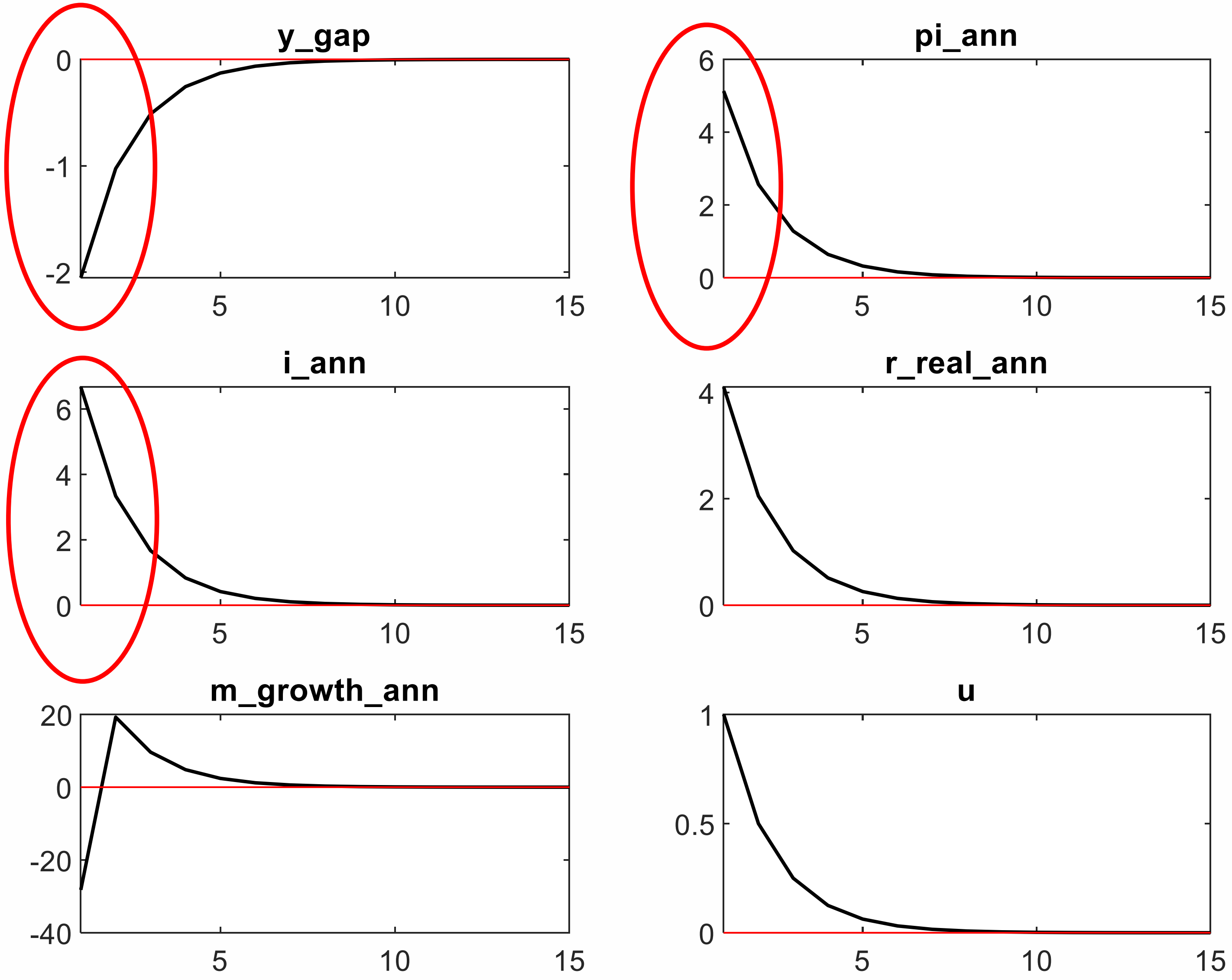
Demand and Supply Shocks

Exercise 4: Simulate the model under preference and cost push shocks and discuss potential trade-offs for monetary policy

The Effects of a Preference Shock $z \uparrow$



The Effects of a “Supply” Shock $u\uparrow$



Interest Rate Smoothing

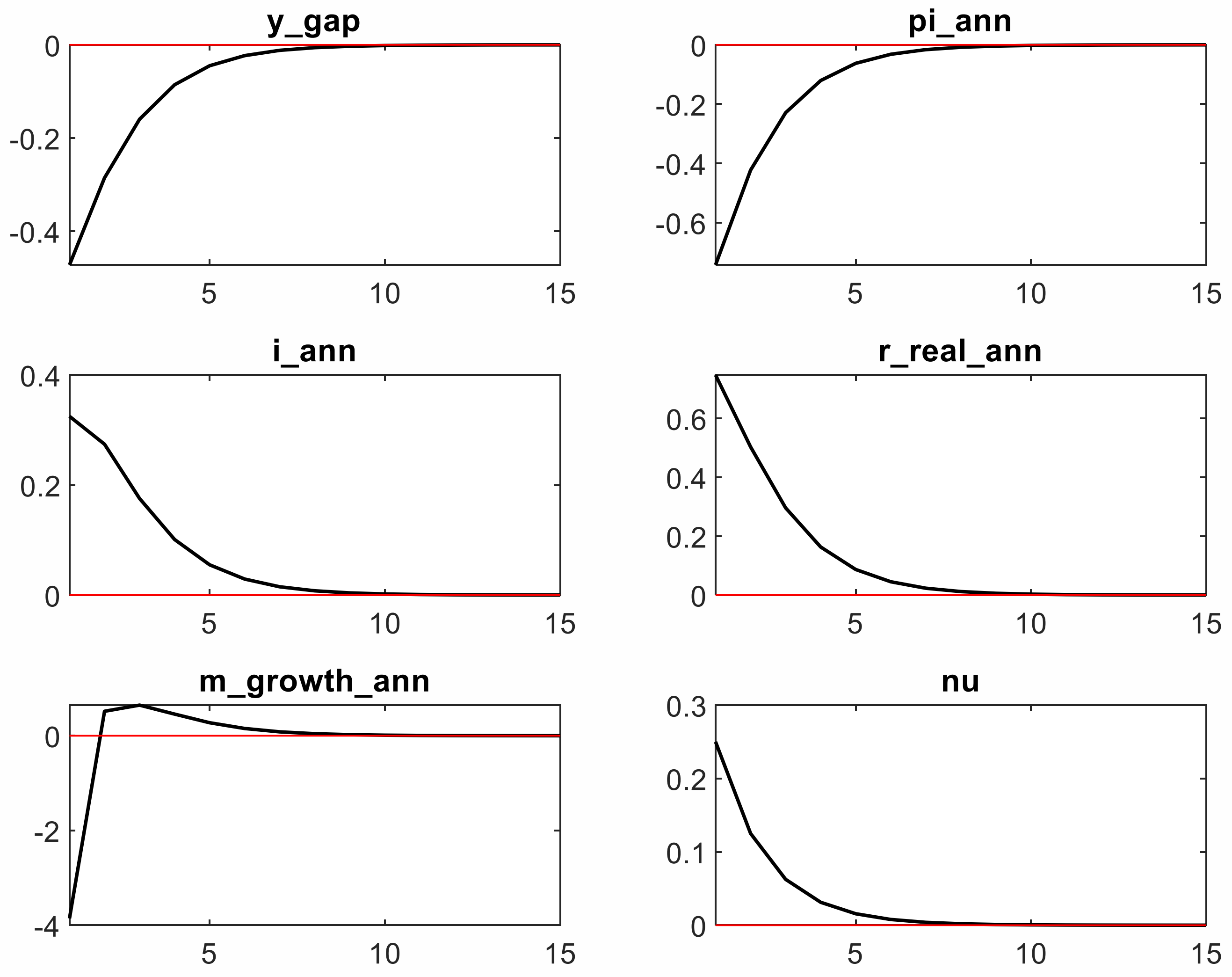
Exercise 5: Replace the Taylor rule

$$i_t = 0.5\, i_{t-1} + 0.5\,(\phi_\pi \pi_t + \phi_y \tilde{y}_t) + v_t$$

and analyze the effects of a monetary policy shock

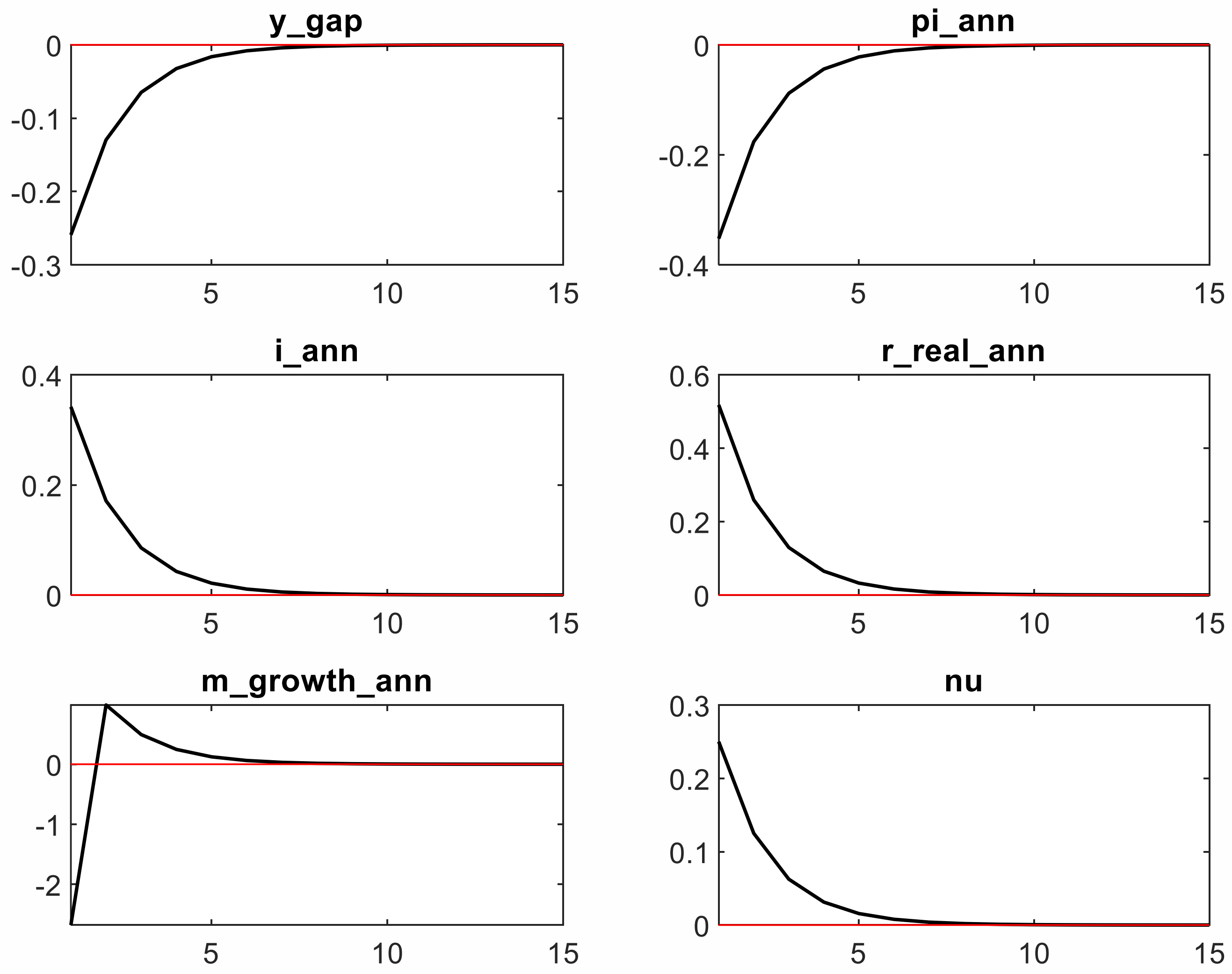
The Effects of a Monetary Policy Shock (Taylor Rule)

Change the rule to $i_t = 0.5\, i_{t-1} + 0.5\,(\phi_\pi \pi_t + \phi_y \tilde{y}_t) + v_t$



The Effects of a Monetary Policy Shock (Taylor Rule)

Baseline



New-Keynesian Phillips Curve Smoothing

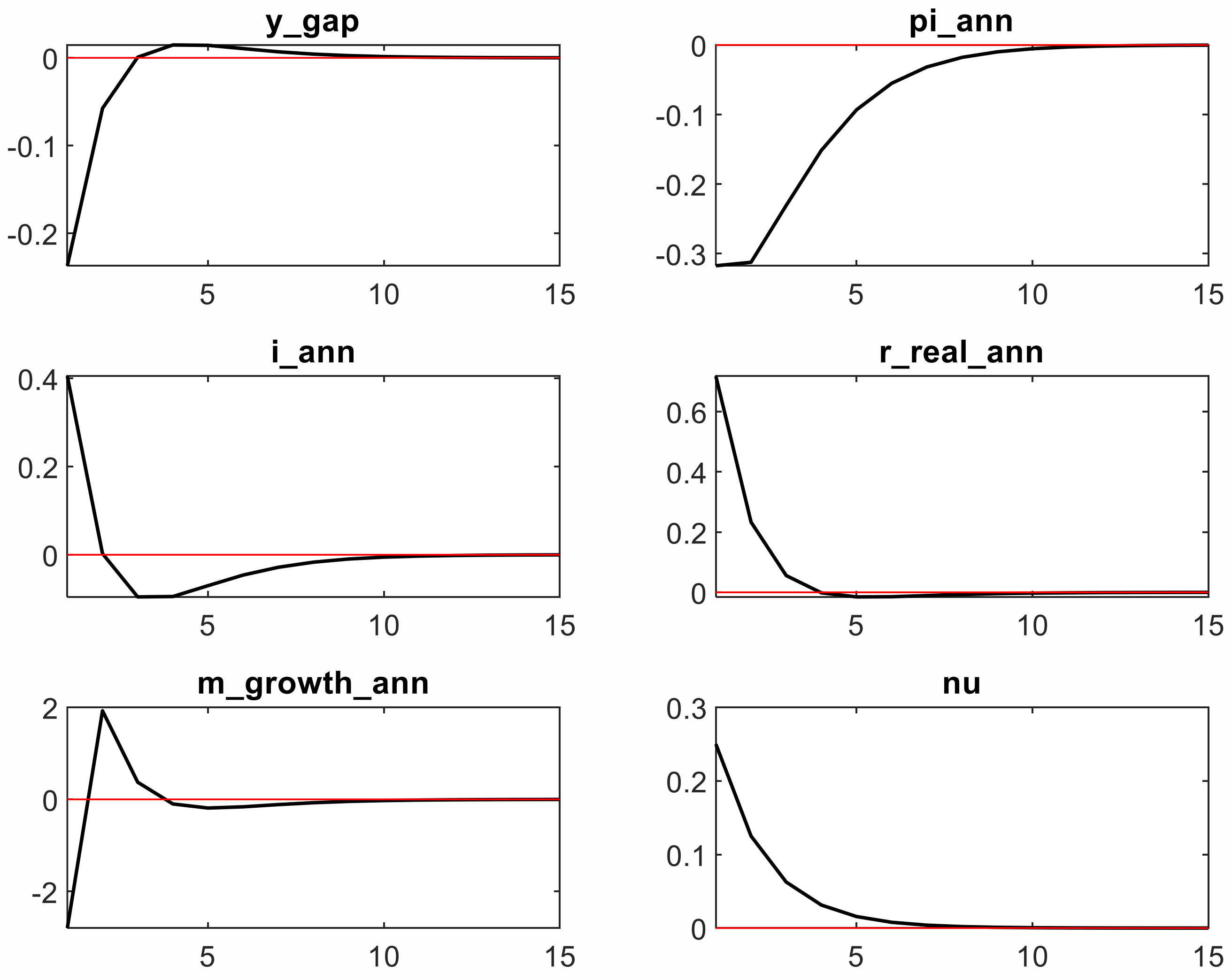
Exercise 6: Add indexation to the NKPC

$$\pi_t = 0.5\,\pi_{t-1} + 0.5\,\beta\mathbb{E}_t\{\pi_{t+1}\} + \kappa\tilde{y}_t$$

and analyze the effects of a monetary policy shock

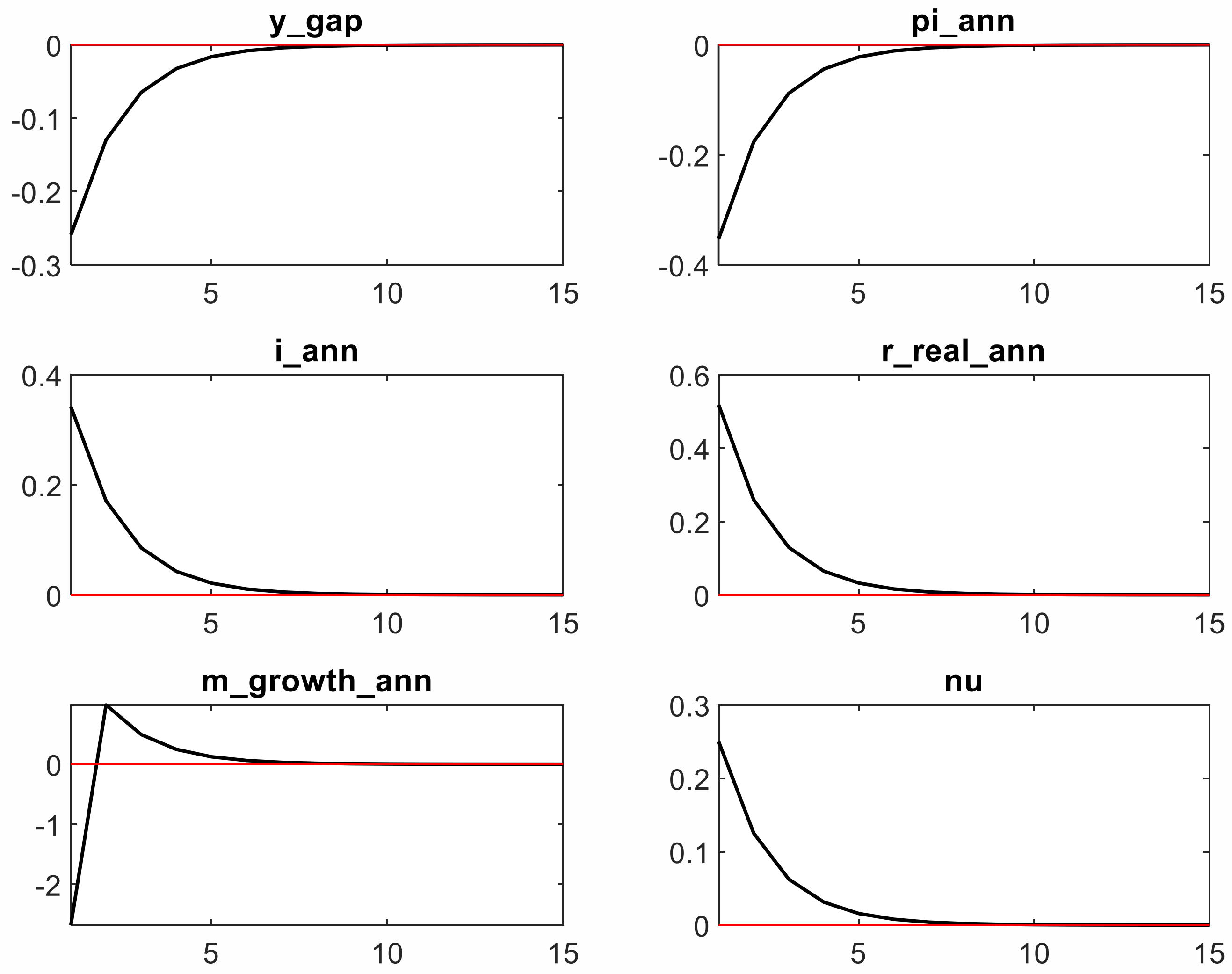
The Effects of a Monetary Policy Shock (Taylor Rule)

Change the NKPC to $\pi_t = 0.5\,\pi_{t-1} + 0.5\,\beta\mathbb{E}_t\{\pi_{t+1}\} + \kappa\tilde{y}_t$



The Effects of a Monetary Policy Shock (Taylor Rule)

Baseline



Habit Formation

- Empirical evidence suggests that the impact of a positive (contractionary) monetary policy shock on output is negative but hump-shaped

- The basic three-equation NK model in L-2 captures the negative impact, but fails to capture the hump shape

- We add “external” habit formation into the basic NK model

- The period utility function changes to (ignore the preference shock Z_t)

$$U(C_t, N_t) = \frac{(C_t - hC_{t-1})^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi}$$

where h measures the degree of habit formation

Habit Formation: FOCs

- The intra-temporal condition

$$\frac{N_t^{\varphi}}{(C_t - hC_{t-1})^{-\sigma}} = \frac{W_t}{P_t}$$

- The intertemporal condition

$$(C_t - hC_{t-1})^{-\sigma} = \beta \mathbb{E}_t \left\{ (C_{t+1} - hC_t)^{-\sigma} \frac{(1 + i_t)}{\Pi_{t+1}} \right\}$$

Habit Formation: Modified DISE

- Following similar steps to the ones we used to derive the DISE in the basic model yields

$$\tilde{y}_t = \frac{1}{1+h}\mathbb{E}_t\tilde{y}_{t+1} + \frac{h}{1+h}\tilde{y}_{t-1} - \frac{1-h}{\sigma(1+h)}(i_t - \mathbb{E}_t\{\pi_{t+1}\} - r_t^n)$$

- Note that when $h = 0$, the modified DISE reduces to the DISE in the basic NK model

$$\tilde{y}_t = \mathbb{E}_t\tilde{y}_{t+1} - \frac{1}{\sigma}(i_t - \mathbb{E}_t\{\pi_{t+1}\} - r_t^n)$$

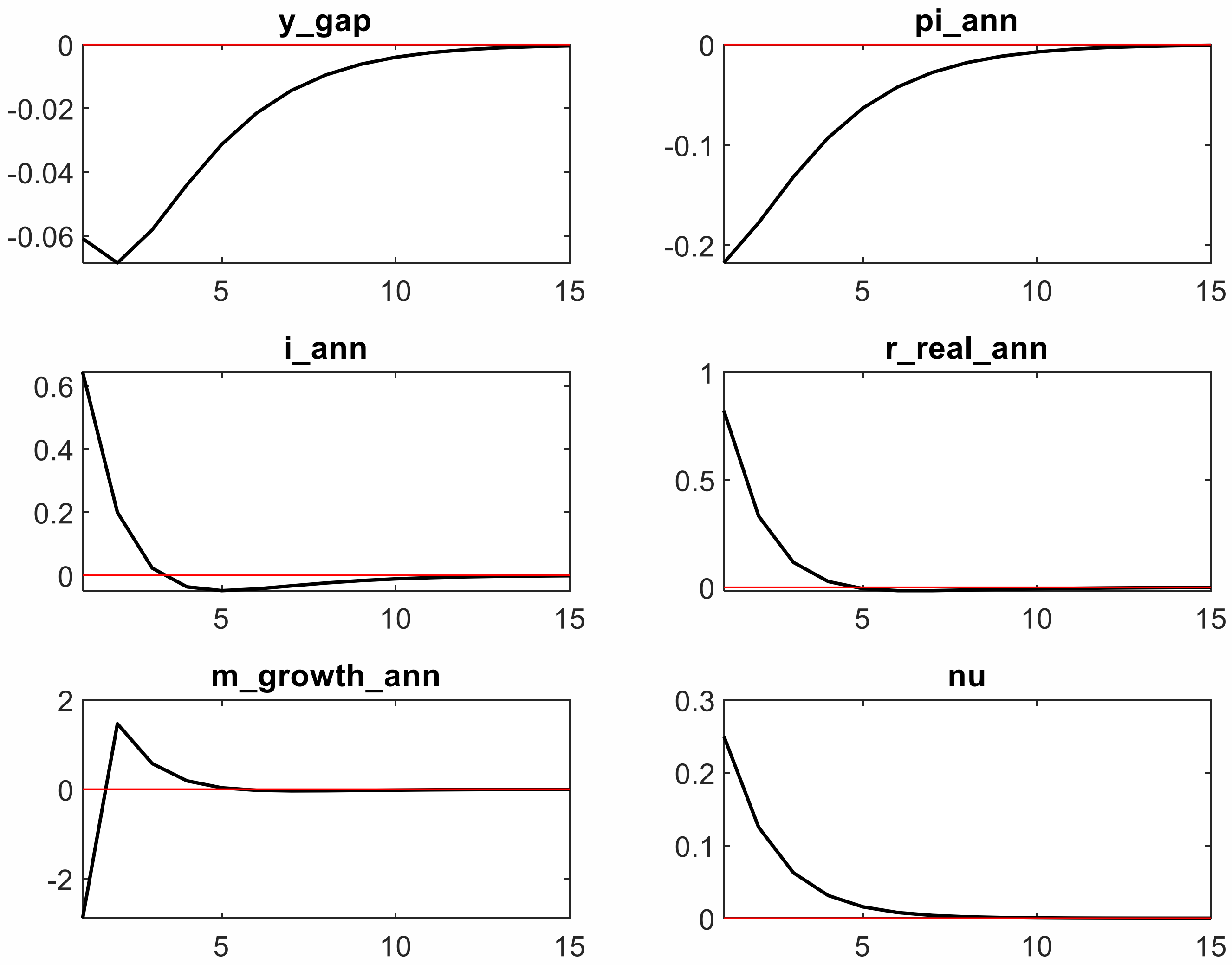
Habit Formation

Exercise 7:

- Modify the Dynare code nkm_Gali.mod by adding habit formation
- Hint: you only need to change the Dynamic IS Equation
- Do not forget to add values to the new parameter, e.g., h = 0.8
- Play around with h
- Analyze the effects of a monetary policy shock

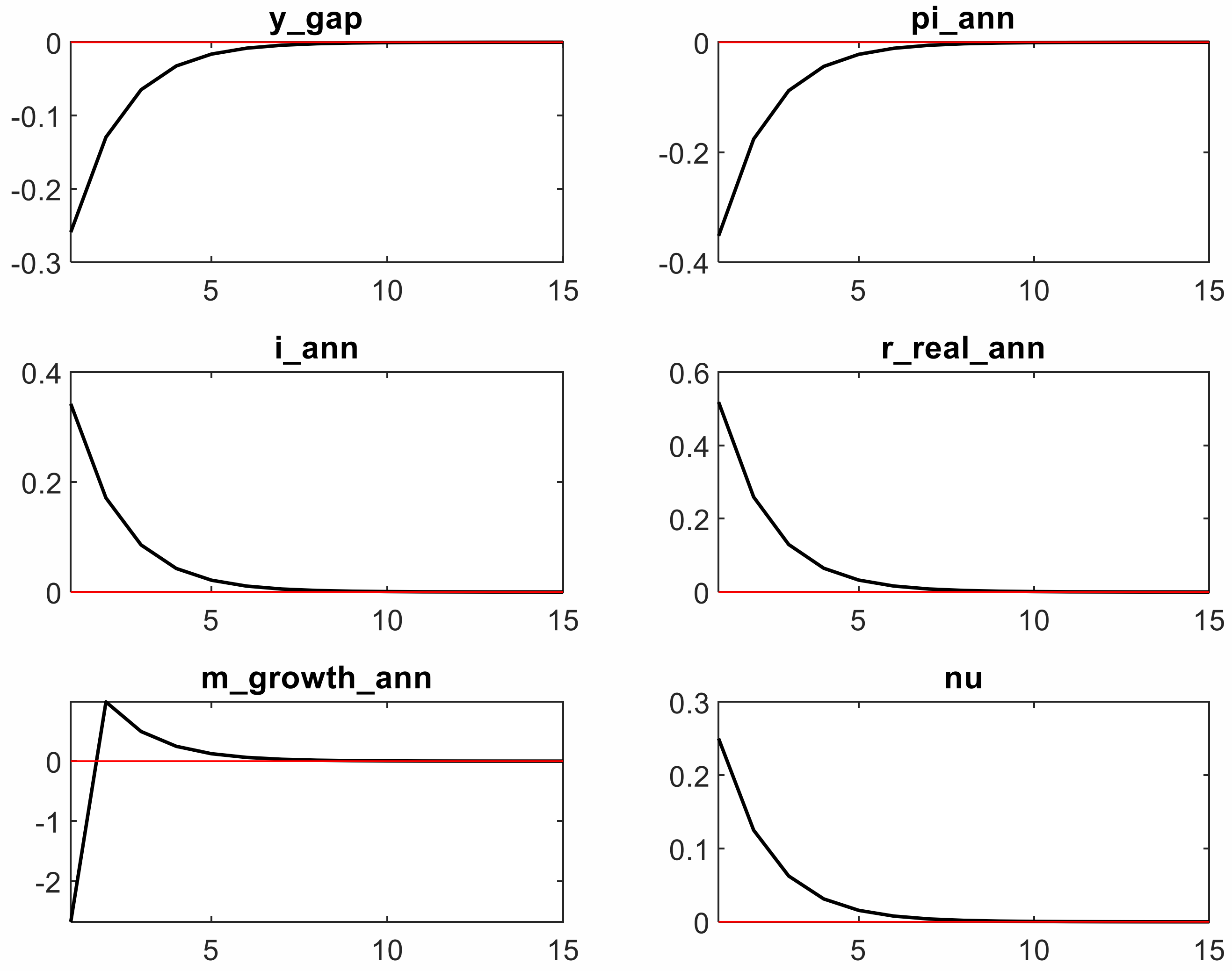
The Effects of a Monetary Policy Shock (Taylor Rule)

Habit Formation



The Effects of a Monetary Policy Shock (Taylor Rule)

Baseline



Habit Formation

Exercise 8: Basic NK + Habit formation + NKPC smoothing + interest rate smoothing, under a monetary policy shock

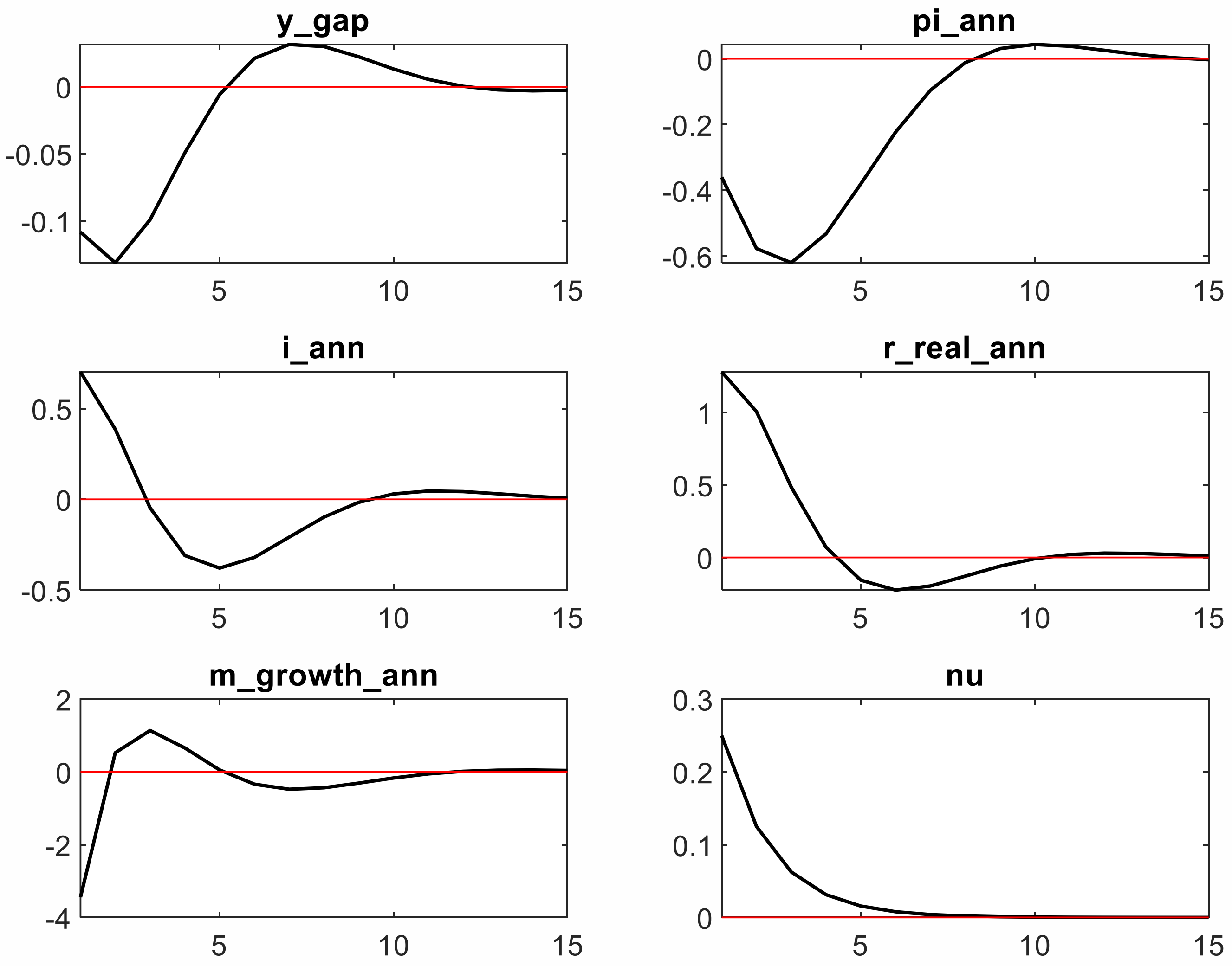
$$\tilde{y}_t = \frac{1}{1+h}\mathbb{E}_t\tilde{y}_{t+1} + \frac{h}{1+h}\tilde{y}_{t-1} - \frac{1-h}{\sigma(1+h)}(i_t - \mathbb{E}_t\{\pi_{t+1}\} - r_t^n)$$

$$\pi_t = 0.5\,\pi_{t-1} + 0.5\,\beta\mathbb{E}_t\{\pi_{t+1}\} + \kappa\tilde{y}_t$$

$$i_t = 0.5\,i_{t-1} + 0.5\,(\phi_\pi\pi_t + \phi_y\tilde{y}_t) + v_t$$

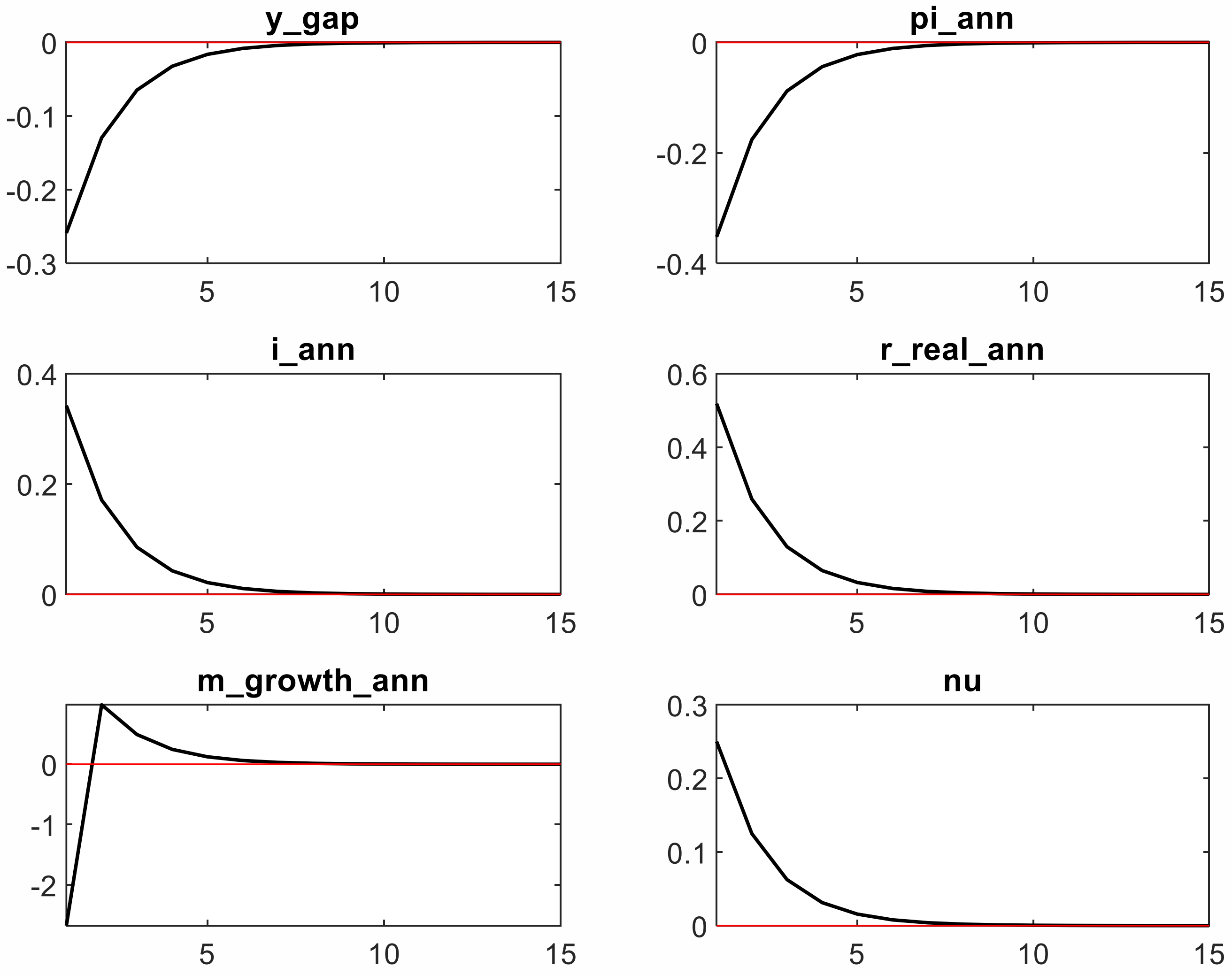
The Effects of a Monetary Policy Shock (Taylor Rule)

Basic NK + Habit formation + NKPC smoothing + interest rate smoothing



The Effects of a Monetary Policy Shock (Taylor Rule)

Baseline



VAR Evidence: Response to a Monetary Policy Shock

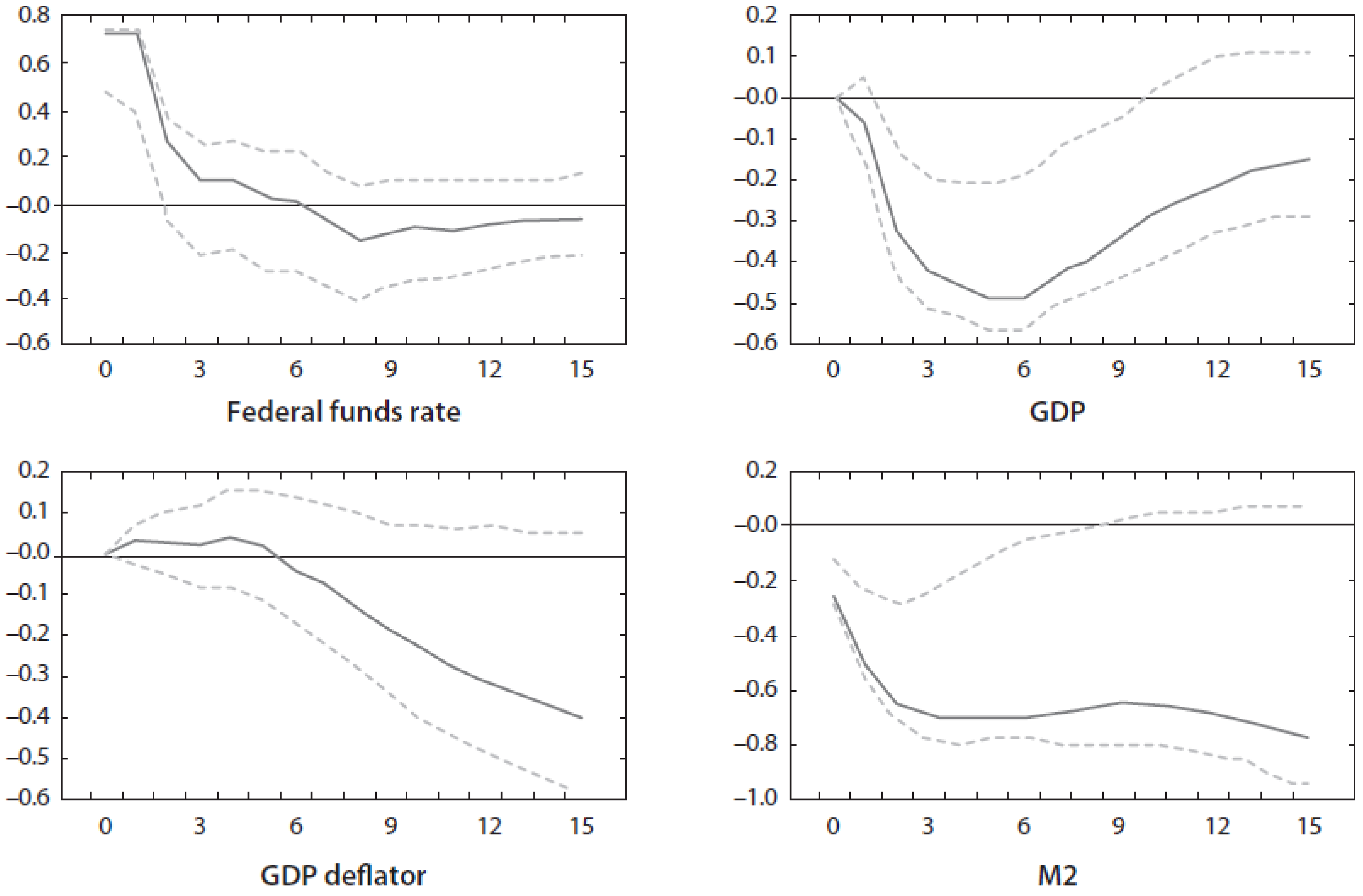


Figure 1.1. Estimated Dynamic Response to a Monetary Policy Shock
Source: Christiano, Eichenbaum, and Evans (1999).

What Have We Learned?

- How to code and simulate the basic NK model in Dynare
- Price-stickiness leads to a real impact of monetary policy
- Adding inertia helps to generate a hump-shaped IRF of output to a monetary policy shock

Thank you!