The Basic New Keynesian Model

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Introduction

Evidence on Monetary Policy, Output, and Prices:

- Short run effects of monetary policy shocks

  (i) persistent effects on real variables
  (ii) slow adjustment of aggregate price level
  (iii) liquidity effect

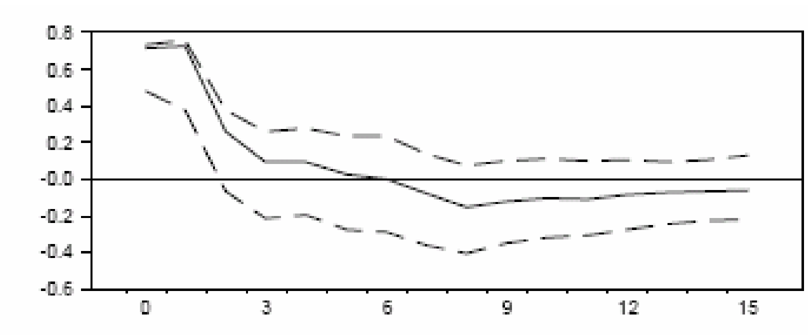
- Micro evidence on price and wage-setting behavior: significant rigidities

Failure of Classical Monetary Models

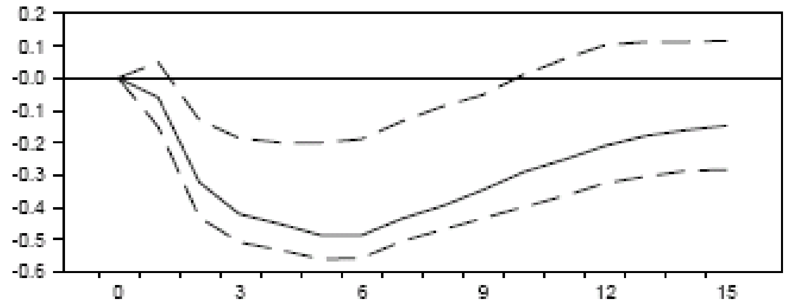
Key ingredients of the NK Model

- monopolistic competition
- nominal rigidities

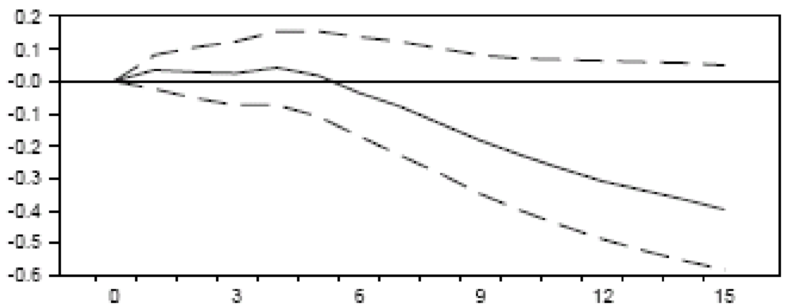
Estimated Dynamic Response to a Monetary Policy Shock



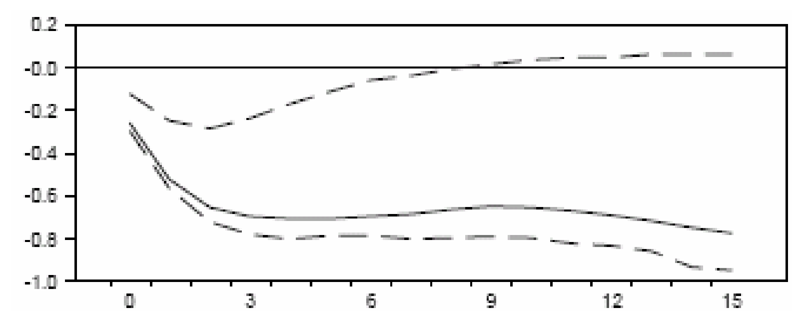
Federal funds rate



GDP



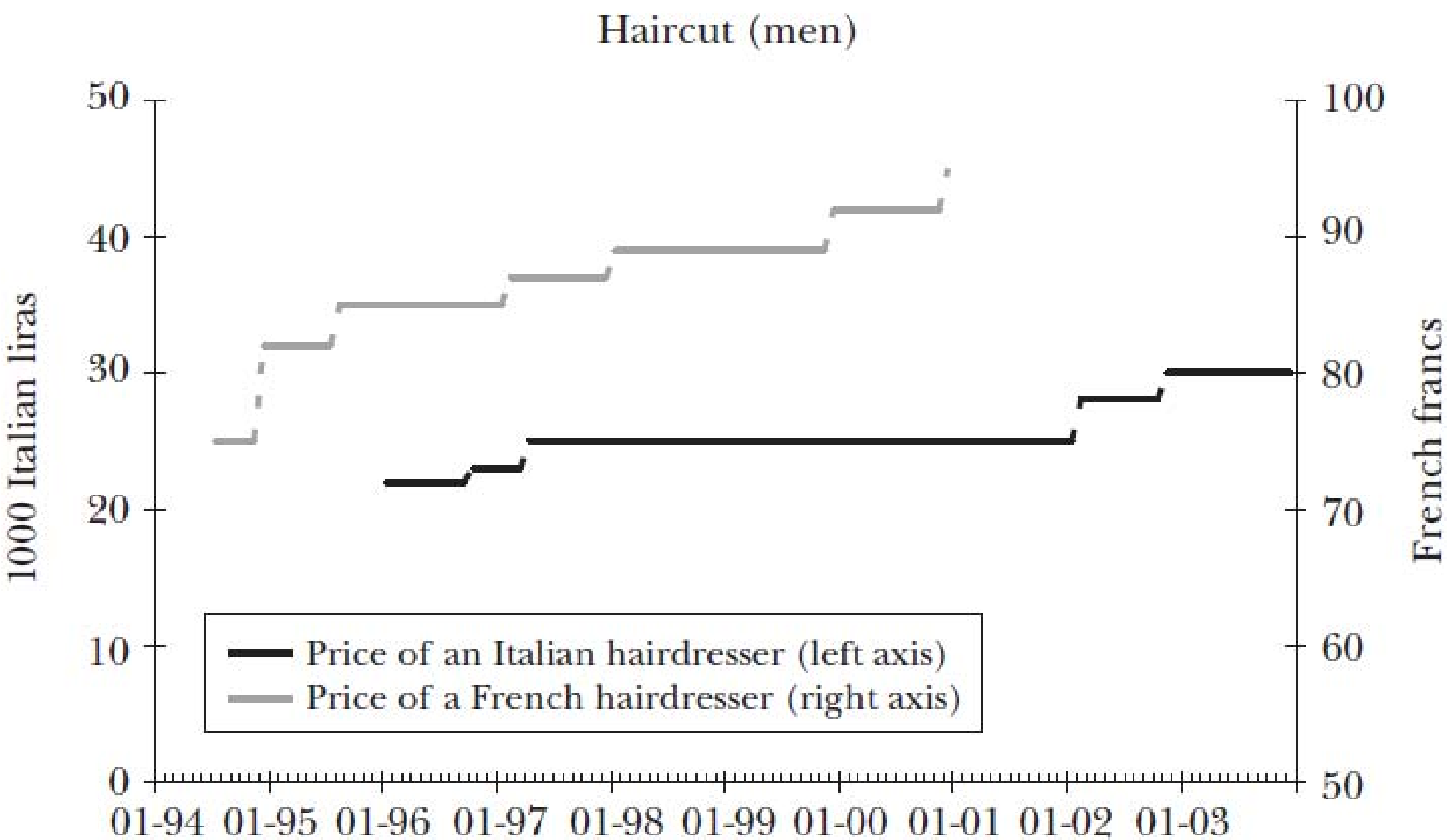
GDP deflator



M2

Source: Christiano, Eichenbaum and Evans (1999)

Micro Evidence on Price Rigidities: An Illustration



Source: Dhyne et al. (JEP 2006)

The Basic New Keynesian Model: Key Blocks

- *New Keynesian Phillips Curve*

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa \widetilde{y}_t$$

where $\widetilde{y}_t \equiv y_t - y_t^n$

- *Dynamic IS Equation*

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

- *Monetary Policy Rule*

Example:

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

Households

Representative household solves

$$\max E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$$

where

$$C_t \equiv \left[\int_0^1 C_t(i)^{1-\frac{1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}$$

subject to

$$\int_0^1 P_t(i) C_t(i) \, di + Q_t B_t \leq B_{t-1} + W_t N_t + D_t$$

for $t = 0, 1, 2, \ldots$ plus solvency constraint.

1. Optimal allocation of expenditures

$$C_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} C_t$$

where

$$P_t \equiv \left[\int_0^1 P_t(i)^{1-\epsilon}\, di\right]^{\frac{1}{1-\epsilon}}$$

Implication:

$$\int_0^1 P_t(i) C_t(i)\, di = P_t C_t$$

2. Other optimality conditions

$$U_{n,t} + \frac{W_t}{P_t} U_{c,t} = 0$$

$$\frac{Q_t}{P_t} U_{c,t} = \beta E_t \left\{ U_{c,t+1} \frac{1}{P_{t+1}} \right\}$$

Specification of utility:

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

implied log-linear optimality conditions (aggregate variables)

$$w_t - p_t = \sigma c_t + \varphi n_t \equiv mrs_t$$

$$c_t = E_t\{c_{t+1}\} - \frac{1}{\sigma}(i_t - E_t\{\pi_{t+1}\} - \rho)$$

where $Q_t \equiv \exp\{-i_t\}$, $\beta \equiv \exp\{-\rho\}$ and $\pi_t \equiv p_t - p_{t-1}$.

Firms

- Continuum of firms, indexed by $i \in [0,1]$
- Each firm produces a differentiated good
- Identical technology

$$Y_t(i) = A_t N_t(i)$$

- Constant desired markup $\mathcal{M} \equiv \frac{\epsilon}{\epsilon - 1}$
- Probability of being able to reset price in any given period: $1 - \theta$, independent across firms (Calvo (1983)).

$$P_t = \left[\theta (P_{t-1})^{1-\epsilon} + (1-\theta)(P_t^*)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$$

- $\theta \in [0,1]$: index of price stickiness
- Implied average price duration $\frac{1}{1-\theta}$

Firms' problem:

$$\max_{P_t^*} \sum_{k=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} \left(P_t^* Y_{t+k|t} - \mathcal{C}_{t+k}(Y_{t+k|t}) \right) \right\}$$

subject to

$$Y_{t+k|t} = (P_t^* / P_{t+k})^{-\epsilon} C_{t+k}$$

for $k = 0, 1, 2, \ldots$where

$$Q_{t,t+k} \equiv \beta^k \left(\frac{C_{t+k}}{C_t} \right)^{-\sigma} \left(\frac{P_t}{P_{t+k}} \right)$$

Optimality condition:

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} Y_{t+k|t} \left(P_t^* - \mathcal{M} \Psi_{t+k} \right) \right\} = 0$$

where $\Psi_{t+k} \equiv \mathcal{C}'_{t+k}(Y_{t+k|t})$ and $\mathcal{M} \equiv \frac{\epsilon}{\epsilon - 1}$ (interpretation).

Equivalently,

$$\sum_{k=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} Y_{t+k|t} \left(\frac{P_t^*}{P_{t-1}} - \mathcal{M} MC_{t+k} \Pi_{t-1,t+k} \right) \right\} = 0$$

where $MC_{t+k} \equiv \Psi_{t+k} / P_{t+k}$ and $\Pi_{t-1,t+k} \equiv P_{t+k} / P_{t-1}$

Perfect Foresight, Zero Inflation Steady State:

$$\frac{P_t^*}{P_{t-1}} = 1 \quad ; \quad \Pi_{t-1,t+k} = 1 \quad ; \quad Y_{t+k|t} = Y$$

$$Q_{t,t+k} = \beta^k \quad ; \quad MC = \frac{1}{\mathcal{M}}$$

Log-linearization around zero inflation steady state:

$$p_t^* - p_{t-1} = (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\{\widehat{mc}_{t+k} + p_{t+k} - p_{t-1}\}$$

where $\widehat{mc}_{t+k|t} \equiv mc_{t+k|t} - mc$.

Equivalently,

$$p_t^* = \mu + (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\{\psi_{t+k}\}$$

where $\mu \equiv \log \frac{\epsilon}{\epsilon-1}$.

Flexible prices $(\theta = 0)$:

$$p_t = p_t^* = \mu + \psi_t$$

$$\Longrightarrow \qquad \mu_t \equiv p_t - \psi_t = \mu$$

The New Keynesian Phillips Curve

- *Staggered Price Setting*

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

$$p_t^* = \mu + (1-\beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t\{\psi_{t+k}\}$$

Implying:

$$\pi_t = \beta E_t\{\pi_{t+1}\} - \lambda(\mu_t - \mu)$$

where $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}$

- *Average Markup*

$$\mu_t = p_t - (w_t - a_t)$$

- *Labor Market*

$$w_t - p_t = \sigma c_t + \varphi n_t$$

$$\begin{aligned} N_t &= \int_0^1 N_t(i)\ di \\ &= \int_0^1 \left(\frac{Y_t(i)}{A_t}\right) di \\ &= \left(\frac{Y_t}{A_t}\right) \int_0^1 \left(\frac{P_t(i)}{P_t}\right)^{-\epsilon} di \end{aligned}$$

Taking logs,

$$n_t = y_t - a_t + d_t$$

where $d_t \equiv \log \int_0^1 (P_t(i)/P_t)^{-\epsilon}\, di$ (second order).

Up to a first order approximation:

$$n_t = y_t - a_t$$

- *Goods Market Clearing*

$$y_t = c_t$$

- *Average Markup and the Output Gap*

$$\mu_t = (1+\varphi)a_t - (\sigma+\varphi)y_t$$

Under flexible prices:

$$\mu = (1+\varphi)a_t - (\sigma+\varphi)y_t^n$$

Combining both:

$$\mu_t - \mu = -(\sigma+\varphi)\,\widetilde{y}_t$$

- *The New Keynesian Phillips Curve*

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \kappa \widetilde{y}_t$$

where $\kappa \equiv \lambda\,(\sigma+\varphi)$

- Properties:

(i) Forward-looking

$$\pi_t = \kappa \sum_{k=0}^{\infty} \beta^k E_t\{\widetilde{y}_{t+k}\}$$

$\Rightarrow$ no role for past inflation

(ii) No tradeoff between output gap and inflation stabilization
$\Rightarrow$ "the Divine Coincidence"
$\Rightarrow$ costless disinflations

(iii) Model-based vs. traditional output gap

$$\widehat{y}_t = y_t - f(t)$$

$$\widetilde{y}_t \equiv y_t - y_t^n$$

$\Rightarrow$ may distort empirical assessments
$\Rightarrow$ marginal cost/markup-based estimates (e.g., Galí-Gertler)

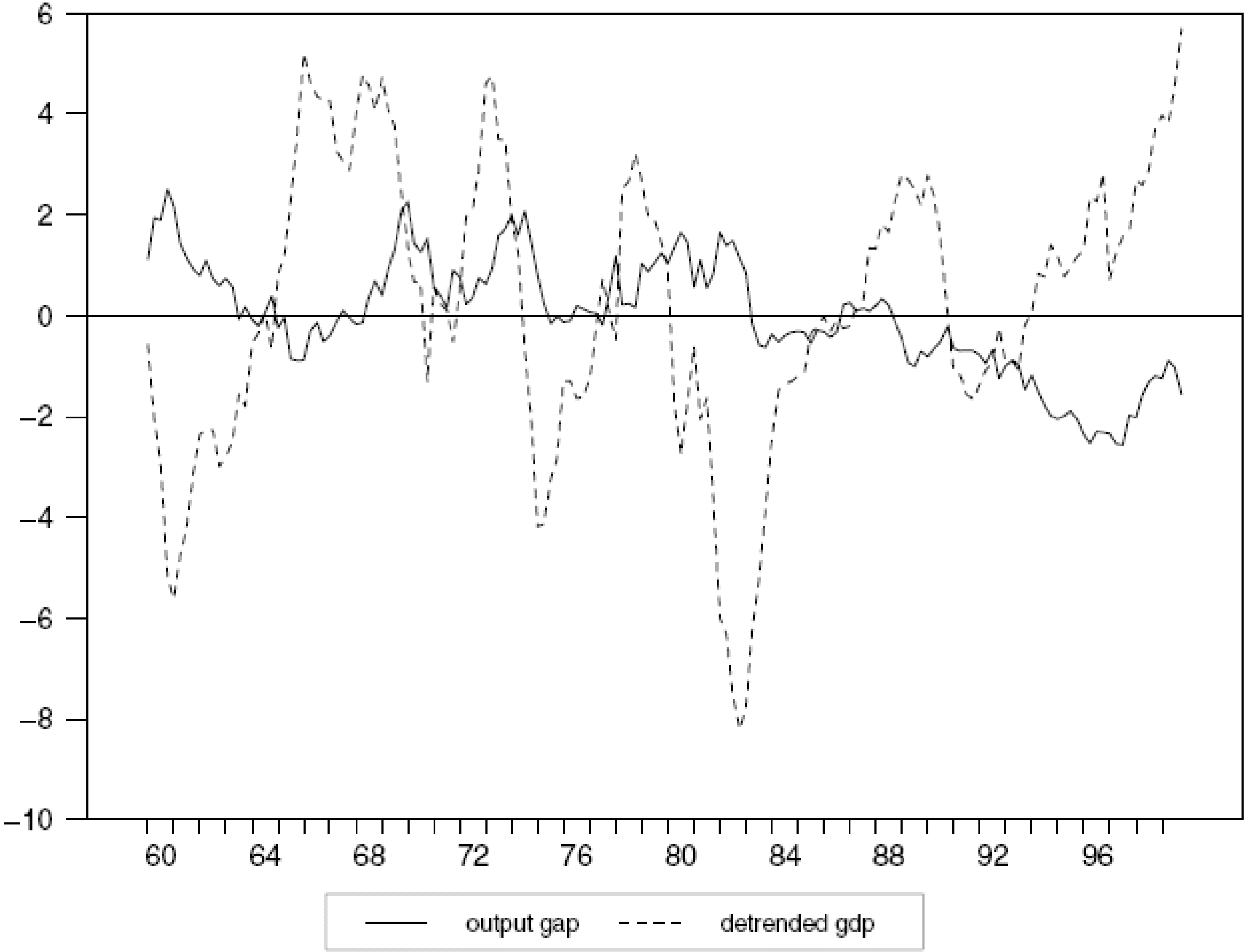


Figure 5.2. Model-based output gap vs. detrended GDP.

Source: Galí (2003)

The Dynamic IS Equation

- Euler equation + goods market clearing

$$y_t = E_t\{y_{t+1}\} - \frac{1}{\sigma}(i_t - E_t\{\pi_{t+1}\} - \rho)$$

Combined with $\widetilde{y}_t \equiv y_t - y_t^n$

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

where

$$\begin{aligned} r_t^n &\equiv \rho + \sigma E_t\{\Delta y_{t+1}^n\} \\ &= \rho + \frac{\sigma(1+\varphi)}{\sigma+\varphi} E_t\{\Delta a_{t+1}\} \end{aligned}$$

Monetary Policy

- Interest rate rule

  Example:

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

  Empirical evidence

- The role of monetary aggregates

  - money demand (ad hoc):

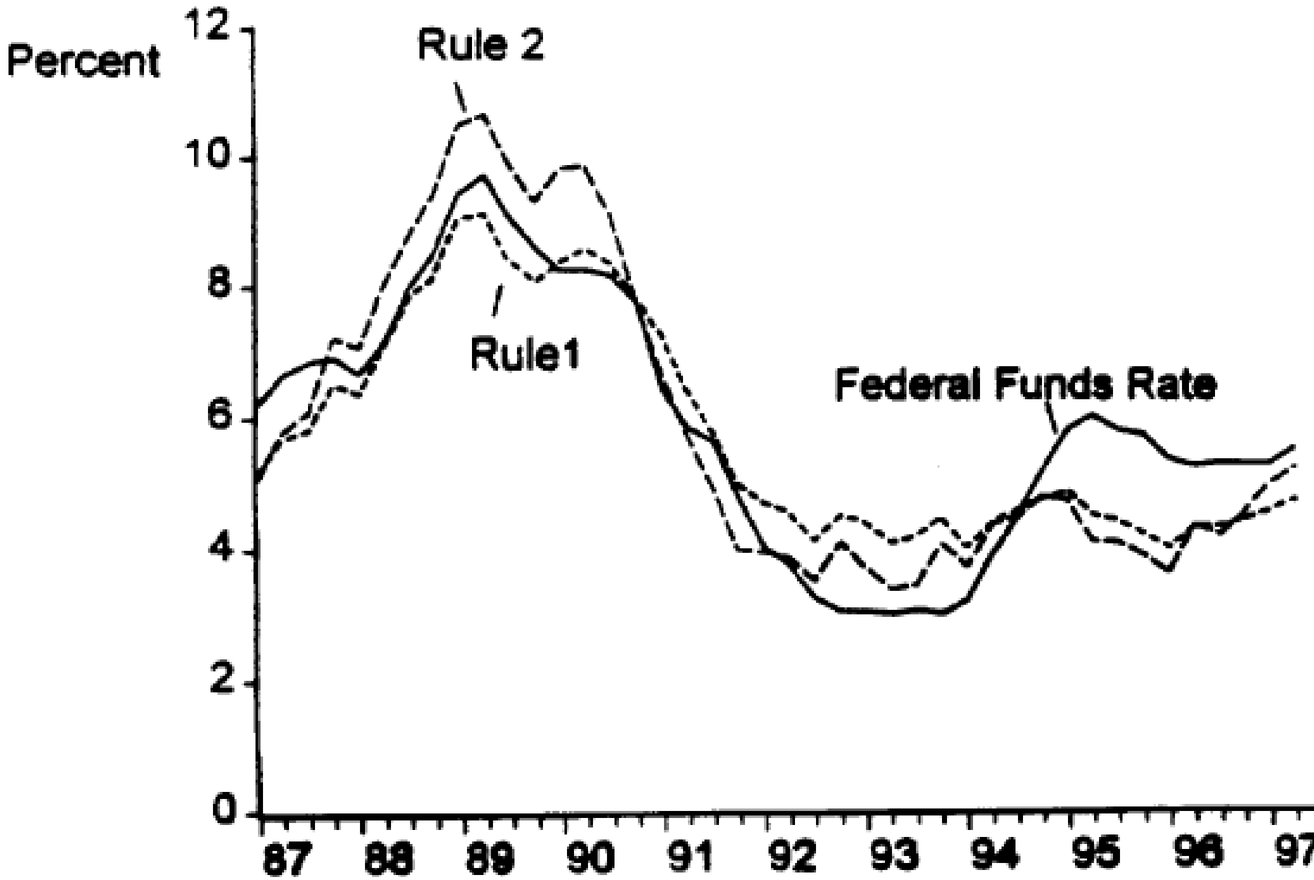
$$m_t - p_t = y_t - \eta i_t$$

  - implied money growth:

$$\Delta m_t = \pi_t + \Delta y_t - \eta \Delta i_t$$

The Taylor Rule (Taylor 1993)

$$i_t = 4 + 1.5(\pi_t - 2) + 0.5\, y_t$$



Source: Taylor 1999

Simulations

- Dynamic effects of monetary policy shocks

$$v_t = \rho_v v_{t-1} + \varepsilon_t^v$$

- Dynamic effects of technology shocks

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a$$

- Calibration

$\rho_a = 0.9, \ \rho_v = 0.5$
$\phi_\pi = 1.5, \ \phi_y = 0.5/4$
$\beta = 0.99, \ \sigma = \varphi = 1, \ \eta = 4.$
$\theta = 2/3$

Figure 3.1: Effects of a Monetary Policy Shock (Interest Rate Rule))

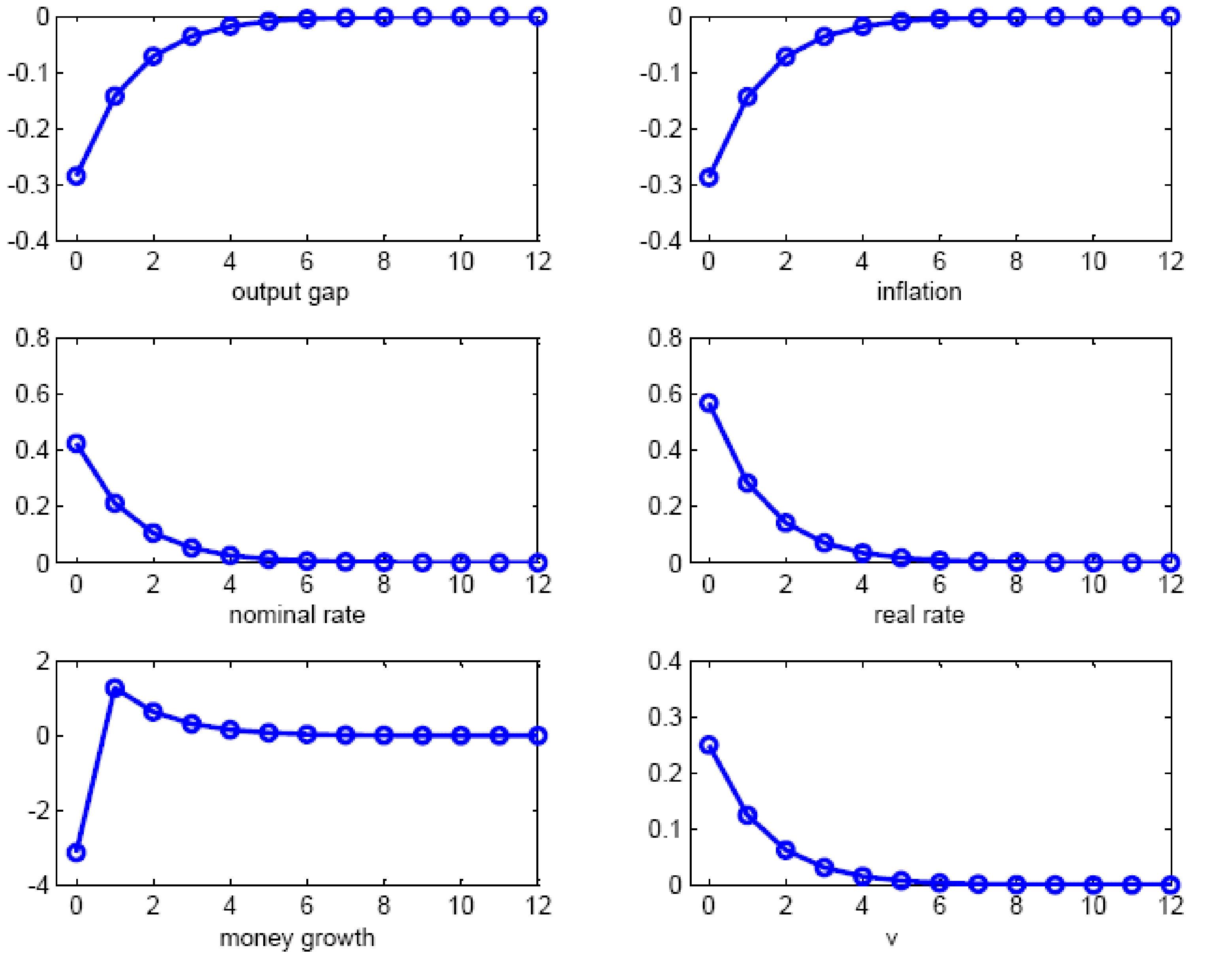


Figure 3.2: Effects of a Technology Shock (Interest Rate Rule)