Previous lecture

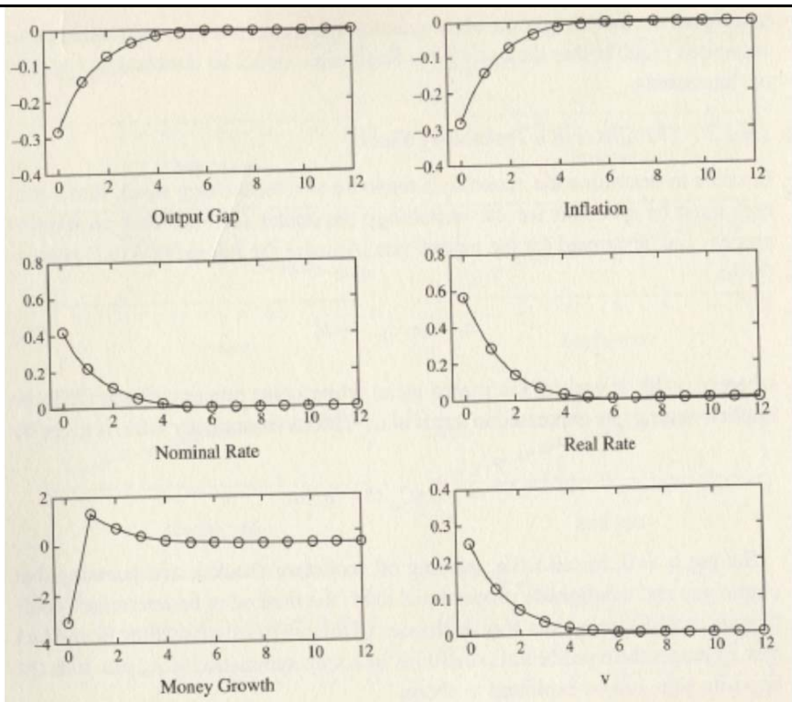
- New Keynesian Model
- This lecture: More on Phillips curves

Three equations

$$\pi_t = \gamma + \beta E_t\{\pi_{t+1}\} + \kappa\left(y_t - y_t^n\right)$$

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

$$i_t = \rho + \phi_\pi \pi_t + \phi_y\left(y_t - y_t^n\right) + v_t$$



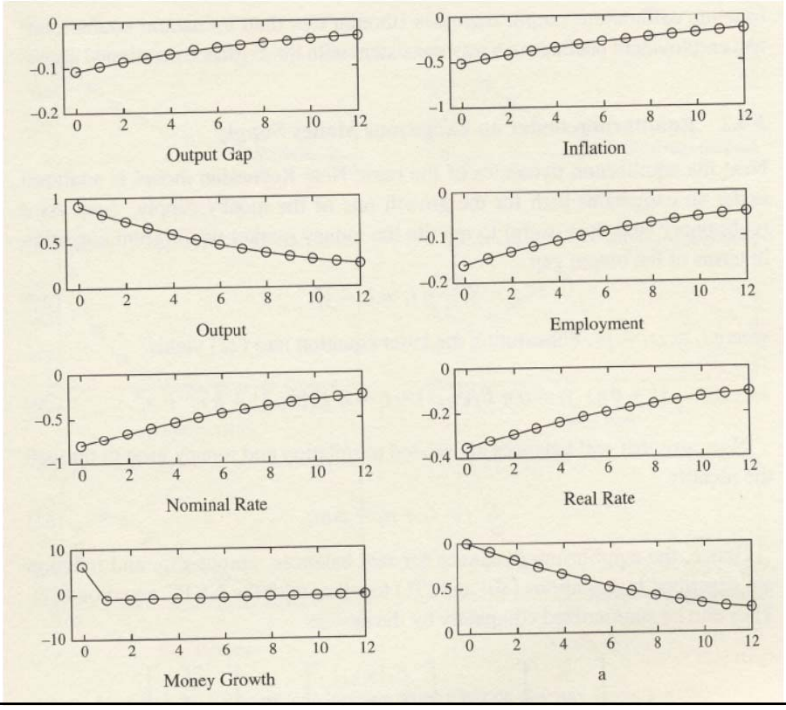
Equilibrium unique if

$$\kappa(\phi_\pi - 1) + (1-\beta)\phi_y > 0$$

…or technology shock

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

$$\rho_a = 0.9$$



More on policy

- Optimal policy
  - Uniqeness
  - Realistic rules
    - Information requirements
      - Unobservables like flexible price output or interest rate
- Simple policy rules
  - Taylor rules
- More on this later

More on Phillips curves

- Expectations
- Price setting

Inattentive agents, Mankiw and Reis Sticky information

- firms gather information and recompute optimal prices slowly over time
- a fraction of the firms obtains new information about the state of the economy and computes a new path of optimal prices
- other firms continue to set prices based on old plans and outdated information
- each firm has the same probability of being one of the firms updating their pricing plans, regardless of how long it has been since its last update

Sticky information model

$$p_t^* = p_t + \lambda\left(y_t - y_t^n\right)$$ optimal price

$$x_t^j = E_{t-j}\left\{p_t^*\right\}$$ price based on old plans

$$p_t = \gamma \sum_{j=0}^{\infty} (1-\gamma)^j x_t^j$$ aggregated

$$p_t = \gamma \sum_{j=0}^{\infty} (1-\gamma)^j E_{t-j}\left\{p_t + \lambda(y_t - y_t^n\right\}$$

$$\pi_t = \left[\frac{\gamma\lambda}{1-\gamma}\right]\left(y_t - y_t^n\right) + \gamma \sum_{j=0}^{\infty} (1-\gamma)^j E_{t-1-j}\left\{\pi_t + \lambda\Delta\left(y_t - y_t^n\right)\right\}$$

Interpretation

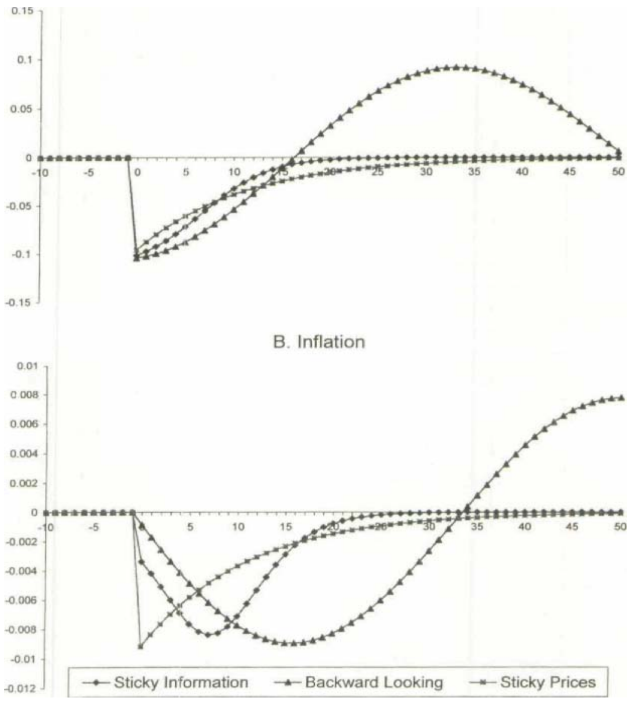
- Inflation depends on output, expectations of inflation, and expectations of output growth
- past expectations of current economic conditions
- large differences in the dynamic pattern of prices and output in response to monetary policy

Theoretical properties

- a policy of permanently falling inflation will keep output permanently high in NKPC
- the sticky-information model satisfies the strict version of the natural rate hypothesis

Dynamic responses

- More realistic dynamic responses in sticky information models compared to NKPC
- Hybrid Phillips curve
- Other properties of model



Hybrid curve, Gali and Gertler 1999

$$\pi_t = \delta x_t + (1 - \phi)E_t\{\pi_{t+1}\} + \phi\pi_{t-1}$$

- The addition of the lag term is designed to capture the inflation persistence that is unexplained in the baseline model
- adaptive expectations on the part of a subset of price setters
- In this instance the estimated model is consistent with the old Phillips curve: expected future inflation does not enter significantly in the inflation equation; lagged inflation enters with a coefficient near unity, as in the traditional framework

Hybrid curve

- from the fraction firms that are able to reset their price only a fraction will do so
- a fraction instead use a rule-of-thumb that makes them set the price equal to the average of recently (last period) adjusted prices plus an adjustment for expected inflation, based on lagged inflation

$$\pi_t = \lambda\left(mc_t - mc\right) + \gamma_f E_t\left\{\pi_{t+1}\right\} + \gamma_b \pi_{t-1} + \varepsilon_t$$

$$\lambda = (1-\varpi)(1-\theta)(1-\beta\theta)\phi^{-1}$$

$$\gamma_f = \beta\theta\phi^{-1}$$

$$\gamma_b = \varpi\phi^{-1}$$

$$\phi = \theta + \varpi\left[1-\theta(1-\beta)\right]$$

Estimation problems

- Unobservables
  - marginal cost gap
  - output gap
  - expected inflation
- Parameters to be expected (structural)
  - identification
  - model uncertainty
  - simultaneity

Estimating the gap

- Real marginal cost $\frac{\partial C(Y,w)}{\partial Y}$
- Output gap $w =$ vector of input prices
  - Potential output
  - HP filter
  - Output at flexible prices

$Y_t = A_t K_t^{\alpha_k} N_t^{\alpha_n}$ Cobb-Douglas production function

$MC_t = (W_t/P_t)/(\partial Y_t/\partial N_t)$ marginal cost

$$\frac{\partial Y_t}{\partial N_t} = \frac{\alpha_n Y_t}{N_t}$$

$$MC_t = \frac{S_t}{\alpha_n}$$

$S_t \equiv W_t N_t / P_t Y_t$

$mc_t = s_t$ deviation from steady state

Cost function

$$\frac{\partial C(Y,w)}{\partial Y} = C'(Y,w)$$
$$\frac{\partial C(Y,w)}{\partial w_i} = x_i'(Y,w)$$

- Cobb-Douglas simplistic
- Marginal cost independent of output
- Cost shares constant (in steady state)

Translog example

$$\log c = a_0 + \sum_i a_i \log w_i + \frac{1}{2}\sum_i \sum_j a_{ij} \log w_i \log w_j + \sum_i b_i \log w_i \log y + 0.5g \log y \log y$$

$$s_i = a_i + \sum_j a_{ij} w_j + b_i \log y$$ demand for inputs as shares

$$mc = \left[\sum_i b_i \log w_i + g \log y\right]\frac{c}{y}$$ marginal cost

simultaneous estimation of input demand and Phillips curve

Another Phillips curve

- Sticky prices in some firms
- Adjustment costs
- Threshold for price adjustment
- Many firms
- Small and large shocks

Shocks

- Relative shocks -> relative price changes
- Small shock -> no price change
- Large shock -> price change
- Mean of relative price changes = 0

Distribution of shocks/relative prices

Figure 1. A symmetric distribution of relative shocks

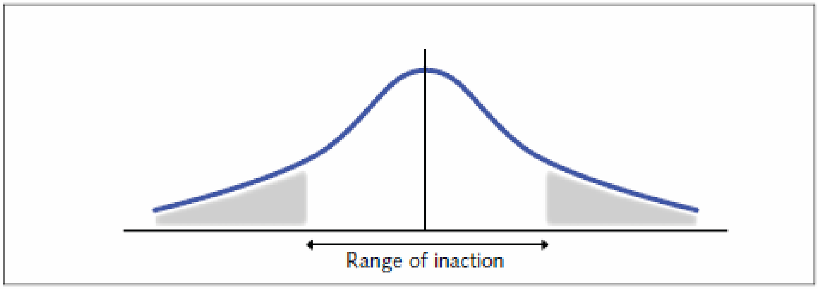


Figure 2. A positively skewed distribution of relative shocks

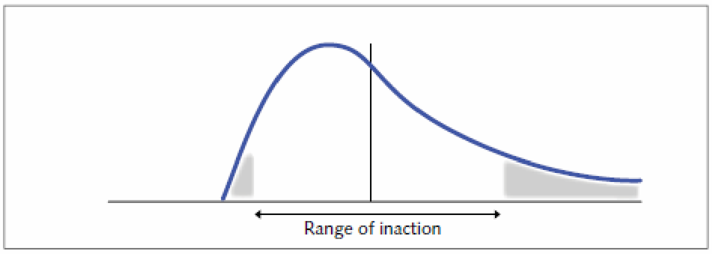


Figure 3. A negatively skewed distribution of relative shocks

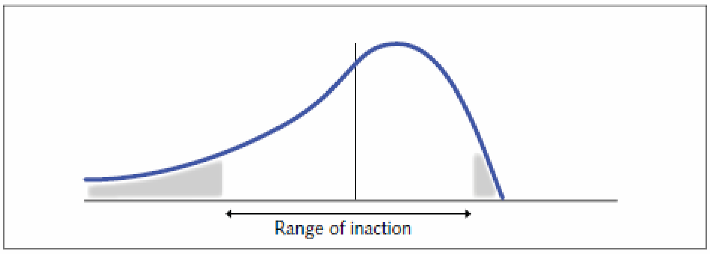
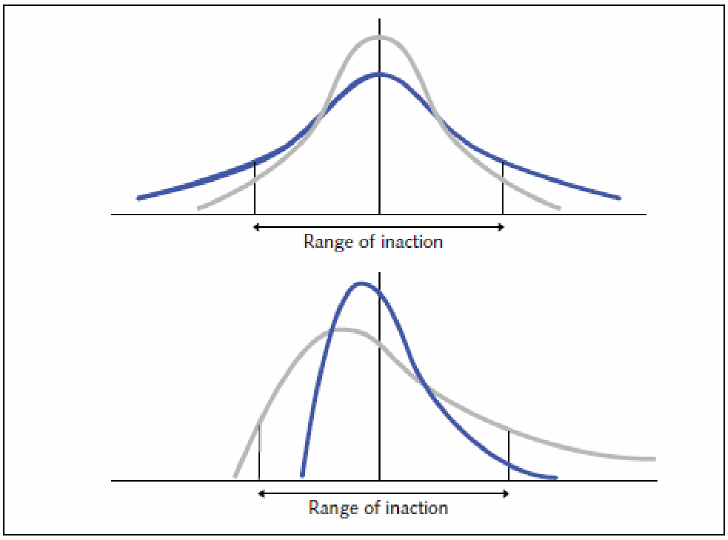


Figure 4. Relationship between variance and skewness in the distribution of relative shocks



$$\pi_t = \beta_0 + \beta_1 \Delta w_t + \beta_2 \Delta \rho_t + \beta_3 \pi_{t-1} + \beta_4 \left(U_t - \bar{U}_t\right) + \beta_5 \Delta p_t^{oil} +$$
$$\beta_6 \Delta p_t^{metals} + \beta_7 \Delta p_t^{food(a)} + \beta_8 \Delta p_t^{food(b)} + \beta_9 g_t$$

$$\beta_{10}\sigma_t^3 + \beta_{11}\sigma_{t-1}^3 + \beta_{12}\sigma_t^2 + \beta_{13}\sigma_t^3\sigma_t^2$$

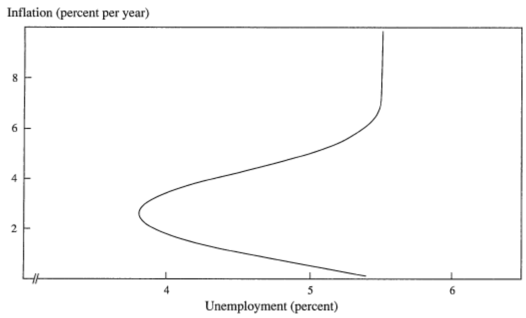
TABLE 3. REGRESSIONS WITH MODEL RESIDUALS – ε_t – AS DEPENDENT VARIABLE

	Model		
	VAR	Bayesian VAR	N. I. Economic Research
Variable	Coefficient (p)		
	Quarterly 1980–2003	Quarterly 1981–2003	Monthly 1998–2004
Constant	−0.005012 (0.000)	−0.403792 (0.000)	0.269104 (0.001)
ε_{t-1}	−0.010574 (0.908)	0.096325 (0.292)	0.130121 (0.281)
σ_t^3	2.812243 (0.000)	197.8204 (0.000)	70.25972 (0.062)
σ_{t-1}^3	−1.260631 (0.009)	−80.26362 (0.017)	−16.73187 (0.188)
σ_t^2	5.153802 (0.000)	331.5355 (0.000)	−100.0026 (0.002)
$\sigma_t^3\,\sigma_t^2$	−1205.869 (0.003)	−74240.61 (0.007)	−7991.953 (0.474)
R^2	0.372	0.357	0,292

Note: Quarterly changes have been used for the VAR models, 12-month changes for the forecasts from the National Institute.

Yet another curve – Akerlof, Dickens and Perry

Figure 1. A Hypothetical Long-Run Phillips Curve



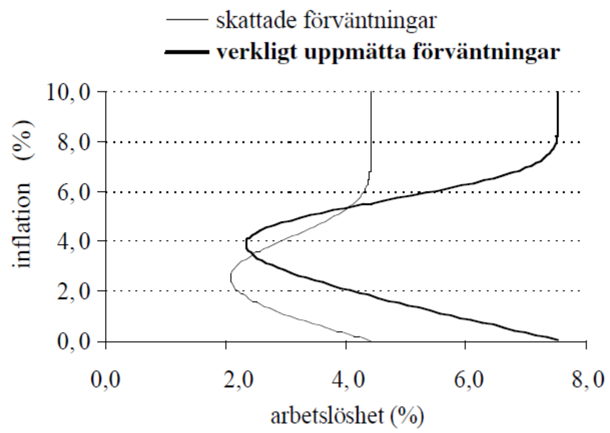
Source: Authors' calculations from calibration of the theoretical model.

Theory

- Near-rational expectations (psychological)
- Firms set efficiency wages and prices
- Some firms near-rational, others rational
- => real wages lower at low inflation
- => long run relationship between inflation and unemployment

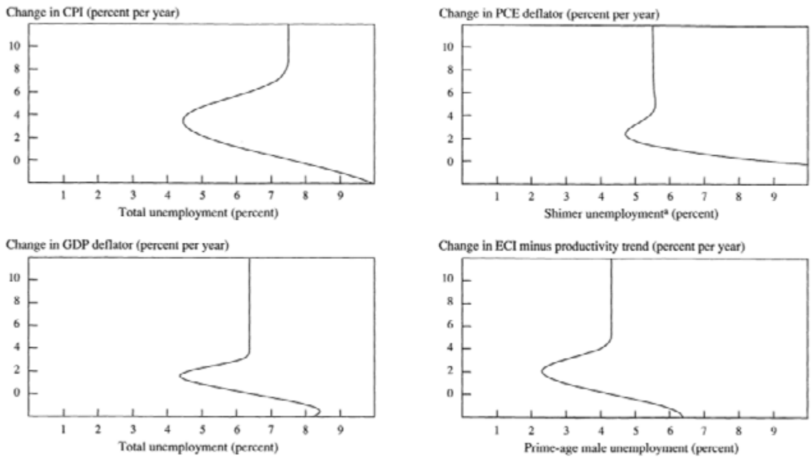
Sweden estimates

Figur 2 **Phillipskurvan: Svenska data 1963–2000.**



US

Figure 7. Long-Run Inflation-Unemployment Relation Estimated with Various Price Indexes



Source: Authors' calculations from the estimated parameters reported in table 2.
a. Shimer's (1998) demographically adjusted unemployment rate.

Inflation measure

- GDP implicit price deflator = CPI in basic model
- (CPI) in practice, narrower measure
- Other prices: wages, import prices, producer prices, etc.

Monetary policy in the basic model

- Literature: Clarida, Gali and Gertler (1999) basic
- Distortions
  - Monopolistic competition
  - Sticky prices
- Monopolistic competition
  - Equilibrium with too low employment and output
  - Efficient equilibrium through subsidy
- Sticky prices
  - Inefficient
    - Too low or too high output due to different markups
    - Relative prices/relative consumption change => inefficient resource allocation

Competitive economy, highest possible welfare

$$C_t(i) = C_t$$

$$N_t(i) = N_t$$

$$-\frac{U_{n,t}}{U_{c,t}} = (1-\alpha)A_t N_t^{-\alpha} \qquad (1-\alpha)A_t N_t^{-\alpha} = MPN_t$$

Monopolistic competition and **flexible prices**

$$P_t = \mathrm{M}\frac{W_t}{MPN_t} \qquad \mathrm{M} = \frac{\varepsilon}{\varepsilon - 1} > 1$$

$$-\frac{U_{n,t}}{U_{c,t}} = \frac{W_t}{P_t} = \frac{MPN_t}{\mathrm{M}} < MPN_t$$

Inefficiency 1

Creating efficiency

$$P_t = \mathrm{M}\frac{(1-\tau)W_t}{MPN_t}$$

subsidy of labor

Choose τ such that $M(1-\tau) = 1$

$$\tau = \frac{1}{\varepsilon}$$

Inefficiency 2

$$\mathrm{M}_t = \frac{P_t}{(1-\tau)(W_t / MPN_t)} = \frac{P_t M(1-\tau)}{(1-\tau)(W_t / MPN_t)} = \frac{P_t \mathrm{M}}{(W_t / MPN_t)}$$

average markup

$$-\frac{U_{n,t}}{U_{c,t}} = \frac{W_t}{P_t} = MPN_t \frac{\mathrm{M}}{\mathrm{M}_t} \neq \text{`}MPN$$

Inefficiency 3

- relative prices change due to some sticky prices
- relative prices change => relative consumption changes
- => inefficient resource allocation

Aim of monetary policy

- max utility of representative consumer
- can be achieved by stabilising price level
- MRS=MRT

- not to stabilise output
- low inflation =0 no object in itself

Optimal policy

$$\pi_t = \beta E_t\left\{\pi_{t+1}\right\} + \kappa(y_t - y_t^n)$$

$$y_t - y_t^n = E_t\left\{y_{t+1} - y_{t+1}^n\right\} - \frac{1}{\sigma}\left(i_t - E_t\left\{\pi_{t+1}\right\} - r_t^n\right)$$

$$r_t^n = \rho + \sigma E_t\left\{\Delta y_{t+1}^n\right\} = \rho + \sigma\psi_{ya}^n E_t\left\{\Delta a_{t+1}\right\}$$

$$i_t = r_t^n$$

Other possibilities

$$i_t = r_t^n + \phi_\pi \pi_t + \phi_y (y_t - y_t^n)$$

$$i_t = r_t^n + \phi_\pi E_t \left\{ \pi_{t+1} \right\} + \phi_y E_t \left\{ y_{t+1} - y_{t+1}^n \right\}$$

Conditions on parameters for uniqueness

$$\kappa \left(\phi_\pi - 1 \right) + (1 - \beta) \phi_y > 0$$

aggressive policy

Problems with optimal rules

- natural rate of interest unobservable
- natural rate of output also unobservable, but the weight on output can be set to zero
- model known and true
- shocks calculated
- => study simple rules

Simulation

$$i_t = \rho + \phi_\pi \pi + \phi_y (y_t - y)$$

	Taylor Rule			
ϕ_π	1.5	1.5	5	1.5
ϕ_y	0.125	0	0	1
$(\sigma_\zeta, \rho_\zeta)$	—	—	—	—
$\sigma(\tilde{y})$	0.55	0.28	0.04	1.40
$\sigma(\pi)$	2.60	1.33	0.21	6.55
welfare loss	0.30	0.08	0.002	1.92

Monetary policy tradeoffs

- Central banks: we care about output, not only inflation
- Tradeoff: strict inflation targeting => too much volatility in real variables
- Flexible inflation targeting, Lars E O Svensson

Loss function, representative consumer

$$L = \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[\left(\sigma + \frac{\varphi + \alpha}{1 - \alpha} \right) \left(y_t - y_t^n \right)^2 + \frac{\varepsilon}{\lambda} \pi_t^2 \right]$$

Loss function

- incresing in ε, θ
- is increasing in α, φ, σ

A. The case of an efficient steady state: short run deviations

$x_t = y_t - y_t^e$ welfare relevant output gap

$E_0 \left\{ \sum_{i=0}^{\infty} \beta^t \left(\pi_t^2 + \alpha_x x_t^2 \right) \right\}$ welfare loss of representative consumer

$y_t^e - y_t^n$ deviation between efficient and natural levels of output = short run deviations

$$y_t - y_t^n \equiv x_t + (y_t^e - y_t^n)$$ definition

$$\pi_t = \beta E_t\left\{\pi_{t+1}\right\} + \kappa x_t + u_t$$ new-new Phillips curve

$$u_t \equiv \kappa\left(y_t^e - y_t^n\right)$$

$$u_t = \rho_u u_{t-1} + \varepsilon_t^u$$ assumption

$$x_t = E_t\left\{x_{t+1}\right\} - \frac{1}{\sigma}\left(i_t - E_t\left\{\pi_{t+1}\right\} - r_t^e\right)$$ dynamic IS

$$r_t^e = \rho + \sigma E_t\left\{\Delta y_{t+1}^e\right\}$$

Tradeoff

- Short-run tradeoff
- Forward-looking NKPC (constraint)
- Discretion vs. committment
- Committment might improve tradeoff due to effects on expectations

Optimal discretionary policy

choose (x_t, π_t)

minimize $\pi_t^2 + \alpha_x x_t^2$ s.t. $\pi_t = \kappa x_t + v_t$

FOC $x_t = -\dfrac{\kappa}{\alpha_x}\pi_t$

Optimal policy yields

$$\pi_t = \alpha_x \frac{1}{\kappa^2 + \alpha_x(1-\beta\rho_y)} u_t$$

inflation

$$x_t = -\kappa \frac{1}{\kappa^2 + \alpha_x(1-\beta\rho_y)} u_t$$

output gap

Simple interest rate rule?

$$i_t = r_t^e + \psi u_t$$

equilibrium interest rate
not unique, no good rule

$$i_t = r_t^e + \phi_\pi \pi_t$$

unique $\phi_\pi > 1$

Optimal policy under commitment

choose sequence $(x_t, \pi_t)_{t=0}^{\infty}$

to minimize $$\frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left(\pi_t^2 + \alpha_x x_t^2 \right)$$

subject to $$\pi_t = \beta E_t \left\{ \pi_{t+1} \right\} + \kappa x_t + u_t$$

$$x_0 = -\frac{\kappa}{\alpha_x} \pi_0$$

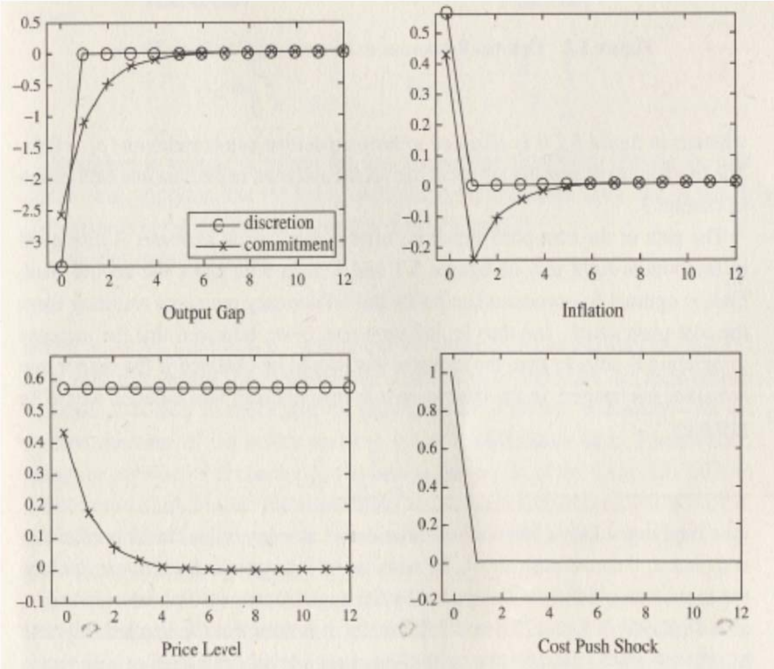
FOC

$$x_t = x_{t-1} - \frac{\kappa}{\alpha_x} \pi_t$$

$$x_t = -\frac{\kappa}{\alpha_x} \hat{p}_t \qquad \hat{p}_t = p_t - p_{t-1}$$

implicit price level target

$$\hat{p}_t = a\hat{p}_{t-1} + a\beta E_t\left\{\hat{p}_{t+1}\right\} + au_t$$ price level dynamics



Discretion vs commitment

- Improved tradeoff in 0, commit to lower future output gaps => current inflation lower for any given output gap
- Worsened in future, but not offset
- Allover improved tradeoff with commitment

B. The case of an inefficient steady state

$$-\frac{U_n}{U_c} = MPN(1-\Phi)$$ wedge

$$\Phi = 1 - \frac{1}{\mathrm{M}} > 0$$

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{2}\left(\pi_t^2 + \alpha_x \hat{x}_t^2\right) - \mathrm{A}\hat{x}_t \right]$$ accounting for inefficiency

$$\mathrm{A} = \Phi \frac{\lambda}{\varepsilon} > 0 \qquad \hat{x}_t = x_t - x$$

x=welfare relevant output gap in the zero inflation steady state

$$\pi_t = \beta E_t \left\{ \pi_{t+1} \right\} + \kappa \hat{x}_t + u_t$$

new-new-new PC

$$u_t = \kappa \left(\hat{y}_t^e - \hat{y}_t^n \right)$$

Optimal discretionary

choose (x_t, π_t)

to min $\frac{1}{2}\left(\pi_t^2 + \alpha_x \hat{x}_t^2\right) - \mathrm{A}\hat{x}_t$

subject to $\pi_t = \kappa \hat{x}_t + v_t$ $\quad v_t = \beta E_t \left\{ \pi_{t+1} \right\} + u_t$

FOC $\hat{x}_t = \frac{\mathrm{A}}{\alpha_x} - \frac{\kappa}{\alpha_x} \pi_t$

Dynamics

$$\pi_t = \frac{\mathrm{A}\kappa}{\kappa^2 + \alpha_x(1-\beta)} + \alpha_x \Psi u_t$$

inflation bias, average inflation increases

$$\hat{x}_t = \frac{\mathrm{A}(1-\beta)}{\kappa^2 + \alpha_x(1-\beta)} - \kappa \Psi u_t$$

Optimal policy under commitment

$$\hat{p}_t = a\hat{p}_{t-1} + a\beta E_t\left\{\hat{p}_{t+1}\right\} + \alpha_x \kappa \mathrm{A} + a u_t$$

price level dynamics

$$\hat{p}_t = \delta\,\hat{p}_{t-1} + \frac{\delta}{1-\delta\beta\rho_u} u_t + \frac{\delta\kappa\mathrm{A}}{1-\delta\beta}$$

steady state

$$\lim_{T\to\infty} p_T = p_{-1} + \frac{\delta\kappa\mathrm{A}}{(1-\delta\beta)(1-\delta)}$$

no inflation bias asymptotically

Conclusions

- Efficient steady state or not matters if discretionary policy
- Results depend on
  - Linear approximations around SS
  - Functional forms
  - Inflation bias with optimal policy (max repr consumers welfare)

More policy problems

- Simple new Keynesian model can be extended
  - Sticky wages
  - Sticky import prices
  - Sticky producer prices
  - Other respects
- Implications for
  - Choice of target variables
  - Model structure and dynamics

Both wages and prices are sticky

- Calvo type for wages
- Both wages and prices sticky, but degree of stickyness can differ

Firms

$$N_t(i) \equiv \left[\int_0^1 N_t(i,j)^{1-\frac{1}{\varepsilon_w}} dj \right]^{\frac{\varepsilon_w}{\varepsilon_w - 1}}$$

definition of index of labor

$$N_t(i,j) = \left(\frac{W_t(j)}{W_t} \right)^{-\varepsilon_w} N_t(i)$$

labor demand

$$W_t = \left[\int_0^1 W_t(i,j)^{1-\varepsilon_w} \, dj \right]^{\frac{1}{1-\varepsilon_w}}$$

aggregate wage index

Maximization problem

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

subject to

$$Y_{t+k|t} = \left(\frac{P_t^*}{P_{t+k}} \right)^{-\varepsilon_p} C_{t+k}$$

demand

NKPC

$$\pi_t^p = \beta E_t \left\{ \pi_{t+1}^p \right\} - \lambda_p \hat{\mu}_t^p$$

$$\hat{\mu}_t^p \equiv \mu_t^p - \mu^p = -(mc_t - mc)$$

$$\lambda_p \equiv \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p} \frac{1-\alpha}{1-\alpha+\alpha\varepsilon_p}$$

Households

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

Optimal wage setting

$$w_t^* = \mu^w + (1-\beta\theta_w)\sum_{k=0}^{\infty}\left(\beta\theta_w\right)^k E_t\left\{mrs_{t+k|t} + p_{t+k}\right\}$$

Specific functions as before

$$\pi_t^w = \beta E_t\left\{\pi_{t+1}^w\right\} - \lambda_w \hat{\mu}_t^w$$

$$\lambda_w = \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\varepsilon_w\varphi)}$$

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

Equilibrium

$\tilde{\varpi}_t = \varpi_t - \varpi_t^n$ wage gap

$\varpi_t = w_t - p_t$ real wage

$\pi_t^p = \beta E_t \left\{ \pi_{t+1}^p \right\} + \kappa_p \tilde{y}_t + \lambda_p \tilde{\varpi}_t$ price inflation

$\pi_t^w = \beta E_t \left\{ \pi_{t+1}^w \right\} + \kappa_w \tilde{y}_t - \lambda_w \tilde{\varpi}_t$ wage inflation

Equilibrium 2

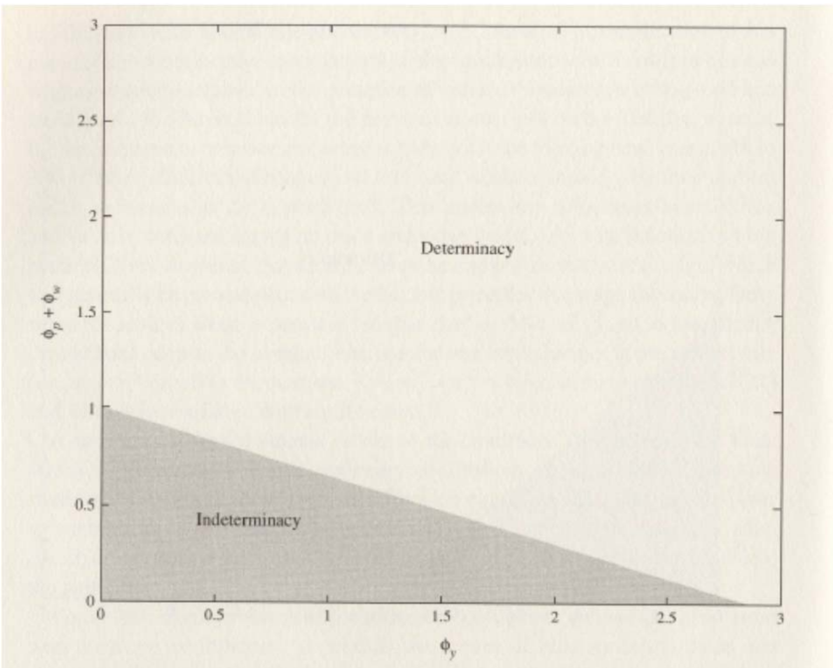
$$\tilde{\varpi}_t \equiv \tilde{\varpi}_{t-1} + \pi_t^w - \pi_t^p - \Delta \varpi_t^n$$

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

$$i_t = \rho + \phi_p \pi_t^p + \phi_w \pi_t^w + \phi_y \tilde{y}_t + v_t$$

Monetary policy with unique efficient equilibrium?

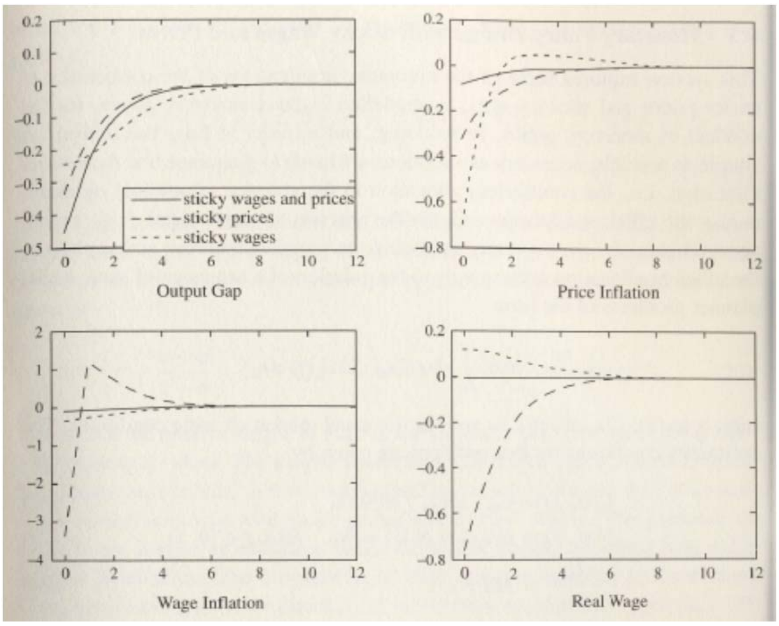
- Determinacy region:



Simulation

$\theta_p = 2/3$ och $\theta_w = 3/4$

$\phi_p = 1.5\ \&\ \phi_w = \phi_y = 0$



Dynamics

- Flexible wages and prices not so realistic
- Both wages and prices should be sticky

Optimal price & wage setting

$$\frac{W_t}{P_t} = -\frac{U_{n,t}}{U_{c,t}} \mathrm{M}_w$$

$$P_t = \mathrm{M}_p \frac{(1-\tau)W_t}{MPN_t}$$

Efficient steady state

- Subsidy is

$$\tau = 1 - \frac{1}{\mathrm{M}_p \mathrm{M}_w}$$

Loss function

$$L = \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left(\left(\sigma + \frac{\varphi + \alpha}{1-\alpha} \right) \tilde{y}_t^2 + \frac{\varepsilon_p}{\lambda_p} (\pi_t^p)^2 + \frac{\varepsilon_w (1-\sigma)}{\lambda_w} (\pi_t^w)^2 \right)$$

$\frac{\varepsilon_w(1-\sigma)}{\lambda_w}$ shows that the welfare costs increase with

a) the elasticity of substitution between different labor types, ε_w,
b) the elasticity of output with respect to labor input, $1-\sigma$, and
c) the degree of wage stickiness, θ_w, which is inversely related to λ_w.

a) and b) amplify the negative effect on aggregate productivity of any given dispersion of wages across labor types while c) increases the degree of wage dispersion for any given rate of wage inflation.

max L w r t

$$\pi_t^p = \beta E_t \{\pi_{t+1}^p\} + \kappa_p \tilde{y}_t + \lambda_p \tilde{\varpi}_t$$

and

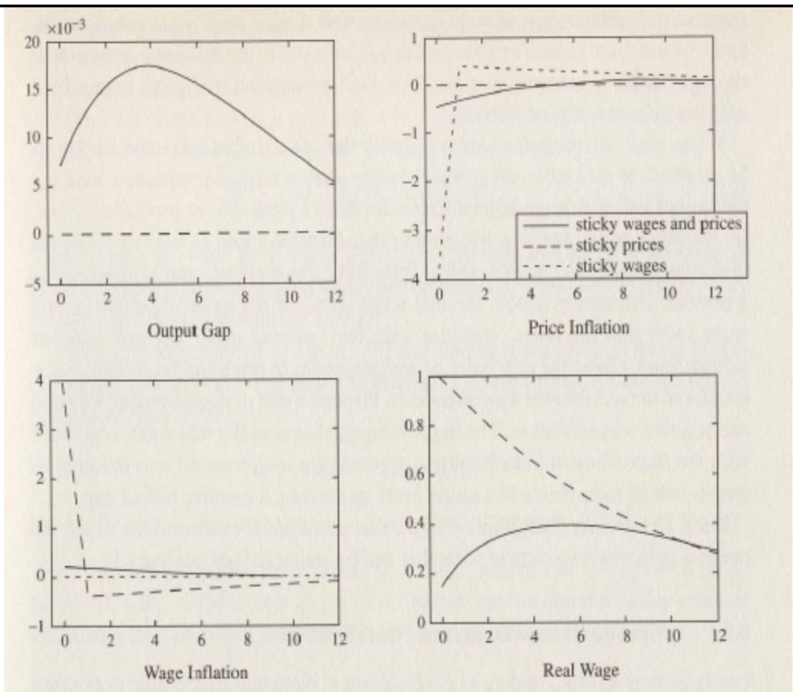
$$\pi_t^w = \beta E_t \{\pi_{t+1}^w\} + \kappa_w \tilde{y}_t - \lambda_w \tilde{\varpi}_t$$

and

$$\tilde{\varpi}_t \equiv \tilde{\varpi}_{t-1} + \pi_t^w - \pi_t^p - \Delta \varpi_t^n$$

Optimal policy

- Flexible wages => stabilize price level
- Flexible prices => stabilize wage level
- Wages & prices sticky => efficiency no longer possible => policy tradeoff
- Structural parameters in weights for wage and price inflation determine optimal policy



Problem

- Too complicated
- Structural parameters difficult to identify
- Output gap unobservable
- Model unknown

Special case

$$\kappa_p = \kappa_w \text{ and } \varepsilon_p = \varepsilon_w(1-\alpha) = \varepsilon \Rightarrow$$

$$\lambda_w \pi_t^p + \lambda_p \pi_t^w = -\frac{\lambda_p}{\varepsilon}\Delta\left(y_t - y_t^n\right)$$

$$\pi_t = (1-\upsilon)\pi_t^p + \upsilon\pi_t^w$$

$$\upsilon = \frac{\lambda_p}{\lambda_p + \lambda_w}$$

$$\lambda_p = \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p}\frac{1-\alpha}{1-\alpha+\alpha\varepsilon_p}$$

$$\lambda_w = \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\theta_w\varphi)}$$

Optimal policy as before

- Stabilize the composite price level with the derived weights
- => output is stabilized as before
- But: Wage inflation should be included in the target variable

Simulations with simple rules

- ✓ strict price inflation targeting
- ✓ strict wage inflation targeting
- ✓ strict composite inflation targeting

$$i_t = \rho + 1.5\pi_t^k$$

		Optimal Policy	Strict Rules			Flexible Rules		
			Price	Wage	Composite	Price	Wage	Composite
$\theta_p = \frac{2}{3}$	$\theta_w = \frac{3}{4}$							
	$\sigma(\pi^p)$	0.64	0	0.82	0.66	1.50	1.08	1.12
	$\sigma(\pi^w)$	0.22	0.98	0	0.19	1.05	0.30	0.42
	$\sigma(\tilde{y})$	0.04	2.38	0.52	0	0.75	1.16	0.01
	L	0.023	0.184	0.034	0.023	0.221	0.081	0.089
$\theta_p = \frac{2}{3}$	$\theta_w = \frac{1}{4}$							
	$\sigma(\pi^p)$	0.29	0	0.82	0.21	1.40	1.45	1.30
	$\sigma(\pi^w)$	1.24	2.91	0	1.63	1.49	0.98	1.25
	$\sigma(\tilde{y})$	0.19	0.61	0.52	0	0.29	0.68	0.32
	L	0.010	0.038	0.034	0.012	0.097	0.104	0.083
$\theta_p = \frac{1}{3}$	$\theta_w = \frac{3}{4}$							
	$\sigma(\pi^p)$	1.64	0	1.91	1.75	2.58	2.10	2.10
	$\sigma(\pi^w)$	0.11	0.98	0	0.06	1.47	0.07	0.10
	$\sigma(\tilde{y})$	0.17	2.38	0.27	0	0.87	0.60	0.58
	L	0.016	0.184	0.021	0.017	0.271	0.030	0.031

Results

- Wage inflation important
- Strict price inflation targeting suboptimal
- Strict better than flexible

Further extensions

- Open economy
  - Prices on tradables
  - Price discrimination or not, pricing to market or law of one price
  - Local currency or producer currency pricing
  - Small/large economy
  - Policy target variable
  - Phillips curve, Dynamic IS Curve, Policy rule