Properties of classical model

- Classical dichotomy
- Always efficient equilibrium
- Inflation does not matter in basic model
- Money in the utility function
  - Zero nominal interest rate
  - Inflation = minus real interest rate
- Productivity the driving force

Keynesian perspective

- Sticky prices
  - Takes time to adjust prices
  - Disequilibrium, not in steady state
- Market form
  - Non-competitive
  - Why not adjust prices?
    - Adjustment cost
    - Attention/information

Non-competitive markets

- Welfare improvements can be achieved through policy
- Steady state output level too low
- Cooperation => non-competitive, e.g. bilateral monopoly => lower transaction costs => welfare?

Sticky prices

- Practice
  - Empirical studies
    - Time series models
    - Structural models
    - Survey methods
    - Interviews
- Theory
  - Models
    - Time dependent
    - State dependent

Practice

- Main results from different studies, vary somewhat but some robust:
- Time or state dependent pricing
  - Both very common
- Implicit and explicit contracts
- Low variability in costs
- Differences across goods
  - goods/services
  - homogenous/heterogenous
  - producer/consumer
- Downward/upward rigidity no big differences
- Menu costs not so important
- Kinked demand curve (fear to loose customers)

Frequency of price changes

- Euro
  - CPI average duration 13 months
- Sweden
  - 27% change less than once a year
- USA
  - 50% of prices last less then 5.5 months (Bils and Klenow)
  - Blinder: Median firm once a year
- Prices more sticky in Europe than in the US

Aggregate price rigidity

$V \equiv P \cdot Y$

$v \equiv p + y$

Define $y^* \equiv$ trend output

Define $\hat{y} \equiv y - y^*$ output gap

Define $\hat{v} \equiv v - y^*$ nominal shock

$p = \alpha \hat{v} \rightarrow \hat{y} = (1-\alpha)\hat{v}$

$p_t = \sum_{i=0}^{n} \alpha_i \hat{v}_{t-i} + \varepsilon_t$

α and the effects of shocks

- High inflation => shorter contracts => more flexible prices
- Low inflation regimes 1990s and onwards => longer contracts
- Real effects of monetary shocks larger in the later period

Table 11. Estimates of α for selected countries before 1990.

Country	α first five quarters	α second year	α after two years
Austria 1972:2 – 1989:4	0.612	0.340	0.952
Belgium 1963:2 – 1989:4	0.898	0.094	0.992
Canada 1963:2 – 1989:4	0.689	0.274	0.963
Denmark 1979:2 – 1989:4	0.535	0.116	0.651
Finland 1977:2 – 1989:4	0.616	0.410	1.026
France 1967:2 – 1989:4	0.724	0.191	0.915
Germany 1967:2 – 1989:4	0.504	0.307	0.811
Greece 1963:2 - 1989:4	1.026	0.000	1.026
Ireland 1963:2 – 1989:4	0.939	0.050	0.989
Italy 1972:2 – 1989:4	0.911	0.115	1.026
Japan 1967:2 – 1989:4	0.988	0.059	1.047
Netherlands 1979:2 – 1989:4	0.784	0.083	0.867
Portugal 1963:2 – 1999:1	0.873	0.085	0.958
Spain 1972:2 – 1989:4	0.952	0.156	1.108
Sweden 1963:2 – 1989:4	0.681	0.301	0.982
United Kingdom 1965:2 – 1989:4	1.013	-0.030	0.983
USA 1963:2 – 1989:4	0.443	0.428	0.871

Table 12. Estimates of α for selected countries after 1989.

Country	α first five quarters	α second year	α after two years
Austria 1990:1 – 1999:1	0.703	0.422	1.125
Belgium 1990:1 – 1998:4	0.321	0.281	0.603
Canada 1990:1 – 1999:1	0.358	0.446	0.804
Denmark 1990:1 – 1999:1	0.665	0.323	0.989
Finland 1990:1 – 1998:4	0.266	0.283	0.549
France 1990:1 – 1999:1	0.293	0.384	0.677
Germany 1990:1 – 1999:1	0.486	0.294	0.780
Greece 1990:1 - 1998:4	0.624	0.540	1.164
Ireland 1990:1 – 1998:4	0.083	-0.513	-0.429
Italy 1990:1 – 1999:1	0.688	0.307	0.995
Japan 1990:1 – 1999:1	0.192	0.671	0.863
Netherlands 1990:1 – 1998:4	0.143	0.160	0.303
Portugal 1990:1 – 1999:1	0.668	0.239	0.907
Spain 1990:1 – 1999:1	0.888	0.187	1.075
Sweden 1990:1 – 1998:4	0.401	0.390	0.791
United Kingdom 1990:1 – 1999:1	0.458	0.744	1.202
USA 1990:1 – 1999:1	0.701	0.474	1.175

Empirical results

- The flexibility parameter for the first 5 quarters varies between 0.5 and 1 and for the second year (quarters 6-9) between 0 and 0.4
- The price adjustment is approximately complete ( ) after two years for almost all countries
- prices are more flexible in the earlier than in the later period for most of the countries

Consequences

- Contract length in low inflation regime
- Monetary shocks more important for real variables in low inflation regime
- Increased stickiness => relative price dispersion => resource allocation

Sticky price

- Benefits
  - Customer relationships
    - Heterogenous goods/adapted to buyers
    - Investments in customer relationships
    - Reduction in search costs
- External economies/diseconomies
  - Sticky price => aggregate price rigidity => resource allocation

NKPC

- Basic new Keynesian model
  - Does not generate enough inflation persistence
  - This is accomplished by ad hoc persistence in the stochastic shocks

Basic New Keynesian Model

- Consumer the same as in the classical model
- Monetary policy - different effects
- MP could possibly affect resource allocation if prices are sticky

- Imperfect competition
- Each firm produces a differentiated good
- Only some of the firms can change the price (optimize)

Households

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

$$C_t = \left(\int_0^1 C_t(i)^{1-\frac{1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}}$$ consumption index

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

Consumers' solution

$$P_t C_t + Q_t B_t \leq B_{t-1} + W_t N_t + T_t$$ aggregate budget constraint

$$C_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\varepsilon} C_t$$ demand functions

Firms

$Y_t(i) = A_t N_t(i)^{1-\alpha}$ production function

$C_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon} C_t$ demand functions

$\log C_t(i) = \log C_t - \varepsilon\left(\log P_t(i) - \log P_t\right)$ logarithmic

$c_t(i) = c_t - \varepsilon\left(p_t(i) - p_t\right)$

Calvo model

- Each firm may only reset their price with probability 1−θ in any given period
- 1−θ is exogenous
- In each period a fraction 1−θ of the producers reset their prices
- a fraction θ keep them unchanged

Calvo 2

- average duration of a price is *1/*1−θ
- θ is a measure of price rigidity

Calvo 3 aggregate price dynamics

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

$$\prod_t = \frac{P_t}{P_{t-1}}$$ definition

$$\prod_t^{1-\varepsilon} = \theta + (1-\theta)\left(\frac{P_t^*}{P_{t-1}}\right)^{1-\varepsilon}$$

$$\pi_t = (1-\theta)(p_t^* - p_{t-1})$$ logarithmic approximation around steady state with zero inflation

Optimal price?

- The optimizing firm will choose the price P_t^*
- that maximizes the current market value of the discounted expected profits generated while that price remains effective (is not reset)

Optimal price, problem

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

ψ_{t+k} cost function

subject to

$Y_{t+k|t}$ Output in t+k for firm that resets price at t

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

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

discount factor for nominal payoffs

$$\log Q_{t,t+k} = k \log \beta - \sigma \Delta y_{t+k} - \pi_{t+k}$$

$$\sigma = 1 \rightarrow \log Q_{t.t+k} = k \log \beta - \left[\Delta y_{t+k} + \pi_{t+k} \right]$$

k=0=>Q=1

Solution

markup

nominal marginal cost

$$p_t^* = \mu + (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k E_t\left\{mc_{t+k|t} + p_{t+k}\right\}$$

$$\mu = \log M = \log\left(\frac{\varepsilon}{\varepsilon - 1}\right)$$

markup

price is the desired markup over a weighted average of their current
and discounted expected future nominal marginal costs, with the weights being
proportional to the probability of the price remaining effective
at each horizon

Equilibrium

$$Y_t(i) = C_t(i)$$

$$Y_t = C_t$$

$$N_t = \int_0^1 N_t(i)di$$

Equilibrium

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

Real marginal cost

$$p_t^* = \mu_t + \log(\psi_{t+k|t})$$

$$mc_t \equiv \log(\psi_{t+k|t}) - p_t$$

$$mc_t = -\mu_t$$

$$\lambda \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}\frac{(1-\alpha)}{(1-\alpha+\alpha\varepsilon)}$$

$$\lambda = \frac{(1-0.67)(1-0.99\cdot 0.67)}{0.67}\frac{(1-0.33)}{(1-0.33+0.33\cdot 3)} = 0.165$$

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda\left[(\log\psi_t - \log\psi) - (p_t - p)\right]$$

Interpretation

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

- If markups are high (relative to steady state) then inflation is low
- Counterintuitive but depends on forward-looking behavior

Interpretation

$$\pi_t = \lambda \sum_{t=0}^{\infty} \beta^k E_t \{ mc_{t+k} - mc \}$$

Expected real marginal cost high relative to steady state

Markups expected to be below steady state => inflation will be high => firms that reset price choose a price above the average price level

Output gap

$$mc_t - mc = \left(\alpha + \frac{\varphi + \alpha}{1-\alpha} \right)(y_t - y_t^n)$$

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

$$\kappa = \lambda \left(\sigma + \frac{\varphi + \alpha}{1-\alpha} \right)$$

$$\kappa = 0.165 \left(1 + \frac{1+0.33}{1-0.33} \right) = 0.49$$

Dynamic IS equation

$$Y_t(i) = C_t(i)$$
$$Y_t = C_t$$

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

remember interpretation

Rewrite the consumer's Euler equation in terms of the output gap

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

Real rate of interest at flexible prices, keeps output at natural level

Equilibrium

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

rewrite

$$r_t^n = \rho + \sigma E_t\{\Delta y_{t+1}^n\}$$
$$= \rho + \sigma \psi_{ya}^n E_t\{\Delta a_{t+1}\}$$
$$y_t - y_t^n = -\frac{1}{\sigma}\sum_{k=0}^{\infty}\left(r_{t+k} - r_{t+k}^n\right)$$

that the output gap is proportional to the real interest rate gap, i.e. the difference between the real interest rate and the natural interest rate.

Monetary policy

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

compare with 3-equation model of Svensson (1997)

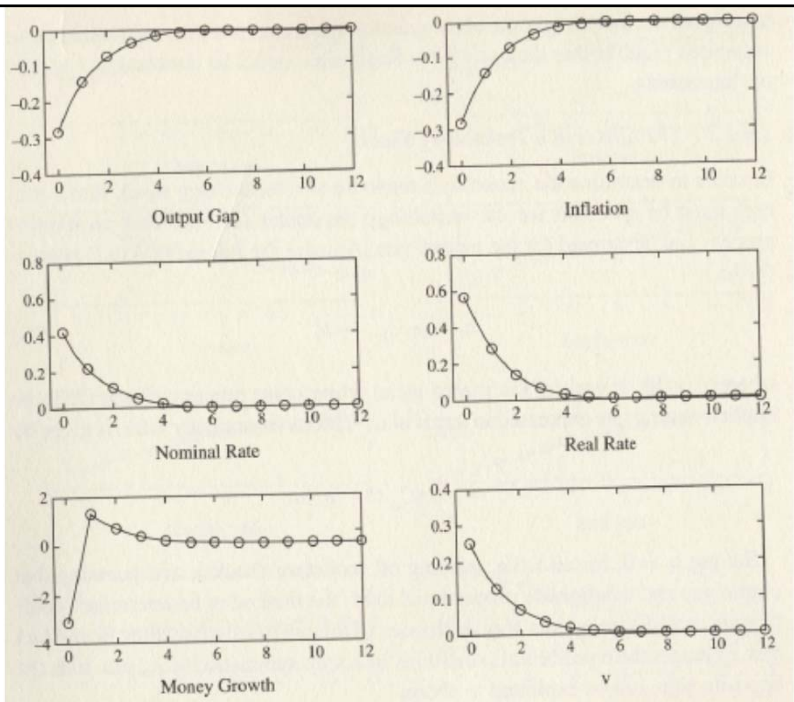
Assume $\phi_\pi = 1.5$ and $\phi_y = 0.125$

$$v_t = \rho_v v_{t-1} + \varepsilon_t^v \qquad \rho_v = 0.5$$

and

$$\beta < 1 \ \simeq 0.99$$
$$\rho \equiv -\log \beta \simeq 0.01$$
$$\sigma \simeq 1$$
$$\varphi \simeq 1$$
$$\alpha \simeq 0.33$$
$$\varepsilon = 6$$
$$\psi_{na} = 0$$
$$\upsilon_n = -0.2$$
$$\psi_{ya} = 1$$
$$\upsilon_y = -0.13$$

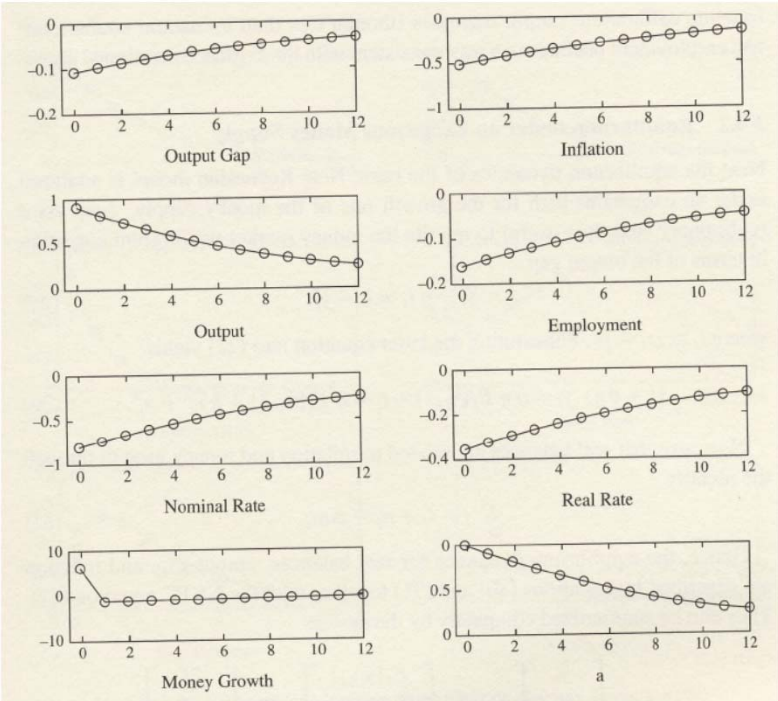
monetary policy shock



and 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