Monetary Economics

Lecture 4: the basic new Keynesian model, part one

Chris Edmond

2nd Semester 2014

This class

- Imperfect competition in the goods market

  1- household demand for differentiated products
  2- static price-setting by monopolistically competitive firms
  3- general equilibrium example

- Reading: Gali (2008), chapter 3 sections 3.0–3.1 and appendix 3.1

Monopolistic competition

- Many *differentiated products* or *varieties*
- Firms have market power if products are not perfect substitutes

  $\Rightarrow$ if so, price $>$ marginal cost (markup pricing)
- But no genuine strategic interactions between firms

Household demand for differentiated products

- CES utility from differentiated products on interval $[0,1]$

$$C \equiv \left(\int_0^1 C(j)^{\frac{\varepsilon-1}{\varepsilon}} \, dj \right)^{\frac{\varepsilon}{\varepsilon-1}}, \qquad \varepsilon > 1$$

Love-of-variety: utility is concave in $C(j)$ (since $0 < \frac{\varepsilon-1}{\varepsilon} < 1$)

- Static budget constraint

$$\int_0^1 P(j)C(j) \, dj \leq Z$$

for some given nominal income $Z > 0$ (exogenous, for now)

Household demand for differentiated products

- Lagrangian with multiplier λ

$$L = \left(\int_0^1 C(j)^{\frac{\varepsilon-1}{\varepsilon}} \, dj \right)^{\frac{\varepsilon}{\varepsilon-1}} + \lambda \left(Z - \int_0^1 P(j) C(j) \, dj \right)$$

- First order conditions

$$C(j) \qquad : \qquad C^{\frac{1}{\varepsilon}} \, C(j)^{-\frac{1}{\varepsilon}} = \lambda P(j)$$

These are for every $j \in [0, 1]$

- Marginal rates of substitution equal to price ratio for any j, k

$$\left(\frac{C(j)}{C(k)} \right)^{-\frac{1}{\varepsilon}} = \frac{P(j)}{P(k)}$$

ε is (constant) elasticity of substitution between products ($\varepsilon > 1$)

Ideal price index

- Aggregate the first order conditions over $j \in [0, 1]$ to characterize multiplier λ. Gives

$$C = \lambda Z$$

- <u>Define</u> *ideal price index* P such that

$$PC \equiv Z \Leftrightarrow \lambda = 1/P$$

- First order conditions

$$C(j) = \left(\frac{P(j)}{P}\right)^{-\varepsilon} C \qquad (\varepsilon > 1)$$

Solution for ideal price index

$$P = \left(\int_0^1 P(j)^{1-\varepsilon}\, dj\right)^{\frac{1}{1-\varepsilon}}$$

Firms: nominal costs

- Nominal cost function $\Psi(Y)$ to produce Y (total variable costs)

- For example, labor costs WN with production function $Y = AN^{1-\alpha}$ implies nominal cost

$$\Psi(Y) = W\left(\frac{Y}{A}\right)^{\frac{1}{1-\alpha}}$$

and nominal marginal cost

$$\Psi'(Y) = \frac{1}{1-\alpha}\frac{W}{A}\left(\frac{Y}{A}\right)^{\frac{\alpha}{1-\alpha}}$$

Firms: static price setting

- Nominal profits for firm j

$$P(j)Y(j) - \Psi(Y(j))$$

- Maximize profits by choice of $P(j)$ taking *demand curve* for $C(j) = Y(j)$ as given

- First order condition characterizes optimal price

$$P(j) = \frac{\varepsilon}{\varepsilon - 1}\Psi'\left(\left(\frac{P(j)}{P}\right)^{-\varepsilon} C\right)$$

- Constant markup $\frac{\varepsilon}{\varepsilon-1} > 1$ over marginal cost

General equilibrium example: households

- Household preferences over *aggregate consumption* and labor supply

$$U(C,N) = \frac{C^{1-\sigma}}{1-\sigma} - \frac{N^{1+\varphi}}{1+\varphi} \quad \text{and} \quad C \equiv \left(\int_0^1 C(j)^{\frac{\varepsilon-1}{\varepsilon}} \, dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

- Budget constraint

$$PC = WN - T$$

where

$$PC = \int_0^1 P(j)C(j) \, dj$$

- First order conditions

$$C(j) = \left(\frac{P(j)}{P} \right)^{-\varepsilon} C \quad \text{and} \quad N^{\varphi} C^{\sigma} = \frac{W}{P}$$

General equilibrium example: firms

- Constant returns $Y(j) = A(j)N(j)$ (does this imply zero profits?)

- Price for j'th firm

$$P(j) = \frac{\varepsilon}{\varepsilon - 1} \frac{W}{A(j)}$$

- Equilibrium

  1- demand equals supply for each product j

$$C(j) = Y(j)$$

  2- demand for labor equals supply of labor

$$N = \int_0^1 N(j)\, dj$$

Aggregation

- Products not perfect substitutes, so define aggregate output

$$Y \equiv \left(\int_0^1 Y(j)^{\frac{\varepsilon-1}{\varepsilon}} \, dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

Implies

$$Y = C$$

- Now define aggregate productivity index by

$$A \equiv \frac{Y}{N}$$

- Can show that solution for A is

$$A = \left(\int_0^1 A(j)^{\varepsilon-1} \, dj \right)^{\frac{1}{\varepsilon-1}}$$

General equilibrium: solving the model

- So price index implied by individual prices

$$P = \left(\int_0^1 P(j)^{1-\varepsilon} \, dj \right)^{\frac{1}{1-\varepsilon}} = \frac{\varepsilon}{\varepsilon - 1} \left(\int_0^1 A(j)^{\varepsilon-1} \, dj \right)^{\frac{1}{1-\varepsilon}} W$$

- Real wage

$$\frac{W}{P} = \frac{\varepsilon - 1}{\varepsilon} \left(\int_0^1 A(j)^{\varepsilon-1} \, dj \right)^{\frac{1}{\varepsilon-1}} = \frac{\varepsilon - 1}{\varepsilon} A$$

General equilibrium: solving the model

- Two equations in two unknowns C, N for given aggregate productivity index A

$$C = Y = A\,N$$

and

$$N^{\varphi}C^{\sigma} = \frac{W}{P} = \frac{\varepsilon - 1}{\varepsilon}\,A$$

- Markup distortion reduces C, N relative to efficient allocation (planner's solution)

Household intertemporal problem

- Household preferences over *aggregate consumption* and labor supply

$$U(C_t, N_t), \qquad C_t \equiv \left(\int_0^1 C_t(j)^{\frac{\varepsilon-1}{\varepsilon}}\, dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

- Intertemporal preferences

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \right\}$$

- Flow budget constraint at every date and state

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

where

$$P_t C_t = \int_0^1 P_t(j) C_t(j)\, dj$$

Household first order conditions

- Differentiated products

$$C_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\varepsilon} C_t$$

- Labor supply

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

- Intertemporal consumption Euler equation

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

Next class

- The basic new Keynesian model, part two
  - dynamic price setting with sticky prices
- Reading: Gali (2008), chapter 3 sections 3.2 and appendix 3.2–3.3