Advanced Macroeconomics

Lecture 13: monetary economics, part one

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1st Semester 2019

This class

- Background on new Keynesian models

- Benchmark monetary model with flexible prices, two versions

  (i) perfect competition
  (ii) monopolistic competition, as precursor to sticky prices

Background

- New Keynesian model builds on real business cycle model

- RBC model, key features
  - intertemporal utility maximization
  - rational expectations
  - representative agent / complete asset markets
  - perfect competition in goods and factor markets

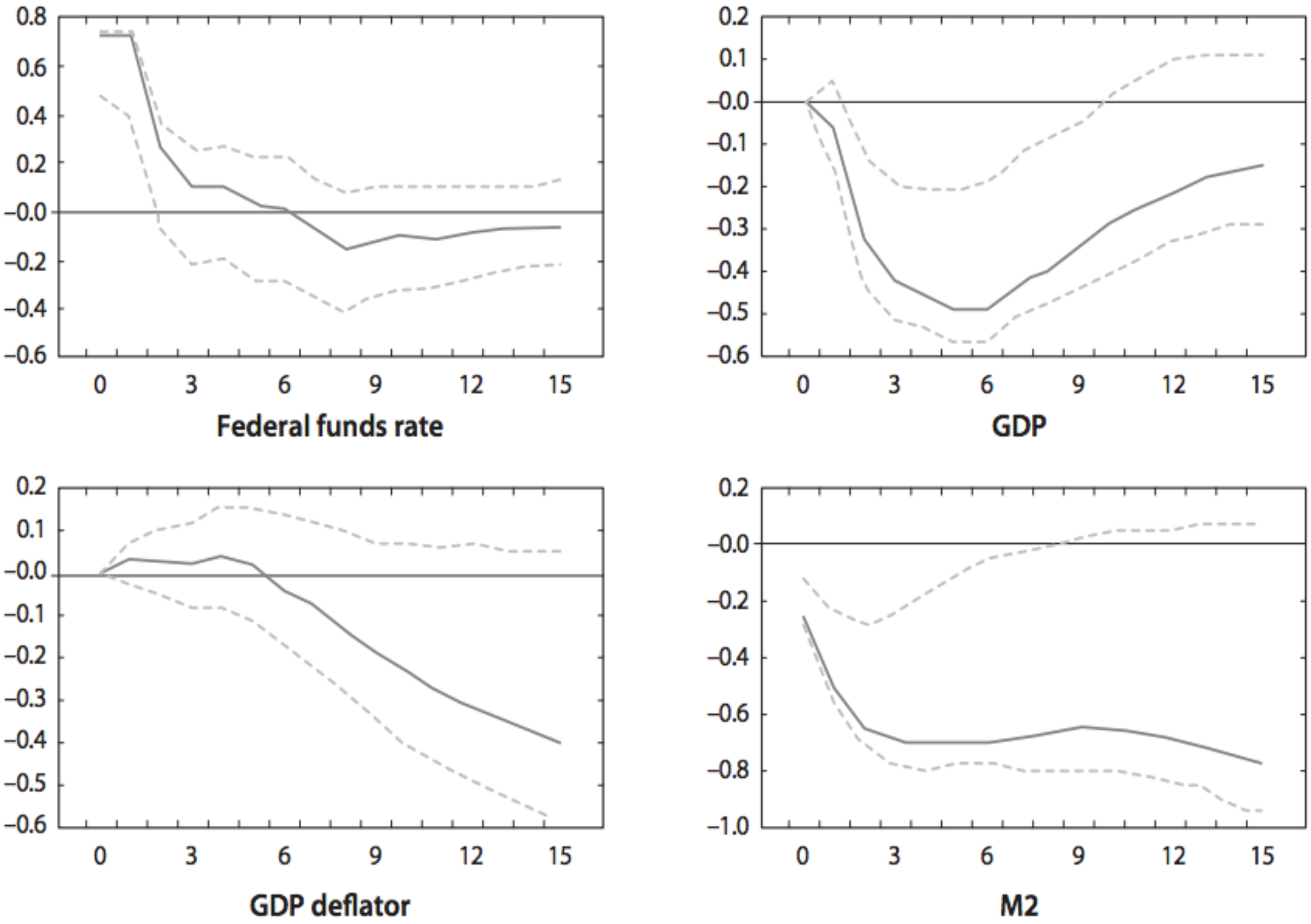
- RBC model, key implications
  - business cycles are Pareto efficient
  - business cycles driven by exogenous productivity shocks (and other exogenous real shocks: terms-of-trade, government spending, etc)
  - money is neutral, implicitly

Background

- New Keynesian model, key features
  - intertemporal utility maximization
  - rational expectations
  - representative agent / complete asset markets
  - imperfect competition in goods and/or factor markets
  - nominal rigidities (prices are *sticky*)

- New Keynesian model, key implications
  - business cycles are inefficient
  - business cycles driven by mixture of exogenous productivity shocks and exogenous monetary policy shocks
  - money is not neutral in the short run
  - money is neutral in the long run

Friedman's 1968 presidential address



Proportional responses to monetary policy shock. Periods in quarters.

Sticky prices: evidence from micro data

- Conventional wisdom circa 2000
  - average duration between price changes key to nonneutrality
  - prices of individual goods & services sticky for $\approx$ 12 months
- Challenged by Bils and Klenow (2004)
  - evidence from micro data, sticky for $\approx$ 4–6 months
- Rebuttal from Nakamura and Steinsson (2008)
  - including transitory sales drives Bils/Klenow result
  - excluding sales, sticky for $\approx$ 8–11 months
- Attention now turning to other moments of the micro data
  - heterogeneity across sectors, products etc
  - skew of changes etc

Benchmark model with flexible prices

- An RBC-style model overlaid with nominal variables
- Simplified setup: no physical capital, no trend growth
- Begin with perfect competition in goods market
- Then monopolistic competition, firms have price-setting power

Representative household

- Maximizes expected intertemporal utility

$$\mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \, u(c_t, l_t) \right\}, \qquad 0 < \beta < 1$$

subject to sequence of budget constraints, for each date and state

$$P_t c_t + Q_t B_{t+1} = B_t + W_t l_t - T_t$$

- P_t denotes price level in *units of account*, W_t denotes nominal wage, and Q_t denotes nominal price of bond that delivers one unit of account next period

- In the background, lump-sum taxes T_t

Representative household

- Lagrangian

$$\mathcal{L} = \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) + \sum_{t=0}^{\infty} \lambda_t \left[B_t + W_t l_t - T_t - P_t c_t - Q_t B_{t+1} \right] \right\}$$

- Some key first order conditions

$$c_t : \qquad \beta^t u_{c,t} - \lambda_t P_t = 0$$

$$l_t : \qquad \beta^t u_{l,t} + \lambda_t W_t = 0$$

$$B_{t+1} : \qquad -\lambda_t Q_t + \mathbb{E}_t \{ \lambda_{t+1} \} = 0$$

$$\lambda_t : \qquad B_t + W_t l_t - T_t - P_t c_t - Q_t B_{t+1} = 0$$

Key equilibrium conditions

- Representative household, labor supply determined by

$$-\frac{u_{l,t}}{u_{c,t}} = \frac{W_t}{P_t} \equiv w_t$$

and consumption Euler equation

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

- Representative firm, labor demand determined by

$$z_t f'(l_t) = w_t$$

- Goods market clearing

$$c_t = y_t = z_t f(l_t)$$

(bond market clears if goods and labor markets clear)

Standard parameterization

- Usual separable isoelastic utility function

$$u(c, l) = \frac{c^{1-\sigma}}{1-\sigma} - \frac{l^{1+\varphi}}{1+\varphi}, \qquad \sigma, \varphi > 0$$

- And for simplicity, suppose linear production function

$$f(l) = l$$

Solving the model

- Essentially same as static case we had in Lecture 10

$$l_t^{\varphi}\, c_t^{\sigma} = w_t = z_t$$

$$c_t = y_t = z_t l_t$$

- Solution, in logs

$$\log c_t = \psi_{cz} \log z_t, \qquad \psi_{cz} = \frac{1+\varphi}{\sigma+\varphi} > 0$$

and

$$\log l_t = \psi_{lz} \log z_t, \qquad \psi_{lz} = \frac{1-\sigma}{\sigma+\varphi} \lesseqgtr 0$$

Consumption Euler equation

- Let i_t denote the nominal interest rate and π_{t+1} denote the inflation rate etc

$$i_t \equiv -\log Q_t, \qquad \pi_{t+1} \equiv \log(P_{t+1}/P_t), \qquad \rho \equiv -\log \beta$$

- Then to a first order approximation consumption Euler equation can be written

$$\mathbb{E}_t\{\Delta \log c_{t+1}\} = \frac{r_t - \rho}{\sigma}$$

where r_t denotes the ex ante ex real interest rate

$$r_t = i_t - \mathbb{E}_t\{\pi_{t+1}\}$$

Classical dichotomy

- A strong form of the '*classical dichotomy*' holds

- All real variables c_t, l_t, y_t, w_t, r_t independent of nominal variables

- In particular, given process for productivity z_t we have

$$\log c_t = \psi_{cz} \log z_t = \log y_t$$
$$\log l_t = \psi_{lz} \log z_t$$

$$w_t = z_t$$
$$r_t = \rho + \sigma \psi_{cz} \mathbb{E}_t \{ \Delta \log z_{t+1} \}$$

- Nominal variables π_t, i_t etc are merely a '*veil*'

Price setting

- Benchmark model features *perfect competition*, firms price takers
- For nominal rigidities, need firms that have price-setting power
- Do this with *monopolistic competition* as in Lecture 7
  - consumers have preferences over bundle of differentiated products
  - firms have market power if products are not perfect substitutes
  - no genuine strategic interactions

Household demand for differentiated products

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

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

- Static budget constraint

$$\int_0^1 P(j)c(j) \, dj = X$$

for some given nominal income $X > 0$

Household demand for differentiated products

- Lagrangian with multiplier λ

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

- First order conditions

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

- Marginal rate of substitution equal to relative price

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

Ideal price index

- Aggregate the first order conditions over j to get

$$c = \lambda X$$

- Define *ideal price index* P such that

$$Pc \equiv X \quad \Leftrightarrow \quad \lambda = 1/P$$

- First order conditions can be rewritten

$$c(j) = \left(\frac{P(j)}{P}\right)^{-\varepsilon} c$$

- Implies ideal price index (aggregate price level) has the form

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

Firms: price setting

- Choose $y(j)$ to maximize profits

$$P(j)y(j) - \frac{W}{z}y(j)$$

subject to the downward-sloping demand curve

$$y(j) = c(j) = (P(j)/P)^{-\varepsilon}\, c$$

- Equivalently, choose $P(j)$ to maximize

$$\left[P(j)^{1-\varepsilon} - \frac{W}{z}P(j)^{-\varepsilon}\right]P^{\varepsilon}c$$

with solution

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

(nominal price is constant markup over nominal marginal cost)

Equilibrium with monopolistic competition

- In symmetric equilibrium

$$P_t(j) = \frac{\varepsilon}{\varepsilon - 1}\frac{W_t}{z_t} = P_t \qquad \text{all } j \in [0,1]$$

- Real wage

$$w_t = \frac{W_t}{P_t} = \frac{\varepsilon - 1}{\varepsilon} z_t < z_t$$

so that on using labor market and goods market clearing

$$\log c_t = \frac{1+\varphi}{\sigma+\varphi}\log z_t - \frac{1}{\sigma+\varphi}\log\left(\frac{\varepsilon}{\varepsilon-1}\right)$$

$$\log l_t = \frac{1-\sigma}{\sigma+\varphi}\log z_t - \frac{1}{\sigma+\varphi}\log\left(\frac{\varepsilon}{\varepsilon-1}\right)$$

- Levels of output and employment less than in perfectly competitive benchmark but response to fluctuations in z_t unchanged

- In the new Keynesian model, this flexible price outcome correspond to the underlying trend or ‘*natural*’ level of output

- With sticky prices, actual output fluctuates around this natural level, there is an ‘*output gap*’