Monetary Economics: Macro Aspects, 3/3 2004
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Plan for today:

1. Money in the short run: Incomplete nominal adjustment (I)
2. Flexible prices and imperfect information

Literature: Walsh (Chapter 5, pp. 199-211 — plus relevant appendix)

3. Plan for next lectures

NOTE: Electronic "internal" evaluation of the course takes place in weeks 10-11.

- Please visit the link on the webpage and spend a few minutes, filling out the on-line forms!

Introductory remarks

- Flex-price models covered so far cannot account for short-run dynamics of real output following monetary shocks
- In case there were any effects, they work through anticipated inflation potentially affecting the consumption-leisure decision
- Magnitude of this effect appears to be modest
- Some "sand in the wheels" appears to be necessary if one shall explain the effects of money on output seen in data
- Obvious candidate is incomplete nominal adjustment. In flex-price models, money neutrality holds **both** in the short **and** long run; clearly, if money neutrality fails in the short run due to incomplete nominal adjustment, the impact of money will clearly be stronger
- Two types of incomplete adjustment are examined:
  - **One** highlights the role of **imperfect information**, while still allowing prices to be flexible; the lack of information, however, make economic agents act such that aggregate money and prices do not move proportionally
  - **Another** highlights the role of **sticky prices and wages**; then a change in the nominal money stock has real effects by definition (as in e.g. standard IS/LM model)

Imperfect information

The general idea according to Friedman

- Theoretical paradox: Why is there long-run neutrality of money but not short-run neutrality?
- After the discovery of the Phillips curve, not a paradox of much attention. Most believed in a long-run trade-off between inflation and unemployment
- I late 1960s, however, Friedman and Phelps argued theoretically that the trade-off at best could only be a short-run phenomenon
- In the long run, prices would adjust, so as to restore a "classical" equilibrium only depending on **real** factors (i.e., money neutrality)
- E.g., inflationary policies eroding the real wage could only have short-run effects, as nominal wage inflation eventually would catch up, restoring the real wage consistent with the "natural rate on employment"

- Friedman's general idea about why short-run effects could occur: **Informational problems ≈ Imperfect information**
- If price and wage inflation suddenly rise, workers **perceive** that their real wage had gone up, even though price inflation had risen the most
  - Labor supply goes up . . .
  - . . . when workers "discover" the even higher price inflation (and discover that real wages had gone down), they . . .
  - . . . reduce labor supply again, restoring equilibrium at the initial real wage (but with possible higher price and wage inflation)
- Central idea: **unanticipated** changes in wages and prices creates **"confusion" about relative prices** (here: the real wage), leading to changes in economic behavior and real variables
- When the "confusion" has been cleared up (over time), the initial equilibrium is restored; hence, only a short-run Phillips-curve trade-off is present

A formal analysis of the idea: A MIU version of Lucas' "Islands model" (1972)

- The economy is made up of a number of isolated "islands"
- Nominal (money) shocks hit the islands, and due to *imperfect information*, agents cannot see whether the shocks are purely local or aggregate shocks
- Very important!
  - If shocks are *known* to be aggregate, relative prices will be *known* to be unchanged, and economic behavior will **not** change
  - If shocks are *known* to be local, on the other hand, relative prices will be *known* to change, and economic behavior **will** change
- To create relevance of both local and aggregate prices for agents, it is assumed that agents after each period are randomly relocated to another island
  - Expectations about future aggregates becomes relevant
- Model is a MIU model without capital but with endogenous labor supply

- Inflation tax considerations are being suppressed letting agents view money transfers as proportional to money holdings
- Superneutrality will hold
- Formally on island i:
  - Budget constraint when transfers are treated as lump-sum (as in previous models):

$$C_t^i + \frac{M_t^i}{P_t^i} = Y_t^i + T_t + \frac{1}{1+\pi_t^i}\frac{M_{t-1}^i}{P_{t-1}^i}$$

    Inflation erodes real money balances
  - Budget constraint here, when transfers are proportional to money holdings:

$$P_t^i C_t^i + M_t^i = P_t^i Y_t^i + \tau_t M_{t-1}^i + M_{t-1}^i$$

$$C_t^i + \frac{M_t^i}{P_t^i} = Y_t^i + \frac{T_t}{1+\pi_t^i}\frac{M_{t-1}^i}{P_{t-1}^i}, \qquad T_t \equiv 1 + \tau_t$$

    Transfers are then viewed as a **return** on real money holdings
  - The erosion of real money holdings due to inflation will be offset by the return due to transfers
  - . . . . superneutrality holds

- Per-period utility function of inhabitant on island i:

$$u\left(C_t^i, M_t^i/P_t^i, 1-N_t^i\right) = \left[\frac{\left(a\left(C_t^i\right)^{1-b} + (1-a)\left(M_t^i/P_t^i\right)^{1-b}\right)}{1-\Phi}\right]^{\frac{1-\Phi}{1-b}} - \frac{\Psi}{1-\eta}\left(1-N_t^i\right)^{1-\eta}$$

- Same functional form as in Chapter 2
- Superscript "i" denotes island/"local" variables
- No superscript denotes economy-wide average variables (=aggregate variables)
- Four relevant equations of the model
  - Production function:

$$Y_t^i = \left(N_t^i\right)^{1-\alpha}, \qquad 0 < \alpha < 1$$

  - Resource constraint on each island:

$$C_t^i = Y_t^i$$

  - Consumption-leisure choice:

$$u_{1-N}\left(C_t^i, M_t^i/P_t^i, 1-N_t^i\right) = \left[(1-\alpha)\frac{Y_t^i}{N_t^i}\right] u_C\left(C_t^i, M_t^i/P_t^i, N_t^i\right)$$

  - Money demand choice:

$$u_C\left(C_t^i, M_t^i/P_t^i, 1-N_t^i\right) = u_{M/P}\left(C_t^i, M_t^i/P_t^i, 1-N_t^i\right) + \beta \mathrm{E}^i\left(\frac{T_{t+1}}{1+\pi_{t+1}}\right) u_C\left(C_{t+1}, M_{t+1}/P_{t+1}, 1-N_{t+1}\right.$$

- For given money processes, these will provide the solution for output, labor supply, consumption and prices

- Log-linearized version is given by (5.1)-(5.3) in Walsh
  - . . . where $C_t^i = Y_t^i$ is substituted in
  - . . . where λ is marginal utility of consumption
- The central transmission channel of money as in Chapter 2
  - If real money balances increase, marginal utility of consumption changes
  - Assuming $b > \Phi$, $u_{C,M/P} > 0$, more real money increases marginal utility of consumption
  - Labor supply and output goes up

- The stochastic process for log of **nominal** money on island i:

$$m_t^i = \gamma m_{t-1}^i + \upsilon_t + u_t + u_t^i, \qquad 0 < \gamma < 1$$

  - u_t^i captures a "local" nominal disturbance on island i, with mean zero (it nets out across islands) and variance σ_i^2
  - u_t is an aggregate shock; u_t has mean zero and variance σ_u^2 (u_t and u_t^i are assumed independent)
  - υ_t is another aggregate shock
- As the u_t^i nets out on average, the aggregate nominal money process is

$$m_t = \gamma m_{t-1} + \upsilon_t + u_t$$

- Informational assumptions:
  - **Known variables** on island i: m_t^i, γm_{t-1}^i and υ_t
  - **Unknown variables**: u_t and u_t^i
  - Hence, agents **can infer** $u_t + u_t^i$ but **not** each shock separately
  - => An observed increase in m_t^i could thus be due to either local or aggregate shocks (or both)

- Important implications in this flex-price model:

- – If an increase in $u_t + u_t^i$ is **known** to be **only** due to an increase in u_t, agents **know** that the increase in aggregate nominal money will be associated with a proportional increase in all prices; hence, their real money balances are unchanged and **no** labor supply effects occur

- – If an increase in $u_t + u_t^i$ is **known** to be **only** due to an increase in u_t^i, agents **know** that the increase in local nominal money will **not** be associated with a proportional increase in all prices; hence, their real money balances increase and labor supply increases

- – **But** . . . they **don't** know what causes $u_t + u_t^i$, and thus m_t^i, to fluctuate!

- So what do they do? Make an estimate of u_t (or, equivalently, u_t^i), *given* the observation of $u_t + u_t^i$
  - I.e.,: Find $\mathrm{E}^i u_t$

- Agents solve a "signal-extraction" problem, as they *extract* information about u_t from the *signal* $u_t + u_t^i$

- One simple method is to assume that expectations about u_t are formed by applying a so-called "linear least squares projection"
- By adopting a linear least squares projection, agents find a estimate of u_t, say $\widehat{u}_t$, which is a linear function of what is observed:

$$\widehat{u}_t = P\left(u_t + u_t^i\right)$$

(this is a linear projection of u_t on $u_t + u_t^i$), where P is the estimation coefficient to be derived

- P is found so as to minimize the expected, squared forecast error:

$$\min_P \ \mathrm{E}\left[\widehat{u}_t - u_t\right]^2$$

- This is

$$\min_P \ \mathrm{E}\left[P\left(u_t + u_t^i\right) - u_t\right]^2$$

$$\min_P \ \mathrm{E}\left[P^2\left(u_t + u_t^i\right)^2 + u_t^2 - 2P\left(u_t + u_t^i\right)u_t\right]$$

- As shocks are independent and have zero means, this becomes

$$\min_P \ \left(P^2 \mathrm{Var}\left[u_t + u_t^i\right] + \mathrm{Var}\left[u_t\right] - 2P\mathrm{Cov}\left[\left(u_t + u_t^i\right)u_t\right]\right)$$

- Solution for P:

$$P\mathrm{Var}\left[u_t + u_t^i\right] - \mathrm{Cov}\left[\left(u_t + u_t^i\right)u_t\right] = 0$$

$$P = \frac{\mathrm{Cov}\left[\left(u_t + u_t^i\right)u_t\right]}{\mathrm{Var}\left[u_t + u_t^i\right]} = \frac{\mathrm{Var}\left[u_t\right]}{\mathrm{Var}\left[u_t\right] + \mathrm{Var}\left[u_t^i\right]} = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_i^2} \equiv \kappa < 1$$

- Hence,

$$\mathrm{E}^i u_t = \widehat{u}_t = \kappa\left(u_t + u_t^i\right)$$

- Intuition and implications:
  - The higher is σ_u^2 relative to σ_i^2 the more likely it is that the change in $u_t + u_t^i$ are caused by changes in u_t rather than in u_t^i (and κ increases)
  - Special case of $\sigma_u^2 = \sigma_i^2$, $\Longrightarrow \kappa = 1/2$ — "fifty-fifty" chance that the shock is caused by u_t and u_t^i, respectively
  - In special case of $\sigma_i^2 = 0$ there are no local shocks, and there is **perfect information**; $\kappa = 1$

- Log-linearized model is solved by method of undetermined coefficients, and central solutions are:

$$p_t = \gamma m_{t-1} + \upsilon_t + \left(\frac{\kappa + K}{1+K}\right) u_t \tag{5.5}$$

and

$$n_t = A\left(m_t - p_t\right) = A\left(\frac{1-\kappa}{1+K}\right) u_t \tag{5.6}$$

- Note:
  - Aggregate nominal money shocks, u_t, have **real effects** under imperfect information, $\kappa < 1$
  - **Only** with $\kappa = 1$, perfect information, will aggregate money shocks be transmitted proportionally onto the price level, leaving real money and employment/output unchanged

- Intuition:
  - Assume that in period t, no local shocks hit. When, e.g., $u_t > 0$, then on **all** islands, $u_t + u_t^i$ goes up
  - Due to imperfect information the observed increase will be believed to some extent to be caused by a local shock
  - On **all** islands, agents therefore believe their real money holdings will go up, and as that increases the marginal utility of consumption (by assumption $b > \Phi$), **all** agents increase labor supply
  - **Aggregate** employment and output increase

- Note that the aggregate increase in activity are due to **misperceptions** about the shock. Even though it is an entirely aggregate shock, agents believe it has some "local" component

- Agents are therefore being "surprised" as their expectations turn out to be wrong ex post

- One can see this as $u_t = m_t - \mathrm{E}_t\left[m_t | \Gamma_{t-1}, \upsilon_t\right]$ (where Γ_{t-1} is the relevant information set):

$$n_t = A\left(\frac{1-\kappa}{1+K}\right)\left[m_t - \mathrm{E}_t\left[m_t | \Gamma_{t-1}, \upsilon_t\right]\right]$$

  I.e., **unanticipated money** matters

- Model thus reconciles tension between long-run neutrality of money and short-run non-neutrality, by assuming imperfect information

- Quantitative effect in calibrated model of a monetary surprise is small however
  - But note that the transmission mechanism is just **one** example of how misperceptions can lead to real effects
  - . . . and a rather indirect one, arising from money's effects on marginal utility of consumption onto the labor supply choice
  - . . . we know from Chapter 2 that this effect is rather weak

- Other implication of model: The higher κ the weaker effects of monetary shocks
  - Hence, countries with high aggregate nominal variability (relative high σ_u^2 and thus high κ) should have steep Phillips curves
  - This is supported by data
- Other important implication of model: Systematic monetary policy has no real effects
  - This is known as the *policy irrelevance hypothesis*
  - Systematic parts of the money process, γm_{t-1} have v_t no real effects; only the unsystematic part
  - Strong statement, which is not supported by data, where both unanticipated and anticipated money seems to matter
  - Typically, one cannot affect the **average** employment and output level by money shocks, but one can nevertheless affect the variability of real variables by a monetary policy rule.
  - One says that the policy irrelevance hypothesis only **holds in weak form**
    - (average employment and output are independent of systematic elements in the policy rule),
  - **but not in strong form**
    - (actual employment and output are independent of any systematic elements in the policy rule)

Summary

- Imperfect information is seen as being one candidate explanation to solve the tension between long-run neutrality of money and short-run non-neutrality
- Lucas' islands model formalizes the misperceptions ideas put forth by Friedman
- While a stylized set-up, the model highlights how imperfect information about aggregate versus disaggregate shocks implies that aggregate nominal shocks have real effects
  - . . . even in a model where prices are fully flexible
  - This insight is general and applies to many variants of the model
  - . . . as long as agents are "confused" and perceive that a relevant **real** variable has changed

- The strong implications concerning potential policy irrelevance, has however lead researchers to search for alternative models of incomplete nominal adjustment; namely those with sticky prices and wages

. . . next time

Plan for next lectures

Monday, March 8

1. Money in the short run: Incomplete nominal adjustment (II)
2. Sticky Prices and Wages

Literature: Walsh (Chapter 5, pp. 211-223 — plus relevant appendix)

Wednesday, March 10

Exercises: