Monetary Economics: Macro Aspects, 10/5 2004
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Plan for today:

Open-economy Aspects (II)
1. The Obstfeld and Rogoff two-country model with sticky prices
2. An example of international monetary policy coordination

Literature: Walsh (2003, Chap. 6, pp. 282-297). Read also (small) Section 6.4 on the small open economy.

As supplementary recent readings on policy coordination, I recommend Benigno (2002, *Journal of International Economics*) and Clarida et al. (2002, *Journal of Monetary Economics*) as well as Chapter 6.5 in Walsh.

Introductory remarks

- A sticky-price version of the Obstfeld-Rogoff model is examined
  - What are the impact of monetary shocks?
  - What are the impacts of an asymmetric monetary shock of Home and Foreign economies?
  - What are the "spill-overs" of unilateral policy?
  - What are the welfare effects of money shocks?
  - ....prelude to issue of policy coordination

- With international spill-overs of unilateral policies, coordination may be desirable:
  - "Inward" oriented policies ignore external effects
    => international inefficiencies
  - Through coordination, the external effects are internalized to benefit of all
  - ....an example is provided as illustration (not within a micro-founded model.....)

The Obstfeld-Rogoff Two-Country Model:

The sticky-price version and money shocks

- The flex-price Obstfeld-Rogoff model featured money neutrality
- To asses the real effects of money shocks Home and abroad, price stickiness is introduced
- Assumption:
  - Producers set their prices for one period, one period in advance
  - I.e., in any period $p_t(z)$ and $p_t^*(z)$ are exogenous
  - Assuming set to steady-state value in previous period, for simplicity $p_t(z) = p_t^*(z) = 0$
- Note that stickiness in producer-prices **does not imply stickiness** in consumer prices:

$$\begin{aligned} p_t &\equiv np_t(h) + (1-n)[s_t + p_t^*(f)] \\ &= (1-n)s_t \end{aligned} \tag{6.11}$$

$$\begin{aligned} p_t^* &\equiv (1-n)p_t^*(f) + n[p_t(h) - s_t] \\ &= -ns_t \end{aligned} \tag{6.12}$$

Changes in the nom. exchange rate will change consumer prices

- E.g., a nominal depreciation, $s_t \uparrow$, increases p_t and decreases p_t^*
- ....and thus the real prices of goods and thereby demand and production!

- Policy experiment:
  - Unanticipated, permanent increase in Home money supply
- Premise for "evaluation" of experiment: After the period of the shock, all prices re-adjust and economy returns to (potentially new!) steady state
  - Hence, **short-run effects** (one period) and **long-run effects** (steady state)
- Central for transmission of shock in short run is **nominal exchange rate effect**
- Central for transmission of shock in long run is **wealth redistribution between countries**
  - I.e., if short-run effects imply current account imbalance, a country will accumulate claims of the other => permanent wealth effects
- **Recap**: Nominal exchange rate is determined from money market equilibrium conditions:

$$\begin{aligned} m_t - m_t^* - (p_t - p_t^*) &= (c_t - c_t^*) - \delta(\pi_{t+1} - \pi_{t+1}^*) \\ m_t - m_t^* - s_t &= (c_t - c_t^*) - \delta(s_{t+1} - s_t) \end{aligned} \tag{6.23}$$

- Solving (6.23) successively forward yields

$$s_t = \frac{1}{1+\delta}\sum_{i=0}^{\infty}\left(\frac{\delta}{1+\delta}\right)^i [(m_{t+i} - m_{t+i}^*) - (c_{t+i} - c_{t+i}^*)]$$

- As.....
  - change in relative money supplies from policy shock is permanent (by assumption)
  - any consumption differential is permanent (by the Euler equations and perfect capital mobility implying equal real interest rates)
- .....we get

$$s_t = \Omega - \mathcal{C} \tag{6.28}$$

  - Where $\Omega > 0$ is money differential
  - Where $\mathcal{C}$ is consumption differential
- Hence, unless the consumption differential increases by more than the money differential, the money shock **depreciates the nominal exchange rate**
  - This will indeed be the case...
  - ...as tedious algebra shows that $\mathcal{C} = \Omega/(1+\psi)$, with $\psi > 0$
- Hence, the policy shock induces a less than proportional nominal exchange rate depreciation (in contrast with the flexible price case)

- Short-run implications
  - Depreciation of exchange rate increases p_t
  - This reduces real price of domestic good, and demand increases!
  - Home and foreign consumption **increases** and Home production increases (thus causing Home consumption to increase the most).....
  - World consumption increases and (by global market clearing) world production increases
    - Foreign production may or may not increase:
    - Demand for foreign goods falls due to decrease in p_t^*, but increases due to increase in c_t^w
  - Home output increases by more than Home consumption
    - => Home current account surplus
    - => Accumulation of claims on Foreign country; i.e., Home net foreign assets go up!
    - (b goes up, and b^* goes down)
- Long-run implications:
  - Higher Home wealth implies permanently higher home consumption (and lower production — country is continuously financing its trade deficit by the interest income on higher asset holdings)
  - So, long-run effects of the monetary shock due to wealth redistribution

- If policy experiment involved symmetric increase in money supplies, no exchange rate effect, and only a one period symmetric expansion, and no wealth redistribution

- Welfare implications of the (asymmetric) shock?
- Intricate but interesting issue (where utility of real money per se is downplayed)
- Note first that the experiment represents a *marginal* change in home money supply (otherwise linearization is not valid)
- Then note that in "pre-shock equilibrium" **all agents are behaving optimally**
  - This implies that changes in Home and Foreign work effort due to relative price changes are of **second order** in welfare terms
    (e.g., the higher income for Home work cancels out the higher disutility of work)
  - This implies that changes in consumption dynamics following current account imbalances are of **second order** in welfare terms (when starting from an equilibrium with optimal consumption smoothing)

- What is left to provide first-order welfare effects? The part in the initial equilibrium that is **suboptimal:**
  - The inefficient output due to monopolistic competition
- The short-run increase in world consumption affects this distortion in a **first-order** welfare-improving way
  - Hence, BOTH COUNTRIES' welfare increases **by the same amount** following **the asymmetric money shock**
    (remember, both production schedules are scaled by world consumption)

- Unilateral money expansion has positive spill-overs
  - Countries have then incentives to perform expansive monetary policies; either unilaterally or coordinated
- Important caveat: It is **unanticipated** money increases that works
  - If anticipated, they would have been build into price setting behavior
  - As a result attempts to boost output above the (inefficient) flex-price level, could lead to an inflation bias
    (model thus provides micro foundations for the Barro-Gordon set-up)

- Obstfeld-Rogoff model highlights the role of the nominal exchange rate for transmission of money shocks in open economies
- Emphasizes importance of micro foundations (the welfare implications could NOT have been assessed properly in an ad hoc model)
- Highlights the spill-overs of unilateral policies
- Invites analysis of policy coordination

- Somewhat involved to analyze coordination issue in O-R model; therefore the issue, and the general messages are conducted in an....*ad hoc* model

Policy coordination

- World is simple, symmetric log-linear two-country model
- Simple AS/AD style model
- Home and foreign AS curves

$$y_t = -b_1\rho_t + b_2\left(\pi_t - \mathrm{E}_{t-1}\pi_t\right) + \varepsilon_t \qquad (6.35')$$

$$y_t^* = b_1\rho_t + b_2\left(\pi_t^* - \mathrm{E}_{t-1}\pi_t^*\right) + \varepsilon_t \qquad (6.36')$$

  - Inflation surprises increase output (one-period nominal wage rigidity)
  - A real exchange rate depreciation, $\rho_t \equiv s_t + p^* - p$ goes up, reduces Home supply
    - as imported inputs becomes more expensive,
    - and/or as the real product wage rises relative to the real consumer wage

- Home and foreign AD curves:

$$y_t = a_1\rho_t - a_2 r_t \qquad (6.37')$$

$$y_t^* = -a_1\rho_t - a_2 r_t^* \qquad (6.38')$$

  - Home demand increases by a real exchange rate depreciation (competition effect)
  - Home demand decreases with the real interest rate r_t
  - (spill-over from other country's output ignored for simplicity; $a_3 = 0$; also demand shocks are ignored $u_t = u_t^* = 0$)

- UIP in real terms:

$$r_t - r_t^* = \mathrm{E}_t \rho_{t+1} - \rho_t \qquad (6.39')$$

- Monetary policy instruments are for simplicity taken to be the inflation rates
- "Welfare functions" of Home and Foreign country (conventional *ad hoc* quadratic loss functions)

$$V_t = \mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \left[\lambda y_{t+i}^2 + \pi_{t+i}^2\right], \quad \lambda > 0, \qquad (6.40)$$

$$V_t^* = \mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \left[\lambda \left(y_{t+i}^*\right)^2 + \left(\pi_{t+i}^*\right)^2\right]. \qquad (6.41)$$

  Notice, "no-above-steady-state target" for output => no inflation bias
- In absence of shocks $\varepsilon_t = 0$, everything is in steady state, and no reason for any policy
- Assuming shock is mean-zero and serially uncorrelated, the policy problem(s) when a shock hits become a static one — the economy is in expectation back in steady state next period
  - Implication: $\mathrm{E}_t \rho_{t+1} = 0$

Solving the model under coordinated monetary policy

- Under coordination, central banks jointly choose π_t, π_t^* so as to minimize

$$V_t + V_t^*$$

  subject to the model's equations

- First, solve the model in terms of the real exchange rate, and thus outputs (to create unconstrained problem)
- The real exchange rate:
  - Demand differential:

$$y_t - y_t^* = 2a_1 \rho_t - a_2 \left(r_t - r_t^*\right)$$

$$\begin{aligned} y_t - y_t^* &= 2a_1 \rho_t + a_2 \rho_t \\ &= \left(2a_1 + a_2\right) \rho_t \end{aligned}$$

    A real depreciation increases relative Home demand through two channels:
    - The direct relative demand shift channel
    - The decrease in the real interest rate differential (as a real appreciation is expected)
  - Supply differential:

$$y_t - y_t^* = -2b_1 \rho_t + b_2 \left(\pi_t - \mathrm{E}_{t-1} \pi_t\right) - b_2 \left(\pi_t^* - \mathrm{E}_{t-1} \pi_t^*\right)$$

    A real depreciation decreases relative Home supply from one source:
    - The direct cost channel(s)

- Equilibrium real exchange rate found from "intersection" of relative demand and supply schedules:

$$\begin{aligned} \rho_t &= \frac{b_2}{B'}\left[(\pi_t - \mathrm{E}_{t-1}\pi_t) - (\pi_t^* - \mathrm{E}_{t-1}\pi_t^*)\right] \qquad (6.42') \\ B' &\equiv 2a_1 + a_2 + 2b_1 \end{aligned}$$

  A Home inflation surprise causes a real depreciation as it increases the supply differential

  – The real exchange rate must depreciate to secure goods market equilibrium: i.e., increase the demand differential

- With solution for real exchange rates, outputs are found as functions of policy instruments from AS-curves:

$$\begin{aligned} y_t &= -b_1\rho_t + b_2\left(\pi_t - \mathrm{E}_{t-1}\pi_t\right) + \varepsilon_t \\ &= -b_1\frac{b_2}{B'}\left[(\pi_t - \mathrm{E}_{t-1}\pi_t) - (\pi_t^* - \mathrm{E}_{t-1}\pi_t^*)\right] \\ &\quad +b_2\left(\pi_t - \mathrm{E}_{t-1}\pi_t\right) + \varepsilon_t \end{aligned}$$

  and thus

$$y_t = b_2A_1'\left(\pi_t - \mathrm{E}_{t-1}\pi_t\right) + b_2A_2'\left(\pi_t^* - \mathrm{E}_{t-1}\pi_t^*\right) + \varepsilon_t \qquad (6.43')$$

$$\begin{aligned} A_1' &\equiv \frac{2a_1 + a_2 + b_1}{B'} \\ A_2' &\equiv b_1/B' \end{aligned}$$

  International policy spill-over:

  – Foreign inflation surprise is expansionary on Home output as it appreciates the real exchange rate
  (it reduces supply differential, and to equilibrate goods market equilibrium, relative demand must shift towards foreign goods necessitating a real appreciation)

- Equivalent output equation for foreign:

$$y_t^* = b_2A_1'\left(\pi_t^* - \mathrm{E}_{t-1}\pi_t^*\right) + b_2A_2'\left(\pi_t - \mathrm{E}_{t-1}\pi_t\right) + \varepsilon_t \qquad (6.44')$$

- Policy problem is to choose π_t, π_t^* to minimize $V_t + V_t^*$ subject to output schedules

- First-order conditions:

$$\begin{aligned} \lambda b_2A_1'y_t + \pi_t + \lambda b_2A_2'y_t^* &= 0, \\ \lambda b_2A_1'y_t^* + \pi_t^* + \lambda b_2A_2'y_t &= 0, \end{aligned}$$

- This implies (shock is mean zero), $\mathrm{E}_{t-1}\pi_t = \mathrm{E}_{t-1}\pi_t^* = 0$, and thus the first condition is

$$\begin{aligned} &\lambda b_2A_1'\left(b_2A_1'\pi_t + b_2A_2'\pi_t^* + \varepsilon_t\right) \\ &+\pi_t + \lambda b_2A_2'\left(b_2A_1'\pi_t^* + b_2A_2'\pi_t + \varepsilon_t\right) \\ &= 0, \end{aligned}$$

- Equilibrium is symmetric, due to symmetric structure, so $\pi_t = \pi_t^*$ =>

$$\begin{aligned} &\lambda b_2A_1'\left(b_2A_1'\pi_t + b_2A_2'\pi_t + \varepsilon_t\right) \\ &+\pi_t + \lambda b_2A_2'\left(b_2A_1'\pi_t + b_2A_2'\pi_t + \varepsilon_t\right) \\ &= 0, \end{aligned}$$

  and thus

$$\pi_{c,t} = \pi_{c,t}^* = -\frac{\lambda b_2}{1 + \lambda b_2^2}\varepsilon_t \qquad (6.45)$$

  "Lean-against-the-wind" policy: If $\varepsilon_t < 0$, central banks jointly expand policies up to point where inflation becomes too high

- Standard stabilization policy implications. The supply shock is "spread out" on output and inflation rates to a relative extent determined by λ

Solving the model under noncooperative monetary policy

- Now, what if central banks do not coordinate?
- It is then assumed that each central bank conducts policy with aim of minimizing "own" loss function, **ignoring** external effects, and **taking foreign policy as given**
- This result in policy **reaction functions.** Their intersection gives the **Nash (1950) equilibrium**: Policy profiles from which unilateral deviation cannot pay
- Home policy problem: Choose π_t to minimize V_t subject to Home output, taking π_t^* as given
- First-order condition

$$\lambda b_2 A_1' y_t + \pi_t = 0;$$

  Compared to condition under coordination:
  Foreign output effects are ignored
- If meeting a $\varepsilon_t < 0$ this implies too little Home expansion
- Using output equation (and, again, $\mathrm{E}_{t-1}\pi_t = \mathrm{E}_{t-1}\pi_t^* = 0$):

$$\lambda b_2 A_1' \left(b_2 A_1' \pi_t + b_2 A_2' \pi_t^* + \varepsilon_t\right) + \pi_t = 0$$

- Defines negatively sloped reaction function; higher π_t^* is met by a Home contraction
- Nash equilibrium is symmetric, so $\pi_t = \pi_t^*$; hence,

$$\lambda b_2 A_1' \left(b_2 A_1' \pi_t + b_2 A_2' \pi_t + \varepsilon_t\right) + \pi_t = 0$$

and thus

$$\pi_{N,t} = \pi_{N,t}^* = -\frac{\lambda b_2 A_1'}{1 + \lambda b_2^2 A_1'} \varepsilon_t \tag{6.48}$$

- "Leaning-against-the-wind" policy again
- Comparison with coordinated policy:
  - When, e.g., $\varepsilon_t < 0$ uncoordinated policy expands too little
  - Why?
  - A unilateral expansion is for given foreign policy perceived to cause a real depreciation => output costs that refrains sufficient expansion
  - Foreign central bank thinks the same....
  - In Nash equilibrium **the real exchange rate does not move** and a more expansive policy would be preferable (as under coordination)
- Result: Noncooperative monetary policy leads to **too unstable output and too stable inflation**
- Implication: Coordination is beneficial as it internalizes the externalities of unilateral policymaking!
  - Here: Positive externalities, so non-cooperation leads to too little "policy activism"

- Is policy coordination generally preferable?
- Depends.....
- May be undesirable if it changes "third party behavior" in adverse directions
  - E.g., with three countries, coordination by two, may induce adverse behavior by the third
  - E.g., in this model with inflation bias considerations, private sector expectations may change adversely under cooperation (Rogoff, 1985, *Journal of International Economics*):
    * Under non-cooperation the perceived real depreciation from monetary expansion is indeed a cost that will reduce equilibrium inflation; under coordination inflation will be higher => coordination may be counterproductive

- Is coordination, if it is beneficial, of quantitative importance?
- Unsettled issue in literature
  - So far, "old-style" analyses based on large-scale econometric models generally found modest gains from coordination
  - New models with microfoundations have yet in calibrated versions also found modest gains
  - However, these models often have very few distortions (to make them tractable) so different policy regimes generally shows small welfare differences

Concluding remarks

- The Obstfeld-Rogoff model highlights
  - The exchange rate channel for macroeconomic equilibrium
  - Wealth redistribution following asymmetric policy shocks
  - Importance of microfoundations for determination of welfare effects of policy interventions
  - The spill-overs of unilateral monetary policymaking in an integrated world
  - Begs the issue of policy coordination

- Policy coordination was seen to be beneficial in simple stylized two-country model
  - Coordinated policies internalize external effects of policy
  - In model, policy had positive externalities, and non-cooperative behavior ignored these and were "too passive"
  - Had policy negative externalities, non-cooperative behavior would ignore the harmful effects abroad and be "too aggressive"
  - Generally, difference between cooperative and non-cooperative policies depends on the nature of the externalities
  - Generally, coordination is beneficial as long as "third parties" do not change behavior

Plan for next lectures

Wednesday, May 12

Inflation Targeting (I)

1. General concepts and implications

2. A simple static way of modeling inflation targeting

Literature: Bernanke and Mishkin (1997, *Journal of Economic Perspectives*); Walsh (2001, downloadable on website)

Wednesday, May 19

Inflation Targeting (II)

1. Example of a dynamic modeling inflation targeting

2. The importance of inflation forecasts

Literature: Svensson (1997, *European Economic Review*). Supplementary reading: Svensson (1999, 2000a,b).