Monetary Economics: Macro Aspects, 31/3 2004
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Plan for today:

- Wrap up from last lectures: Impact of interest rate rule parameters in small model of monetary policy

Interest rate policies (II)

1. Optimal interest rate rule in simple model for policy analysis
2. International evidence on interest rate rules

Literature: Walsh (Chapter 10, pp. 508-515); Clarida et al. (1998); Taylor (1993)

3. Plan for next lecture

NOTE: Problem from last/last lectures is **solved**! Answer will be available on web page very soon!

Introductory remarks

- Last lecture considered the performance of a given interest rule in the Fuhrer Moore model
- What constitutes an optimal interest rate rule?
- What will it achieve, and how?
- Has actual monetary policy in major industrialized economies had any resemblance to what theory says?

- First issue(s) covered in simplified Fuhrer-Moore model
- Second issue covered by examining some empirical evidence on interest rate rules

Optimal interest rate rule in simple model for policy analysis

The modified Fuhrer-Moore model

- Simplifications of the Fuhrer-Moore model to illustrate computation of optimal policy rule for the nominal interest rate:
  - Drop distinction between short- and long term interest rate (just have a short interest rate)
  - Drop forward-looking elements in the AS curve
  - Drop a lag in the IS curve (not done by Walsh)
  - Let shocks be mean-zero white-noise disturbances
- Model is now simple *two-equation* IS/AS model (written explicitly in terms of the nominal interest rate and inflation, so Fisher relationship is not needed)
- IS curve:

$$y_t = a_1 y_{t-1} - a_3 \left(i_{t-1} - \mathrm{E}_{t-1} \pi_t \right) + u_t, \qquad a_1, a_3 > 0 \quad (10.42')$$

- AS curve:

$$\pi_t = \pi_{t-1} + \gamma y_t + \eta_t, \qquad \gamma > 0 \qquad (10.43)$$

("Accelerationist Phillips-curve")

- Simple monetary transmission mechanism:
  - Nominal interest rate affects aggregate demand with a one period-lag
  - Through the Phillips curve, inflation is also affected with a one-period lag
  - Effects are persistent due to the lags in both the IS and AS curve
- Stability of system in absence of further policy response? Requires stability of the system

$$y_t = a_1 y_{t-1} + a_3 \pi_t \qquad (*)$$
$$\pi_t = \pi_{t-1} + \gamma y_t \qquad (**)$$

- To analyze stability, one usually formulates the system in matrix form:

$$\begin{bmatrix} y_t \\ \pi_t \end{bmatrix} = \mathbf{A} \begin{bmatrix} y_{t-1} \\ \pi_{t-1} \end{bmatrix}$$

where $\mathbf{A}$ is a 2×2 matrix. Stability requires that the real parts of the eigenvalues of $\mathbf{A}$ are both numerically **smaller than one** as system contains two predetermined variables y_{t-1}, and π_{t-1} (cf. Blanchard and Kahn, 1980, *Econometrica;* standard technical reference for stability conditions in general dynamic macro-models)

- Find $\mathbf{A}$. From (**) and (*) we get

$$y_t = a_1 y_{t-1} + a_3 \left(\pi_{t-1} + \gamma y_t \right)$$
$$y_t = \frac{a_1}{1 - \gamma a_3} y_{t-1} + \frac{a_3}{1 - \gamma a_3} \pi_{t-1}$$

Also we get

$$\pi_t = \pi_{t-1} + \gamma\left(a_1 y_{t-1} + a_3 \pi_t\right)$$

$$\pi_t = \frac{1}{1-\gamma a_3}\pi_{t-1} + \frac{\gamma a_1}{1-\gamma a_3} y_{t-1}$$

- The system is thus

$$\begin{bmatrix} y_t \\ \pi_t \end{bmatrix} = \begin{bmatrix} \frac{a_1}{1-\gamma a_3} & \frac{a_3}{1-\gamma a_3} \\ \frac{\gamma a_1}{1-\gamma a_3} & \frac{1}{1-\gamma a_3} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ \pi_{t-1} \end{bmatrix}$$

- The eigenvalues λ_1 and λ_2 are computed from:

$$\begin{vmatrix} \frac{a_1}{1-\gamma a_3} - \lambda & \frac{a_3}{1-\gamma a_3} \\ \frac{\gamma a_1}{1-\gamma a_3} & \frac{1}{1-\gamma a_3} - \lambda \end{vmatrix} = 0$$

- This gives a second-order polynomial in λ:

$$\lambda^2 - \frac{1+a_1}{1-\gamma a_3}\lambda + \frac{a_1^2}{(1-\gamma a_3)^2} - \frac{\gamma a_1 a_3}{(1-\gamma a_3)^2} = 0$$

$$\lambda^2 - \frac{1+a_1}{1-\gamma a_3}\lambda + \frac{a_1}{1-\gamma a_3} = 0$$

- The solution is

$$\lambda = \frac{\frac{1+a_1}{1-\gamma a_3} \pm \sqrt{\left(\frac{1+a_1}{1-\gamma a_3}\right)^2 - 4\frac{a_1}{1-\gamma a_3}}}{2}$$

- Parameter values based on estimations on US data by Rudebusch and Svensson (1999, in John Taylor (ed.): "Monetary Policy Rules", Chicago University Press)
  - Persistence in aggregate demand; $a_1 = 0.91$
  - Aggregate demand's real interest rate sensitivity; $a_3 = 0.1$
  - Inflation's sensitivity to aggregate demand; $\gamma = 0.14$
- With these values we get

$$\lambda_1 = 1.0918$$
$$\lambda_2 = 0.8453$$

- System is **unstable**! For a fixed nominal interest rate, shocks to the economy will lead to **explosive** output and inflation paths
  - Intuition: A positive u_t shock increases output, which leads to inflation. This **decreases** the real interest rate, and stimulates output and inflation further, and so on, and so on.....
- The purpose of the derivation of an optimal policy rule is therefore **two-fold:**
  - To secure that the economy **returns to its long-run equilibrium** following a shock
  - Secure the **optimal manner** by which it returns to the long-run equilibrium

Optimal monetary policymaking

- The criterion of monetary policy is to minimize the expected discounted sum of deviations in output and inflation from their long-run equilibrium values
- In each period t, the **loss function** is assumed to be

$$\frac{\lambda}{2}y_t^2 + \frac{1}{2}\pi_t^2, \qquad \lambda > 0.$$

- To solve model note first
  - In period t policy cannot affect output and inflation
  - Period t policy only affects period $t+1$ values (and onwards)
- The objective function is therefore written as

$$L = \frac{1}{2}\mathrm{E}_t \sum_{i=1}^{\infty} \beta^i \left[\lambda y_{t+i}^2 + \pi_{t+i}^2\right], \qquad 0 < \beta < 1 \qquad (10.47)$$

- The policy problem is to minimize L w.r.t. i_t subject to the IS/AS curves
- A trick is introduced in order to make the solution easier
- Since it is period $t+1$ output that can be controlled, forward the IS curve one period:

$$y_{t+1} = a_1 y_t - a_3 \left(i_t - \mathrm{E}_t \pi_{t+1}\right) + u_{t+1}$$

- Inflation expectations follow by forwarding the AS curve and take expectations:

$$\mathrm{E}_t \pi_{t+1} = \pi_t + \gamma \mathrm{E}_t y_{t+1}$$

- Combine the two to get

$$y_{t+1} = a_1 y_t - a_3 \left(i_t - \pi_t - \gamma \mathrm{E}_t y_{t+1}\right) + u_{t+1}$$

- Take period t expectations on both sides (remember $\mathrm{E}_t u_{t+1} = 0$)

$$\mathrm{E}_t y_{t+1} = a_1 y_t - a_3 \left(i_t - \pi_t - \gamma \mathrm{E}_t y_{t+1}\right)$$

- This gives solution for $\mathrm{E}_t y_{t+1}$

$$\mathrm{E}_t y_{t+1} = \frac{a_1 y_t - a_3 \left(i_t - \pi_t\right)}{1 - \gamma a_3}$$

  which is inserted into the IS curve:

$$y_{t+1} = \frac{a_1 y_t - a_3 \left(i_t - \pi_t\right)}{1 - \gamma a_3} + u_{t+1}$$

- But in period t, y_t and π_t are **predetermined** from the perspective of policy. Hence, one can treat

$$\theta_t \equiv \frac{a_1 y_t - a_3 \left(i_t - \pi_t\right)}{1 - \gamma a_3} \qquad (10.51')$$

  as the policy instrument!

- The IS now curve becomes:

$$y_{t+1} = \theta_t + u_{t+1} \qquad (10.52)$$

- The AS curve becomes:

$$\begin{aligned} \pi_{t+1} &= \pi_t + \gamma\theta_t + \gamma u_{t+1} + \eta_{t+1} \\ &= \pi_t + \gamma\theta_t + v_{t+1} \end{aligned} \qquad (10.53)$$

- Finding the optimal value of θ_t residually provides i_t as a function of y_t and π_t
- Solution technique is dynamic programming. We solve it in the exercises next time!
- Solution for the nominal interest rate becomes

$$i_t = \left[1 - \frac{B\,(1 - a_3\gamma)}{a_3}\right]\pi_t + \frac{a_1}{a_3}y_t$$

- $B < 0$ and a function of the model parameters

Qualitative Implications:

- Coefficient on inflation is larger than one.
  This **secures stability** of model:
  - If $u_{t+1} > 0$, output and inflation increase
  - This **increases the real interest rate**, when the nominal rate responds by more than one to inflation
  - This reduces output and inflation, and brings back the economy to long-run equilibrium
- Higher weight on output stabilization, higher λ, lower coefficient on inflation ($B < 0$ increases)
- If **no** weight on output stabilization, $\lambda = 0$, **still** a response to output!
  - Hence, **arguments in optimal policy rules say nothing about policy goals!**
  - Here, it is optimal to respond to output even for $\lambda = 0$, as higher output today gives information about higher output tomorrow (when $a_1 > 0$) and higher inflation;
  - Output is **an intermediate target** (it provides relevant information about future inflation)

Quantitative Implications:

- Use the estimated values of the parameters to assess the optimal coefficients:
- Walsh's parameterization yields of model equations, along with $\lambda = 1$ and $\beta = 0.989$:

$$i_t = 1.50\pi_t + 4.37y_t$$

- Other parameterization (Ball), yields:

$$i_t = 1.48\pi_t + 0.8y_t$$

- The Svensson/Rudebusch estimates yield (with $\lambda = 1$ and $\beta = 0.96$):

$$i_t = 9.11\pi_t + 9.1y_t$$

(much higher coefficients as the aggregate demand is less sensitive to real interest rate changes than in the other calibrations)

- These differences highlight that one should be careful when interpreting **observed** interest rate coefficients:
  - Observing a relatively high coefficient on inflation does not necessarily signal a "strong preference" for inflation stability!
  - It could just be that the structural parameters in the economy **requires** a strong response to inflation in order to satisfy a "mild preference" for inflation stability.
- In any case, by adopting an interest rate rule the central bank:
  - Secures stability of the economy when it is hit by shocks
  - Minimize the weighted sum of output and inflation variability

International evidence on interest rate rules

- The derivation of optimal interest rate policy provides testable implications:
  - A central bank aiming at stabilizing the economy should follow an interest rule which has a higher than one coefficient on inflation
  - Also, a positive coefficient on output should be observed
- Most famous empirical account of the relationship between nominal interest rates and macroeconomic aggregates is the article:

John B. Taylor (1993):
"Discretion versus Policy Rules in Practice"

- Article summarized nicely the research frontier at that time:
  - Acknowledgement of Lucas critique
  - Monetary policy is not ineffective
  - Importance of credibility
  - Time inconsistency problems lead to favor of rules over discretion
  - "Flexible" rules responding to economic developments preferable to rigid rules

- Taylor stresses that one should not follow rules mechanically, and also that they should be relatively **simple**
- Even though not to be followed mechanically, the "rules" approach is to be meant as not to fall into discretionary policymaking ("start from scratch every period"); it is merely viewed as providing **systematic behavior**
- The cited studies consider performance of nominal interest rate rules in large-scale econometric models
  - Consensus is that output and inflation stability are best secured by responding towards these variables **directly**
- Confirmed by Taylor's own research (on a G7-multicountry econometric model)
- The representative policy rule:

$$r = p + 0.5y + 0.5\,(p - 2) + 2 \tag{1}$$

  where r is the nominal interest rate, p is inflation, y is output deviation from trend (inflation target and steady-state real interest rate is 2)
- Note that an inflation increased raises the nominal rate by 1.5, i.e., raises the real interest rate by 0.5
- Equation (1) is now know as <u>**the**</u> **Taylor rule**
- Figure 1 shows that it describes actual US monetary policy remarkably well

- One example of **not** being a mechanical rule: Oil price increases following the first Gulf War
  - Mechanical adherence to rule would have called for increased r (inflation rose more than output fell)
  - But the increase in inflation was *judged* to be temporary, so increasing r could be harmful
- Another example: Rising long interest rates in early 1990
  - As we know, higher long rates can be signal of expectations about higher future inflation
  - Could call for a monetary tightening
  - But, it was *judged* that real interest rate had increased due to expected German unification (causing German budget deficit, increased demand for capital), spilling over to the US through integrated world capital markets

Evidence for interest rate rules in other countries

- Clarida, Galí and Gertler (1998) estimate "Taylor type rules" for Germany, Japan, US, UK. France and Italy (1979 and onwards)
- Main differences from conventional Taylor rule:
  - Responses to expected future inflation ("Forward-looking Taylor rule")
  - Partial adjustment of interest rates to economic developments ≈ interest rate "smoothing"
- Main results for Germany, US and Japan:
  - The forward-looking Taylor rule describes actual policymaking well (better than "backward-looking specifications")
  - When expected inflation increases, the nominal rate is raised sufficiently to raise the real interest rate
  - Some response to output also ("modest stabilization component")
  - Interesting that Germany with its history as a "monetary targeter," does not respond significantly to money growth (**typo** in last column of Table 1! Coefficient in money supply row should be 0.07 (not 0.7))

- Main results for UK, France and Italy:
  - Less convincing results — **not surprising** as for the most part of the period, these countries had no monetary autonomy (pegged their currencies vis-à-vis the German mark; German interest rate is a highly significant explanatory variable)
  - What **if** they had responded to internal economic conditions?

  => How far off were actual interest rates from those under such counterfactuals? May give indication about the causes of the breakdown of the EMS
  - Indeed, around the breakup, these countries had much higher interest rates than had they followed a Taylor rule and responded to own economic developments
  - A "blow" against trying to obtain monetary credibility by pegging to a credible bank (the Bundesbank)?
  - A "blow" against EMU?

Plan for next lectures

Monday, April 5 (last lectures before Easter):

Exercises:

Question 1 and 2 from the exam, June 2003 (available on the webpage); don't cheat yourself and dig up the solutions (at least not until after you have make a serious try at the solutions)

Wednesday, April 14 (first lectures after Easter):

1. The modern "New Keynesian" model of monetary policy analysis
2. Stability properties
3. Optimal monetary policy under discretion

Literature Clarida et al. (1999, *Journal of Economic Literature*, 1661-1675) and Walsh (2003, Chapter 5, pp. 230-247). The latter is "only" supplementary reading and provides the formalities of the micro foundations for the model used by Clarida et. al)