Monetary Economics: Macro Aspects, 4/2 2004
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Plan for today:

1. What are the "stylized facts" about money and economic aggregates?
2. Empirical problems/issues

Literature: Walsh (2003, Chapter 1)

3. Plan for next lectures

What are the "stylized facts" about money and economic aggregates

Long run correlations

- Consensus estimates show correlations between growth in monetary aggregates and inflation close to one
  - Hence, a reasonable characterization is that long-run changes in money growth are reflected in equivalent changes in inflation rates
  - Causality?
- Long-run effects on output growth are less robust
  - Some find positive correlations between money growth and output growth
  - Some find no correlation between inflation and output growth
  - Some find negative correlation between inflation and output growth
  - Results hinge on which countries are used; e.g., some find negative inflation effects in high inflation countries and zero or slightly positive effects for low-inflation countries
- Despite more uncertainty about the relationship between of monetary aggregates and real economic activity the Taylor quote represents the consensus view in the economics profession:

- “*about which there is now little disagreement, . . . that there is no long-run trade-off between the rate of inflation and the rate of unemployment*”
  - I.e., the long-run Phillips curve is *vertical*

- Inflation and nominal interest rates in the long run?
  - Fisher equation: $i_t = r_t + \mathrm{E}_t \pi_{t+1}$
  - In steady-state, $i^{ss} = r^{ss} + \pi^{ss}$
  - Higher long-run inflation should raise long-run interest rates
  - Roughly confirmed by empirical analyses

Short run correlations

- Examining the short-run effects of monetary policy on real activity: much more controversial
- Aim is to assess whether monetary aggregates are correlated with real activity at *business cycle frequencies*
  - One usually uses detrended data; i.e., data exhibiting deviation from an underlying, hypothetical trend value which would prevail in absence of any shocks or frictions in the economy
  - Issue is then whether above average monetary aggregates are associated with above or below average economic activity
- Figure 1.1 shows dynamic correlations for three monetary aggregates (M0, M1, M2) and GDP (USA data for 1967-2000).
  - In particular M2 exhibits a pattern: It is positively correlated with GDP at *lags* and negatively correlated at *leads*
  - I.e., if M2 is above average, it is associated with above-average GDP ahead in time; money *leads* output

- Again, simple correlations tell little about causality
- E.g., Friedman and Schwartz' classic study, which concluded that money movements *cause* output movements after long (and variable) time, has been questioned
- The positive correlations may as well reflect that money adjust endogenously to real output movements ("reverse causality")
  - The endogeneity of money is predominant for broader measures of money (such as M2), and in cases where the central bank uses the nominal interest rate as an instrument
  - Indeed, some find that the positive correlation is only prevalent for broad monetary aggregates ("inside money"), as it reflects the banking system's endogenous response to changes in economic activity.
    - E.g., increased demand for deposits by firms and consumers in anticipation of an upcoming boom, will increase broad monetary aggregates, even though the ensuing boom in not caused by money

- Lots of econometric work has therefore been conducted to assess the effects of money on output

- Early famous econometric studies regressed (often nominal) output on money and other variables
- Friedman and Meiselman (1963) found statistically significant coefficients on money
- Such "St. Louis" regressions were influential, but again the issue of endogeneity pops up
  - If money is endogenous, the regressions are misspecified
  - Also, at the extreme, if monetary policy is successful in stabilizing output, then money and output would be uncorrelated, and a St. Louis regression would show that money has no effect on output — even though it has!
- Sims (1972) introduced so-called *Granger causality* analysis, and found that money Granger caused output
  - That is, lagged values of money have some predictive power for output (while the opposite is not true)
- Findings less robust when other variables, e.g., interest rates, are included in empirical analysis (indicating that how one *measures* monetary policy matters)
- This and other evidence that followed are therefore somewhat mixed

- We now look at other problems using St. Louis regressions...
- ...and look at the most recent method of assessing the real effects of money on output in the short run

Empirical problems/issues

Problems with using simple regressions for policy uses: The Lucas critique

- Estimated relationship between output, y_t, and money, m_t:

$$y_t = a_0 m_t + c_1 z_t + c_2 z_{t-1} + u_t \qquad \text{(1.3 simplified)}$$

- Output stabilizing money supply rule (given z_t and u_t are zero in expectations):

$$\begin{aligned} m_t &= -\frac{c_2}{a_0} z_{t-1} + v_t \\ &= \pi_2 z_{t-1} + v_t, \quad \pi_2 \equiv -\frac{c_2}{a_0} < 0 \end{aligned} \qquad \text{(1.4 simplified)}$$

  v_t is a "control error" — an unanticipated, *unsystematic* part of monetary policy

- Resulting output *if* (1.3) is true: $y_t = a_0 v_t + c_1 z_t + u_t$. Hence, the *systematic* monetary policy response towards z_{t-1} works!
- No monetary theory needed in order to stabilize output!
- This can be *very dangerous* in design of the policy rule (Sargent): Suppose the *true* model for output is:

$$y_t = d_0 v_t + d_1 z_t + d_2 z_{t-1} + u_t \qquad \text{(1.5 simplified)}$$

  I.e., only *unanticipated* monetary policy has real effects. *Many* theoretical models have this feature

- With the policy rule, $v_t = m_t - \pi_2 z_{t-1}$, so

$$\begin{aligned} y_t &= d_0 [m_t - \pi_2 z_{t-1}] + d_1 z_t + d_2 z_{t-1} + u_t \\ &= d_0 m_t + d_1 z_t + [d_2 - d_0 \pi_2] z_{t-1} + u_t \end{aligned} \qquad \text{(1.6 simplified)}$$

- This is *observationally equivalent* to (1.3)
  - **I.e., even if only unsystematic monetary policy matters, a simple estimation can give the false impression that systematic monetary policy matters!**
- What is even worse: The estimated coefficients depend on policy parameters!
  - (Here: coefficient "$d_2 - d_0\pi_2$" depends on π_2)
  - Hence, a systematic change in policy (here, a change in π_2) will change the estimated coefficients
  - Simple estimated relationships will "break down" when the policy rule changes
    $\Longrightarrow$ One *cannot* evaluate the implications of a policy change using the estimated relationships
  - An example of Lucas' (1976) famous and influential *critique of policy evaluation*

- To see this assume one believes in (1.3) based on an empirical investigation
- One then want to assess the output effects of a policy rule that reacts less towards z_{t-1}:

$$m_t = (\pi_2 + \varepsilon) z_{t-1} + v_t, \quad \varepsilon > 0$$

- Resulting output when one believes in the estimation:

$$\begin{aligned} y_t &= a_0 [(\pi_2 + \varepsilon) z_{t-1} + v_t] + c_1 z_t + c_2 z_{t-1} + u_t \\ &= a_0 \left[\left(-\frac{c_2}{a_0} + \varepsilon \right) z_{t-1} + v_t \right] + c_1 z_t + c_2 z_{t-1} + u_t \\ &= a_0 v_t + c_1 z_t + a_0 \varepsilon z_{t-1} + u_t \end{aligned}$$

  One will conclude that z_{t-1} now affects y_t by $a_0\varepsilon$
- But if (1.5) is the true model, the change in policy rule has *no effect* on output, and the conclusion is false!
  - Even though m_t systematically responds less towards z_{t-1} — allowing a greater impact on output of size $d_0\varepsilon = a_0\varepsilon$ — this will be perfectly neutralized by the *decrease in the coefficient* on z_{t-1}: $d_2 - d_0 (\pi_2 + \varepsilon)$
  - It falls by $d_0\varepsilon$ as a result of the shift in the policy rule
  - *No output effects* of a systematic change in the policy rule
- This calls for use of models where coefficients are *invariant* to changes in policy rules
- This calls for *theories* of how money affects the economy (this helps identifying whether (1.3) or (1.5) have policy invariant coefficients)

Using VAR analysis for assessing policy effects

- Vector Autoregressive (VAR) methods have been widely adopted to empirically assess the impact of monetary policy
- One estimates a system like

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = A(L) \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} \tag{1.8}$$

  - y_t is, e.g., output and x_t is the policy variable
  - $A(L)$ is a matrix polynomial in L (the lag operator) — so independent variables can go far back in time
  - u_{yt} and u_{xt} are innovations to output and policy, defined as linear combinations of output and policy shocks:

$$\begin{bmatrix} u_{yt} \\ u_{xt} \end{bmatrix} = \begin{bmatrix} e_{yt} + \theta e_{xt} \\ \phi e_{yt} + e_{xt} \end{bmatrix} = \begin{bmatrix} 1 & \theta \\ \phi & 1 \end{bmatrix} \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix} \tag{1.9}$$

- Main purpose is to estimate the impact of a policy shock on output
- I.e., how will a certain realization of e_{xt} affect output in the short, medium and long run?
  - What is the *impulse response pattern*?

- Problem: Estimation of (1.8) gives the parameters of $A(L)$, and the residuals u_{yt} and u_{xt}
- One cannot, however, as long as $\theta \neq 0$ and $\phi \neq 0$, say anything about the individual effects of e_{yt} and e_{xt}
  - As θ and ϕ are unknown, knowledge about $u_{yt} = e_{yt} + \theta e_{xt}$ and $u_{xt} = \phi e_{yt} + e_{xt}$ makes inference about e_{yt} and e_{xt} impossible
  - The VAR model is not *identified*
  - Hence, one needs to place an *a priori* restriction on either θ or ϕ
- E.g., *assign* a particular value to θ. Then one can estimate ϕ, and infer the shocks e_{yt} and e_{xt}:
  - Use that

$$\begin{aligned} u_{xt} &= \phi e_{yt} + e_{xt} \\ &= \phi \left[u_{yt} - \theta e_{xt}\right] + e_{xt} \\ &= \phi u_{yt} + (1 - \phi\theta)\, e_{xt} \end{aligned}$$

  - Estimate u_{xt} on u_{yt}, and obtain an estimate of ϕ
  - The residual from the estimation is $(1 - \phi\theta)\, e_{xt}$ from which e_{xt} can be inferred as both ϕ and θ are known (the shock e_{yt} can then readily be inferred)
- One can then assess the impact of a shock e_{xt} as the system

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = A(L) \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & \theta \\ \phi & 1 \end{bmatrix} \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix}$$

is identified

- How can one just assign a value to either θ or ϕ?
- By using appropriate *identifying restrictions*. But "appropriate" leaves room for judgement......
- Example with simple version of the VAR:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} a_1 & a_2 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} 1 & \theta \\ \phi & 1 \end{bmatrix} \begin{bmatrix} e_{yt} \\ e_{xt} \end{bmatrix}, \quad 0 < a_1 < 1 \tag{1.10}$$

- Hence,

$$\begin{aligned} y_t &= a_1 y_{t-1} + a_2 x_{t-1} + e_{yt} + \theta e_{xt} \\ x_t &= \phi e_{yt} + e_{xt} \end{aligned}$$

- Output can be solved as (though successive iteration back in time)

$$\begin{aligned} y_t &= \sum_{i=0}^{\infty} a_1^i \left(e_{yt-i} + \theta e_{xt-i}\right) + a_2 \sum_{i=0}^{\infty} a_1^i \left(\phi e_{yt-i-1} + e_{xt-i-1}\right) \\ &= e_{yt} + (a_1 + a_2\phi) \sum_{i=0}^{\infty} a_1^i e_{yt-i-1} + \theta e_{xt} + \sum_{i=0}^{\infty} a_1^i \left(a_1\theta + a_2\right) e_{xt-i-1} \end{aligned}$$

- The impulse response pattern of output following a policy shock can now be assessed:
  - Period t: θ
  - Period $t+1$: $a_1\theta + a_2$
  - Period $t+2$: $a_1 (a_1\theta + a_2)$
  - Period $t+3$: $a_1^2 (a_1\theta + a_2)$

    .

    .

- Possible identifying assumptions:
  - $\theta = 0$. This is assuming that a policy shock has no contemporaneous effect on output (in VAR-language: policy is "ordered last")
  - $\phi = 0$. This is assuming that the policy variable is exogenous to contemporaneous output shocks (in VAR-language: policy is "ordered first")
  - $\theta + (a_1\theta + a_2) + a_1 (a_1\theta + a_2) + a_1^2 (a_1\theta + a_2) + ... = 0$. This is assuming that the cumulative effect of the policy shock policy is zero. If y_t is representing output *growth*, this corresponds to an assumption that policy is neutral on the output level in the long run

- All involves a *judgement* about what is a reasonable identifying assumption

- Other potential problems with the VAR approach:
  - What is the relevant monetary policy variable?
  - A satisfactory VAR should include more variables than just output (and this increases the number of identifying restrictions accordingly). Which ones?
  - The data frequency will matter for the appropriateness of identifying restrictions
  - Monetary policy is seen as a sequence of exogenous and random events; monetary policy's endogenous nature is neglected
    - ∗ So if monetary policy is a feedback rule, one could conclude that $e_{xt} = 0$, all t
    - ∗ I.e., conclude that monetary policy did not matter even though it may have played an important role for how the economy have adjusted to other shocks
  - Different operating procedures and policy instruments across various time periods will make the results sensitive to choice of period

- Nevertheless, several VAR studies have some common findings:
  - A *contrationary* monetary policy shock (an increase in the short interest rate), has a "hump-shaped" impact on output, and a *negative* effect on output is most prominent after some time
  - See Figure 1.5 and for a four-variable VAR (with a "$\theta = 0$" type of identifying restriction). At two-year ahead perspective, movements in the short interest rate accounts for more than 25% of output variability
  - A "price puzzle" is apparent: Prices *increase* after a contractionary policy shock; in contrast to common priors
    - Possible explanation: The VAR ignores some of the monetary policymakers' information; e.g., forecasts about rising inflation due to factors the policymakers cannot offset, or maybe the policymaker reacts too late to raising prices
    - Introducing forward-looking variables like asset prices in a VAR sometimes eliminates the price puzzle; they act as a proxy for the policymaker's forecasts

- Despite many methodological problems and issues, the VAR literature at least tend to confirm that monetary policy *do have* effects on output in the short and medium run

Other approaches to address monetary policy and output

- Structural Econometric Models
  - These are typically models with various estimated behavioral equations (consumption functions, labour supply schedules, etc.)
  - Monetary policy is typically modelled as a feedback rule, making it possible to assess the implications of various policy regimes
  - Earlier models in 1960s and 1970s (like Danish "ADAM" and "SMEC" were vulnerable to the Lucas critique, but recent models have progressed (both small-scale and large scale models)
  - Reassuring that results from these models regarding policy shocks are not grossly inconsistent with the VAR results

- The "Narrative approach" (initiated by Friedman and Schwartz)
  - Exogenous shifts in monetary policy are saught identified by reading policy directives and minutes from FOMC meetings
  - Romer and Romer, e.g., identifies six instances of clear contractionary shifts in monetary policy
  - All of these are followed by recessions
  - Again supportive of the view that monetary policy matter for output in the short and medium run

- Examination of disinflations
  - Has bringing down inflation (presumably through contractive monetary policy) had negative output effects?
  - Some empirical studies say yes, some say no
  - Approach suffer from identification problems: Is disinflation a result of contractive monetary policy?
  - Also, if disinflation is *credible*, it may have no output effects; yet monetary policy shocks may still be important for output
    - ∗ Consider simple expectations-augmented Phillips-curve:

$$\pi = \mathrm{E}[\pi] + \gamma y, \quad \gamma > 0$$

      - · If inflation, π, is brought down, and $\mathrm{E}[\pi]$ goes down accordingly (the disinflation is *credible*), output, y, is unchanged
      - · If $\mathrm{E}[\pi]$ does not go down, the disinflation has output costs (y falls)

Summary

- In the long run:
  - Monetary policy has predominantly effects on prices, and not output
  - Changes in money growth rates are reflected in changes in inflation rates, and nominal interest rates and very small effects on output growth
- In the short run:
  - The impact of monetary policy on real output is more controversial
  - Many empirical problems arise when assessing the impact
  - Some consensus have emerged: Monetary policy shocks produce a "hump-shaped" impact on output, and the maximum effect is reached after some lag
  - Endogenous monetary policy responses, and their impact, are only understood within structural econometric models, which are not vulnerable to the Lucas critique

- So, we need *theories* to think about how monetary policy affects the economy.
- In terms of "policy shocks" but, in particular, in terms of assessing how endogenous responses to the state of the economy affect economic fluctuations

Plan for next lectures

Monday, Feb. 9

1. Money in the utility function (start)
   - a. Short on the Tobin effect mentioned in Chapter 2's introduction
   - b. The basic money in the utility function model
   - c. Optimal behavior and steady-state equilibrium properties: Long-run superneuttrality of money

Literature: Walsh (2003, Chapter 2, pp. 43-59)

Wednesday, Feb. 11

1. Money in the utility function (continued)
   - a. Welfare costs of inflation
   - b. Potential non-superneutrality of money
   - c. Dynamics and calibration

Literature: Walsh (2003, Chapter 2, pp. 59-80, but check the Appendix as well)