Monetary theory

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Chapter 1: Empirical evidence on the relationship(s) between money and output

Inroduction

- The basic question : what is the impact of monetary policy ?
- Monetary policy should at a minimum affect the amount of money in the economy.
- We need first to look at the evidence on the relationship between money and economic activity.
- What is economic activity ? $\rightarrow$ output and prices.
- We need to look at the evidence at different horizons $\rightarrow$ distinction between short and long run.

How to measure the relationships?

- There are several approaches to measure these relationships.
- Correlation is the most basic approach $\rightarrow$ problems
- Use of econometric techniques to capture the relationships $\rightarrow$ OLS (old) and VAR (more recent).
- Empirical issues: reverse causality and observational equivalence.

Which variables to explain and to use?

- Output : aggregate income, cycles extracted from GDP.
- Prices.
- Monetary aggregates : M0, M1, M2, ...
- Increasing use of nominal interest rates (see Chapter 4).
- Also look at the real interest rates.
- No attention to exchange rates, ... $\rightarrow$ closed economy.

Long-term correlations

- Evidence based on correlations computed at the annual frequency over a period of 30 years and for 110 countries.
- The findings might differ from one country to the other but in general quite similar across countries.
- In the long run, the correlation between **inflation and money** lies between 0.92 and 0.96.
- This is consistent with the quantitative theory of money : $MV = PY$.
- But this is a statistical relationship and does not imply any causal relationship.$\rightarrow$ Monetary policy is by no means exogenous.

Long-term correlations

- No robust correlation between **money and economic activity**.
- we face all possible cases. $\rightarrow$ no robustness across countries.
- Low GDP growth along with low inflation.
- Low GDP growth along with high inflation.
- Some possible extensions: the relationship depends on the level of inflation: $+$ for low inflation, $-$ for high inflation countries.

Short-run correlations

- Limits of long-term: properties in steady-state.
- Short-run should capture the impact at macroeconomic horizons (in terms of months or quarters).
- Problem : Short-run correlations will also capture:
- the response of MP to economic fluctuations.
- the way private agents react to shocks (example : credit crunch; permanent income).
- $\rightarrow$ Lucas critique : the relationships are not invariant, i.e. they depend on the way MP is conducted.

Figure

- Dynamic correlations : $corr(y_t, M_{t+j})$ for $j = -8, ..., +8$.
- One uses the cyclical part of GDP_t.
- Three alternative measures of MP : M0, M1, M2.
- Example: Dynamic correlations

Comments

- Fluctuations in money seem to be ahead of those observed for economic activity.
- True for M0, less true for M1, not true for M2.
- The increase shows up with a time lag of about 4 to 6 quarters.
- For M2, patterns reflect the endogenous nature of money wrt to economic activity.
- additional plots for cyclical parts of GDP along with detrended money Example: plots GDP-money
- additional plots for cyclical parts of GDP along with interest rates (3 months) (might be more relevant for evidence after 70's). Example: plots GDP-interest rates
- Graphical analysis has some limitations : are correlations significantly different from 0 ?

A note on endogeneity

- From correlations, it is difficult to assess the causal relationship running from one variable to the other.
- What about Money ? Money is also endogenous.
- Example : Credit crunch in 1992-1993 : uncertainty about the future economic situation $\rightarrow$ decrease in the loans by the banks to households and firms $\rightarrow$ decrease in M1 and M2.
- What about interest rates ? Endogenous as well $\rightarrow$ Taylor Rule: $i_t = c + b_y y_t + b_\pi \pi_t$
- In Taylor's opinion, CBs should adjust their interest rates to deviations of output and inflation from their target values (more on this in chapter 2).

regressions: Friedman and Schwartz

- One way to overcome some limitations of correlation is to use simple econometric techniques.
- Friedman and Schwartz look at relationships between ouptut and money over a period of 100 years in the US
- $y_t^n = y_t + p_t =$
  $y_0^n + \sum_{i=0} a_i A_{t-i} + \sum_{i=0} b_i m_{t-i} + \sum_{i=0} h_i z_{t-i} + u_t$
- past values of money are supposed to affect current values of output if there is some causal relationship ($b_i > 0$) : this the idea of Granger causality.
- results : b_i are positive and significantly different from zero.

regressions: Friedman and Schwartz

- Are we sure that m_{t-i} are exogenous ? no because
- m_t is included and we have seen reasons why it depends on $y_t \rightarrow$ OLS estimates are incorrect.
- CBs make economic forecast and can react before the obervation of the evolution of $y_t \rightarrow m_{t-i}$ are also maybe endogenous.

Problem of observational equivalence

- Suppose that we want to use regression models for economic policy, and in particular to choose the value of the monetary instrument, i.e. m_t
- we start from one atheoretical relationship : $y_t = y_0 + a_0 m_t + a_1 m_{t-1} + c_1 z_t + c_2 z_{t-1} + u_t$
- In this model, we assume that the total value of m_t and m_{t-1} affect output.
- Suppose that we want to minimize fluctuations of y_t around y_0 and suppose $E(z_t) = 0$.
- We obtain $m_t = -\frac{a_1}{a_0} m_{t-1} + \frac{c_2}{a_0} z_{t-1} + v_t$ or $m_t = \pi_1 m_{t-1} + \pi_2 z_{t-1} + v_t$ where v_t is de control error over the instrument (the money stock).

Problem of observational equivalence

- This might be used as a monetary rule; but a crucial condition should be that a_0, a_1,c_1 and c_2 are constant and do not depend on the type of rule : Lucas critique . Is this fulfilled ?
- The use of previous analysis might be dangerous. Why ? observational equivalence.
- Suppose that the true model is the following:
  $y_t = y_0 + d_0 v_t + d_1 z_t + d_2 z_{t-1} + u_t$, or
  $y_t = y_0 + d_0 (m_t - \pi_1 m_{t-1} + \pi_2 z_{t-1}) + d_1 z_t + d_2 z_{t-1} + u_t$.

Problem of observational equivalence

- In this model, only monetary surprises affect output.
- nevertheless, the regression model turns out to be the same as before:
  $y_t = y_0 + d_0 m_t - d_0 \pi_1 m_{t-1} + d_1 z_t + (d_2 - d_0 \pi_2) z_{t-1} + u_t$
  with $d_0 = a_0$;$-d_0 \pi_1 = a_1$, ...
- we have a problem of observational equivalence : the first parameter can either capture the impact of m_t or the impact of v_t. $\rightarrow$ you need to know the true model
- How ? $\rightarrow$ What does the theory say ?

Lucas critique

- Another problem: Lucas critique .
- Indeed, if the true model is the second one with monetary surprises affecting output, then the parameters capturing the impact of money are not constant.
- Indeed, $d_0\pi_1 = a_1$ and π_1 depends on the adopted rule.
- $\rightarrow$ the parameters are not invariant with respect to the type of monetary rule.
- Lucas critique : the empirical relationships are not invariant to changes in the policy regimes.

The VAR approach

- Popular approach developed in the 80's by Sims
- One way to account for the problem of endogeneity : the aim is to use autonomous changes in monetary policy
- VAR $=$ **V**ector **A**utoregressive **R**egressions

The VAR approach

- Bivariate system : 2 equations : one for y_t (output) and one for x_t (money).
- $y_t = \sum_{i=1}^{p} a_i y_{t-i} + \sum_{i=1}^{p} b_i x_{t-i} + u_{y_t}$
- output is related to past values of output and past values of money plus a contemporaneous innovation of output.
- $x_t = \sum_{i=1}^{p} c_i y_{t-i} + \sum_{i=1}^{p} d_i x_{t-i} + u_{x_t}$
- money is related to past values of output and past values of money plus a contemporaneous innovation of money.

Innovations in the VAR approach

- In the VAR approach, innovations are linear combinations of shocks.
- These shocks are autonomous (exogenous) shocks that directly affect either output or money.
- In the case of money, these shocks might considered as policy shocks decided by the monetary authorities
- $u_{y_t} = e_{y_t} + \theta e_{x_t}$
- $u_{x_t} = \phi e_{y_t} + e_{x_t}$
- Idea : isolate these e (the shocks) to study the dynamics of their impact.
- In general, we cannot isolate the shocks e from the u innovations unless we make identifying assumptions. Example : $\phi = 0$

Innovations in the VAR approach

- Once these shocks have been identified, one can investigate the dynamic effects of these shocks on the variables of interest.
- Example : suppose e_{x_t} and e_{y_t} have been identified
- $y_t = a_1 y_{t-1} + b_1 x_{t-1} + u_{y_t}$, $0 < a_1 < 1$
- $x_t = u_{x_t}$
- $y_t = a_1 y_{t-1} + u_{y_t} + a_2 u_{x_{t-1}}$
- $y_t = \sum_{i=0}^{\infty} a_1^i u_{y_{t-i}} + \sum_{i=0}^{\infty} a_1^i a_2 u_{y_{t-i}}$.

Innovations in the VAR approach

- One can compute the effect of the **innovation** u_{x_t} on the sequence of y_t:
- 0,a_2,a_1a_2,$a_1^2a_2$
- in turn, by substituting in the u the expression in terms of e, one can compute the impact of the **shocks** on y_t
- $y_t = \sum_{i=0}^{\infty} a_1^i(e_{y_{t-i}} + \theta e_{x_{t-i}}) + \sum_{i=0}^{\infty} a_1^i a_2(\varphi e_{y_{t-i-1}} + e_{x_{t-i-1}})$
- $y_t = e_{y_t} + (a_1 + a_2\phi)\sum_{i=0}^{\infty} a_1^i e_{y_{t-i-1}} + \theta e_{x_t} + (a_1\theta + a_2)\sum_{i=0}^{\infty} a_1^i e_{x_{t-i-1}}$
- The dynamic of the impact of the shocks over time is given by : θ,$a_1\theta + a_2$,$a_1(a_1\theta + a_2)$,$a_1^2(a_1\theta + a_2)$, ...

Innovations in the VAR approach

- One needs to estimate a_1, $a_2 \rightarrow$ one gets the residuals (innovations) u
- One needs to set up identifying restrictions to identify the shocks e from the innovations (residuals) u.
- $\longrightarrow$ One can estimate ϕ and/or θ
- One can recover the dynamic effects of shocks (*Impulse Response Functions*)
- Problem : several restrictions are possible $\rightarrow$ it depends on our view of how the economy is working.

Identifying assumptions

- $\phi = 0 \rightarrow u_{y_t} = e_{y_t} + \theta e_{x_t}$
- $u_{x_t} = e_{x_t}$;
- $\rightarrow$ we suppose that monetary policy does not respond to output shocks in a contemporaneous way .
- this might be true at a monthly frequency because it is unlikely that the CB will react immediately. But less true at a quarterly frequency because no reaction within a 3-months period is unlikely (the CBs constantly scrutinize the stance of the business cycle).

Identifying assumptions

- $\theta = 0 \longrightarrow u_{x_t} = e_{x_t} + \phi e_{y_t}$
- $u_{y_t} = e_{y_t}$;
- $\longrightarrow$ we suppose that output does not react to monetary policy in a contemporaneous way .
- this might be true if there are lags operating in the process of transmission of MP.

Identifying assumptions

- Adopt the classical view of neutrality of money in the long run .
- $\theta + a_1\theta + a_2 \sum_{i=0}^{\infty} a_1^i = 0$
- $\Leftrightarrow \theta = -a_2$ (hint : $\sum_{i=0}^{\infty} a_1^i = \frac{1}{1-a_1}$ if $a_1 < 1$ which is the case)
- We impose here the long-run effect to be zero in the estimation.

Criticism

- Up to now, bivariate systems $\rightarrow$ very simple view of the economy
- Room for including more variables : y output but also inflation. Recently, debate on reaction of MP to asset prices (see for instance The Economist March 05).
- x not only monetary stocks but also interest rates, money reserves , ...
- $\rightarrow$ Analysis becomes more complex.

A VAR model for the US

- Results obtained from a VAR model on US economy with 4 variables: prices (CPI), business cycle (ICI), Log of M1 (M1) and (short-run) interest rates (Fed funds).
- 2 periods of investigation : 1965:1- 1979:9 and 1983:1-1994:12 (monthly data).
- Identification through assumption $\theta = 0$ (no immediate response of price and business cycle to a shock on either M1 or FF)
- Impulse response functions (dynamic effects of MP shocks over time) in Figure 1.4
  Example: impulse responses

Interpretation of Figures

- U shape response of output.
- Suggest that a rise in the FF has some impact in the short to medium run but not in the long run.
- Typical horizon : 1,5 to 2 years (24 months); 0 in the short-run; 0 in the long-run.
- For the price response : Price puzzle $\longrightarrow$ might be explained by the fact the CB reacts mostly on anticipated values of inflation .

Evidence from Variance decomposition

- What share of variability of output is explained by a shock of a specific variable at a given horizon ?
- Variance decomposition during the first period.
  Example: variance decomposition sample 1
- Variance decomposition during the second period.
  Example: variance decomposition sample 2
- Confirms that the typical effect is observed after 2 to 3 years.
- The explanatory power is higher for M2 in the first period and higher for interest rates in the second period $\longrightarrow$ suggests a big shift in the type of used instruments in the beginning of the 80's.
- This big shift will be rationalized in chapter 4 : Optimal choice of MP instruments .

Conclusions

- 2 main conclusions that lead to further investigation.
- In the short or medium run, MP has some influence on output and prices.
- In the long run, no impact of output $\longrightarrow$ we need to try to understand why $\longrightarrow$ theoretical model.
- Empirical relationships are subject to the Lucas critique and to problems of observational equivalence $\longrightarrow$ we need a structural theoretical model in mind to understand the empirical findings $\longrightarrow$ Chapter 2 .