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MONETARY SHOCKS AND THE NOMINAL INTEREST RATE

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ABSTRACT

This paper reconsiders the effects of monetary shocks on the nominal interest rate in a standard macroeconomic model. It is demonstrated that when the policy objective is controlling the money stock, money supply shocks generate a situation of excess demand for money. The positive relationship between nominal interest rates and monetary innovations in the U.S. following the 1979 change in regime is thus not puzzling, but perfectly consistent with standard theory. Nominal interest rate decreases are only possible when "fine-tuning" rules are adopted.

1. Introduction

The response of nominal interest rates to monetary shocks has received considerable attention in the literature in recent years. In particular, the finding that unanticipated money was associated with increases in nominal interest rates in the U.S. following the 1979 change in regime appears to be a fairly well established empirical regularity. Such a "puzzle" has mainly been investigated in partial equilibrium models [1]. The present paper attempts to offer an explanation based on a standard rational expectations macroeconomic model where changes in policy regimes are explicitly modelled. The basic idea is rather simple. A negative relationship between nominal interest rates and unanticipated monetary shocks can only occur when the monetary authorities are, at least to some extent, engaged in "fine-tuning" the economy. On the other hand, when the policy emphasis is placed on controlling monetary aggregates, unanticipated monetary shocks boost output and money demand and thus nominal interest rate increases are necessary to restore equilibrium. In other words, a money supply random shock generates a situation of excess demand for money and not of excess supply. The puzzle is thus only apparent.

The scheme of the paper is as follows. Section 1 describes the simple macroeconomic model. The effects of unanticipated monetary shocks on the nominal interest rate under an active and passive monetary rules are derived in sections 2 and 3, respectively. A summary of the main results is presented in section 4.

2. A simple macroeconomic model

The simplified model chosen consists of a new classical supply function[2]

$$(1) \qquad y_t = \alpha(P_t - E_{t-1}P_t)$$

a Fisher equation

$$(2) \qquad r_t = a + E_t P_{t+1} - P_t$$

and a portfolio balance equation

$$(3) \qquad m_t - P_t = \beta y_t - \delta r_t$$

where y, P, r and m are, respectively real output, the price level, nominal interest rate and money supply; a is a constant and E_t denotes the mathematical expectation conditional on the available information set, containing the model and present and past values of all variables. Equation (2) rules out any influence of monetary innovations on the expected real interest rate, according to, e.g., the empirical finding by Litterman and Weiss (1985). The rational expectations augmented Phillips-curve (1) denies any role for chronic price rigidities [3] and allows an explicit analysis of the interactions between monetary and real variables.

In order to concentrate on the effects of money supply shocks we have ignored any other source of uncertainty. Explicit consideration of supply shocks, money demand shocks and a stochastic Fisher equation would not alter the essence of the analysis, while complicating the algebra. The only disturbance is thus given by the random component of the money supply process. For the sake of simplicity, the main body of the paper focusses on the following, simple class of monetary rules

$$(4) \qquad m_t = \bar{m}_t + \varepsilon_t$$

where $\bar{m}_t$ is perfectly controllable by the monetary authorities and ε_t is white noise. We consider two simple alternative forms for $\bar{m}_t$, before and after the change in regime. A more complex monetary rule is analyzed in the Appendix; the main results are not affected.

There seems to be a widespread consensus (see, for example, Barro (1984)) that some sort of countercyclical response has characterized the period prior to the change in regime of 1979. This kind of policy behaviour can be modelled in our framework as

$$(5) \qquad \bar{m}_t = m_{t-1} - \mu \varepsilon_{t-1} \qquad\qquad\qquad \mu > 0.$$

The restriction on the sign of the feedback parameter is meant to capture the desire of the authorities to reduce the destabilizing impact of nominal shocks on real output.

On the other hand, the abandonment of "fine-tuning" strategies in favour of direct control of monetary aggregates after the change in regime is represented by a normalized Friedman-type fixed money growth rule

$$(6) \qquad \bar{m}_t = m_{t-1}$$

Combining equations (1) - (3), the semi-reduced form solution for the price level can be easily derived as[4)

$$(7) \qquad P_t = K^{-1}(m_t + \gamma E_{t-1} P_t + \delta E_t P_{t+1})$$

where $\gamma \equiv \alpha\beta$, $K \equiv 1 + \gamma + \delta$

We can now turn to the analysis of the effects of monetary innovations on the nominal interest rate under either policy regime.

3. Fixed money growth rules and the nominal interest rate

In this section we attempt to show that the behaviour of nominal interest rates in response to monetary shocks is perfectly explainable within a standard macroeconomic framework.

Under the fixed money growth rule (6), the semi-reduced form for the price level becomes

$$(8) \qquad P_t = K^{-1}(m_{t-1} + \varepsilon_t + \gamma E_{t-1}P_t + \delta E_t P_{t+1})$$

A "minimal state" solution (see, for example, McCallum, 1983) can be postulated as

$$(9) \qquad P_t = \pi_0 m_{t-1} + \pi_1 \varepsilon_t$$

where π's are undetermined coefficients.
From (9), we obtain

$$E_{t-1}P_t = \pi_0 m_{t-1}$$
$$(10)$$
$$E_t P_{t+1} = \pi_0(m_{t-1} + \varepsilon_t)$$

Substituting (10) into (8) and equating coefficients with (9'), the solutions for the undetermined coefficients turn out to be

$$\pi_0 = 1$$
$$(11)$$
$$\pi_1 = K^{-1}(1 + \delta)$$

The final reduced form for the price level is thus:

$$(12) \qquad P_t = m_{t-1} + K^{-1}(1 + \delta)\varepsilon_t$$

Leading (12) one period and taking expectations

$$(13) \qquad E_t P_{t+1} = m_{t-1} + \epsilon_t$$

The impact of monetary shocks on the nominal interest rate can now be easily derived, using the Fisher equation, as

$$(14) \qquad \frac{dr}{d\epsilon_t} = \frac{d(E_t P_{t+1} - P_t)}{d\epsilon_t} = K^{-1}\gamma > 0$$

Equation (14) clearly indicates that there is no puzzle at all about nominal interest rate behaviour and money supply shocks, since a positive relation-ship is reconcilable within a textbook macroeconomic model[5]. In other words, the increase in the nominal interest rate following a positive money supply shock comes about because there is a situation of <u>excess demand for money</u> (and not of excess supply) under a fixed rule.

It should be noted again that our result emerges from the explicit consideration of the output supply equation (1). Failure of modelling (1) would imply an instantaneous full adjustment of the price level to monetary shocks, so that real money balances <u>always</u> remain constant. No nominal interest rate change would, of course, occur in such a case, as can be easily seen by setting $\gamma = 0$ in equation (14).

Therefore, the behaviour of nominal interest rates can be explained without recourse to more complicated explanations, even when one accepts the validity of the Fisher equation and, in general, the invariance of ex-ante real rates of return with respect to random monetary disturbances. Nominal interest rate increases in response to positive shocks could be hardly explainable by standard macroeconomic theory only when independence between real output supply and unanticipated nominal shocks is also assumed. Of course, the nominal interest rate would raise, even ignoring the output supply equation (1), if the private sector were to expect ex-ante sustained inflation in spite of the announced constant money growth rule.

In fact, an autoregressive money growth process would require nominal interest rate increases, as shown in the Appendix, since the expected real rate of interest is assumed to be constant over time. It is worth stressing

again that "lack of credibility" becomes necessary to explain nominal interest rate movements only when one assumes dichotomy between real and unanticipated monetary variables.

In synthesis, the nature of the policy rule is the crucial factor determining nominal interest rate movements in the macroeconomic framework considered. An active monetary rule would indeed reverse the interest rate response to monetary shocks, as demonstrated in the next section.

4. Active policy and the nominal interest rate

As already discussed, we can proxy an active policy behaviour by assuming a countercyclical rule as in (5). In this case, the semi-reduced form for the price level becomes

$$(8') \qquad P_t = K^{-1}(m_{t-1} + \epsilon_t - \mu\epsilon_{t-1} + \gamma E_{t-1}P_t + \delta E_t P_{t+1})$$

The guess solution is now

$$(9') \qquad P_t = \pi_0 m_{t-1} + \pi_1 \epsilon_t + \pi_2 \epsilon_{t-1}$$

From (9'), we can derive

$$(10') \qquad \begin{array}{l} E_{t-1}P_t = \pi_0 m_{t-1} + \pi_2 \epsilon_{t-1} \\[2mm] E_t P_{t+1} = \pi_0 m_{t-1} + (\pi_0 + \pi_2)\epsilon_t - \pi_0 \mu\epsilon_{t-1} \end{array}$$

Substituting (10') into (8') and equating coefficients with (9') we obtain the solutions for the undetermined coefficients as

$$(11') \qquad \begin{array}{l} \pi_0 = 1 \\[2mm] \pi_1 = K^{-1}[1 + \delta(1-\mu)] \\[2mm] \pi_2 = -\mu \end{array}$$

The final reduced form for the price level is given by

$$(12') \qquad P_t = m_{t-1} + K^{-1}[1 + \delta(1-\mu)]\epsilon_t - \mu\epsilon_{t-1}$$

Leading (11) one period and taking expectations

$$(13') \qquad E_t P_{t+1} = m_{t-1} + (1-\mu)\epsilon_t - \mu\epsilon_{t-1}$$

The impact of monetary shocks on the nominal interest rate is now given by

$$(14') \qquad \frac{dr}{d\epsilon_t} = K^{-1}[\,(1-\mu)(K-\delta) - 1\,]$$

Recalling that $K \equiv 1 + \gamma + \delta$, a negative response of interest rates to monetary shocks requires

$$(15) \qquad \mu > \gamma(1 + \gamma)^{-1}$$

It is clear that such a condition is not a stringent one. For example, assuming that the monetary authorities were engaged in minimizing deviations of actual output about its "natural level" (here normalized to zero, for simplicity), the optimal value of the feedback parameter, say μ^*, would easily satisfy the inequality (15)[6]:

$$(16) \qquad \mu^* = \delta^{-1}(1 + \delta)$$

The intuition of this result is straightforward. As long as the authorities are engaged in an active stabilization policy, the impact of monetary shocks on real output and hence on money demand is dampened[7]. The increase in real money balances thus requires a fall in the nominal interest rate in order to restore equilibrium.

It is worth pointing out that such a result would also hold in a partial equilibrium framework, that is ignoring the output supply equation (1), for any value of the feedback parameter μ. When a policy aimed at reacting against disturbances to the money supply growth process is implemented, the price level increase is less than proportional. The reason is that private agents expect the current shock to be partially offset in the future. The associated increase in real money balances unambiguously requires a fall in the nominal interest rate[8].

5. Summary and conclusions

Our stripped-down textbook macroeconomic model appears to be capable to explain interest rate movements when changes in policy regime are explicitly taken into account.

When the monetary authorities are unconcerned with output stabilization, random monetary shocks boost output and money demand in such a way that increases in the nominal interest rates are necessary to bring about equilibrium. On the other hand, when the policy objective is minimizing the output effects of nominal shocks, the standard situation of excess supply of money occurs and hence a nominal interest rate fall is required to restore equilibrium.

In conclusion, the response of nominal interest rates to monetary shocks does not seem to be a theoretical puzzle after all.

Notes

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1. Two popular rationales are the following.

    (i)   Unanticipated monetary injections are perceived by the market as a signal of an up-surge in inflation and hence nominal interest rates increases occur to maintain expected real interest rate constant.

    (ii) Observed monetary shocks are perceived by the market as very short-term phenomena. Private agents expect that the FED will "reverse the trend" in pursuit of stable, pre-announced monetary targets. Such an anticipation of future monetary contractions generates expectations of higher future interest rates and hence the actual current interest rate increases, in line with term-structure stories.

    A detailed analysis of the two hypotheses together with empirical tests is presented by Roley and Walsh (1985). See also, among others, the work by Nichols, Small and Webster (1983) and Roley (1983).

2. Similar models have been extensively used to address different macroeconomic issues. See, for example, McCallum (1986), Goodfriend (1987) and Barro (1989).

3. An approach based on an open economy macroeconomic model with sticky prices can be found in Engel and Frankel (1985).

4. We have assumed, for simplicity, that a = 0.

5. It should be noted that our result is totally different from the so-called "expected inflation hypothesis". The only thing in common is the Fisher relation, which, of course, implies that expected inflation and the nominal interest rate move together. However, our approach does not hinge on the alleged signalling role of monetary shocks in a partial equilibrium framework but emphasizes rather the interrelationship between real and monetary variables.

6. The value for μ^* is derived as follows. From (12')

$$E_{t-1}P_t = m_{t-1} - \mu\epsilon_{t-1}$$

From (1), output is perfectly stabilized about its natural level, say $y^* = 0$, when

$$y = \alpha(P_t - E_{t-1}P_t) = \alpha K^{-1}[1 + \delta(1 - \mu^*)]\epsilon_t = 0.$$

7. In the extreme case of perfect stabilization there would be no output effect at all of monetary shocks, as shown in note 6. Recalling that when $\mu = \mu^*$ the price level is simply given by

$$P_t = m_{t-1} - \mu^*\epsilon_{t-1}$$

and using (13'), we obtain

$$\frac{dr_t}{d\epsilon_t} = (1 - \mu^*) = -\delta^{-1}$$

8. When $\gamma = 0$, (14') collapses to

$$\frac{dr_t}{d\epsilon_t} = -K^{-1}\mu$$

and thus a negative response of the nominal interest rate to monetary shocks always occurs. No restriction on the size of the countercyclical policy parameter is required in this case.

On the other hand, if we assume that monetary growth is characterized by an ARMA process such as

$$\Delta m_t = \eta \Delta m_{t-1} + \epsilon_t - \mu \epsilon_{t-1}$$

the effect of nominal disturbances is given by

$$\frac{dr_t}{d\epsilon_t} = (1 + \delta - \eta \delta)^{-1} (\eta - \mu) \gtreqless 0 \text{ if } \eta \gtreqless \mu,$$

as shown in the Appendix.

APPENDIX

The impact of monetary shocks on the nominal interest rate when monetary growth follows an ARMA process like

(A1) $\qquad m_t - m_{t-1} = \eta(m_{t-1} - m_{t-2}) + \epsilon_t - \mu\epsilon_{t-1}$

can be derived as follows.

Using equations (1) - (3), the semi-reduced form solution for the price level is given by

(A2) $\qquad P_t = K^{-1}\left[(1 + \eta)m_{t-1} - \eta m_{t-2} + \epsilon_t - \mu\epsilon_{t-1} + \gamma E_{t-1}P_t + \delta E_t P_{t+1}\right]$

The guess solution is now

(A3) $\qquad P_t = \pi_0 m_{t-1} + \pi_1 \epsilon_t + \pi_2 \epsilon_{t-1} + \pi_3 m_{t-2}$

Taking conditional expectations

(A4) $\qquad E_{t-1}P_t = \pi_0 m_{t-1} + \pi_2 \epsilon_{t-1} + \pi_3 m_{t-2}$

(A5) $\qquad E_t P_{t+1} = \left[\pi_0(1 + \eta) + \pi_3\right]m_{t-1} - \eta\pi_0 m_{t-2} - \mu\pi_0\epsilon_{t-1} + (\pi_0 + \pi_2)\epsilon_t$

Substituting (A4) and (A5) into (A2) and equating coefficients with (A3) we obtain

(A6)

$$\pi_0 = \frac{(K - \gamma)(1 + \eta) - \eta\delta}{(K - \gamma)^2 - \delta[(K - \gamma)(1 + \eta) - \eta\delta]}$$

$$\pi_1 = K^{-1}[1 + \delta(\pi_0 + \pi_2)]$$

$$\pi_2 = -\mu(K - \gamma)^{-1}(1 + \delta\pi_0)$$

$$\pi_3 = -\eta(K - \gamma)^{-1}(1 + \delta\pi_0)$$

From equations (A3) and (A5), the impact of money supply shocks on the nominal interest rate is simply given by

$$\text{(A7)} \qquad \frac{dr_t}{d\epsilon_t} = \pi_0 + \pi_2 - \pi_1$$

The four cases considered in the text can now be easily derived as follows.

(I)   Fixed monetary growth rule

$$\mu = 0, \ \eta = 0$$

$$\frac{dr_t}{d\epsilon_t} = \frac{\gamma}{K}$$

(II)   Countercyclical monetary growth rule

$$\eta = 0, \ \mu > 0$$

$$\frac{dr_t}{d\epsilon_t} = K^{-1}[\gamma - \mu(1 + \gamma)]$$

(III)   Autoregressive monetary growth rule

$$0 < \eta < 1, \ \mu = \gamma = 0$$

$$\frac{dr_t}{d\epsilon_t} = \eta(1 + \delta - \eta\delta)^{-1}$$

(IV)   "ARMA" monetary growth rule

$$0 < \eta < 1, \ \mu > 0, \ \gamma = 0$$

$$\frac{dr_t}{d\epsilon_t} = (\eta - \mu)(1 + \delta - \eta\delta)^{-1}$$

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