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by Karl Brunner and Allan H. Meltzer

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Few subjects in monetary analysis have received more attention than the principles used to guide the conduct of monetary policy. Two types of issues arise frequently in these discussions. One is the issue of strategy. The central bank or monetary authority responds to some events and ignores others. If not by explicit choice, then after the fact, the actions of the monetary authority reflect a strategy chosen from the positions that lie along the spectrum between invariant rules and unrestricted authority. The second is the choice of tactics, or procedures, for carrying out policy. Much of the literature on this issue for the past decade is concerned with the choice of money, interest rates or some combination of money and interest rates as targets or indicators of monetary policy.¹

Many of the differences about strategy and tactics can be traced to three differences in assumption. First is the quantity and quality of information about the position of the economy available to policymakers and other individuals when policy decisions are made. Second is the difference in information available in the government and private sectors about the structural relations determining the response to policy and non-policy changes. Third is the difference in the information about the underlying stochastic structure.

Marschak (1953) argued that knowledge of structure was critical for identifying the effect of policy changes. Only when parameters are fully identified can a policymaker infer the effects of policy on the economy. The best work on econometric models can be viewed as an attempt to identify...
the structure of the economy to improve policy. Lucas (1976) showed that the completely identified structure cannot be obtained because the structure does not remain invariant to policy changes. Kydland and Prescott (1978) extended these results. They showed that even when policymakers and the public have complete knowledge of structure, optimal control procedures can produce results inferior to fixed rules and can increase the amplitude of fluctuations. The Kydland and Prescott results imply that whenever agents learn about the policy process, the use of econometric models and optimal control techniques to make policy decisions can convert a stable system into an unstable system.

Earlier, Sargent and Wallace (1975) analyzed the effects of a deterministic policy rule. The public and the monetary authority have the same information about the deterministic and stochastic structure of the economy. Both know the structure, including the values of all parameters, and both know the policy rule followed by the authorities. Expectations are rational in the sense of Muth (1960). It is not possible under these conditions for the policymaker to do better than follow a pre-announced (known) rule for monetary growth. Any superior information about the structure, or changes in structure, can be learned or purchased. No advantage accrues to either the policymaker or society if monetary policy introduces variability into the money supply process.

The results in Sargent and Wallace give the policymakers and the public more information about the policy process than either group possesses. Monetary policy is not made under conditions of certainty about the growth rate of money. It is as difficult to separate transitory from permanent changes in money growth as it is to separate transitory and permanent changes in other variables. See Brunner, Cukierman and Meltzer (1979).
The conclusion that rules for monetary policy are superior to activist policies antedates the formal analysis of the rational expectationists. Milton Friedman (1953) considered an economy in which there are variances of real and nominal variables and covariance between the two. For monetary policy to reduce rather than increase variability by activist policy, policymakers must be able to offset the real variability. Since activist policies increase the variance of money growth, a positive covariance between growth of money and output implies that policy increases variability. To assume a reduction in variability, the covariance must be negative. Friedman's analysis does not require any assumptions about the information available to policymakers and the public about the structure of the economy.

This paper considers two issues about the conduct of monetary policy in a world of rational expectations and incomplete knowledge about the structure of the economy and the structure of stochastic stocks. First, we show that constant growth of money reduces the variability of the economy under rather general circumstances. Then we consider some institutional problems of monetary policy and the role of monetary arrangements in increasing or reducing the variance of money growth.

Making Monetary Policy When Information Is Incomplete

Policy making typically proceeds under conditions of uncertainty about the structure of the economy and the types of shocks that have occurred. Private decisions are made under the same conditions. A basic problem for every decision maker is to infer the duration of changes in money, interest rates, output, prices and other variables. Meltzer (1977) and Brunner, Cukierman and Meltzer (1979) adapt the
fundamental idea presented in Friedman (1957) and represent these decisions as a problem of deciding whether real and nominal shocks are permanent or transitory changes. Knowledge of the economy is summarized in a simple structure with well-known properties.

Equation (1) is the quantity equation, with $m$, $v$, $p$, and $y$ the logarithms of money, velocity, the price level and real output respectively. Money is the monetary base and velocity is the ratio of total spending to the demand for base money.\(^2\)

\[
(1) \quad m + v = p + y
\]

Output and the price level fluctuate in response to real and nominal shocks. We take first differences of (1) to express all variables as measured, relative rates of change.

\[
(2) \quad \Delta m + \Delta v = \Delta p + \Delta y.
\]

The measured relative rates of change of output or the price level differ from the steady state equilibrium rates of growth whenever there are permanent or transitory changes. Equations (3) and (4) partition the observed rates of change in $p$ and $y$ into permanent and transitory components.

\[
(3) \quad \Delta p = \Delta p_1 + \Delta p_2
\]

\[
(4) \quad \Delta y = \Delta n + \Delta z
\]

Permanent and transitory shocks to the rate of price change are denoted $\Delta p_1$ and $\Delta p_2$ respectively; $\Delta n$ is the normal rate of growth of output, given by a neo-classical production function, and $\Delta z$ is the excess of actual growth over normal growth.
The rates of change in (3) and (4) are related by equations (5) and (6).

(5) \[ \Delta P_1 = E(\Delta m + \Delta v - \Delta n | I_t) \]

(6) \[ \Delta P_2 = \theta \Delta z + u \]

Equation (5) makes the expectation \( E \), conditional on uncertain and incomplete information about the underlying shocks available at time \( t \), \( I_t \). Let \( E^* \) denote beliefs about \( \Delta m + \Delta v - \Delta n \) based on full information. \( E^* \) differs from \( E \) because of type I and type II errors; transitory shocks are interpreted as permanent, and permanent shocks are interpreted as transitory.

Substituting (3), (2) and (5) into (6), we solve for \( \Delta z \).

(7) \[ \Delta z = \frac{1}{1+\theta} [(\Delta m + \Delta v - \Delta n - u - E^*) + (E^* - E)] \]

The criterion used to judge policy is the extent to which policy increases, or reduces, the variability inherent in nature and market processes. The measure of variability defined in (8) consists of three terms: the natural variation produced by nature and market processes, \( NV \); the variability generated by monetary policy, \( PV \); the bias, \( B \) resulting from uncertain and incomplete information.3

(8) \[ E^*(\Delta z - E^*\Delta z)^2 = E^*(\Delta z)^2 = \frac{1}{1+\theta} (NV + PV + B) \]

(9) \[ NV = \sigma(\Delta v | s, \pi) + \sigma^2(\Delta n | s, \pi) + \sigma^2(u | s, \pi) \]

\[ PV = [\sigma^2(\Delta m | s, \pi) + \rho_{mv}(s, \pi)\sigma^2(\Delta v | s, \pi)]^2 - \rho^2_{mv}(s, \pi)\sigma^2(\Delta v | s, \pi)\]

\[ B = (E^*\Delta m - E\Delta m)^2 + (E^*\Delta v - E\Delta v)^2 + (E^*\Delta n - E\Delta n)^2 \]
The notation emphasizes that all of the terms in $E^*(\Delta z)^2$ depend on the true state of the economy, $s$, and the policy regime, $\pi$. This dependence is obvious for the variance of $\Delta m$ and the correlation, $\rho_{mv}$, between $\Delta m$ and $\Delta v$. Following Kydland and Prescott (1978), the motion of the system is not invariant to the policy rule or procedure so $\Delta v$, $\Delta n$, the price adjustment, $\delta$, the variance of $u$ and the components of the bias depend on $\pi$ and $s$ also.

Equation (8) suggests that a useful measure of our criterion for monetary policy is the total variability of real output $E^*(\Delta z)^2$ relative to $NV$, adjusted for a constant.

$$C(s, \pi) = \frac{E^*(\Delta z)^2}{NV} - \frac{1}{(1+\delta)^2}$$

The criterion, $C$, depends on the state and the policy regime. A given policy regime, $\pi$, can in principle make $C$ negative by keeping the correlation of $\Delta m$, $\Delta v$ at a value that makes $PV$ negative. Reliable information about $\Delta m$, $\Delta v$ and $\Delta n$ contributes to a negative value of $C$ by reducing the bias.

In the absence of bias, a negative value of $C$ indicates that policy stabilizes the economy by smoothing the variability inherent in nature and market processes. A positive value of $C$ shows that policy increases variability; $PV + NV$ exceeds $NV$. With constant money growth and no bias, $E = E^*$, and $PV = 0$, so $C = 0$. Constant money growth maintains $C = 0$ for any state, $s$.

For the present, we set $B = 0$. The pairs $s, \pi$ that govern $C$ can be arranged in a matrix. There is a column for each possible, but unknown,
value of \( s \) and a row for each value of \( \pi \). Each pair \( s, \pi \) determines a value of the criterion function, \( C \). For any admissible policy regime, there are states in which the value of \( PV \) is positive; in these states policy increases variability. Moreover, some states transform any policy into a destabilizing process, so every row of the matrix contains positive values.

A policy of constant money growth is a row vector with zero in every column. The value of zero is not the lowest value in the matrix, however. There is a negative value, between zero and -1, in every column. This follows from the fact that an optimal \( \pi \) can be determined for every \( s \). The optimal \( \pi \) produces a criterion value

\[
(11) \quad C(s, \pi) = -\frac{1}{(1+\theta)^2} \cdot \rho_{mv}^2(s, \pi) \frac{\sigma^2(\Delta V|s, \pi)}{\sigma^2(\Delta V|s, \pi) + \sigma^2(\Delta \pi|s, \pi)} < 0
\]

The first and third term are necessarily less than unity, and the underlying stochastic nature of the process assures that \( \rho_{mv}^2 < 1 \). A shock structure producing a large \( \theta \) and a large variance of the normal rate of growth shifts the optimal criterion value toward zero.

From (9) we find that the minimum value of \( PV \) is

\[
(12) \quad \sigma^2(\Delta m|s, \pi) = -\rho_{mv}^2(s, \pi) \sigma^2(\Delta V|s, \pi).
\]

Equation (12) assures that \( PV \) is negative. Money is manipulated so that the variance of \( \Delta m \) just cancels the effect of the variance of \( \Delta V \) on \( E^*(\Delta z)^2 \). This maximizes the contribution of policy to reducing overall variance for any given \( s \), an appealing solution as shown by the many statements of policymakers about "leaning against the wind."

The appeal is illusory. We have neglected the feedback from the policy regime to the structure of the economy and the state \( s \). As shown by Lucas...
(1976), Kydland and Prescott (1978) and Sargent and Wallace (1975), rational expectations imply that people learn the optimal policy, adjust their behavior and thus change $s$.

Suppose an optimal $\pi_1$ has been set in response to $s_1$. Rational adjustment shifts the state and replaces $s_1$ with $s_2$, forcing a revision of the regime to $\pi_2$ and so on. The monetary authority will not be able, under the fullest information available, to impose a stable solution centered at the lowest negative value in a column of the criterion function. The solution moves to other columns along the (initially) optimal row including, in principle, columns that yield positive values of the criterion function. Since every row contains some positive values, every policy regime is converted by at least some states into a destabilizing arrangement. Further, we know that there are destabilizing policy regimes for every state. The displacement of the solution along the initial row produces an uncertain performance with intermittent phases of (possibly increasing) instability. Even with full information, activist policy does not minimize instability. In contrast, a policy of constant monetary growth lowers $\text{PV}$ to zero and anchors the system's variability at a relatively low level.

This conclusion is reinforced when there is uncertainty about the prevailing state $s$. Consider the following inequalities.

\[
\max_s \min_{\pi} C(s, \pi) \leq \min_{\pi} C(s, \pi) < 0 < \min_s \max_{\pi} C(s, \pi)
\]

Our previous argument established that any realization, by choice, accident or good fortune, of $\min_{\pi} C(s, \pi)$ will not survive. The authorities have no guarantee that an activist policy of finding the maxmin will avoid a
policy regime that destabilizes the economic system. The maxmin value of $\pi$ may be a cell in the C matrix, determined by the actual state, which yields a positive value of the policy variation $PV$ and economic instability. A minmax policy on the other hand always yields a positive value of $C$. It seems unduly pessimistic, and it is clearly suboptimal to accept policy regimes that increase variability beyond the variability, $NV$, inherent in nature and market processes.

Constant money growth offers a superior alternative. The value of the criterion function is set equal to zero. Variability in the economy remains but is reduced below $NV$.

$$E^*(\Delta z)^2 = \frac{1}{(1+\theta)^2} \cdot NV.$$  

We now relax the constraint, $B = 0$. $B$ increases the value of $E^*(\Delta z)^2$ in (8) and raises the ratio on the left of (10). The lowest value in each column of the C matrix is raised, and there are fewer negative values and more positive values in each column of the C matrix. The prospect that activist monetary policy increases variability rises. A policy of constant monetary growth sets the first component of $B$ equal to zero and eliminates uncertainty about the value of $\Delta m$. As before, constant money growth reduces $PV$ to zero.

Incorporation of uncertainty about the true values of $\Delta m$, $\Delta v$ and $\Delta n$ reenforces one previous conclusion but weakens another. Constant money growth reduces variability, as before, but does not keep $C = 0$. Measured variability exceeds $NV$ if $B$ is large and $\theta$ is small.

The benefits of constant money growth do not imply that the same constant will be chosen everywhere. We have not chosen the optimal value
of $\Delta m$ or shown that such an optimum exists. We know that whenever $\Delta n$
d changes

$$\Delta p_1 = E(\Delta m + \Delta v - \Delta n)$$

will change. A policy of avoiding inflation, or maintaining constant
inflation requires that $\Delta m$ change in the same direction as $\Delta n$.

Unfortunately, no one knows how to distinguish promptly between
permanent and transitory changes in $y$ or other variables, so we cannot
determine the proper timing for policy response except in a general way.
A policy of rapid response to changes that are believed to be permanent
invites central bankers to engage in activist policies, but a policy of
excessive delay imposes costs also by allowing the system to experience more
or less inflation (or deflation) than the desired rate. The optimal timing
of responses, and factors on which it depends, merit attention.

Institutional Problems

The rational expectations literature, Sargent and Wallace (1975),
shows that a deterministic money supply process does not affect the
probability distribution of output or unemployment. The money stock is
not governed by a deterministic process, however, so the variance of the
stochastic process governing the money stock affects the variance of the
distribution of the real variables.

Two related aspects of the money supply process are considered in
this section. The first requires only brief discussion. Policymakers
can reduce the variability of the money supply process by changing
institutional arrangements. Institutional change is capable of lowering
the variance of money growth and the uncertainty component $(E*\Delta m - E\Delta m)^2$. The second aspect involves the usefulness of the so-called two stage procedure
for controlling money by using an operating target.
With fluctuating exchange rates, the monetary authority can control the monetary base. History offers numerous examples of episodes in which the growth rates of money, conventionally defined, and the monetary base differed substantially. The problem for the monetary authority is to use the information implicit in the two growth rates to infer the effects of monetary policy on the criterion function or goal variables.

One common solution to the problem is to ignore it. "Money" in equation (9) is defined as base money and other sources of variability are included in $\sigma^2 \Delta v$. The $\sigma^2 \Delta m$ and $(E \Delta^* m - E \Delta m)$ in equation (9) refer to the growth rate of base money as in the previous section, and the conclusions reached about the advantages of a constant growth rate of money apply to the growth rate of the base.

If money is defined as currency and deposits, we can rewrite $\sigma^2(\Delta m | s, \pi)$ from the previous section as the sum of three terms.

$$
\sigma^2(\Delta m | s, \pi) = \sigma^2(\Delta \mu | s, \pi) + \sigma^2(\Delta b | s, \pi) + 2 \text{cov} (\Delta \mu, \Delta b | s, \pi)
$$

where $\sigma^2(\Delta \mu)$ is the variance of the relative rate of change of the money multiplier in the expression:

$$
m = b + \mu
$$

The variances and covariance in (13) are conditioned on the policy regime, $\pi$, and the structure, $s$. The latter now includes the institutional arrangements that govern the money supply process such as reserve requirement ratios, rediscounting arrangements, etc. The term $(E^* \Delta m - E \Delta m)^2$ in $B$ representing uncertainty about money growth must be subdivided also into components representing the base and the money multiplier.
Suppose that $\sigma^2(\Delta b \mid s, \pi)$ is held at zero by choosing a constant growth rate for the base. The value of $\sigma^2(\Delta m \mid s, \pi)$ will not, in general, be zero. The realtive variability of $\Delta m$ and $\Delta b$ depend on $\text{cov} (\Delta m, \Delta b)$ and, therefore, depend on the institutional arrangements imposed by the monetary authority. Differential reserve requirements, ceiling rates on deposits, and other familiar arrangements change $\sigma^2(\Delta m)$ relative to $\sigma^2(\Delta b)$.

Some effects of intermediation, and disintermediation, can be expressed in terms of the covariance. With ceiling rates on bank deposits, high nominal interest rates in the open market lower the growth of money relative to the growth of the base and lower the covariance. The reduction in the covariance occurs because $m$ depends on interest rates on deposits relative to open market rates. When the ceiling rate on deposits, say, $\text{max } i^t$, is reached, the variance of $i^t$ and the covariance of $i^t$ and $i$ fall to zero.

A two stage procedure uses the information about the structure of the monetary system to infer the future effects of monetary policy on the economy. The same constant growth of the base will have different short-term effects on the rate of growth of output and on inflation when there is intermediation than when there is disintermediation. When there are permanent changes in financial structure, policymakers can change the growth rate of the base to the rate consistent with a zero value of the criterion function. Transitory changes can be reduced by changing the institutional arrangements that affect the financial system by increasing the variance $\sigma^2 \Delta u$ and $\text{cov} (\Delta u, \Delta b)$. Ignoring the separate information about policy and its future effects given by $\Delta m$ is inefficient.

Benjamin Friedman (1977) reaches opposite conclusions. He argues the two stage procedure involving a target and indicator of monetary
policy is inefficient. Friedman assumes that the monetary authority knows the deterministic and stochastic structure of the economy, but the public does not. The monetary authority knows, also, that all shocks are transitory. Information about current values is incomplete, but other information, including the lag structure connecting policy changes to the criterion is known also. The basic inference problem deciding whether changes are permanent or transitory (temporary or long-lasting), does not arise for the monetary authority in Friedman's analysis.  

Under the conditions Friedman posits, the two-stage procedure is inefficient. If we believed that the policymakers had the information that Friedman gives them and that the structure (s) remained invariant with respect to policy rules and procedures, we would have little hesitation about sharing his conclusion. The two-stage procedure was developed, however, to address the more relevant problem that arises when the structure is not invariant, neither policymakers nor the public know the structure, and permanent and transitory changes often cannot be separated until long after the changes are observed.

Conclusion

Risks in nature and market processes can be increased or reduced by policy procedures and institutional arrangements. Where expectations are rational and the public is unable to distinguish promptly between permanent and transitory changes in rates of change, a policy of constant money growth reduces the variability of output growth.
We have shown that a policy of constant money growth is superior to more activist policies under a wide range of circumstances. We have not shown that constant money growth is optimal in all circumstances. Nor have we shown the precise rate at which money growth should be held constant.

Our analysis implies that attempts to offset temporary changes in output by activist monetary policies increases the variability of real output in three ways. First, the variability of policy adds directly to the variability inherent in nature and market processes. Second, people must learn to distinguish between permanent and transitory changes in the growth rate of money. Third, as the rational expectationists have emphasized, learning about the policy "rule" alters the structural parameters of the economy and therefore changes the response.

A final section discusses some institutional aspects of monetary policy including the use of targets and indicators. Institutional structure is often neglected in analysis at this level of generality. A main result of recent work in monetary theory is that permanent changes in institutional structure may offer greater opportunities for reducing the variability of output and prices than the activist policies of recent decades.
Footnotes

1. The terms "target" and "indicator" refer to the methods of implementing and interpreting policy. The terms are used in the sense of Brunner and Meltzer (1967).

2. The analysis is made applicable to a small, open economy by using the quantity theory in Brunner (1976). Let

\[ \alpha M^V + (1 - \alpha^*) M^*V^* + PG = PY \]

and let asterisks denote foreign variables. \( G \) is the value of real government spending, \( \alpha \) is the share of domestic output spent on domestically produced goods, and \( (1 - \alpha^*) M^*V^* \) is home country exports. In the open economy, velocity is a weighted average of home country and rest-of-the-world velocities.

\[ v = \frac{\alpha}{1 - g} \bar{V} + \frac{1 - \alpha^*}{1 - g} \frac{M^*X}{M} \bar{V}^* \]

The ratio \( G/y \) is written as \( g \).

3. We assume in (eq (9) and elsewhere that there is no covariance involving \( \Delta n \) or the bias.

4. In the open economy, discussed in footnote 2, the term \( (E^* \Delta v - E \Delta v)^2 \) in \( B \) includes uncertainty about foreign variables, exchange rates and \( \alpha \). Extension to an open economy appears to strengthen the case for constant money growth.

5. Relations between central banks and governments, independence of the central bank, the use of differential reserve requirements, payment of interest on required reserves, and limitations on interest rates paid on deposits are examples of institutional arrangements that increase the variance of money growth and uncertainty about the rate of growth.

6. It should be clear that \( \sigma^2 \Delta u \) depends on market interest rates and deposit rates because the composition of deposits depends on relative rates of interest and the multiplier of a functional reserve banking system depends on the composition of deposits. For a demonstration that \( \sigma^2 \Delta u \) can be written as a sum of (weighted) variance of \( \Delta i^t \) and \( \Delta i \), see Brunner and Meltzer (1968). Control of interest rates is not the only institutional arrangement (s) that causes \( \text{cov}(\Delta m, \Delta b) \) to change. The effects of fractional reserve banking and proposals for 100% money were common during the era in which bank failures were more common.

7. In Brunner and Meltzer (1967, p. 188) the indicator problem arises when we do not have precise "quantitative estimates of many of the
parameters of a general equilibrium macromodel, of the speeds of adjustment of many of the variables, and the distribution of the effect of monetary policy through time."

8. Our commitment is less than complete because Friedman (1977) uses interest rates as the target of monetary policy. Computations based on the variances in his table (Friedman 1977, p. 322) suggests that this choice is suboptimal. Using Poole's (1970) criterion and the variances in Friedman's extended IS-LM system implies that he should have chosen the growth of money or the growth of unborrowed reserves as the policy variable.
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