Stabilization Policy: A Framework for Analysis

Arthur J. Rolnick
Research Department, Federal Reserve Bank of Minneapolis

The Employment Act of 1946 mandated that the federal government take an active role in promoting "maximum employment, production, and purchasing power." Yet it failed to establish specific goals and a specific *modus operandi.* It was left to Congress and the administration to set the goals and to the economics profession—in particular the Council of Economic Advisors—to derive the policy strategy. Over the years this has resulted in a vast amount of research concerned with macroeconomic stabilization policy. Topics studied include the effect of lags on optimal policy, the use of discretion or judgment versus explicit rules, the relative strength of fiscal and monetary policy, the use of feedback rules versus nonfeedback rules, the optimal banking structure, and the role of intermediate targets.

It is not our purpose here to review this research nor to prescribe a way of conducting policy. Rather, it is to describe and defend a meaningful framework for studying these and other questions concerning stabilization policy.

An accepted framework for thinking about most decision-making problems has three elements:

- —The goals or objectives or, more technically, the objective function.
- —The constraints or, in several different words, the opportunity set, the set of attainable outcomes, or the model.
- —The optimal policy or the best course of action, which is the solution to the problem: maximize the objective function subject to the constraint or model.

In Section I we consider some theoretical examples to illustrate how this framework might be applied to issues in stabilization policy. In Section II we assess some current policy issues to demonstrate that this framework provides a rich mode of analysis and that it directs attention toward sensible questions.

I. The Policy Framework

Our examples center around a relatively simple objective function and an aggregate macroeconomic model. The examples differ mainly with respect to the degree of uncertainty embedded in the model.

Assume the policy maker's goal is to control income (Y). In particular, the policy maker wants to maintain a level of income (Y^*) over some fixed horizon ($t=1,\ldots,N$). An example of an objective function which expresses such a concern is

$$(1) \qquad U = -\sum_{t=1}^{N}(Y_t - Y^*)^2.$$

The problem is to find the time path of the variable the policy maker controls — referred to as the policy instrument and assumed here to be the interest rate (r) — which maximizes the objective function U. To do this we must have some notion, that is, some model, which embodies the economic process of income determination and, just as importantly, links this process to the policy instrument. For purposes of illustration, we use a model which is a version of the one that appears in introductory macro texts. It consists of the following equations:

$$(2) \qquad C_t = \alpha_1 + \alpha_2 Y_{t-1} \qquad \alpha_1, \alpha_2 \geq 0 \text{ and } \alpha_2 \leq 1$$

$$(3) \qquad I_t = \beta_1 + \beta_2 r_t \qquad \beta_2 \leq 0, \beta_1 \geq 0, \beta_1 = \beta_0 r^e_{t+1} \text{ and } r^e_{t+1} \text{ is fixed}$$

$$(4) \qquad Y_t = C_t + I_t$$

where Y_t is income, C_t is consumption, I_t is investment, and r_t and r^e_{t+1} are the current rate and the expected future rate of interest, respectively. Equation (2) is a simple linear version of a consumption equation which states that current consumption is equal to a constant (α_1) plus a fraction (α_2) of last period's income. Equation (3) is a linear version of an investment equation which states that current investment is equal to a positive function of the expected future rate of interest ($\beta_1 = \beta_0 r^e_{t+1}$) plus a negative function of the current rate (β_2). We initially assume expectations are fixed and treat β_1 as a constant; later we relax this assumption and examine the policy implications. Equation (4) defines income as the sum of consumption plus investment.

A model, in effect, is a description of an opportunity set or a set of attainable outcomes. The implied opportunity set of the model set forth in (2) through (4) is readily found by substituting (2) and (3) into (4) which yields

(5) $$Y_t = \delta_2 + a_2 Y_{t-1} + \beta_2 r_t$$

where $\delta_2 \equiv a_1 + \beta_1$.

Using the objective function (1) and various versions of the opportunity set (5), we are now ready to derive optimal rules: the settings of the policy instrument ($\tilde{r}_t$ for $t=1,\ldots,N$) that maximize (1) subject to the constraints imposed by the model. More specifically, the plan is to consider five different versions of (5). In the first, we assume all parameters are known and specify that a_2 is zero so that (5) reduces to a static, deterministic model. In the second, we let a_2 take on a nonzero value so that (5) is dynamic but still deterministic. In the third and fourth versions, we add parameter uncertainty: the third being the static case, the fourth being dynamic. In the last version, we relax the assumption of fixed expectations.

A. A Static, Deterministic Model

Here we assume that the policy maker knows the coefficients of the model and, specifically, that $a_2 = 0$. Equation (5) then reduces to

(5′) $$Y_t = \delta_2 + \beta_2 r_t.$$

Since the model is deterministic and static, the problem reduces to finding the value of r_t, for any arbitrary period, which produces the desired level of income. This model is static because the current setting of the instrument affects only current income. It is deterministic because we have assumed the coefficients δ_2, a_2, and β_2 are known. The optimal setting for r_t ($\tilde{r}_t$) is found by substituting Y^* for Y_t in (5′) and solving for r_t. This yields

(6) $$\tilde{r}_t = (Y^* - \delta_2)/\beta_2$$

for all t. Notice that in every period we achieve Y^* exactly and that $\tilde{r}_t$ is the same.

B. A Dynamic, Deterministic Model

Again assume the policy maker knows the coefficients, but now assume a_2 is not equal to zero. Equation (5) represents the opportunity set

(5) $$Y_t = \delta_2 + a_2 Y_{t-1} + \beta_2 r_t.$$

Since the parameters δ_2, a_2, and β_2 are known, the model is deterministic, but it is dynamic in the sense that past income affects current and thus future income. From the policy point of view, however, it is only dynamic in a trivial way. As in the static model, we are always able to exactly hit the target income, and the optimal value of the instrument is unchanged over time. This is readily seen by looking at the first period decision,

$$Y_1 = \delta_2 + \alpha_2 Y_0 + \beta_2 r_1$$

where Y_0 is some initial value of income. The optimal value of r_1 is

$$r_1 = (Y^* - \delta_2 - \alpha_2 Y_0)/\beta_2 \tag{7}$$

which produces $Y_1 = Y^*$. Now for $t=2,\ldots,N$, the optimal value for r_t is

$$\tilde{r}_t = [Y^*(1-\alpha_2) - \delta_2]/\beta_2 \tag{8}$$

which produces $Y_t = Y^*$.

C. A Static, Stochastic Model

In the previous examples we assumed the policy maker knew the coefficients. In general, since economic structures must be estimated from finite data sets, we are not so lucky. Instead, we must deal with stochastic models where the policy maker is in the position of choosing among alternative actions, consequences of which are uncertain. There is a well-developed theory of choice in such circumstances, which states that under highly plausible axioms the decision maker should rank actions on the basis of their expected utilities.† The problem of finding the optimal policy is then one of finding the policy rule which maximizes the expected value of the preference function subject to the structural relationships defined by a stochastic model of the economic process.

Consider again the case where $\alpha_2 = 0$ but where the other parameters are unknown and must be estimated from a finite data set. With $\alpha_2 = 0$, our model is static, and to determine optimal policy for any given period, we need only to maximize the expected utility of a one-period utility function.

$$\begin{aligned} E[U] &= -E(Y_t - Y^*)^2 \\ &= (\hat{Y}_t - Y^*)^2 + \sigma_{\hat{Y}}^2 \end{aligned} \tag{1'}$$

where

$$\begin{aligned} Y_t &= \delta_2 + \beta_2 r_t + \epsilon_t, \\ \hat{Y}_t &= \hat{\delta}_2 + \hat{\beta}_2 r_t, \\ \sigma_{\hat{Y}}^2 &= E(Y_t - \hat{Y}_t)^2, \end{aligned} \tag{9}$$

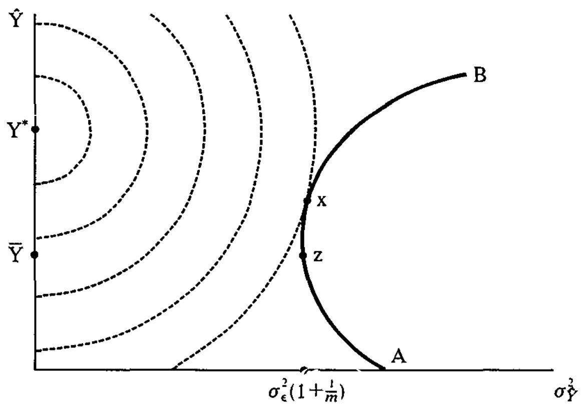
†An exposition of this theory is given by Arrow [1]. (Note that numbers in brackets [ ] correspond to the reference list, p. 17.)

and where ϵ_t is a random disturbance with variance σ_ϵ^2 and mean zero and $\hat{\delta}_2$ and $\hat{\beta}_2$ are the best linear unbiased estimates of δ_2 and β_2 having variances σ_δ^2 and δ_β^2, respectively. Assuming r_t is exogenous over the estimation period, the variance of forecasted income is

$$\sigma_{\hat{Y}}^2 = \sigma_\beta^2(r_t - \bar{r})^2 + \sigma_\epsilon^2(1+\tfrac{1}{m}). \tag{10}$$

(The quantity $\bar{r}$ is the mean value of the interest rate over the estimation period, and m is the number of observations. It follows from (9) that $\bar{Y}$ equal to $\hat{\delta}_2 + \hat{\beta}_2\bar{r}$ is the mean value of income over the estimation period.) From (9) and (10) we see that if we set r_t lower than $\bar{r}$, we would predict higher than average income but at the expense of some additional uncertainty about our forecast. Only if we set r_t equal to $\bar{r}$, or equivalently equate the desired level of income Y^* to the average income level over the data period $\bar{Y}$, do we minimize forecast variance. This tradeoff, or opportunity set, is represented in the figure by the curve AB. Point Z, where r equals $\bar{r}$, is the point of minimum variance; the forecasted value of income is the mean value over the data period. For income levels above $\bar{Y}$, where r is less than $\bar{r}$, the tradeoff between forecast and forecast variance is positive. For income levels below $\bar{Y}$, where r is greater than $\bar{r}$, the tradeoff is negative.

The objective function is represented in the figure by a set of semicircles centered at Y^* (the dotted curves). Points on a semicircle represent combinations of forecasts and forecast variances yielding the same expected value of the objective function. The expected value decreases the further the points are from the origin (Y^*). The tangency (point x) represents the "best" combination of forecast and forecast variance attainable.†



†This analysis is more fully developed in Brainard [2].

One of the major conclusions resulting from this model is that the more uncertainty about the impact of policy (the greater σ_β^2), the closer the policy instrument r_t should be set to its mean level $\bar{r}$ over the estimation period.† This is readily seen by substituting (9) and (10) into (1′), taking the derivative with respect to r_t, setting the derivative to zero, and solving for the optimal value of r_t. This yields

$$\tilde{r}_t - \bar{r} = \frac{\beta_2 (Y^* - \delta_2 - \beta_2 \bar{r})}{\beta_2^2 + \sigma_\beta^2}.$$

As σ_β^2 becomes larger, *ceteris paribus,* the deviation between $\tilde{r}_t$ and $\bar{r}_t$ becomes smaller.

D. A Stochastic, Dynamic Model

Finding the optimal policy begins to get more complicated when we incorporate both uncertainty and lags into the framework. In general, the solution to the problem exists, yet technically it is difficult to derive. The difficulties arise because not only is there a contemporaneous tradeoff between forecast and forecast variance, but there is also a more complex tradeoff over time.

To illustrate, consider the opportunity set

$$(11) \qquad \hat{Y}_t = \hat{\delta}_2 + a_2 Y_{t-1} + \hat{\beta}_2 r_t \qquad \hat{\beta}_2 < 0.$$

Here we again assume δ_2 and β_2 have to be estimated, but now we let a_2 be some positive known coefficient. Again assuming r_t is exogenous over the data period, the variance of forecasted income is given by (10); thus, by (10) and (11) we still have a contemporaneous tradeoff. But we also have a tradeoff over time, since by (11) any decision made last period affecting Y_{t-1} affects this period's opportunity set. Consequently, the optimal rule must take account of the dynamic nature of the decision-making problem, and this usually makes the rule more difficult to derive.‡

E. An Endogenous Expectations Model

We began these examples by assuming that the expectation of the future rate of interest was fixed (recall $\beta_1 \equiv \beta_0 r^e_{t+1}$). We now relax this assumption and briefly discuss its policy implications. Suppose the expectation of future rates is a function of the current rate. This implies that when we solve for the optimal rule, we can no longer treat β_1 as fixed. It will change in some systematic way with different settings of the policy instrument.

†This conclusion does not follow, however, when a change in r_t produces information about the structure that outweighs the cost of higher variance.

‡See Kareken *et al.* [3] for an example where uncertainty enters only because of additive disturbances.

As a result, the optimization problem is somewhat more complicated. Essentially, it involves estimating the expectations function and solving the model with β_1 as an endogenous variable.

A major result of endogenizing expectations is that if expectations are correct on average, there exists a class of models in which the policy rule will have no "real" effects.† Whether or not expectations are correct on average, however, if they are functions of the policy rules, using models with fixed expectations may seriously misrepresent the impact of policy.‡

To summarize, we have analyzed several versions of a simple macro model. They differed mainly in degree of uncertainty embedded in the economic process. This analysis not only illustrated the framework set out at the beginning of this paper, but also established the following policy implications:

- Given an objective function and a model, finding the optimal rule is a technical problem, although possibly one that is difficult to solve.
- The degree of difficulty is directly related to the degree of uncertainty about the economic process.
- The more uncertainty, the less the optimal setting of the policy instrument deviates from its historical mean.
- If expectations are functions of the policy rule, using models with fixed expectations may seriously misrepresent the impact of policy.

II. Some Current Policy Issues

The proposed framework consists of an objective function, an opportunity set or model, and a rule which maximizes the objective function subject to the opportunity set. Within this mode of analysis, many policy issues can be clarified and many, in principle at least, can be resolved. We now examine some of these issues in an attempt to defend and to illustrate the usefulness of the framework.

A. The Role of Judgment or Discretion in the Policy Process

This framework, many economists and policy makers contend, is fine in theory, but not in practice. The real world, they argue, is too complicated to model. Any rule resulting from such a model should be supplemented by whatever information and judgment is not part of the formal structure.

Although the phrases "too complicated" and "information and judgment not part of the formal structure" are commonly used in such criticisms, the meaning of these phrases often varies. In responding to this criticism, therefore, we consider different interpretations.

"Too complicated" seems to imply too much uncertainty. But if it

†See Sargent and Wallace [7].

‡See Lucas [4].

means that the economic process contains *no* systematic relationships, then judgment can fare no better than formal models. Similarly, if it refers to unforeseen one-time economic shocks — an oil embargo, for example — then while models estimated on past data have little to offer the policy maker, neither does the judgmental method.† On the other hand, if "too complicated" refers to uncertainty about systematic relationships that hold on average, then, as we demonstrated in Section I this type of randomness can be incorporated into the framework.

We have argued that if uncertainty cannot be modeled formally, we cannot judgmentally improve the policy process. But what about using "information and judgment not part of the formal structure" to improve policy? Again, we consider various interpretations. Using information not part of the model may mean that some key equations are missing or that, because most models contain aggregate relationships, more information exists than they can analyze. Both of these interpretations are criticisms of the current state of model building. In principle, however, these models can be expanded to include all known systematic relationships and can be estimated on a disaggregated level consistent with the data.

Another interpretation of using judgment, which we believe to be the more common, is that of using the expertise of the experienced forecaster. This forecaster is supposed to have deep and intuitive insights into the workings of the economy which enable production, on average, of more accurate predictions than explicit models. But how can we choose an optimal strategy based on a single forecast? We need to know the implications of many different strategies. Morever, if we cannot reproduce and test the "expert's" forecasting techniques, there is no possibility for learning and little for empirical verification.

Thus, we conclude that framework cannot be dismissed simply on grounds that the economy is too complicated or that intuition works better. If there is a role for discretionary policy or judgment, it must be made explicit and part of the formal structure.

If we can agree, at least in principle, that we can construct a model that can take account of all relevant information and that explains economic data, then with such a model a number of other issues can be resolved.

B. Fiscal Vs. Monetary Policy

Consider the fiscal versus monetary policy debate. Fiscal policy, monetarists argue, has much less effect on aggregate income than monetary

†To illustrate, consider two of the judgmental policy prescriptions made in response to the price increase which followed the 1973 oil embargo. One was to have a once and for all matching increase in the money supply so that monetary policy would not become unduly restrictive. Another was no change in the money supply, since any increase would only further increase the price level. Which policy should have been followed? Without previous experience and some kind of model, it's difficult to say.

policy. Advocates of fiscal policy reverse the ordering. But within the decision framework presented above, this controversy seems to be irrelevant. In general, if there is more than one policy instrument, both will be used.

C. Fixed Vs. Feedback Rules

Another argument which seems to lose its relevance is that due to long and variable lags, the impact of policy is so uncertain that it is best to have a fixed rule. Long and variable lags, it can be shown, are neither necessary nor sufficient conditions for ruling out feedback rules. As long as the uncertainty about lag responses is not infinite, a feedback rule is optimal.

The controversy between fixed rules and feedback rules, however, is still a meaningful issue and one which can be addressed conceptually within this framework. The answer, it turns out, depends critically on the way expectations are modeled. In particular, if expectations of future variables are formed "rationally," that is, the forecasts of these variables are on average correct, then there exists a class of models in which a fixed rule is as good as any feedback rule; and this class of models includes most of the models found in the macroeconomic literature.[†]

D. The Optimal Monetary Framework

The optimal monetary instrument and the optimal banking structure are two other issues that can be addressed within this framework. Both, however, are only interesting in a stochastic model.

On determining the optimal instrument, the policy maker is assumed to have the choice of setting either the rate of interest or the money stock. Determining which instrument yields the higher expected value of the objective function when it is set optimally resolves the issue.[‡]

On determining the optimal banking structure, there are a host of issues. They include whether or not we should increase or decrease reserve requirements, equalize reserve requirements between deposit types, equalize reserve requirements between different classes of banks, and finally, whether or not we should tie the discount rate to a market rate. Again given the appropriate stochastic model, these are sensible questions and, in principle, can be answered.[§]

E. The Role of Intermediate Targets

The models we consider contain some variables which are directly controlled by the policy maker (instrument variables), some which appear in the policy makers' utility function (goal variables), and some that may be influenced by policy but do not appear in the utility

†See Sargent-Wallace, op. cit.

‡See Poole [5].

§See Rolnick [6].

function (intermediate variables). The role of the latter variables has recently become a topic of debate. The policy maker usually has more current data on intermediate variables than on goal variables. But how should this information affect the policy response? Some argue that intermediate variables should serve as proxies for goal variables; they argue that they can be used as intermediate targets until more data become available. Within the framework advocated in this paper, however, it has been shown that unless the economic structure is very special, the policy maker should not use these variables as targets.† The data on intermediate variables generally tell us something about unobserved goal variables. We should respond, therefore, not in order to stabilize intermediate targets but in order to offset undesired movements in goal variables. Responses intended to stabilize intermediate variables will generally be quite different from responses intended to stabilize goal variables.

We have examined several policy issues and have seen how the framework advocated in this paper helps to clarify and possibly resolve these issues. Although current research has only scratched the surface on these policy debates, if we are to have any hope of eventually fulfilling the mandate of the Employment Act of 1946, we must adopt an explicit decision-making framework. Vague pronouncements about achieving full employment with price stability, so-called experienced forecasters, and *ad hoc* policy prescriptions must be replaced by a specific objective function, an explicit model of the economy, and the implied best rule.

†See Kareken *et al.*, op. cit.

References

1. Arrow, Kenneth J. *Essays in the Theory of Risk Bearing.* Chicago, Illinois: Markham Publishing Company, 1971.
2. Brainard, William. "Uncertainty and the Effectiveness of Policy." *American Economic Review* Vol. 57, No. 2 (May 1967): 411-25.
3. Kareken, John H., Thomas J. Muench, and Neil Wallace. "Optimal Open Market Strategy: The Use of Information Variables." *American Economic Review* Vol. 63, No. 1 (March 1973): 156-72.
4. Lucas, Robert E., Jr. "Econometric Policy Evaluation: A Critique." In *The Phillips Curve and Labor Markets,* ed. by Karl Brunner and Allan H. Meltzer. Rochester, N.Y.: North Holland, Vol. 1 (1976): 19-46.
5. Poole, William. "Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model." *Quarterly Journal of Economics* Vol. 84, No. 2 (May 1970): 197-216.
6. Rolnick, Arthur J. "Evaluating the Effectiveness of Monetary Reforms." *Journal of Monetary Economics* Vol. 2, No. 3 (July 1976): 271-96.
7. Sargent, Thomas J., and Neil Wallace. "'Rational Expectations,' the Optimal Monetary Instrument, and the Optimal Money Supply Rule." *Journal of Political Economy* Vol. 83, No. 2 (April 1975): 241-54.