CONTROL THEORY AND ECONOMIC STABILIZATION: A COMMENT ON THE KALCHBRENNER AND TINSLEY AND PRESCOTT PAPERS

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One of the more important questions in the area of quantitative economic policy concerns the suitability of optimal control theory for economic stabilization problems. Despite extensive theoretical and applied research in this area, the question of the appropriateness of control theory has still not been completely resolved. The papers by Kalchbrenner and Tinsley and by Prescott are, therefore, most welcome for they clarify, in quite different ways, some of the critical issues bearing on this question. Prescott draws on the extensive theoretical research of the past decade, and Kalchbrenner and Tinsley proceed from their operational experience at the Federal Reserve Board.

The conclusion I would draw from these papers is that optimal control can indeed be very useful for stabilization problems, provided that expectations and all auxiliary information are adequately treated. The problems which arise in attempting to satisfy this proviso are, however, nontrivial. I will confine my comments to the issues that have particular relevance to this conclusion.

1. Rational Expectations and the Power of Monetary Policy

I share Prescott's view that the rational expectations assumption does not imply that active monetary policy will be ineffectual in stabilizing fluctuations in output and employment. His model of long-term wage contracts is a lucid example of how different monetary policies, though fully anticipated, result in different behavior of both employment and the price level. Phelps and Taylor (1977) and Fischer (1977) have reached similar conclusions in the context of models with more detailed development of the persistence effects of "sticky" prices or wages in a rational expectations setting. The implication of these results is that the rational expectations assumption per se does not preclude the efficacy of optimization techniques for monetary stabilization problems.

*The views expressed here are my own and do not necessarily reflect those of the Council of Economic Advisers.

2. Optimal Control or Optimal Design

Prescott does argue, however, that optimal control theory is inappropriate for stabilization problems because it inherently treats certain variables (usually expectations) as if they were invariant when, in fact, they are sensitive to policy decisions. Instead, he argues, optimal design theory should be used to find policy rules which generate the best operating characteristics for the economy.

The distinction between control and design is, in my opinion, computational rather than substantive. The implication of rational expectations is not that optimal design should be used instead of optimal control. Rather, any optimization technique used for macroeconomic stabilization should be able to incorporate the endogeneity of expectations. For example, much of the optimal control theory literature is concerned with techniques which are very similar to the design approach advocated by Prescott. Whittle (1963), Box and Jenkins (1970), and Chow (1970) all find solutions to optimal control problems by restricting the class of policies to a particular parametric form (usually linear feedback) and optimizing with respect to a set of parameters. These techniques usually result in computational schemes (such as matrix-Riccati equations) which also appear in dynamic programming approaches. These methods of optimal control can also be modified to incorporate rational expectations; see Taylor (1976). My conclusion, therefore, is not that optimal control theory is inappropriate for stabilization problems, but simply that its incorrect use is inappropriate.

As a computational matter, however, approaches to optimal control which are as general as dynamic programming (where the class of policies is unrestricted) do not appear to yield quick solutions to specific problems with rational expectations. An important unresolved area of research, therefore, is the development of optimal control techniques for rational expectations models which do not restrict policy to a particular class. For example, Prescott points out that the optimal linear policy for his wage contract model may be dominated by a nonlinear policy. As yet, there is no general method for determining that nonlinear policy.

3. Consistent or Cooperative Policies

The issue of consistent policies also has important implications for the use of optimal control theory. If policymakers have incentives to change their optimal plan in subsequent periods--as the finite horizon patent example illustrates--then one might argue that consistent rather than optimal control policies should be used. The consistent approach is to choose the best second-period solution given the first-period solution of economic agents. This is a noncooperative solution and is clearly suboptimal, as the patent example illustrates. These inferior solutions might be avoided, however, under an incentive structure that discourages movement away from optimal policies. One set of incentives relevant to many economic problems embodies the constraints which the future places on decisions in earlier periods–as in the infinite horizon patent example with no discounting. Repetition is a way to encourage cooperative behavior in many game situations, but whether sufficient incentives exist to guarantee the cooperative solution in macroeconomic stabilization problems is an open question. If these do not exist, or are not strong enough, then contractual arrangements which force the stabilization authorities to follow certain rules might be necessary.

The difficulty of maintaining an optimal monetary policy for price "shocks" is a case in point. Many econometric estimates of price and wage equations imply that optimal monetary policy (with a social welfare function that depends on both employment and inflation) should partially accommodate shocks to the price level, permitting some increase in unemployment but not as much as would be implied by unresponsive monetary growth. If this optimal monetary policy were announced ahead of time, then workers and firms could make their own contingent price and wage plans compatible with the policy. Faced with such a policy, workers would be discouraged from bargaining for, and firms would be discouraged from granting, nominal wage increases which completely compensate for price shocks--doing so would mean an excessive loss of employment and sales. Once price shocks occur, however, there is a great temptation for policymakers to completely accommodate the shocks in order to prevent any loss in output. Of course, general expectations of such a policy switch could have disastrous results for wage and price determination.

One way to increase incentives to maintain the optimal solution would be to demonstrate, perhaps through the use of optimal control theory, the cost of changing an announced strategy. The development of theoretical and empirical rational expectations models, which measure the welfare cost of noncooperative stabilization policies, could be useful for this purpose. As an example, one implication of the policy analysis in Phelps and Taylor (1977) is that monetary policy may at times have to penalize the economy in the short run for the sake of beneficial long-run effects on the system.

4. The Problem of Model Selection

One of the practical difficulties in the implementation of optimal control theory is the choice of an appropriate econometric model. It is now common practice when conducting a policy exercise to run simulations on a number of models; each gives different policy answers. The answers are even more diverse when optimal control is applied to various models. One of the more troublesome examples of this policy identification problem has been pointed out by Sargent (1976).

Several practical solutions to this problem were investigated in the paper by Kalchbrenner and Tinsley. One method is to calculate the optimal policy for each model and to simulate these policies on the other models, choosing the policy which minimizes the maximum loss. The rationale is that one of the models should be similar to the real world, and that, by following this procedure, errors will be small. It is not hard to find counterexamples, however, in which such a procedure gives disastrous results.

This problem of model selection is not unique to macroeconomic policy analysis, however. The calculation of optimal tax policies, for example, requires good elasticity and incidence estimates, but these vary as widely as do estimates of macroeconomic parameters.

5. Instrument Instability

Another important practical problem with most macroeconomic policy applications is that the optimal policy calls for implausibly large and sometimes unstable fluctuations of the instruments. Heavy weights on the policy instruments in the objective function is the usual remedy for this problem, as in the Kalchbrenner and Tinsley procedure. However, there is little theoretical justification for such weights, and they may seriously bias the estimated policy trade-offs. Fortunately, the bias is usually toward a more unfavorable trade-off, so that subjective adjustment will improve the estimated gains to optimal control. A better approach, however, would be to reestimate those parameters of the model which generate the instrument instability, or, alternatively, to estimate the extent of the uncertainty about those parameters and build this uncertainty into the control solution.

6. Feedback or Simultaneous Policy

Most applications of optimal control are constrained by the measurement interval of a quarterly econometric model. Policy decisions for a quarter must stay fixed at one value throughout the quarter. A quarter, however, is usually too long for monetary instruments to remain immobile. And, the advantage of the automatic fiscal stabilizers is that there is no lag between economic conditions and economic stimulus or restraint.

A more satisfactory approximation to these optimal stabilization problems would be a simultaneous rather than a feedback policy. In fact, current monetary operating procedures which attempt to stabilize the federal funds rate in the very short run are essentially based on a simultaneous rule. Increases in the federal funds rate bring forth open market purchases on the same trading day. The relevant considerations for simultaneous policy analysis are analogous to those raised in Poole's (1970) study of random shocks to LM-IS curves.

Because long-run monetary policy is really a succession of short-run changes, control theory in its current feedback form may inherently sacrifice some short-run maneuverability. If so, then feedback control theory may not necessarily be an improvement over current operating procedures. For example, historical policy sometimes does better on average than feedback policy, possibly because the actual policy is based on such short-run simultaneous rules. The work at the Federal Reserve Board discussed by Kalchbrenner and Tinsley that integrates monthly and other auxiliary information into the quarterly forecasts is suggestive of the possible gains from this simultaneous approach to policy. It also illustrates the importance of incorporating all available information if optimal control theory is to be applied successfully to macroeconomic stabilization problems.

REFERENCES

Box, G.E.P., and Jenkins, G.M. (1970). Time Series Analysis Forecasting and Control. San Francisco: Holden-Day.

Chow, G.C. (1970), "Optimal Stochastic Control of Linear Economic Systems," Journal of Money, Credit and Banking, 2: 291-302.

Fischer, S. (1977), "Long-term Contracts, Rational Expectations, and the Optimal Money Supply Rule," Journal of Political Economy, 85: 191-205.

Kalchbrenner, J.H., and Tinsley, P.A. (1977), "On Filtering Auxiliary Information in Short-run Monetary Policy," Carnegie-Rochester Conference Series on Public Policy, 7, eds. K. Brunner and A.H. Meltzer, Amsterdam: North-Holland.

Phelps, E.S., and Taylor, J. (1977), "Stabilizing Powers of Monetary Policy under Rational Expectations," Journal of Political Economy, 85: 163-90.

Poole, W. (1970), "Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model," Quarterly Journal of Economics, 84: 197-216.

Prescott, E.C. (1977), "Should Control Theory Be Used for Economic Stabilization?" Carnegie-Rochester Conference Series on Public Policy, 7, eds. K. Brunner and A.H. Meltzer, Amsterdam: North-Holland.

Sargent, T.J. (1976), "The Observational Equivalence of Natural and Unnatural Rate Theories of Macroeconomics," Journal of Political Economy, 84: 631-40.

Taylor, J.B. (1976), "Estimation and Control of a Macroeconomic Model with Rational Expectations," working paper, Columbia University.

Whittle, P. (1963). Prediction and Regulation by Linear Least Squares Methods. Princeton: van Nostrand.