Working Paper

historical copy

Research Department
Federal Reserve Bank
of Minneapolis

FEDERAL RESERVE BANK OF MINNEAPOLIS
INCORPORATED MAY 18, 1914

Rational Expectations and Policy Evaluation in Macroeconometric Models

Paul A. Anderson

May 1977

Working Paper #: 82

PACS File #: 2650

Preliminary

To be presented at the summer meetings of the Econometric Society in Ottawa on June 22, 1977.

This paper puts forward a method of policy simulation with an existing macroeconometric model under the maintained assumption that individuals form their expectations rationally. This new simulation technique grows out of Lucas' criticism that standard econometric policy evaluation permits policy rules to change but doesn't allow expectations mechanisms to respond as economic theory predicts they will. This technique is applied to versions of the St. Louis Federal Reserve model and the FRB-MIT-Penn model to simulate the effects of different constant money growth policies.

I shall briefly summarize the current practice of policy evaluation and the Lucas critique in the first section. The second section includes an explanation of the method I propose. The third section includes the two illustrative applications. In the conclusion, I cannot resist the temptation to offer some opinions about the use and usefulness of econometric models.

Econometric Policy Evaluation

The rise of econometric models is certainly the success story of the last decade and a half in economics. The use of computer modeling has greatly expanded the scope of policy advice that economists provide and enhanced our forecasting abilities.

In this essay, we shall concern ourselves with what are sometimes termed "structural" econometric models; systems of simultaneous equations which attempt to explicitly isolate the decisions of specific agents in specific behavioral equations. The most important use of such models is to produce conditional forecasts, i.e., to show the differences in outcomes which would result in different environments (usually different policy environments). It is widely conceded that for short-term unconditional forecasting, these models appear to be dominated by nonstructural time series methods, e.g., see Nelson [1972]. However, in the area of policy simulation, these models seem to have given us the ability to evaluate proposed policy rules by experimentation rather than relying solely on theory and introspection. This experimentation goes by the name of econometric policy evaluation.

We shall define econometric policy evaluation as the positive economic task of predicting what the distributions of outcomes of endogenous economic variables would be in the future if alternative government policy rules are followed. The economic system may be viewed as a mechanism which transforms the exogenous processes into resultant endogenous processes. Policy simulation involves changing that mechanism in order to represent the structure of the economic system after the proposed policy change.

In practice, this is accomplished by modifying equations which describe government behavior or sometimes by simply specifying different time paths for exogenous variables which are believed to be controllable by government policy.[1/] This procedure will only yield reliable results if the parameters of the nongovernmental sectors of the model would remain unchanged if the policy were actually instituted. In the terminology of Sims [1977], the structure must be invariant to policy interventions of the type proposed. Current models are manipulated as if their structures are invariant with respect to all policy changes. There is both empirical evidence and theoretical analysis to support the view that existing models are, in fact, not invariant to the policies currently simulated.

The empirical evidence is disturbing though, perhaps, not compelling. We know of no models which pass standard statistical tests for invariance over the sample period. Attempts to perform these tests on existing models sometimes draw sharp criticism from model builders[2/] who often eschew such tests themselves. In one believes policy to have been changeable over the past, the passage of these tests would certainly be a minimal requirement for any model one wished to use for extensive analysis of hypothetical new policies. In the absence of such confirmatory test results, the belief that the parameters of a given model will not change with future policy changes might be considered as more an act of faith than a scientific opinion.

There are also good theoretical reasons for doubting the invariance of the structures of existing econometric models. The equations of most current models are thought to follow from models of individual and group decisions. The relevant models are often thought to be those where agents optimize over time in a stochastic setting. (Some of the most recent theoretical work is summarized in Muench and Wallace [1974].) In such settings, agents' behavior often depends on their beliefs about the future, and they pay attention to the past partially as a help in anticipating and preparing for future outcomes.

Those beliefs about the future are, of course, not directly observable, but this proved to be no obstacle to estimation of behavioral equations. In his classic paper, Nerlove [1958] showed that the unobservability of expectations could, in some sense, be overcome for description of past behavior. By substituting an expectations equation based on past data into a supply equation based on expectations of the future, he was able to express such forward-looking behavior in terms of observable quantities and estimate the parameters of a supply relation.

Although explicit identification of expectations did not seem necessary for estimation, it is necessary for simulation. For the purposes of policy evaluation, it is generally assumed that the final equations like that estimated by Nerlove are invariant. However, the optimizing theories mentioned above imply that the parameters of such estimated relationships will change if a new policy rule is adopted. This is because optimizing individuals will react to the change in the outlook for the future, but equations of the form considered here cannot reflect the change in outlook, since they are stated only in terms of past data.

The heart of this line of criticism is succinctly stated by Lucas [ ] in a syllogism near the end of his paper: a) the equations of econometric models are optimal decision rules conditioned by the agents' environment, b) the optimal rules change if policies which are thought to have an effect are instituted, and therefore, c) the parameters of estimated models will change in a systematic way as different policy rules are adopted.

Policy evaluation in such a situation becomes more difficult than previously believed, since one has to infer in some way how the parameters of various behavioral relations will change as agents perceive and react to the new policy rule. In particular, in behavioral equations where expectations are important, one must identify how agents' forecasts will change if new policies are adopted.

Whether these hypothesized shifts of decision rules are of enough quantitative importance to invalidate current simulation methodology has not been determined by any formal testing procedure that I know of. Recognition of the central importance of expectations in many of the key relationships of existing models fosters speculation that some of the "parameter shift" currently being experienced can be explained by the shifting of expectations rules. Several current models rely on estimated Phillips curve relationships for a great deal of their real dynamics. If the shifts of expectations are important, policies designed to reduce unemployment by increasing inflation may be a great disappointment in practice, even though they appear desirable on the basis of econometric policy simulations.

To emphasize the dependence of such "empirical" policy prescriptions on insensitive expectations, several authors (Sargent and Wallace, Lucas and Barro, among others) have presented small analytic macro models which incorporate a postulate about the evolution of expectations which differs from the "no-change" postulate implicit in existing procedure. In the context of these models, standard econometric policy evaluation techniques indicate the optimality of certain types of feedback rules, but, because of shifting expectations, all feedback rules are actually powerless to affect the levels of real economic activity. These demonstrations emphasize the potential weakness in policy evaluation which ignores shifts in expectations rules and highlight the urgency of empirical investigation in this area.

The Rational Expectations Hypothesis

The shifting of expectations rules has been recognized as a practical problem for policy evaluation. Drawing on his own experience, Shiller [1975] stated:

> "In fact, if one looks at one of the major econometric models one is impressed that most of the essential behavioral relations are based on assumptions about how expectations are formed . . . Even the IS-LM model . . . has at its foundation some assumptions about expectations and changes in expectations shift all of the curves. It is, in fact, substantially for this reason that it has been such a tricky business to predict the macroeconometric effects of policy."

Lacking a theory which predicts how expectations rules will respond to policy changes, model users are often forced to make admittedly ad hoc adjustments to the forecasting rules embedded in their models. Later in the paper quoted above, Shiller claims:

> "Behavioral relations which rely on such expectations proxies[3/] usually work pretty well. They may also predict very badly if something happens which changes the way people form their expectations, e.g., if price controls are instituted or there is a sudden hyperinflation. Not knowing how expectations will respond to such changes, macroeconometric model builders are sometimes obliged to make some outright guesses of their own as to how this policy would affect the mechanism which generates price expectations."

The essence of our approach will be to replace the guesses Shiller describes with more systematic predictions of the shifts in expectations rules. These predictions are based on a maximizing theory of expectations formation, the rational expectations hypothesis.

The rational expectations hypothesis was so named in Muths' [1961] well-known article.[4/] It is a maximizing theory about the efficient use of information by agents. It may be stated as the hypothesis that agents act as if responding to the true distribution of economic random variables conditional on the information available to them.

Writing before the Muth article had appeared in print, Nerlove [1961] was quick to recognize the econometric applicability of the rational expectations hypothesis:

> "From the standpoint of economic theory, the rational expectations hypothesis is the most attractive hypothesis concerning the formation of expectations which has been formulated to date, and which is sufficiently simple to be used in connection with time-series analysis."

Recent empirical work, including Shiller [1972] and several articles by Sargent, has tended to bear out Nerlove's insight by demonstrating the detailed, testable restrictions on data that the rational expectations hypothesis (REH) can deliver.

The simplicity mentioned by Nerlove contributes greatly to the usefulness of the REH in econometric investigation. By invoking the REH, the investigator need only deal with actual conditional distributions of observed random variables. In contrast, if one uses an alternative such as Bayesian learning, he must pile on assumptions about agents' prior distributions and estimation methods. A maximizing plan of research probably should involve investigating the explanatory power of the simple hypothesis before tackling the more complex task.

Nerlove's explicit identification of time series analysis is particularly insightful, and, indeed, it is on the dynamic aspects of the rational expectations hypothesis that our subsequent demonstrations build. The operative characteristic of the REH for policy evaluation is not that forecasts are optimal per se, but rather that agents' forecasts are adjusted optimally in response to an announced (or otherwise perceived) policy change. Many of the neutrality proofs of the small, illustrative models mentioned above would still go through if the expectations mechanism were changed to include a constant, systematic deviation from the true conditional mean of the forecast quantity. It is the adjustment of agents' expectations which neutralizes the hoped-for effects of nominal policies.

We propose a numerical algorithm for manipulating existing econometric models under the maintained assumption that the forecasts implicit in behavioral equations adjust in precisely the manner and amount that the entire model predicts actual quantities will change as a result of a given policy change. I accept the specification of a given model as true and representative of the structure of the economy over the sample period but transform the expectations mechanisms so that, for each simulation, the adjustment of individual expectations is consistent with the actual forecasts of the model.[5/] To understand the method proposed here, we will consider an equation of the form

(1) $$ay_t + bz_t + cp_t^e = e_t$$

where y_t and z_t are vectors of endogenous and predetermined variables, respectively, p_t^e is the agents' forecast of price in period t,[6/] based on information available at time t-1; a, b, c are conformable with y_t, z_t, and p_t^e, and e_t is a white-noise error term. In existing models an equation like (1) is usually combined with an autoregressive expectations mechanism of the form of equation (2)

$$(2) \qquad p_t^e = \sum_{s=1}^{n} d_s p_{t-s}$$

to yield an equation of the form of equation (3)

$$(3) \qquad ay_t + bz_t + c \sum_{s=1}^{n} d_s p_{t-s} = e_t.$$

Equation (2) is an example of a static expectations rule which may have described the price process well over the sample period. If a policy change alters the price process in the real economy, the agents represented by equation (3) would adopt a new forecasting rule for p. However, a simulation of that policy would leave equation (3) unchanged and, hence, would have an internal inconsistency. The agents of equation (3) would be assumed to act on forecasts generated by (2), whereas the entire model would imply a different price forecast.

The essence of our method for simulating the model subject to rational expectations is to eliminate that inconsistency between forecasts. We change the computer coding so the p_t^e, instead of being predetermined each quarter, is determined simultaneously with the endogenous variables and is equal to the forecast of price made by the model as a whole.

This procedure is, however, far from mechanical. In working with equations of the form of (3), one must first be sure that the distributed lag expression which one is replacing corresponds solely to an agent's expectations and doesn't involve, for example, some technological aspects as well. Second, as equation (3) is usually estimated by time series methods, the coefficient c is not identified econometrically.

Often, in the past, the ad hoc identifying restriction

$$\sum d_s = 1$$

has been maintained. For many economic variables, the optimal predictor would not obey that restriction (or the smoothness restrictions often added to it). A suitable identifying restriction may often be derived from economic theory, e.g., invoking the efficient markets hypothesis in portfolio demand. Without strong cues from the underlying microeconomics or independent empirical evidence, one's judgment must come into play. One can suggest several ad hoc methods, each of which would be appropriate for some class of models.

The mathematical and computational problems both become more difficult if the expectations involved in equation (1) are forecasts of economic variables for several periods into the future rather than a single period. Many properly posed multiperiod stochastic decision problems yield a solution in terms of forecasts which reach infinitely far into the future.

Truncation of the infinite forward distributed lag is no different from approximations which have typically been made, but if even a single future term remains in a decision rule, simulation becomes much more difficult. The time path of the model can no longer be solved simply period by period, since the forecast of the model for time t+k depends on the forecast of some variables for dates t+k+1 and later. This is an inconvenient consequence of using the model's own forecasts to proxy for expectations.

One possible method of simulation in such a situation is to run a sequence of multiperiod predictions using the forecasts from one entire simulation as the expectations for the next simulation. If such a sequence converged, we would have an internally consistent solution in the same sense as the easier problem. This has not been implemented to our knowledge. If used it would require one to make some terminal assumption about certain variables, e.g., inflation, many periods in the future. Positing some "reasonable" number as the expected value of the inflation rate for twenty or thirty quarters isn't something we would shrink from. In such a context, one would be at least able to determine exactly what effect alternative terminal assumptions would have on the experiment performed.

It may well be that the evaluation of a certain policy rule based on "rational expectations simulations" of a given model may not differ greatly from that based on standard simulations. A sizable difference in the response of the two models to a certain rule points up the importance of the expectations hypothesis in the results and may cause the investigator or model builder to reconsider assumptions which were, perhaps, made rather casually during initial modeling.

In the next section we present the results of simulating a certain set of policy rules in two existing econometric models, first in the standard manner and then by transforming expectations as described above.

Experiments With Two Macroeconometric Models

We report the results of simulations of constant money growth rates using two econometric models, the St. Louis Federal Reserve model and a version of the FRB-MIT-Penn (FMP) model.[7/] For each model, three ex post. simulations were run using the unaltered model structure to represent the effects of increasing the money supply (M1) at four, six, and eight percent. After the structure was transformed as described above, the three simulations were repeated with all of the exogenous variables and all of the coefficients (except those connected with expectations) at the same settings used for the first set of simulations.

It is quite likely that, for example, the four percent simulations from an original structure and its transformed verions will be quite different. However, we are mainly interested in the differences between four, six, and eight percent money in the original and transformed structures. In particular, we wish to see if the difference in the effects of, for example, four percent and eight percent money is substantially altered by imposing rational expectations.

Since our purpose is illustrative, many aspects of these tests which might be treated in a detailed, systematic evaluation were not considered. The simulations are deterministic rather than stochastic. The exogenous variables are set at actual levels rather than forecast by the generating mechanism actually used for projecting future values. In the FMP model, no intercept adjustments were used. The simulation periods differ. With one exception, described later on, we know of no a priori reason why the choices we have made are likely to make the results reported here unrepresentative of the two models. It is certainly possible that more such simulation may prove us to be mistaken. We shall present the results from the models in the next two subsections. The final subsections deal with other types of policy experiments and extended expectational horizons.

A. The St. Louis Model

The simulation experiments were carried out using the version of the model included in the original paper of Anderson and Jordan [1970]. However, description of the changes made to the model is easier if we consider the following simplified version which contains five endogenous variables, three exogenous variables, and three random disturbances.

$$\text{(SL1)} \qquad \Delta p^e_t = A(L)\,\frac{p_{t-1}}{u_{t-1}}$$

$$\text{(SL2)} \qquad \Delta y_t = B(L)m_t + C(L)e_t + v_{1t}$$

$$\text{(SL3)} \qquad \Delta p_t = D(L)(\Delta y_t - xf_t + x_{t-1}) + .86\Delta p^e_t + v_{2t}$$

$$\text{(SL4)} \qquad x_t = y_t/p_t$$

$$\text{(SL5)} \qquad u_t = G(L)\,\frac{xf_t - x_t}{xf_t} + v_{3t}$$

where A(L), B(L) . . . are one-sided polynomials in the lag operator L. The five endogenous variables are nominal GNP(y), constant dollar GNP(x), the implicit GNP deflator (p), the unemployment rate (u), and the expected change in the price level (Δp^e). The three exogenous variables are the money supply (m), government expenditures (e), and full-employment output (xf). The v_i's are the random disturbances.

Equation (SL1) is an expectations equation where expected inflation is a weighted sum of past inflation rates. The weights, however, are variable and vary inversely with the unemployment rates in the past periods. Equation (SL2) is termed the total spending equation. Equation (SL3) is referred to by the authors as the price equation. Equation (SL4) is the identity of real output, nominal output, and the price level. Equation (SL5) relates the unemployment rate to capacity utilization, a rough empirical approximation sometimes called "Okun's Law." Equations (SL1) and (SL3) correspond to equations (2) and (1) above.

In order to simulate this model under the assumption of rational expectations, we simply drop equation (SL1) from the model and replace Δp_t^e in equation (SL3) by the expression Δp_t to yield:

$$\Delta p_t = C(L)(\Delta y_t - xf_t + x_{t-1}) + .86\Delta p_t$$

or, more compactly

$$\Delta p_t = \frac{1}{1-.86} C(L)(\Delta y_t - xf_t + x_{t-1}).$$

The effects of four, six, and eight percent constant money growth rates in the original and RE versions of the St. Louis model were simulated from the initial conditions of 1960I by solving dynamically through 1965IV. Both sets of simulations used actual values of the exogenous variables (excluding m, of course). All of the coefficients were the same for both models. Tables 1 and 2 contain the inflation and unemployment rate paths from those simulations. The quarterly inflation rates have been converted to annual rates.

The simulations using the original St. Louis model demonstrate an exploitable trade off between inflation and unemployment. Higher money growth rates not only increase the rate of inflation but also decrease the unemployment rate substantially. However, when the rational expectations adjustment is made to the structure of the St. Louis model, that trade off virtually disappears.

There is almost no change in the unemployment rate path when the money supply growth rate is increased from four percent to eight percent.

Table 1

Simulation Results From Original Version of St. Louis Model

M1 Growth Rate	Inflation Rate* 4%	Inflation Rate* 6%	Inflation Rate* 8%	Unemployment Rate 4%	Unemployment Rate 6%	Unemployment Rate 8%
Date						
1960 I				5.8	5.8	5.8
II	1.9	2.0	2.0	5.9	5.8	5.8
III	1.7	1.9	2.1	5.9	5.7	5.5
IV	1.7	2.0	2.3	5.6	5.3	4.9
1961 I	1.7	2.2	2.7	5.3	4.7	4.1
II	1.8	2.5	3.2	5.0	4.2	3.5
III	2.0	2.9	3.7	4.7	3.8	2.9
IV	2.2	3.2	4.2	4.5	3.5	2.4
1962 I	2.3	3.6	4.8	4.4	3.2	2.0
II	2.5	3.9	5.4	4.2	2.9	1.5
III	2.7	4.3	6.1	4.0	2.6	1.2
IV	2.8	4.7	6.9	4.0	2.5	1.0
1963 I	3.0	5.0	7.9	4.0	2.4	0.9
II	3.0	5.3	9.2	4.0	2.4	1.0
III	3.1	5.7	10.8	4.1	2.5	1.2
IV	3.2	6.1	12.0	4.1	2.5	1.4
1964 I	3.3	6.5	13.8	4.1	2.6	1.8
II	3.4	7.0	15.3	4.0	2.6	2.3
III	3.5	7.3	16.7	3.9	2.6	2.9
IV	3.6	7.7	17.8	4.0	2.9	3.7
1965 I	3.6	8.1	18.8	4.2	3.2	4.6
II	3.7	8.4	19.4	4.3	3.5	5.6
III	3.8	8.6	19.6	4.3	3.7	6.4
IV	4.0	8.8	19.5	4.1	3.8	7.2

---

*Annual percentage rate

Table 2

Simulation Results From Rational Expectations
Version of St. Louis Model

M1 Growth Rate		Inflation Rate* 4%	6%	8%	Unemployment Rate 4%	6%	8%
Date							
1960	I				5.8	5.8	5.8
	II	1.0	1.5	2.0	5.8	5.8	5.7
	III	1.3	2.6	3.8	5.7	5.6	5.4
	IV	2.5	4.5	6.5	5.5	5.2	5.0
1961	I	4.1	6.7	9.4	5.2	4.9	4.6
	II	5.4	8.5	11.6	5.1	4.8	4.5
	III	6.2	9.5	12.7	5.1	4.9	4.6
	IV	6.2	9.5	12.7	5.3	5.0	4.8
1962	I	5.8	8.8	11.8	5.4	5.2	5.0
	II	5.2	8.0	10.8	5.5	5.4	5.2
	III	4.4	7.0	9.5	5.5	5.4	5.2
	IV	3.5	5.9	8.3	5.6	5.5	5.3
1963	I	2.7	5.0	7.3	5.6	5.5	5.4
	II	2.0	4.4	6.7	5.6	5.5	5.3
	III	1.7	4.1	6.4	5.6	5.5	5.3
	IV	1.8	4.2	6.4	5.5	5.4	5.2
1964	I	2.3	4.5	6.9	5.4	5.3	5.1
	II	3.1	5.3	7.4	5.3	5.1	4.9
	III	3.5	5.6	7.6	5.2	5.0	5.0
	IV	3.4	5.6	7.6	5.3	5.1	5.0
1965	I	3.1	5.3	7.3	5.4	5.2	5.0
	II	2.9	5.1	7.2	5.4	5.3	5.1
	III	3.1	5.3	7.4	5.4	5.2	5.0
	IV	3.6	5.6	7.6	5.2	5.1	4.9

*Annual percentage rate

The unemployment rates for the four and eight percent rational simulations never differ by more than six-tenths of one percent, and the mean difference is only three-tenths. In contrast, the four and eight percent simulation unemployment rates from the original model differ, at times, by over three percent, and the mean difference is 1.2 percent, four times larger than that for the rational expectations simulations.

The large short-term decreases in the unemployment rate produced by increasing the money growth rate in the original model result from systematically mistaken expectations of the inflation rate. This can be seen by examining the difference in the rate of inflation and the expected rate of inflation implicit in different model simulations. Table 3 includes the values of the "expected forecast error" calculated as

$$(4) \qquad FE = \frac{\Delta p_t^e}{p_{t-1}} - \frac{\Delta p_t}{p_{t-1}}$$

where Δp_t^e, Δp_t, and p_{t-1} are values from the two and eight percent money growth simulations of the original model. The two percent growth rate was chosen for this illustration because two percent was approximately the average rate of money supply growth over the sample period.

The eight percent simulation shows a mean forecast error roughly ten times that of the two percent simulation and a root mean square forecast error roughly fifteen times larger. The pattern of the errors in the eight percent simulation is especially instructive. The agents in this model are expected to underestimate the inflation rate by more than three percent for six consecutive quarters and by more than two percent of ten consecutive quarters. The absolute size of these errors and the slowness with which expectations "catch up" to actual inflation will seem "unrealistic" to many readers. But the belief,

Table 3

Errors in Forecasts of Inflation Implicit in Simulation of Original St. Louis Model

	2% Money Growth	8% Money Growth
	Forecast errors* in percent at annual rates	
1960I	0.25%	0.20%
	0.34	0.10
	0.39	-0.16
	0.39	-0.62
1961I	0.31	-1.18
	0.22	-1.76
	0.14	-2.31
	0.07	-2.78
1962I	0.00	-3.16
	-0.08	-3.47
	-0.12	-3.65
	-0.11	-3.69
1963I	-0.07	-3.59
	0.00	-3.33
	0.07	-2.94
	0.13	-2.42
1964I	0.13	-1.82
	0.09	-1.15
	0.07	0.46
	0.10	0.46
1965I	0.14	1.31
	0.16	2.11
	0.10	2.82
	-0.01	3.46

---

*Negative value indicates inflation will be underestimated by agents.

based on a simulation of this model, that a sustained high rate of money growth will drive down the unemployment rate is predicated on just such a pattern of forecasting errors.

B. The FMP Model

The changes to the FMP model to impose rational expectations are much more extensive than those made to the St. Louis model. Expectational distributed lags were replaced in several equations. The most important of these are the Phillips curve, demand for consumer durables, cost of capital identity, and the interest rate term-structure equation.

The coefficients of the expectations terms were chosen to be consistent with the natural rate and efficient market hypotheses. In the Phillips curve, for example, the coefficient of expected inflation was chosen to be exactly one. Such choices probably maximize the impact of this rational expectations alteration to the model's structure.

The results of two sets of constant money growth simulations are reported in Tables 4 and 5. As in the St. Louis model, the imposition of rational expectations greatly reduces the real impact of sustained monetary expansion. Neither the original or transformed version demonstrates an observable trade off of the type that was evident with the original St. Louis model. This probably results from using a simulation period in which the intended model generates high rates of unemployment. In the FMP model, monetary expansion has little effect on prices at such high unemployment levels. The choice of a different sample period probably could bring forth a trade off similar to that observed in the previous section.

Table 4

Simulation Results From Original Version of FMP Model

M1 Growth Rate	Inflation Rate* 4%	Inflation Rate* 6%	Inflation Rate* 8%	Unemployment Rate 4%	Unemployment Rate 6%	Unemployment Rate 8%
Date						
1971 I				7.6	7.6	7.6
II	3.4	3.4	3.4	7.6	7.6	7.6
III	1.7	1.7	1.7	7.0	6.9	6.8
IV	1.4	1.4	1.4	6.9	6.8	6.7
1972 I	5.7	5.7	5.7	7.7	7.5	7.3
II	0.8	0.8	1.4	7.8	7.4	7.1
III	2.5	2.8	2.8	7.4	6.9	6.4
IV	3.6	3.9	3.9	8.0	7.2	6.6
1973 I	4.7	4.7	4.9	8.3	7.3	6.5
II	5.1	5.4	5.7	8.4	7.0	5.9
III	4.8	4.8	5.3	8.6	6.7	5.1
IV	4.0	4.7	5.5	8.5	6.1	4.0
1974 I	6.0	6.8	9.1	8.3	5.5	2.9
II	5.9	0.5	4.1	8.6	5.4	2.3
III	3.1	4.4	9.5	8.6	5.0	1.6

*Annual percentage rate

Table 5

Simulation Results From Rational Expectations
Version of FMP Model

	Inflation Rate*			Unemployment Rate		
M1 Growth Rate	4%	6%	8%	4%	6%	8%
Date						
1971 I	4.6	4.6	4.6	7.7	7.7	7.7
II	4.6	4.6	4.6	8.0	8.0	8.0
III	3.1	3.1	3.2	7.9	7.8	7.8
IV	1.1	1.1	1.2	8.4	8.3	8.3
1972 I	6.2	6.1	6.2	9.6	9.6	9.5
II	1.1	1.2	1.6	10.0	10.0	9.9
III	3.0	3.0	3.0	9.8	9.7	9.6
IV	3.6	3.6	3.7	10.3	10.2	10.1
1973 I	4.3	4.4	4.4	10.2	10.0	9.9
II	4.6	4.8	4.9	9.4	9.2	9.0
III	2.7	3.0	3.3	8.3	8.1	7.8
IV	2.4	2.9	3.6	6.6	6.3	5.9
1974 I	5.2	5.9	7.5	4.4	4.0	3.6
II	-0.3	2.1	6.7	2.4	2.0	1.4

---

*Annual percentage rate

C. Further Considerations

In the examples presented here, models are altered to impose that expectations of the current period's (as yet unobservable) prices be consistent with the model's own forecasts. Rationality in the forecasting of other important variables can be handled in the same way.

In particular, a consumption function derived from the life-cycle hypothesis relates current consumption to current and (expected) future incomes. If we could econometrically identify the coefficients of those forecast terms, the multiperiod simulation technique proposed above could be used to implement rational expectations of future income.

In particular, simulation of the effects of different tax policies in a model which maintained efficient forecasts of future incomes might provide an interesting comparison with the recent results of Modigliani and Steindel [1977]. They find that simulations of the MPS and DRI models seem to imply that a temporary tax rebate provides more short-term stimulus to the economy than a permanent tax cut of equal dollar value in the first year of the policy. It is possible that the one-time rebate does not cause agents to revise their expectations of future incomes upward, while the permanent tax cut does engender such optimism. (In fact, in the case of the rebate, recognition of the created tax liability might suggest a downward adjustment.) However, the distributed lags of those two models cannot distinguish between the two cases. The large income increment in the quarter the rebate is disbursed will unavoidably cause the "agents" of those models to project higher incomes. In a model which treated expectations explicitly, the results of the Modigliani-Steindel experiment might be quite different.

Conclusion

Our purpose has been to demonstrate that the rational expectations hypothesis may be implemented in econometric models to help improve econometric policy evaluation, as Lucas stated. While the experiments described here may seem arbitrary and ad hoc, that appearance stems largely from the lack of explicit microfoundations for the model relationships examined. The method of simulation described here should become less arbitrary as model builders implement more microeconomic theory in their structural equations. In particular, models in which agents optimize over time under uncertainty can deliver the explicit expectational terms and identifying restrictions to permit a treatment of this type.

Footnotes

[1]/The assumption made in most econometric models that certain quantities controlled by the government may be considered exogenous has been approached (by some) with skepticism, e.g., see Nelson [1977].

[2]/An example is the remark by Fromm and Klein [1976] about "third-party scholars."

[3]/Here he refers to fixed-weight distributed lags of past prices.

[4]/Of course, skilled detective work may push "discovery" back another twenty years. A similar concept is considered in Modigliani and Grunberg [1954].

[5]/Cyert and DeGroot [1974] define a concept of consistent expectation which is identical with rational expectations under the maintained hypothesis that we know the true model (the assumption I maintain during these experiments).

[6]/Price is only one of many economic variables that agents may wish to forecast.

[7]/The references for these models are well-known. The St. Louis Federal Reserve model was first described in Anderson and Jordan [1970]. An early version of FMP is described by deLeewuv and Gramlich [1968]. The version of the FMP we actually use is that one existing at the Federal Reserve just prior to the major GNP accounts revision. A newer version has been specified and estimated using revised data.

References

Anderson, Leonall C., and Keith M. Carlson, 1970, "A Monetarist Model for Economic Stabilization Policy," Federal Reserve Bank of St. Louis Review, April, pp. 7-25.

Cyert, R. M., and M. H. DeGroot, 1974, "Rational Expectations and Bayesian Analysis," Journal of Political Economy, Volume LXXXII, May.

deLeewuv, F., and E. Gramlich, 1968, "The Federal Reserve-MIT Econometric Model," Federal Reserve Bulletin, January.

Fromm, Gary, and Lawrence Klein, 1976, "The NBER-NSF Model Comparison Seminar: An Analysis of Results," Annals of Economic and Social Measurement, Volume 5, Number 1, pp. 1-29.

Koopmans, Tjalbg, 1947, "Measurement Without Theory," Review of Economics and Statistics, Volume 29, pp. 161-172.

Lucas, Robert E., Jr., 1976, "Econometric Policy Evaluation: A Critique," in Karl Brunner and Allan Meltzer, eds., The Phillips Curve and Labor Markets, (North Holland, Amsterdam), pp. 19-46.

Modigliani, Franco, and Emile Grunberg, 1954, "The Predictability of Social Events," Journal of Political Economy, Volume XLII, pp. 465-478.

________________, and Charles Steindel, 1977, "Is a Tax Rebate an Effective Tool for Stabilization Policy?," Brookings Papers on Economic Activity, March 1977.

Muench, Thomas, J., and Neil Wallace, 1974, "On Stabilization Policy: Goals and Models," American Economic Review, Volume 64, pp. 330-337.

Muth, John F., 1961, "Rational Expectations and the Theory of Price Movements," Econometrica, Volume XXVIIII, pp. 315-325.

Nelson, Charles R., 1972, "The Prediction Performance of the FRB-MIT-Penn Model of the U.S. Economy," American Economic Review, Volume LXII, pp. 902-917.

________________, 1977, Review of The Brookings Model: Perspectives and Recent Developments, Gary Fromm and Lawrence Klein, eds., in Journal of Money, Credit and Banking, May 1977, pp. 375-377.

Nerlove, Marc, 1958, The Dynamics of Supply: Estimation of Farmers' Response to Price, (John Hopkins, Baltimore).

____________, 1961, "Time Series Analysis of the Supply of Agriculture Products," in Earl O. Heady, et al., eds., Agricultural Supply Functions, (Iowa State University Press, Ames).

References, continued

Shiller, Robert J., 1972, Rational Expectations and the Structure of Interest Rates, unpublished Ph.D. dissertation, Massachusetts Institute of Technology.

_______________, 1975, "Rational Expectations and the Dynamic Structure of Macroeconomic Models: A Critical Review," revised version of paper presented to the Conference on the Monetary Mechanism in Open Economies, (Helsinki), August 1975.

Sims, Christopher, 1977, "Exogeneity and Causal Ordering in Macroeconomic Models," in Preston Miller, ed., New Methods in Business Cycle Research: Proceedings From a Conference, (Minneapolis Federal Reserve Bank).