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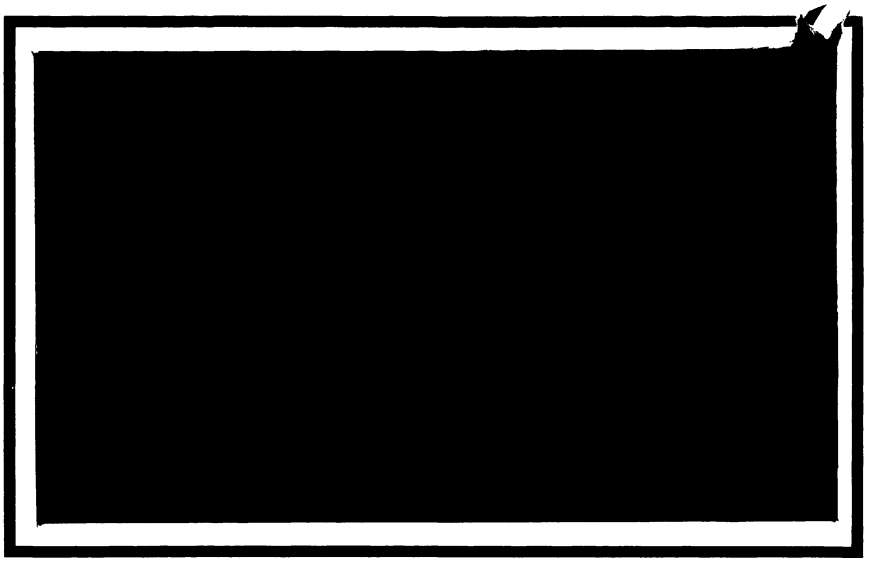

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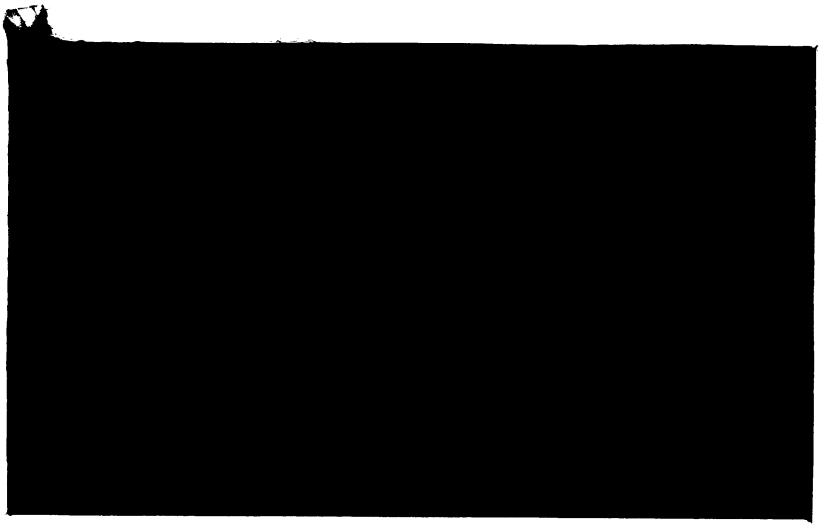

MACROECONOMETRICS AMIDST SENSE AND NONSENSE

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Abstract

This paper attempts to place the so-called Rational Expectations Revolution in macroeconomics into proper perspective regarding its implications both for policy analysis and econometric modelling. It is concluded that Rational Expectations is of much less practical importance to policy analysis than is commonly thought. The aspect of Rational Expectations known as the Lucas Critique, however, must be considered seriously in the process of econometric modelling, although its practical import may be far less sweeping than its proponents claim.

I. Introduction

Each November for the past thirty years the University of Michigan's Research Seminar in Quantitative Economics (RSQE) has published a forecast of macroeconomic activity in the United States for the following year or more. Obviously, these have all been true ex ante forecasts, and in addition they have all been based on a macroeconometric model developed by the research staff at RSQE. It was probably never the exact same model two years in a row. Rather, the model developed year by year as more knowledge was gained, more and better data became available, and more detailed information was desired. However, the only real discontinuity in model development occurred when RSQE switched from an annual to a quarterly model in about 1969-70.

During the 1960's Professor Daniel Suits, then the Director of RSQE, was often criticized for the fact that the model changed year by year. Econometricians complained that RSQE was frustrating science by making it impossible to evaluate the Michigan Model because no version ever existed for more than a year at a time. Suits argued that while he understood the frustration, it was simply more important to keep working on the model. He was quite satisfied that improvements were being made and that was the more appropriate thing to do. As I will argue subsequently,

Suits was undoubtedly quite right about what was the appropriate way to behave, and for more reasons than any of us would have understood a decade or more ago.

Has this macroeconometric forecasting activity been useful, valuable, successful? By the test of the market some necessary degree of success must have been achieved. The operation has remained in existence for 30 years with customers from the private sector paying for perceived value. That doesn't prove that our forecasts have been at all accurate in any absolute sense, only that we are roughly as reliable as other forecasters, for the price.

Consider Figure 1, however, which summarizes the recent record of our forecasts by focussing on actual and predicted annual changes in real GNP in billions of constant dollars for the period 1971-82.[1] Perfect forecasts would produce a scatter diagram with all points lying along the 45°-line, a virtual impossibility in a world of ε's.

Our results do, however, seem to be quite good. Over the period in question the annual first differences in real GNP ranged from a negative $28 billion to a positive $71 billion, with a mean of plus $26 billion and a standard deviation of $36 billion (all in round numbers). Our forecast error was under $9 billion in six of these twelve years, and exceeded $20 billion in only two of the years.

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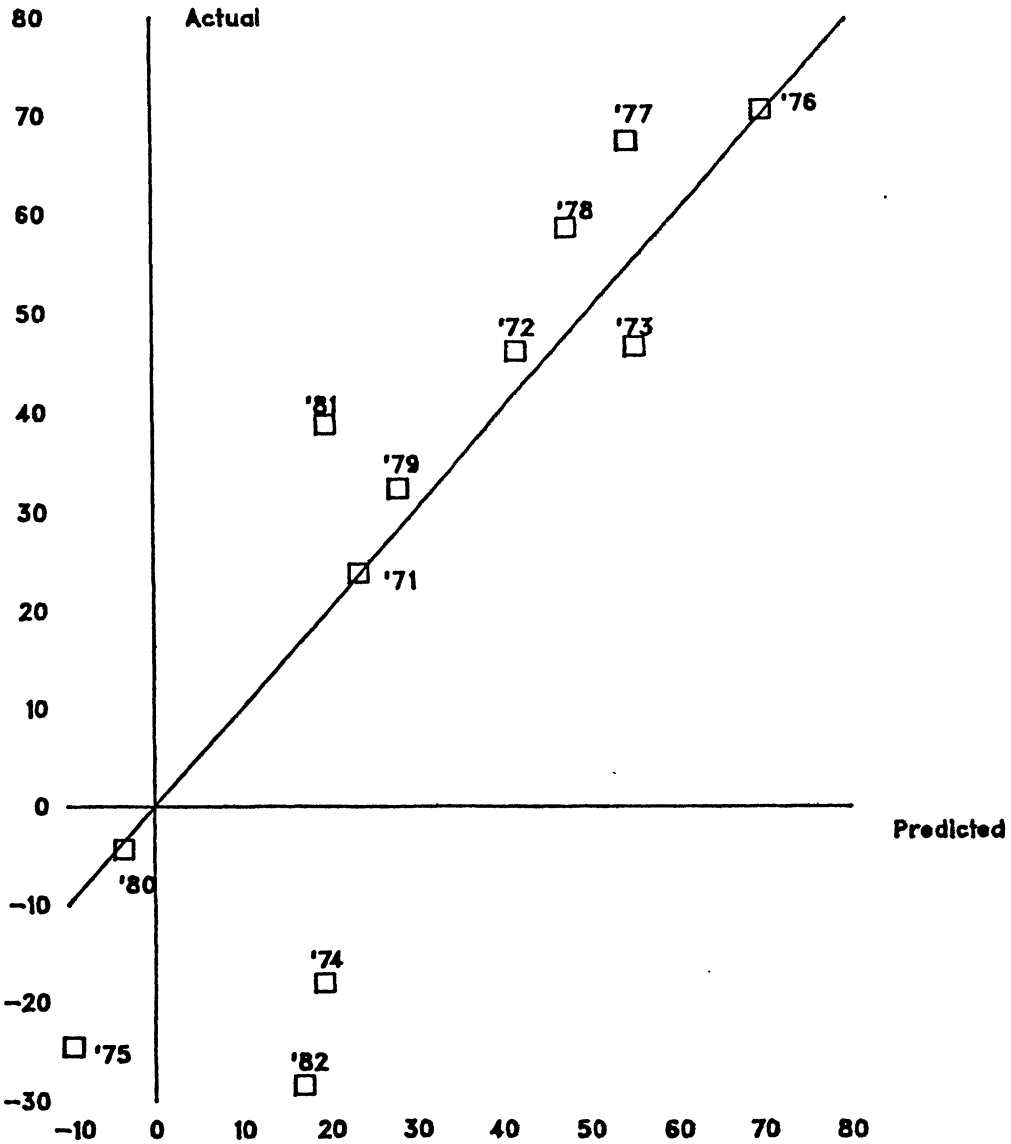
[1] For each year the predicted change in real GNP was forecast the preceding November. The constant dollars are 1972 dollars beginning with 1976, and 1958 dollars earlier. Source: Hymans, Crary and Howrey (1982), and subsequent published data revisions.

FIGURE 1
RSQE Forecast Accuracy, 1971–82
Annual change in Real GNP, Actual vs. RSQE Forecast
of Preceding November, billions of constant dollars



The latter are the two points which show up the furthest away from the 45°-line in Figure 1 and, indeed, lie in the fourth quadrant -- the only two cases in which we predicted the wrong sign for the change in real GNP. I would summarize Figure 1 as follows: When we were good, we were actually very good by any reasonable absolute standard, and that was about 70-80 percent of the time; when we were bad, we were quite bad, but at least they were few and far between.[2]

The RSQE record, as in Figure 1, is not unique. While I haven't done the comparable arithmetic for the other major U.S. models, I strongly suspect that a similar degree of success would be revealed. One would think that a record such as that revealed in Figure 1 would be accompanied by an enviable degree of respect for macroeconometric modeling among professional economists. How, then, can one explain the following statement written by Professor Christopher Sims in 1982: "... among academic macroeconomists the conventional methods (of macroeconometric modeling) have not just been attacked, they have been discredited."[3] Sims need not have qualified the statement by limiting it to macroeconomists.

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[2] I am quite aware that there is more to forecasting accuracy than just real GNP, but my point is to summarize here with a broad brush. For a more complete analysis see McNees (1981).

[3] Sims (1982) p.107, parenthesis added for clarity. It should be made clear that Sims himself argues against the validity of the state of affairs which the quoted statement properly reflects.

As I interpret developments of the past decade, I would describe the following sequence of events. The Rational Expectations (RE) School was launched in the early 1970's by two brilliantly insightful papers by Robert Lucas (1972A, 1972B).[4] These papers immediately raised important questions about econometric specification, questions not limited in applicability to macroeconometrics, and enunciated what is now referred to as the "Lucas Critique" of traditional econometrics. This was followed by a series of papers by Sargent and Wallace, e.g. (1973, 1976), which combined with Lucas' work to popularize the Rational Expectations Hypothesis (REH) -- essentially a theoretical demonstration of the inability of traditional macro-stabilization policies to have their putative effects on the real variables in the macroeconomy, sometimes called the "Policy Ineffectiveness" theorem.

The combination of the Lucas Critique and the Policy Ineffectiveness theorem -- often, even now, regarded by many as the same thing -- nearly removed all semblance of legitimacy from traditional macroeconometric modeling during the period from about the last third of the 1970's to about 1981 -- precisely when the major models were actually doing quite well. Within the past two years or so macroeconometrics has just begun to emerge from its consignment to the trash-heap. It's been marred and scarred

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[4] I distinguish between the RE School and the formal concept of RE which is generally attributed to the earlier work of Muth (1961).

and re-interpreted and it's not yet -- by any stretch of the imagination -- fully respectable. But it is re-emerging and, I suggest, in what will turn out to be a somewhat different form which will have profound implications for the processes of specification and estimation.

My purposes in the remainder of this paper will be

1) to explore the connection between Rational Expectations and the Lucas Critique,
2) to distinguish between the Lucas Critique and the so-called Rational Expectations Hypothesis,[5] and
3) to indicate why I believe macroeconometrics will survive the Lucas Critique, but in a somewhat altered state.

II. Rational Expectations and the Lucas Critique

Suppose that the economy may be appropriately represented by the following structural linear econometric model:

$$(1) \quad \Gamma y_t = \Phi y_t^* + \Theta y_{t-1} + \Psi x_t + \mu z_t + \varepsilon_t$$

where y_t, x_t, and z_t are vectors of endogenous, policy-instrument, and exogenous variables, respectively; y_t^* is a vector of unobservable expected or anticipated values

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[5] Kenneth Wallis's excellent paper (1980) notes this distinction in a framework similar to that used in this paper. Wallis, however, concentrates on the econometric problems, given an RE model; my purpose is to assess the importance of these matters for practical model construction.

corresponding to y_t; ε_t is a white noise disturbance vector; and Γ, Φ, Θ, Ψ and μ are coefficient matrices with Γ invertible. The equation system in (1) can be pre-multiplied by Γ^{-1} to yield the following reduced form:

$$(2) \quad y_t = Ay_t^* + By_{t-1} + Cx_t + Dz_t + v_t$$

where $v_t = \Gamma^{-1}\varepsilon_t$, $A = \Gamma^{-1}\Phi$, and so on.

If y_t^* is unobservable, the process generating y_t^* must be known if the model is to be useable. The RE School claims that the only tenable expectations generating process for an endogenous variable is one which is fully consistent with the structure which generates the observed values of the endogenous variable. Thus, y_t^* should be determined by the structural model itself and all the relevant data available at the time the expectation is formed. We shall therefore think of y_t^* as the Rational Expectation of y_t as of time t-1; i.e., $y_t^* = E(y_t|S_{t-1})$, the conditional expectation of y_t given the information set at time t-1 (S_{t-1}) which includes all relevant variables dated t-1 or earlier and the correct model as well.

With this understanding of y_t^* in (2) we can take the conditional expectation operator (*) through equation (2) to yield

$$(3)\quad y_t^* = Ay_t^* + By_{t-1} + Cx_t^* + Dz_t^*$$

since $E(y_t|S_{t-1}) = y_t^*$, by definition (and similarly for x_t^* and z_t^*);

$E(y_{t-1}|S_{t-1}) = y_{t-1}$, since S_{t-1} includes the information y_{t-1};

and $E(v_t|S_{t-1}) = 0$.

Assuming (3) to be well-defined, $(I-A)^{-1}$ exists and (3) may be solved to yield

$$(4)\quad y_t^* = (I-A)^{-1}(By_{t-1} + Cx_t^* + Dz_t^*).$$

Substituting the righthandside of (4) for y_t^* in (2), and noting that $(I-A)(I-A)^{-1} = I$ implies that $A(I-A)^{-1} = (I-A)^{-1}-I$, yields

$$(5)\quad y_t = (I-A)^{-1}(By_{t-1} + Cx_t^* + Dz_t^*) + C(x_t - x_t^*) + D(z_t - z_t^*) + v_t$$

or

$$(5')\quad y_t = y_t^* + C(x_t - x_t^*) + D(z_t - z_t^*) + v_t.$$

Equation (5') has the following interpretation: the endogenous variables will differ from their rational expectations only as the result of unpredictable policy settings ($x-x^*$) and unpredictable exogenous factors ($z-z^*$ and v); for later reference I label this result RE1.

Equation (5) has a further implication of great importance. Suppose the model is truly characterized by Rational Expectations, so that A is not a null matrix, and it is desired to <u>estimate</u> the parameter matrices in (5). Obviously, estimation will require that $[C(x_t - x_t^*) + D(z_t - z_t^*) + v_t] = w_t$ be treated as a composite disturbance. Suppose further that z_t^* is known to be determined via a first-order vector autoregressive process independent of (5) so that z_t^* may be represented by $\bar{D}z_{t-1}$. The model to be estimated is, therefore,

$$(5'') \quad y_t = [(I-A)^{-1}B]y_{t-1} + [(I-A)^{-1}C]x_t^* + [(I-A)^{-1}D\bar{D}]z_{t-1} + w_t$$

If x_t^* is unobservable but policy is set according to an understood policy rule involving variables already contained in (5'') and x_t^* is replaced by the conditional expectation of the policy rule equation, the resulting version of (5'') will be estimable. But predictions from the estimated equation will be valid only for the given policy rule which produced the estimable version of (5''). That is, the parameters in the estimable version of (5'') will involve a

confounding of the original structural parameters and the parameters of the policy rule, and the resulting equation cannot properly be used to simulate the effects of an alternative policy rule. This is the Lucas Critique of standard econometric policy simulation studies and will be labelled RE2.[6]

Note that RE1 has absolutely nothing to say about the path of y_t and is therefore of little practical importance; it merely extends to $(y_t - y_t^*) = [y_t - E(y_t|S_{t-1})]$ a property analogous to that applying to $(y_t - Ey_t)$. The Lucas Critique, however, is of more fundamental importance. It makes clear that the existence of a policy rule (i.e., purposeful economic policy) in a Rational Expectations context spells trouble. Without Rational Expectations, we could estimate equation (5) using the observed policy settings x_t and then simulate the resulting equation to estimate the impact of a change in policy, even if policy is set by a policy rule.[7] Before continuing with this concern

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[6] In fact, as Albert Ando has pointed out to me, RE2 is a special case of a general problem which always results from the presence of unobservables, regardless of the form of the model.

[7] Note that if A = 0 in equation (5) so that no expectations enter, or if y_t^* refers to some expectation process which can be written down independently of the model itself, the estimable equation system will contain x_t, not x_t^*. In effect, we are back to equation (2) (with a direct substitution for y_t^* if $A \neq 0$). Then if policy is determined by a rule dependent on endogenous variables,

deriving from the Lucas Critique (RE2) let us consider the Policy Ineffectiveness theorem to see whether that adds further complications.

III. Rational Expectations and Policy Ineffectiveness

There is little point to worrying about RE2 if stabilization policy is a waste of time because it has none of its putative effects. That result -- a tax cut won't increase real GNP, tight money won't raise unemployment, etc. -- has been mislabeled the Rational Expectations Hypothesis. That is, it is often thought that RE is sufficient for REH; in fact RE is not even necessary for REH. And, in particular, RE1 is not REH.

Equation (5') says that y_t will differ from y_t^* only to the extent that there are unanticipated policy disturbances $(x_t - x_t^*)$. That is not the same as saying that standard, conscious, anticipated stabilization policy has no effect on y_t or y_t^*. Indeed, according to equation (4) x_t^* will in general affect some components of y_t^* unless $(I-A)^{-1}C$ is a null matrix. And if the first element of y_t^* is, for example, real GNP, then anticipated policy will affect anticipated (and actual) real GNP unless the first row of

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proper estimation will require an instrumental variable procedure, but econometric model simulation will remain a legitimate technique for policy evaluation. The latter result is well known; see Goldfeld and Blinder (1972).

$(I-A)^{-1}$ is orthogonal to the columns of C; that is, unless some special economic structure beyond just RE is assumed. The most obvious such assumption is, of course, perfect price flexibility and instantaneous market-clearing, and that indeed is the basis for REH.[8] But that is nothing new. It has long been known that instantaneous market-clearing leaves monetary and fiscal policies affecting nominal variables and the composition of real aggregates, but not the level of real aggregates such as total output and employment. If this had any relevance to the real world, macroeconomics would never even have developed as a policy-relevant area of economics.

It hardly seems necessary to spend much time trying to prove that instantaneous market clearing is importantly counterfactual. If the REH -- the Policy Ineffectiveness Theorem -- depends critically on a grossly counterfactual assumption, it can be dismissed as an interesting theorem. Standard stabilization policy may be ineffective or even counterproductive on particular occasions, but not of necessity.

What remains, therefore, is RE2 -- the Lucas Critique -- not REH.

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[8] See, for example, Sargent and Wallace (1976), Wallis (1980), and the very interesting book by David K.H. Begg (1982).

IV. Macroeconometric Modelling after the Lucas Critique

Rational Expectations implies not that stabilization policy doesn't work, but that econometricians may have to figure out an entirely new way to estimate the effects of stabilization policies. Thus, Rational Expectations is not destructive of governmental stabilization policy, but is there justifiable concern that it might be quite destructive of macroeconometric modelling as we know it?

Can it really be, in other words, that expectations are rational in the sense required to vitiate standard econometric modelling? Consider again the process of going from equation (2) to equation (5). That is deceptively simple mathematics which serves only to disguise a terribly formidable information requirement. Somehow, economic agents have to know or sense or behave as if they know the numerical details of a complex economic structure which the best econometricians will then have an extremely difficult time even estimating. And unless lots of agents do succeed in this regard there won't be any Darwinian process steering the rest to behave as if they also understood the quantitative details of the structure.[9]

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[9] The only reason the steps from equation (2) to equation (5) are even deceptively simple, is that I have assumed that no term like y^*_{t+1} appears in the model. If rational expectations of future values are present, the mathematics are not even deceptively simple and the solution properties of the model are highly problematical. See Begg (1982, Chapter 3) and Chow (1981, Chapter 15).

All this doesn't prove that an RE representation of the economic system isn't the most nearly correct, but it hardly seems likely enough to adopt as the working hypothesis.

Further, even if we grant Rational Expectations, is it clear that policy rules really do change in the sense required for the Lucas Critique to have force? Do the policy authorities switch from one regime which shapes all expectations of the relevant future to an entirely new, previously unheard of regime which immediately reshapes all expectations of the relevant future. Sims presents a series of forceful political and economic arguments against this interpretation in his "Policy Analysis with Econometric Models" [Sims, (1982)].

Let me suggest a slightly different line of argument based on an example. Suppose that some disturbance or set of disturbances has produced an excessively large capital/output ratio.[10] Under normal, equilibrium conditions a few years of growth would generate a high enough level of output to justify the capital stock. Initially, of course, excess capacity will cause investment demand to diminish which will reduce the level (hence, growth) of output unless prices are sufficiently flexible to keep aggregate demand from declining. Absent the requisite degree of immediate price flexibility, demand and production will contract until enough capital is "worn away" or something else happens to

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[10] Capital can be thought of in this context as either fixed capital or inventories (non-financial working capital).

raise demand and output. Should the policy authorities leave the economy in the resulting recession, or try and speed the economy on its way back toward what would be considered the normal level of production and employment?

What expectations would be generated if the monetary authorities elected to increase the rate of growth of the money supply? Would the public regard this as a permanent change in policy? Why should anyone think so? Presumably the central bank has done this sort of thing before, there is nothing in the situation to suggest that anyone thinks the economy's natural growth rate has increased, so why would the monetary authorities be altering the growth of the money supply permanently, and why would it be rational for anyone to behave as though it were? This policy is clearly a transitory easing of credit conditions to induce an increase in demand and return the economy to its normal path more rapidly than would otherwise occur. The rational expectation should be that money growth will ultimately return to its normal or expected path as well, as it normally does following a cyclical deviation.

Viewed this way, it would seem to be unlikely that the Lucas Critique would apply routinely to most situations that we speak of loosely as a change in policy. But now let me suggest a recent instance in which it might have applied. In 1981, the Reagan Administration engineered a three-step 25 percent cut in personal income taxes, along with a big increase in the planned path of defense spending, and

promised that the result would be declining budget deficits and, within three years, a balanced budget. Within about six months it dawned on most people that if this policy were allowed to continue as planned, the result would be huge deficits which would at first worsen and then at least persist for many years into the future. This was indeed a seemingly permanent policy change which implied persistent upward pressure on interest rates. The result was an almost immediate increase in interest rates of sufficient magnitude to negate the fiscal stimulus. The economy was in a recession and stayed in the recession despite an obviously stimulative fiscal policy.

A new policy regime and a real shift in expectations about interest rates -- and interest rates are indeed highly flexible -- produced a result highly suggestive of both the Lucas Critique and the Ineffectiveness theorem. The conditions were just right: the policy was dramatically different, and the market most affected was highly efficient. Money market efficiency is, of course, not at all surprising. Similar efficiency in the setting of multitudes of prices and wages is beyond the realm of possibility.

V. The Moral of the Story

The lasting impact of the Rational Expectations Revolution will be that it has forced the profession to more careful thought about the determination and modeling of expectations formation processes. Perhaps it will even lead to more serious attempts to measure expectational variables.

It will also have led us away from the fanciful notion that macroeconometric models can and should be faithful translations of dynamic microeconomic theory. For one thing, there isn't much in the way of useful dynamic micro theory, particularly if micro behavior is not dominated by instantaneous market-clearing.

Thus, as Sims recently put it (1982, pp.122-123): "... existing large-scale models ... represent a valuable summary of a great deal of historical experience and ... forecasts from them are useful. ... the identifying restrictions are pragmatically adjusted to avoid obvious conflicts with the data, so that they can be regarded as convenient simplifications." In essence this means that macroeconometric models can be regarded as something between an atheoretical vector autoregression and a classical structural econometric model.[11] There should be more lags on more variables than we might understand from a microtheoretic viewpoint.[12] But we can surely continue to use what we do understand or believe about how the macroeconomy works to exclude certain current endogenous

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[11] See Malinvaud (1981) and Feldstein (1982) for discussions of policy analysis and econometrics which are consistent with this view.

[12] There is another reason to expect long lags to appear in macroeconometric equations, and that has to do with proper temporal aggregation. It can be shown that if the true structural equation involves monthly behavior, proper aggregation to calendar quarters will require that the number of quarterly lags exceed the number of monthly lags in the original behavioral equation. See Greene (1982, Chapter 3).

variables from certain equations. That is, we can and should continue to use the identifying restrictions which we understand from theory and prior empirical analyses. It should of course be recognized that such systems are not truly behavioral. They combine provisionally accepted behavioral insights with so-called "final form" properties. As such, the estimated parameters may not exhibit long run statistical stability. The research agenda in model construction must include routine testing of parameter stability, careful consideration of possible regime changes -- including occasional changes in policy regimes, technological shifts, changes in tastes, and so on -- and the willingness to prune the sample period of observations irrelevant to the current behavior of certain variables. Practicing model proprietors have long behaved in just about this way and will have to continue to do so.

Economics is a social science. Some of us may have tried to forget that for a while, but we're slowly returning home and macroeconometrics should improve in the process.

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