Research Review

New Developments in Macroeconomic Theory: A Prospectus and Appraisal

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Although the battles that are fought in [the economics literature] appear to be fought with antique pop guns, the bullets are real and they may soon be fired at you

Robert Solow

Introduction

There is no longer, if there ever was, any question but that the workings of the macroeconomy have major impacts on the agricultural sector Indeed, one of the invited paper sessions at the 1982 American Agricultural Economics Association (AAEA) meetings focused exclusively on "Current Macroeconomic Policies and U S Agriculture " Furthermore, some of the important influences of macroeconomic policy on the farm sector have been recently and extensively discussed in an excellent survey article by Prentice and Schertz (*80*) and in an article by Tweeten (*108*) in which the latter goes so far as to state that "the economic structure of the farming industry in the long run will depend more on federal taxation, money supply and trade policies in the Federal Reserve System, the Internal Revenue Service, and Department of State than on commodity programs in the U S Department of Agriculture" (*108*, p 864) [1] Although the Prentice and Schertz monograph provides a useful discussion of standard monetarist and Keynesian theories, both of which to varying degrees provided the foundation for the economic policies implemented during the fifties through the midseventies, a new theory—the new classical macroeconomics—also merits attention This recent theory gained prominence during the turbulent seventies, when the claims that fiscal and monetary policy could smooth the business cycle were called into question Broadly contemptuous of the fact that the predominant views of the macroeconomy seemed to be unable to explain the recent period of simultaneously high inflation and sluggish output growth, some economists claimed this new theory could explain how to reduce inflation quickly and without loss of output

We believe it is in the interest of the agricultural community to become familiar with this new theoretical development in macroeconomics because it may, as Tweeten suggests, have a substantial influence eventually on what happens in the agricultural sector Moreover, this theory already has operational components directly applicable to the agricultural sector (see, for example, *13, 33, 37, 41, 102, 105*) Our article will, therefore, attempt to present, as well as to appraise, the new classical macroeconomics One of our major conclusions is that the new classical economics is far more complementary with traditional macroeconomic theory than either advocates or detractors have thus far emphasized

The New Classical Macroeconomics

A crucial element of the new classical approach is the modeling of business cycles within an equilibrium framework As it is assumed that expectations are formed rationally, these models are frequently referred to as rational expectations models However, this assumption is but one of several identifying this class of models [2] The other major assumptions are (1) perfect wage and price flexibility will occur, leading to continuous market clearing, (2) economic agents possess imperfect information about some important economic variables, (3) some form of the "Lucas-Rapping supply function" applies in which (as described later) nominal shocks have only temporary influences on real variables, and (4) a variant of the natural rate hypothesis

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[1] Italicized numbers in parentheses refer to items in the References at the end of this article

[2] We shall describe these models synonymously as new classical, rational expectations, or equilibrium cycle models

holds in which perceived nominal variables produce no real effects The importance of these assumptions will become clear as we describe a basic rational expectations model

Rational Expectations Defined

The concept of rational expectations was first postulated by Muth (*74*) when he suggested that, as expectations are informed predictions of future events, it seems only reasonable to consider them exactly like predictions from a relevant theory of economic behavior This postulate can be stated more rigorously as follows Based on a given information set, the subjective probability distributions of outcomes are assumed to be distributed about the objective probability distributions of outcomes This equating of subjective and objective probability distributions is based on the notion that, because information is a relatively scarce commodity, economic agents within an economy will use it optimally More specifically, the structure of the pertinent economic model is assumed to be information which is known and thus used in the formation of expectation [3] However, it is not assumed that the predictions of individuals are always correct (perfect foresight) or that expectations are the same for all agents (homogeneous expectations)

Malliaris and Brock (*70*) contend that rational expectations is a plausible theory because (1) the hypothesis is applicable to all dynamic problems, and expectations in different markets would not have to be treated in different ways, (2) if expectations were not moderately rational, there would be opportunities to make profits, and (3) rational expectations is a hypothesis that can be modified with its analytical methods remaining applicable in systems with incomplete or incorrect information (*70*, p 153)

A Basic Rational Expectations Model: Its Policy Implications

We will use a simple model developed by Sargent and Wallace (*90*) to describe the basic features of a rational expectations model We start by assuming that the demand for goods and services (an IS equation) is given by the following equation (where all subsequent variables except the interest rate are in natural logarithms)

$$Y_t^d = Y_p - \alpha(r_t - P_t^e) + u_{1t} \qquad (1)$$

where

Y_t^d = demand for goods and services,
Y_p = the trend or natural level of output,
r_t = the nominal rate of interest,
P_{t+1}^e = expected price for period t + 1 determined in period t,
$\dot{P}_t^e$ = The expected rate of inflation determined in period t − 1—that is, $(P_{t+1}^e - P_t^e)$, and
u_{1t} = a random error term such that $u_{1t} \sim N(0, \sigma_1^2)$

Turning to the money market (or an LM equation), we can assume that the money demand function is given by

$$M_t^d = P_t + \gamma Y_t - \tau r_t + u_{2t} \qquad (2)$$

where

M_t^d = the demand of money,
P_t = actual price level during period t,
Y_t = equilibrium output, and
u_{2t} = a random error term with $u_{2t} \sim N(0, \sigma_2^2)$

whereas the money supply (M^s) is exogenously determined by monetary authorities and will be explained more fully

Aggregate supply is assumed to be given by the following equation [4]

$$Y_t^s = Y_p + \beta(P_t - P_t^e) + u_{3t} \qquad (3)$$

where

Y_t^s = aggregate supply,
U_{3t} = a random error term such that $u_{3t} \sim N(0, \sigma_3^2)$,

and the other variables are as described above

[3] Adaptive expectations is another widely employed expectation scheme, whereby the expectations of a variable are based solely on past values of that variable Only in the unlikely case that prices, when actually modeled, are found to display a random walk will rational and adaptive expectations yield the same results

[4] Notice that when there is no uncertainty so that $P_t^e = P_t$, then the aggregate supply curve becomes vertical and one obtains essentially the classical model—hence, the term new classical macroeconomics For the theoretical development of the new classical aggregate supply curve, see (*58, 60, 62, 94*)

Using equations (1), (2), and (3) and the equilibrium or market clearing conditions, $M^d = M^s = M$ and $Y^d = Y^s = Y$, to solve for the reduced-form price equation, one obtains:

$$P_t = \frac{-\gamma\alpha}{D} Y_p + \frac{\tau\alpha}{D} P^e_{t+1} + \frac{(\beta - \alpha)\tau + \beta\gamma\alpha}{D} P^e_t + \frac{\alpha}{D}(M_t - u_{2t}) + \frac{\tau}{D} u_{1t} - \frac{\tau + \gamma\alpha}{D} u_{3t} \quad (4)$$

where $D = \beta\tau + \alpha + \gamma\beta\alpha$

Assuming that expectations are formed rationally, then

$$P_t = E(P_t | \Omega_{t-1}) \quad (5)$$

where Ω_{t-1} represents the information set available to every economic agent at time $t - 1$

Applying the conditional expectations operator to equation (4), one obtains

$$E(P_t) = \frac{-\gamma\alpha}{D} Y_p + \frac{\tau\alpha}{D} E(P_{t+1}) + \frac{(\beta - \alpha)\tau + \beta\gamma\alpha}{D} E(P_t) + \frac{\alpha}{D} E(M_t) \quad (6)$$

This equation states that the conditional expectation of the price level is determined by future price expectations and the expected money stock. Next, we subtract the expected price level from the actual price level, yielding,

$$P_t - E(P_t) = \frac{\tau}{D} = u_{1t} - \frac{(\tau + \gamma\alpha)}{D} u_{3t} - \frac{\alpha}{D} u_{2t} + \frac{\alpha(M_t - E(M_t))}{D} \quad (7)$$

Substituting equation (7) into equation (3) yields

$$Y_t = Y_p + \frac{\alpha\beta}{D}(M_t - E(M_t)) + u_t \quad (8)$$

where $u_t = \frac{\beta\tau}{D} u_{1t} - \frac{\beta\alpha}{D} u_{2t} - \frac{\beta(\tau + \gamma\alpha)}{D} u_{3t}$

According to equation (18), output depends only on the difference between the actual money supply and the expected money supply. To determine the expected money supply, we now postulate a policy feedback rule wherein policymakers attempt to stabilize output at the full employment level. This procedure is captured in the following equation

$$M^s_t = M_{t-1} + \lambda(Y_p - Y_{t-1}) + u_{4t} \quad (9)$$

where u_{4t} is a random error so that $u_{4t} \sim N(0, \sigma^2_4)$ [5] This equation indicates that the monetary authorities will increase (decrease) the money supply during recessionary (inflationary) periods. Based on the principle of rational expectations, one can now solve for the expected money supply. Doing so yields

$$E(M_t \mid \Omega_{t-1}) = M_{t-1} + \lambda(Y_p - Y_{t-1}) \quad (10)$$

Subtracting equation (10) from equation (9) yields $M_t - E(M_t) = u_{4t}$. This means that equation (8) reduces to

$$Y_t = Y_p + \frac{\alpha\beta}{D} u_{4t} + u_t \text{ or}$$

$$Y_t - Y_p = \frac{\alpha\beta}{D} u_{4t} + u_t \quad (11)$$

The importance of this result is that the systematic component λ is not present in equation (11), which means that the monetary authorities cannot systematically affect output. Only the random element in the money supply, u_{4t}, affects output, but this component represents unanticipated movements, and is thus uncontrollable by the monetary authorities. On the basis of this finding, Sargent and Wallace established the "superneutrality" proposition of monetary policy: differences between actual and full employment output follow a random

[5] It is assumed throughout that $E(u_i u_j) = 0$ for all $i \neq j$ where $i,j = 1, \ldots 4$. This assumption is somewhat dubious as equations (1-3) are simultaneous so that joint probability distributions are implied. Sargent and Wallace make this assumption for computational tractability, however, as this need not be the case, this particular approach is limited.

walk, and thus are not subject to being stabilized by the monetary authorities [6]

Okun (*77*) and Schultze (*92*) criticize Sargent and Wallace for pretending that "all the world were a wheat pit " They argue that the real world is predominantly composed of customer markets, not auction markets, which are based on forward contracts, thereby implying considerable wage and price rigidities Subsequent papers have, therefore, introduced rigidities into the Sargent-Wallace model and have then examined the resulting implications

Whether or not the strong policy impotence result holds will depend mainly on the specification of output given by equation (3) In one study, when Lucas (*57*) assumes that production is withheld in anticipation of higher prices in future periods, actual output is then influenced by the systematic component of the policy feedback rule In a subsequent article, however, McCallum (*65*) once again obtains the Sargent-Wallace neutrality result using the Lucas supply function specification, but only after discounting $E(P_{t+1})$ appropriately by the rate of interest

The policy impotence hypothesis no longer holds once certain modifications are made in the output supply equation For example, Fischer (*36*) specifies a model in which wages are constant for two periods because of contracts In this case, the aggregate supply function becomes

$$Y_t^s = \frac{1}{2} \sum_{i=1}^{2} (P_t - \underset{t-1}{E} (P_t)) + u_{3t} \qquad (12)$$

Aggregate supply is now no longer influenced only by the current informational error between actual and expected price Instead, monetary policy, even with the assumption of rational expectations, can systematically influence real wage rates and thereby aggregate output because the authorities' actions will not be fully and contemporaneously reflected in current nominal wage rates Taylor (*101*) and Gray (*46*) also develop similar models of overlapping wage contracts in which, in any given period, some contracts are being negotiated while others are still in force In this situation, monetary policy is again effective because of the sluggishness of wages relative to prices

Phelps and Taylor (*79*) specify yet another model, one based on the assumption that firms set their prices in the period previous to the one in which they sell their output This type of advanced price setting enables monetary policy to affect real variables without influencing prices in the current period The following aggregate output equation as posited by Phelps and Taylor incorporates this price stickiness

$$Y_t^s = \alpha_0 + \alpha_1 E_{t-1} (P_t) + \alpha_2 P_{t-1} + \alpha_3 M_t + u_{3t} \qquad (13)$$

In this type of model, monetary policy can clearly affect real output However, McCallum (*67*) demonstrates that slow price adjustment *per se* is not incompatible with the policy ineffectiveness hypothesis. One can demonstrate this hypothesis by positing an aggregate supply equation in which the superneutrality result holds no matter what rigidities are introduced The key factor guaranteeing the policy ineffectiveness hypothesis in this situation is that the length of the period during which the wage is rigid is no longer than the period for policy action to be effective [7]

The Problem of Persistence

Strictly interpreted, the expectational errors described above should be randomly distributed over time if expectations are formed rationally If so, it directly follows that output should be uncorrelated over time Needless to say, this is not the case

[6] Note that all right hand side variables are considered orthogonal to the error term when rational expectations models are estimated Thus, tests of causality or, more properly, exogeneity are closely linked to the time series models of rational expectations theorists (see, for example, (*84, 89*)) Unfortunately, causality tests are subject to serious theoretical and empirical complications which, in our view, limit their usefulness See (*28*) for a discussion of this point Note also that the emphasis is on cyclical movements, which is why applied rational expectationists detrend and deseasonalize their data One attempts to work with economic time series which are, in other words, covariance stationary and purely indeterministic

[7] Readers are advised to consult the survey article by McCallum (*68*) for a more complete discussion of alternative supply functions and their implications for policy effectiveness One might add that, although McCallum's counterexamples are effective debating points, they appear somewhat artificial in describing real world relative rigidities between wages and policy implementation Perhaps recognizing this, McCallum (*66*) provides a more recent and shrewder critique of sticky wage/price models

when one examines the data Quite the contrary, all the available evidence indicates that output and unemployment are highly serially correlated The observed "persistence" of positive output-price and money-output relationships over business cycles would seem to contradict policy neutrality

Most rational expectations supply functions are modified to include a lagged output term as an explanatory variable to account for this observed serial correlation However, this procedure for dealing with persistence has been criticized by Modigliani (*73*) as being *ad hoc*, as no rigorous theoretic framework is provided to justify the inclusion of this additional variable In response, rational expectations adherents have subsequently offered several explanations to account for the lagged term One explanation is based on the notion that costs of adjustment prevent instantaneous adjustments Another, advanced by Lucas (*55*) and explicitly derived by Sargent (*88*), is based on information lags which lead to serial correlation. More specifically, a model based on Phelps' (*78*) work with dispersed markets, called "islands," and informational discrepancies is used to generate demand-induced price-employment correlations in the economy as well as to provide a theory of the persistence effects associated with aggregate-demand shocks. Lucas' basic argument is that economic agents engaged in market activity are exposed to a continuum of dynamic and unanticipated opportunities that will not remain constant while an individual conducts an information search In such a situation, real and nominal effects cannot be immediately disentangled so that serial correlation occurs

Another explanation for serial correlation or persistence is based on the existence of inventories Blinder and Fischer (*14*) demonstrate that a sudden price change can be met by altering inventories so that changes in production will be less than sales If prices remain the same in the next period, production could be increased to rebuild inventories to their original level As a result, a lagged increase in production of varying duration would occur while the original inventory stock is being restored Even if no surprise price change occurred in time $t + 1$, the output gap in time $t + 1$ would still depend positively on the output gap in previous periods Unfortunately, none of these explanations for persistence appears entirely satisfactory

Rational Expectations, Stability, and Multiple Equilibria

Thus far we have examined the rational expectations hypothesis as well as the use of lagged variables to explain observed price and output movements Whenever lagged variables appear, however, the question of convergence of the economic system naturally arises When considering this question, Shiller (*95*) contends that "these (rational expectations) models may explode rather than converge because the expectations mechanism held at time t influences the behavior of Y and hence the revised expectations mechanism in time $t + 1$ Because of the arbitrary nature of the adjustment mechanism, we cannot generally tell which models will explode and which will not " Furthermore, he argues that the possibility exists that "we are left with a fundamental indeterminancy for the solution of rational expectation models and infinity of potential solutions for all but those degenerate models which yield zero order difference equations "

Both these issues are serious because they suggest that rational expectation models may be specified so as to permit the possibility of self-fulfilling unstable expectations As Flood and Garber (*38*) note, a price bubble can develop when the actual market price depends positively on its own expected rate of change Because economic agents under rational expectations will not make systematic prediction errors, price and its expected rate of change are positively related, suggesting a similar relationship between price and its actual rate of change Thus, one may be in a situation in which an "arbitrary self-fulfilling expectation of price change may drive actual price changes independently of market fundamentals" (*38*, p 746).

Rational expectations proponents vary in their response to this criticism Muth (*74*) originally attempted to dismiss this issue by pointing out that "for a bounded solution, the coefficient of the larger (unstable) root vanishes, the initial condition is then fitted to the coefficient of the smaller root " In other words, if the general solution for price is

$$P(t) = A_1\lambda_1 + A_2\lambda_2 \qquad (14)$$

and $\lambda_2 > 1$, then $A_2 = 0$ and A_1 is determined by the initial condition However, Sargent and Wallace

(*90*) argue against unstable roots because of "a terminal condition that has the effect of ruling out 'speculative bubbles'" Minford (*71*) expresses perhaps the most popular defense against this particular weakness when he asserts that past history has not provided examples of prices exploding to infinity Because this information becomes a part of the model itself, it is presumed that one need only consider converging solution [8] Nevertheless, those who believe the dynamics for explosive behavior still exist have challenged this argument, although admitting that some exogenous action (for example, policy) may serve to dampen the instability.

Burmeister (*20, 21*) believes the non-uniqueness question may be more serious for equilibrium models than for those models wielding "free parameters" and producing disequilibrium price adjustments which are anathema to the new classicists In any event, the issues of stability and multiple equilibrium have not yet been adequately resolved in the new classical economics literature

The Lucas Critique and Time-Inconsistency

Perhaps the most important consequence of the rational expectations literature is hypothesis, formulated by Lucas (*56*), that the behavior of economic entities is not invariant to changes in the economic environment For example, when the Government changes its policy rules, it is assumed that individuals will observe this change and modify their behavior so as to maximize their objective functions This means that traditional econometric models may be seriously flawed when used for policy analysis because these models simply extrapolate past behavior based on old policy rules into the future In econometric parlance, the linkage between behavioral and policy coefficients (referred to as "cross-equation restrictions") needs to be taken into account Stated another way, the coefficients in those equations describing the behavior of economic agents (such as supply and demand fuctions) should be restricted by the coefficients (or policy parameters) in those equations modeling economic policies Hansen and Sargent (*48, 49*) are among the first to do empirical work taking these restrictions into account, particularly with respect to large econometric models Their analysis suggests that incorporating the appropriate the appropriate restrictions will be extremely difficult [9]

Kydland and Prescott (*53*) and Prescott (*81*) have taken the "Lucas critique" one step further by arguing that formulating Government policy using optimal control theory is invalid when economic agents maximize their objective functions using rational expectations because any policy result will be either "time-inconsistent" or suboptimal By time-consistency, they mean the following Suppose individuals formulate their optimal behavior in an initial period t where they have accurately anticipated all future Government policy variable magnitudes for each time period over a finite horizon If these individuals follow their optimal plan until a period j and then recalculate an optimal plan for all succeeding periods, the original plan is considered to be time-consistent when the recalculated optimal plan is simply the continuation of the original plan derived in the first period for all periods after j Kydland and Prescott further state that when expectations are formed rationally by economic agents and when they are aware of the authorities' decision rule, the Bellman principle of optimality is inapplicable To understand their point, consider the optimal rule for patents as an instance of time-inconsistency Ideally, the Government would like to break its commitment with firms enjoying monopoly patent rights and thereby have the advantage of a competitive environment with the current technology now used under existing patents However, the Government would also have to pledge to honor future patents to stimulate new inventions In a future time period, however, these new inventions would be old and, once again, the Government could terminate all past patents As expressed by Barro, "the policy that optimizes at all dates subject to the initial conditions applying at those dates is subject to a time-inconsistent property where earlier plans are not followed through" (*4*, p. 59) Once anticipated by private individuals, a steady or fixed policy is a time-consistent policy, but

[8] However, price bubbles have occurred with individual commodities whether for 17th century Dutch tulips or for world sugar during the 1973 74 commodity boom See Conway (*25*) for a discussion of this issue

[9] The insight of Lucas is independent of rational expectations so that one could conceive of "irrational expectations" producing the same parameter instability in econometric models See (*12*) for estimation of a policy reaction function

it results in suboptimal technological advance Analogous policy considerations can easily be imaged within the context of the agricultural sector, such as international trade agreements, buffer stock price stabilization programs, and crop set-aside programs Some critics, like Modigliani (*73*), have argued that time-inconsistency would emerge as an obstacle only when policymakers and private individuals maximize heterogeneous and incompatible objective functions However, Calvo (*22*) has provided a counter example, demonstrating the possibility of a time-inconsistent result emerging *even* when policymakers and private individuals have the same objective functions

Kydland and Prescott's finding apparently supports the superiority of rules rather than discretion in the conduct of economic policy The longstanding debate between rules and discretion can thus be revised in the framework of the new classical models to distinguish between rules without feedback and rules with feedback Now that "optimal" policy rules might be suboptimal or time-inconsistent, a dilemma emerges as to whether policymakers should adhere to their original optimal rule or subsequently revise it Kydland and Prescott prefer adherence, whereas Lucas and Sargent (*64*) believe this rule does not necessarily follow, based on the assumptions of their model Instead, Lucas and Sargent contend that it is entirely possible that policymakers could achieve a higher level of total (additive) intertemporal utility by continually revising their plans every period than they could by adhering to an initial policy program The counterargument in favor of rules put forth by Kydland and Prescott is that the Government runs the risk of "crying wolf " They specifically claim that policy announcements by the authorities would lose their credibility if the announcements were continually subject to revision Lack of credibility, in turn, would increase the variance of an individual's reaction function, make its identification more problematic, and thus lead to indeterminate consequences To avoid this situation, Kydland and Prescott, as well as Lucas, suggest that one simulate over a number of different policy rules and then implement the one with the superior operating characteristics The significance of this proposal is that authorities would no longer seek the *optimum optimorum*, but would be forced to settle for a second best solution

Credibility: Can Disinflation be Painless?

According to rational expectation proponents, credibility by both monetary and fiscal authorities is necessary for stable economic growth In particular, inflation can be reduced only by a change in the current and prospective fiscal and monetary policy regimes that will reduce inflationary expectations Temporary restrictive fiscal and monetary actions will not suffice, only a permanent change in the policy regime from "what is perceived as a long-term Government policy involving the high average rates of government deficits and monetary expansion in the future" will keep (*87*, p 2) If such an "abrupt" change in Government strategy "is sufficiently binding as to be widely believed," Sargent argues that the cost in foregone output and unemployment could be small As evidence for his position, Sargent (*86, 87*) cites events in Austria, Hungary, Germany, Poland, France, and Czechoslovakia during the twenties as examples where "credible" policies ended dramatic hyperinflations or prevented them from occurring at near-zero output cost

Imposing a gold standard on a government is one way to establish credibility, Sargent contends, because the government issuing demand notes and long-term debt would promise to convert any outstanding notes into gold, on demand, or to levy sufficient taxes to honor its debt That government would be expected to meet its debt obligations while simultaneously refraining from *seigniorage* [10]

Sargent and Wallace (*91*) and Sargent (*85*) rely on the credibility issue to argue for coordination of monetary and fiscal policies because of their connection via the Government budget restraint The Federal Reserve Board's policy regarding open market operations will influence the flow of potential *seigniorage* revenues which, as noted below, is a part of the intertemporal budget constraining fiscal policy They show that this situation strongly influences the desirability of Friedman's "k-percent rule" for the monetary base Thus, one can envision a situation where such a rule is undesirable, whether over the long run or not First, it could happen when the amount of outstanding Govern-

[10] *Seigniorage* is revenue from money creation For an analysis, see (*10*)

ment interest-bearing debt is so large that a pretax real interest rate greater than the rate of growth in fiscal output is needed to place the debt Second, a situation could occur in which the monetary and fiscal authorities clash If fiscal policy dominates monetary policy so that there is an ironclad rule for Government expenditures and explicit taxes, then a concomitant monetary accommodation may be needed to finance the growth rate of total Government indebtedness Finally, there is the case in which the deficit path the authorities select is significantly in deficit in a present value sense This condition seems to represent the economic situation in many Latin American countries today

Arguments in support of the Friedman k-percent rule hinge on whether or not the dominating fiscal regime just described occurs A k-percent rule doggedly adhered to by the monetary authorities is a way to discipline fiscal policy Thus, a monetary authority that is stronger than its fiscal policy counterpart will announce and administer a k-percent rule for the monetary base, thereby dictating the flow of *seigniorage* revenues for the fiscal authorities, who are then forced to lower Government expenditures, increase tax revenues, and/or employ bond financing so as to balance the budget This scenario seems to describe the current situation in West Germany where the Bundesbank has adopted such a rule and appears to have successfully adhered to it

New Classicism: Empirical Results

Econometric investigations of the rational expectations hypothesis, although numerous, suffer from severe limitations One problem is that rational expectations and adaptive expectations are "observationally equivalent," as Sargent (*89*) demonstrated This means that both expectational theories may produce results that are equally consistent with the data As a result, economists cannot test directly which theory is best supported by the evidence

Indirect tests have therefore been attempted, but with mixed results Barro (*7, 8, 9*), in particular, has produced many studies attempting to determine whether only unanticipated money (or money shocks) affects output His findings indicate that anticipated money growth is neutral, whereas unanticipated money growth has real effects However, by respecifying the way expectations are formed, Small (*96*) and Gordon (*42*) generated results that contradict Barro's findings This reversal of results points out a weakness in testing rational expectations models, namely, that there is a joint hypothesis involving the specification of the model as well as the expectations mechanism

Furthermore, only if strong assumptions hold can parameters be found that remain invariant under policy changes (as Lucas desires) In this situation, a varying parameter approach is the most general because it makes fewer *a priori* assumptions about the economic environment If the coefficients do vary, then it is impossible "to roll back econometric models to the levels where parameters do remain invariant" (*106*, p. 12) Swamy, Barth, and Tinsley (*99*) have also demonstrated that there are serious problems with the ARMA models used to estimate the unobservable exogenous processes in the new classical models They point out specifically that stationarity has been inappropriately assumed and that there are identification problems associated with stationary models and unrestricted reduced forms which have not yet been addressed [11]

One very suggestive study by Neftci and Sargent (*75*) argues that a change in the distributed lag relationship of output on the actual money supply will occur when the feedback policy rule of the monetary authorities changes at some point in time if the neutrality hypothesis is true, whereas no change will occur if a relationship between output and innovations in the money supply is found They hypothesized a policy break during 1964 and, using a Chow test, found the evidence supported the neutrality proposition Yet the Chow test is not robust as there is a difficulty in correctly characterizing policy behavior by time periods Furthermore, Neftci and Sargent's alternative hypothesis for this test is only a single arbitrary break in policy regime In fact, a structural break is possible in every period and, on that basis, Swamy and Tinsley (*100*) show that the Chow test is statistically inconsistent, and Resler, Barth, Swamy, and Davis (*82*) discuss problems with detecting structural change based on existing tests

[11]Conway and Fryar (*27*) provide a further discussion of econometric estimation difficulties with rational expectations models

Theoretical Weaknesses of the Rational Expectations Approach

One fundamental problem analyzed by Swamy, Barth, and Tinsley (*99*) is the contradiction between the Muth-Lucas-Sargent rational expectations hypothesis and the Bayesian definition of rationality based on coherence and other consistency requirements [12] As they point out, the problem is that the rational expectations hypothesis requires the equality of subjective and objective probabilities (they rely on three different definitions of objective probabilities for comprehensiveness) of events In contrast, the subjective Bayesian principle of rationality relies entirely on subjective probabilities, thereby requiring no such equality They also argue that the rational expectations hypothesis may be considered a linguistic axiom, this being too restrictive for practical use As an alternative, Swamy and others build a competitive, logically consistent, microeconomic model based on a Bayesian framework of subjective expectations which, when aggregated across individuals, becomes a stochastic coefficient macroeconomic model suitable for empirical use

Rational expectations proponents are circumspect in discussing how the "true" underlying structure of the economy becomes known, how fast agents can obtain information about this structure, and what the information costs are The assumption by proponents appears traditionally to be that individuals acquire knowledge of the structure of the economy rapidly and freely for epistemological ease A more realistic view is that it takes a long time for economic agents to discover (if they ever do) the true structure of the economy and hence to adjust their expectations appropriately For this reason, rational expectations may be more appropriately considered to be a longrun, steady state phenomenon However, if a break in structure occurs during the transition period toward a longrun equilibrium, problems arise A more reasonable assumption, noted by Friedman (*39*), is that knowledge of the new structure is costly to obtain and, therefore, will be acquired adaptively If so, activist policies under this regime will generate real effects

[12]See (*31*, chapters 6 and 7) for a rigorous definition of these axiomatic principles Coherence, as defined by de Finetti (*30*), is the most important consistency requirement It amounts to restricting a given belief system so that it would be impossible for any individual to lay multiple fair bets in such a way that the individual wins under all possible outcomes When coupled with other axioms, the suggestion is that the probabilities of elementary events will sum to 1 and that conjunctive and disjunctive events will obey both the product and addition rules

Using Hicks' (*50*) terminology, real time is abstracted from the new classical models, and logical, not historical, time becomes the criterion, as rational expectations proponents consider the length of temporal expectations formation to be "whatever it takes" to allow individuals the opportunity to acquire sufficient information to assure that expectations are fulfilled

Finally, a contradiction to the Sargent-Wallace policy impotence result described above arises when one takes into account the portfolio balance theory as put forth by Buiter (*19*), Tobin (*103*), and Hadjimichalakis (*47*) Perfectly anticipated increases in the money growth rate will increase the perfectly anticipated inflation rate and thereby induce substitution of capital for real balances This increases the capital stock and hence generates impacts on output and employment so that money is not neutral after all

Implications of the New Classical Macroeconomics for the Government Budget

The new classical macroeconomics provides interesting policy prescriptions when one considers the Government budget An examination of Christ's (*24*) formulation of the Government budget restraint (GBR) clarifies this issue As Christ noted, the Federal Government must satisfy the following constraint

$$G + iB = T + dM + dB - dA \tag{15}$$

or

$$\text{Deficit} = G + iB - T = dM + dB - dA \tag{16}$$

where i is the nominal rate of interest ($i = r + \pi^e$), π^e is the expected inflation rate, and r is the real rate This equation states that Government expenditures on goods and services (G) minus taxes (T) plus interest paid on the Government debt outstanding (iB) must be financed by issuing more outside money (M) and/or bonds (B) and/or selling assets (A) Equation 15 clearly shows that the Government does not have a free hand to determine all the macroeconomic policy variables simultaneously Instead, at least one policy tool must be endogenously determined Another point made clear

by equation (15) is that a government's budget constraint is not quite the same as an individual's Notice specifically that by increasing the money supply and generating inflation, the Government can reduce its real deficit This it does by reducing the real value of Government bonds and other outstanding liabilities However, because the nominal interest rate incorporates inflationary expectations, this inflationary tax may be moderated to the extent the inflation is fully anticipated and is thereby embodied in the rate of interest (that is, $\pi = \pi^e$) The specific influence of inflation on the GBR is shown by the following equation [13]

$$G/P + rB/P + \pi M/P - T/P - \pi A/P = d(B/P) + d(M/P) - d(A/P) \quad (17)$$

The new classical school believes that the influence of tax cuts on inflation and output depends on whether or not the deficit is bond-financed If it is, there will be neither inflation nor real effects if individuals engage in "ultrarational" behavior [14] In this case, as Barro (*1, 6*), David and Scadding (*29*), and others argue, there is no essential difference between debt and tax finance This view is also referred to as the "Ricardian equivalence" theorem because it traces back to Ricardo's tract on the full capitalization of the tax when bond sales are used to finance the debt A Government sale of securities which is fully anticipated by individuals means that private spending will be reduced by exactly the same amount as the bond-financed deficit because individuals will realize that the issuance of Government securities means a higher future tax liability for which savings must be increased Under this behavorial assumption, aggregate demand remains constant when taxes are cut, leaving prices and real output unchanged Moreover, the IS-LM curves remain unchanged, thus leaving the interest rate unaffected However, the composition of output has changed, private spending has dropped by an amount equal to the increase in Government spending

Of course, strong assumptions underlie this analysis In particular, the model depends on finite-lived individuals linked across generations by bequests [15] Because of this assumption and other factors, many individuals have criticized these models, including Feldstein (*35*), Buchanan (*17*), Buiter (*18*), Drazen (*32*), Carmichael (*23*), Stokey (*98*), Brewley (*16*), and Tobin (*104*). The main criticisms are (1) altruism may be absent between parent and child, (2) the generational chain may be broken by people without children, (3) constraints on wealth transfers among generations may arise from imperfect rental, mortgage, and annuity markets, and (4) survival is uncertain so that the private risk of death will be greater than the social risk Empirical evidence on the ultrarationality hypothesis, as discussed in a survey article by Stevens (*97*) and a recent study by Feldstein (*34*), seems to indicate that discounting of bond-financed deficits is less than complete

In contrast to taxes, the output effects of Government expenditures, as demonstrated by Barro (*5*), depend on whether they are perceived as temporary or permanent In the case of permanent Government expenditure changes, the assumption is made that tax rates will be adjusted so as to generate sufficient revenues to match the change in permanent Government expenditures Thus, concomitant changes in tax rates will only result from a new and permanent level of Government expenditure Based on this reasoning, Barro (*2, 5*) and Kydland and Prescott (*52*) argue that if all changes in Government spending were permanent, then tax rates should be constant or nearly constant over the business cycle so that the budget would be balanced on average, with surpluses and deficits arising only from random output fluctuations

In contrast, according to Barro (*3*), temporary tax and Government expenditure changes significantly influence output because incentives for intertemporal substitution of work and production are created The greatest incentives arise in the case of transitory expenditures which are not considered as close substitutes for private spending (for example, wartime expenditures) Individuals recognize that income is temporarily increased and will react by

[13] Barth and Cordes (*10*), Barth and Morrell (*11*), and Turnovsky (*107*) discuss these and other dynamic considerations of the GBR

[14] This behavior is used to explain "Denison's Law"—the observed stable relationship between gross private saving and gross national product in the United States

[15] A recent and growing interest has developed in extending Samuelson's (*83*) overlapping generations model to examine a number of macroeconomic issues involving the intertemporal allocation of resources We point this out because this type of model is an equilibrium one and assumes perfect foresight or rational expectations See McCallum (*69*) and Kareken and Wallace (*51*) for a discussion of this literature

temporarily increasing their labor supply At the theoretical level, the basic result is that aggregate demand is unaffected while aggregate supply increases As far as empirical work is concerned, Barro (*5*) found support for the view that temporary movements in defense purchases, generally associated with war episodes, almost doubled the response in output as compared with an equal and permanent shift in defense purchases

Conclusions

A remarkably persuasive recent article by Boland (*15*) puts forth the proposition that an empirical test can be "true" only if the theory behind it has logical validity More than 2,300 years ago, Aristotle constructed necessary conditions in the form of axioms for admissible arguments (that is, the principles of deductive reasoning) An argument is logical when two rules of inference hold (1) *modus ponens*, which states that the truth of every assumption implies the truth of all conclusions, and (2) *modus tollens*, which states that when one conclusion is false, at least one assumption is false It is unfortunate that discerning the truth of assumptions in economic theory is impossible because the problem of induction has never been solved This problem means that the new classicists are unable to have their propositions logically verified from the truth of economic particulars

As a result, the sophisticated falsification criterion developed by Popper and emphasized in economics by Friedman[16] considers the absolute truth of competing theories less important than testing them to discover which one has the most successful logically derived conclusions or predictions This process may be performed by use of statistical techniques and historical evaluation The new classicists have thus far succeeded in demonstrating observational equivalence with traditional models as well as in providing historical examples that seem to support some of their arguments Yet others, like Gordon (*43, 45*), have produced historical counter examples supporting the view that a credible reduction of inflation by the authorities will be painful both in terms of unemployment and lost output

The contribution of this new economic program may ultimately lie not so much in explaining the historical record as in ascertaining the microeconomic foundations used to produce its macroeconomic conclusions The primary value of the new classical school may be its attempt to develop a coherent, economic explanation of subjective expectation formation by use of optimization and game-theoretic techniques so as to explain cyclical movements in key macroeconomic variables better In this respect, the Lucas critique and the time inconsistency proposition have already emerged as potentially important contributions to interpreting and to reformulating econometric policy analysis [17] Economists are now more aware that authorities are not playing a game against nature whose response is invariant to policy changes Instead, the game is played against alert and rational agents who will react to policy stimuli As a result, the new classical macroeconomics has been valuable in demonstrating how the length of real policy influence could be briefer and that the impact and predictability of those policies may be weaker than previously believed Rather than viewing the new classical approach as a distinct macroeconomic program, we believe it may be more appropriate to consider it a part of the most important new scientific research program to emerge over the past decade information theory and probabilistic economics [18] This important research is being rapidly incorporated into all areas of economics, including public finance, industrial organization, labor economics, and public choice Although the assumptions of new classical models tend to coincide with the underlying monetarist models, they can also be modified to yield disequilibrium Keynesian results [19] The dramatic policy neutrality conclusion that resulted in such a highly controversial introduction of the new classical models is being toned down considerably by its originators As Sargent and Lucas now state, "the point of this example was to show that

[16]See (*26*) for a brief discussion of Popper, Friedman, and Lakatos, as well as other influences on economic methodology

[17]We believe recent challenges to the Lucas critique by pro ponents of Vector Autoregression (VAR) models are misplaced In addition to McCallum's (*66*) rebuttal to their argument, time series models such as VAR suffer from an incomplete theoretical development See (*28*) and (*100*) for a more complete explanation

[18]See (*54*) for an illuminating discussion of this research program

[19]Notice that deviations of variables from their trend values may not be a sign of market failure, and furthermore, even if they are, the most appropriate way for the Government to inter vene, if at all, may be through providing of information One way is through the development of contingent claims markets, such as options and futures markets See (*40*) and (*76*) for a full discussion

within precisely that model used to rationalize reactive monetary policies, such policies could be shown to be of no value It hardly follows that *all* policy is ineffective in *all* contexts" (*63*, p 60) and "[t]his is a narrow special case, requiring arbitrary assumptions about information flow which has found little or no empirical support" (*93*, p 11) This important qualification has only recently been admitted openly

In summary, we contend that research based on the new classical macroeconomics approach may be viewed as extending, rather than replacing, traditional models Greater recognition of the stochastic nature of macroeconomics can only add to policymakers' understanding of how the economy works and can thereby lead to improved policy recommendations Lucas (*59*) perhaps put these new contributions in the proper context "[t]here is no point in letting tentative and, I hope, promising first steps harden into positions that must be defended at all costs" (*59*, p 713)

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The Food and Agricultural Policy Simulator: An Addendum

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In a recent article, "On the Misuse of Theil's Inequality Coefficient," by Leuthold in this journal (*3*), the author criticizes the use of a version of Theil's inequality coefficient to validate the performance of an econometric model [1] Referring to the article, "The Food and Agricultural Policy Simulator," by Salathe, Price, and Gadson (*4*), Leuthold suggests that "The [Theil inequality coefficients] U's reported by Salathe, Price, and Gadson are probably much too low, reflecting greater accuracy than is really the case " Leuthold also raises a number of issues regarding the use of the Theil inequality coefficient presented by Salathe, Price, and Gadson, and he indicates they should report additional validation statistics for the Food and Agricultural Policy Simulator (FAPSIM) The purpose of this note is to address some of the issues Leuthold raises and to present additional validation statistics for FAPSIM

Three versions of the Theil inequality coefficient are frequently used to evaluate econometric models These statistics are defined as follows

$$U = \left(\sum_{t=1}^{T} (Y_t - \hat{Y}_t)^2\right)^{1/2} / \left[\left(\sum_{t=1}^{T} Y_t^2\right)^{1/2} + \left(\sum_{t=1}^{T} \hat{Y}_t^2\right)^{1/2}\right] \quad (1)$$

$$U_1 = \left(\sum_{t=1}^{T} (Y_t - Y_t)^2\right)^{1/2} / \left[\left(\sum_{t=1}^{T} Y_t - Y_{t-1})^2\right)^{1/2} + \left(\sum_{t=1}^{T} (\hat{Y}_t - Y_{t-1})^2\right)^{1/2}\right] \quad (2)$$

$$U_2 = \left(\sum_{t=1}^{T} (Y_t - \hat{Y}_t)^2\right)^{1/2} / \left(\sum_{t=1}^{T} (Y_t - Y_{t-1})^2\right)^{1/2} \quad (3)$$

where Y_t is the actual value of the variable at time t, $\hat{Y}_t$ is the predicted value at time t, and T is the number of time periods used for validation The version used by Salathe, Price, and Gadson was the Theil U statistic

Leuthold criticizes the use of this statistic for two reasons First, this statistic is sensitive to additive transformations of the data as pointed out by Theil (*6*) In other words, if c denotes an arbitrary constant, then in general

$$\left(\sum_{t=1}^{T} (Y_t - \hat{Y}_t)^2\right)^{1/2} / \left[\left(\sum_{t=1}^{T} Y_t^2\right)^{1/2} + \left(\sum_{t=1}^{T} \hat{Y}_t^2\right)^{1/2}\right] \neq$$

$$\left(\sum_{t=1}^{T} ((Y_t + c) - (\hat{Y}_t + c)^2)\right)^{1/2} / \left[\left(\sum_{t=1}^{T} (Y_t + c)^2\right)^{1/2} + \left(\sum_{t=1}^{T} (\hat{Y}_t + c)^2\right)^{1/2}\right]$$

Leuthold suggests that this property is a major cause for concern, stating that, "if one moves the decimal point to the right for each variable, one can generate lower [Theil U] coefficients" (*3*) However, the type of transformation described by Leuthold is *not* an *additive* transformation, but a *multiplicative* transformation of the data The Theil U statistic is not sensitive to multiplicate transformations because

$$\left(\sum_{t=1}^{T} (\hat{Y}_t - Y_t)^2\right)^{1/2} / \left[\left(\sum_{t=1}^{T} Y_t^2\right)^{1/2} + \left(\sum_{t=1}^{T} \hat{Y}_t^2\right)^{1/2}\right] =$$

$$\left(\sum_{t=1}^{T} (cY_t - c\hat{Y}_t)^2\right)^{1/2} / \left[\left(\sum_{t=1}^{T} (cY_t)^2\right)^{1/2} + \left(\sum_{t=1}^{T} (c\hat{Y}_t)^2\right)^{1/2}\right]$$

for any nonzero constant c This means that the units used to measure Y_t will not affect the value of the Theil U statistic Therefore, the results presented in (*4*) do not reflect a "unit problem" as Leuthold suggests

One also has to wonder why it is necessarily inappropriate to use a validation statistic which is not invariant with respect to an additive transformation, especially when this statistic is used to measure the predictive power of a model in terms of a price or a quantity series For example, suppose we have a data series $[Y_t]$ for the price of some commodity, and suppose c is an arbitrary constant Is there some meaningful interpretation that can be

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[1] Italicized numbers in parentheses refer to items in the References at the end of this note

[2] Kost (*1*) claims that an additive transformation of this type will always reduce the value of U However, this is not necessarily the case

attached to the new series [$Y_t + c$], and, if not, why would anyone be interested in determining how well the model predicts this variable?

A second criticism of the Theil U statistic which Leuthold raises is that this statistic is bounded from above by 1 Leuthold seems to suggest that this property somehow leads to "low [Theil] U coefficients," thereby overstating the predictive power of a simulation model As Theil showed, both the Theil U and U_1 statistics are constrained to lie between zero and 1 Both statistics will attain a value of 1 only if the predicted values represent the worst possible forecasts of the actual values (in the sense defined by Theil) Both the Theil U and U_1 statistics will equal 0 only if the model predicts the historical values perfectly over the entire validation period Thus, both Theil's U and U_1 statistics are constrained to lie within the unit interval, and the end points of the interval may be interpreted as corresponding to opposite extremes in model forecast accuracy The fact that Theil's U statistic is bounded from above by 1 is a useful property because the value of 1 provides a benchmark representing the worst possible model forecasts This property in no way causes this statistic to overstate the predictive ability of a simulation model

Leuthold also criticizes the use of Theil's U statistic because "A U in actual values will always be less than a U when data are measured as changes" This statement implies that U will always be less than U_1 and U_2 However, using the example below, we can show that U is not necessarily less than U_1 or U_2 Suppose we have the following data series for Y_t and $\hat{Y}_t$

	Time period				
Variable	0	+1	+2	+3	+4
Y_t	0 000	0 000	0 081	0 052	0 001
$\hat{Y}_t$	—	000	000	000	000

— = Not applicable

then U = 1, U_1 = 0 49045, and U_2 = 0 96246 [a] Thus, there is no reason to expect that the Theil U statistic will always be less than either U_1 or U_2

[a]Although the values chosen for Y_t and $\hat{Y}_t$ in this example may appear artificial, they were, in fact, obtained from a validation study of a dairy sector model (*5*)

For all the data series included in the model validation of FAPSIM, however, the Theil U statistics are less than their corresponding Theil U_1 and U_2 statistics (see following table) But the Theil U_1 and U_2 statistics do not appear unreasonable, thereby confirming the earlier model validation results reported in (*4*) The Theil U_1 and U_2 statistics do result in changes in relative results among commodities as compared with the Theil U statistic as Leuthold suggests This result is not surprising because of the differences in the properties of the Theil U, U_1, and U_2 statistics

As Kost points out, each of Theil's inequality coefficients has different properties and interpretations (*2*) This means that each coefficient provides different information about the forecast accuracy of a model The same is true of other statistics that have been proposed for model validation (*1*) No single measure provides a complete summary of a model's forecast ability as each has specific limitations For this reason the mean absolute relative error, the turning point error, and the plots of actual versus forecasted values were presented in conjunction with the Theil U statistic in the validation of FAPSIM (*4*) Leuthold appears to be overly concerned with the properties of the Theil U statistic, failing to recognize the shortcomings of other validation statistics (such as Theil's U_1 and U_2 statistics) He also seems to have overlooked the additional information beyond the Theil U statistic presented in the validation of FAPSIM

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Theil inequality coefficients for the Food and Agricultural Policy Simulator

Variable description	Validation statistic		
	Theil U	Theil U_1	Theil U_2
Pork production	0'024	0 282	0 562
Beef production	019	347	714
Broiler production	014	243	495
Turkey production	021	300	560
Egg production	013	552	1 157
Milk production	006	247	516
Price of barrows and gilts	048	272	512
Price of slaughter steers	042	267	601
Price of utility cows	058	257	587
Price of broilers	036	275	562
Farm price of turkeys	046	245	490
Farm price of eggs	052	353	673
Farm price of milk	025	277	591
Acreage planted of wheat	030	276	546
Acreage planted of corn	011	177	389
Acreage planted of barley	037	350	728
Acreage planted of sorghum	085	542	1 770
Acreage planted of oats	035	412	845
Acreage planted of soybeans	042	449	943
Acreage planted of cotton	047	252	499
Farm price of wheat	062	230	456
Farm price of corn	063	300	637
Farm price of barley	083	320	804
Farm price of sorghum	082	421	853
Farm price of oats	036	184	366
Farm price of soybeans	060	258	595
Farm price of cotton	062	302	679
Total cash receipts from farm marketings	016	126	259
Total farm production expenses	010	087	181
Net farm income	077	279	584
Consumer price index, all food	019	205	490
Consumer price index, all items	.003	036	073