Some of Milton Friedman's Scientific Contributions to Macroeconomics

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On July 15, 1987, the Hoover Institution held a symposium to celebrate Milton Friedman's seventy-fifth birthday on July 31. The symposium was organized by Senior Fellows Robert Hall and Thomas Sargent. Thomas Sargent delivered the following remarks to open the seminar prior to topical panel discussions.

Scientific work in macroeconomics is valuable to the extent that it fulfills one or more of three purposes. First, it can resolve a paradox stemming from a conflict between theory and observations and do so in a way that respects the discipline both of economic theory and of statistics. Second, it can clarify aspects of monetary and fiscal policy either for the purpose of helping governments design and administer institutions and mechanisms or for the purpose of helping outside observers understand those institutions and their decisionmaking processes. Third, the work can have a creative legacy, in the sense that it identifies and structures a class of problems and a way of studying them that subsequent researchers can build on.

A good way to pay tribute to Milton Friedman is to describe how his work in macroeconomics served these three purposes. I will mention his work on consumption, the natural unemployment-rate hypothesis, monetary rules, the optimum quantity of money, and monetary history.

The Consumption Function

Friedman's work (1956, 1963) on the permanent income theory of consumption endures. This theory, motivated by empirical puzzles surrounding a relationship at the core of the Keynesian system, involved new ways of implementing dynamic theories econometrically; was full of implications about the size and time structure of fiscal policy "multipliers"; helped to pose a set of questions about the formulation, estimation, and simulation of macroeconometric models that formed the basis of a fruitful research program that continues to occupy many macroeconomists; and created a foundation for much subsequent research on monetary economies. Friedman used a dynamic theory of Irving Fisher (1930) to explain some puzzles that had arisen from attempts to use a static Keynesian macroeconomic model to interpret time series and cross-section observations on consumption and income.

Irving Fisher's idea was that consumption should be a function of the present value of income, not of its current value. But how does one make a theory cast in present values, which are unobservable, yield implications about observations on consumption and income? Friedman did so by using the notion of "permanent income," a concept related to but not identical with present value. In discussing what alternative meanings "permanent income" could have, Friedman was wrestling with the difficult issue of how a theory like Fisher's, carefully but nonparametrically framed in the context of a two-period diagram, could be used to interpret observations organized in terms of covariances and regression coefficients.

To model the cross-section data, Friedman used a distinction between "permanent" and "transitory" income to motivate a signal extraction problem that econometricians had to solve to interpret the data correctly. Friedman posited that consumers knew that their current income consisted of two orthogonal parts: a "permanent" part, out of which they would wish to consume as if it were the income from a consol, and a "transitory" part, out of which they would wish to consume as if it were a nonrecurring windfall (technically, a white noise). Friedman posited that private agents had direct observations on the permanent and the transitory components of their income (they recognized windfalls for what they were) but that the econometrician only had data on the sum. To interpret the cross-section data correctly, the econometrician had to do a "signal extraction" to arrive at an estimate of the "permanent" component of income from observations on the sum of permanent and transitory income recorded in the data.[1] Parameters characterizing the covariance

structure of permanent and transitory income help determine the population regression of measured consumption on measured income.

To model the time series data, Friedman used the concept of "adaptive expectations" to create a statistical representation of "permanent income."[2] The adaptive expectations hypothesis posited that agents formed expectations about the future value of some economic variable (over what horizon?) as a geometric distributed lag of past values. The idea was that by taking a geometric moving average of past observations on measured income, the consumer (and the econometrician) could obtain an estimate of permanent income. Friedman (1963) conjectured that the decay parameter in the geometric distributed lag ought to equal the factor by which the consumer discounted future utility.[3] Friedman estimated his model on time series data using a version of the method of maximum likelihood.

One measure of the greatness of Friedman's work on consumption is the quality, depth, and influence of the work done by other researchers who were inspired by questions posed but left unanswered in Friedman's work. Another measure of greatness is the extent to which this subsequent work has left intact or strengthened Friedman's original insights. In 1960 John Muth (1960) took up the task of making more precise the sense in which Friedman's "adaptive expectations" could be interpreted as an optimal measure of a precisely defined concept of "permanent income." Muth formulated an "inverse optimal predictor" problem: for what stochastic process for income and for what forecasting horizon would Friedman's adaptive expectations (geometric distributed lag) formulation emerge as the optimal (in the linear least-squares sense) forecast of future income? Muth showed that if the first difference of income were a first-order moving average process, then Friedman's adaptive expectations scheme would be optimal over any horizon greater than or equal to one period. The independence of the optimal forecast from the horizon made precise a sense in which there is a "permanent income," namely, a rate of income that can be expected to hold over any horizon. Further, Muth showed that if income had an "error components" structure, being the sum of a random walk and a white noise, then that sum would have a first difference that is a first-order moving average, implying that it is optimally forecast via Friedman's adaptive expectations scheme. Muth's paper was the first systematic and formal application of the "rational expectations" hypothesis in macroeconomics. In retrospect, we see that Friedman presented Muth with a well-posed problem that was a sitting duck for the application of linear prediction theory.

Lurking between the lines in Muth's paper is the Robert Lucas (1976) critique which waited fifteen years to be unearthed, for Muth not only

had discovered one example of a stochastic process that made "adaptive expectations" equivalent to "rational expectations" but had shown that example to be unique. Thus, if the stochastic process for income were different from one whose first difference was a first-order moving average, then the optimal forecast of future income would not be given by adaptive expectations. Furthermore, by working out a few examples along the lines of Muth's, it becomes evident that if the process for income were changed, owing, say, to a government intervention that alters the law of motion of tax rates, then the appropriate formula for permanent income would change and thus the consumption function would alter. This dependence of the consumption function on the form of the stochastic process for income is one of three examples in the Lucas critique.

Just as Muth and Lucas built on and clarified the concept of permanent income as an optimal forecast of future income, Robert Hall (1978) showed how a well-posed optimal control problem for a consumer (or a fictitious social planner) could give rise to a version of Friedman's permanent income model for the time series. Hall showed how, if preference shocks were precluded, a version of Friedman's model would give rise to the prediction that consumption (or more generally, an adjusted marginal utility of consumption) ought to follow a martingale. Hall's formulation strengthens and makes more precise the strong consumption-smoothing implication of the model. Hall's martingale implication is easily tested econometrically and provides a simple example of the method of estimating some parameters via restrictions imposed by Euler equations, an approach that was significantly extended by Lars Hansen and Kenneth Singleton (1982).

The basic insight of the permanent income model is that in response to a possibly erratic and unsmooth income stream, consumers would optimally smooth their consumption streams by borrowing and lending or by physically investing. Friedman's econometric work, as well as Hall's, is motivated by a problem confronting a single agent and does not describe settings of complete economic equilibria. Left open in the formulations of Friedman and Hall is the question of with whom the consumer might borrow and lend or physically invest with to smooth consumption. Subsequent work has fruitfully pursued this question. In a pure exchange economy (no productive investment, pure consumption loans) consisting of infinitely lived agents, patterns of endowments can be arranged so there is no aggregate risk but there is verifiable uncertainty in the realization of individual consumer's endowments. When the aggregate endowment in such an economy is constant through time, though individual endowments vary stochastically over time, there emerges a version of Friedman and Hall's formulation at the individual level, as a special case of an Arrow-Debreu complete markets risk-sharing mechanism.[4] Such a setup requires enough heterogeneity among agents' endowments and such constancy of the aggregate endowment that it is feasible for each agent in the economy to smooth consumption over time. Another famous model emerges as a special case of this pure exchange economy when it is assumed that the aggregate endowment is not constant over time but follows some exogenous Markov process, and when conditions are imposed on preferences sufficient to support a representative consumer. This is the case modeled in Lucas's "Asset Prices in an Exchange Economy" (1978). In Lucas's model, asset prices and rates of return fluctuate to make consumers content to consume an exogenous income process that cannot be smoothed in the aggregate.

Each of the preceding two models assumes that all possible loan and insurance markets are open. But what if all loan markets are shut down for some reason and the only available asset is fiat currency? Work to answer this question was begun by Truman Bewley (1980), pursued by Robert Townsend (1980), and is continuing today in the hands of Jose Scheinkman and Laurence Weiss (1986). This research often has produced a version of Friedman's permanent income theory of consumption as well as a version of Friedman's prescription for a monetary-fiscal policy that supports the "optimum quantity of money."[5]

A less enduring, but at the time (1956) very important, aspect of Friedman's work on consumption concerned its implications about the size and time structure of "multipliers" in Keynesian macroeconomic models. When included as the most important argument of both the consumption function and the demand function for money, Friedman's adaptive expectations formulation of permanent income had the effect of raising the immediate monetary policy multiplier and lowering the immediate fiscal policy multiplier. Furthermore, within the Keynesian model the presence of permanent income in each of those functions so seriously complicated the dynamic responses of income to monetary and fiscal policy shocks that one needed to solve a complicated system of difference equations and could not rely simply on textbook IS-LM curves to work out the responses. As Donald Tucker (1966) showed, there could be some very surprising (from a static IS-LM vantage point) outcomes from such dynamics. Being more careful about the dynamics of such models was an important line of work spawned in part by Friedman's work on permanent income. That line was fruitful for a time but died out once the cross-equation restrictions of rational expectations macroeconomics

replaced multipliers as the focus of quantitative macroeconomic policy analysis.[6]

The Natural Unemployment-Rate Hypothesis

Friedman's work displayed a fruitful sense for recognizing situations when one could progress by analyzing a single-agent problem (as in his formulation of the permanent income model of consumption) or when one needed to specify aspects of a complete system.[7] His work on the natural unemployment-rate hypothesis is an example in which he reasoned about how an entire macroeconomic system is put together to explain some observations (the Phillips curve) that were puzzling from the viewpoint of equilibrium macroeconomic theory and to shed light on the implications for optimal monetary and fiscal policy that could be inferred from those observations.

The "Phillips curve" is the inverse relationship between inflation and the unemployment rate that was traced out by U.S. data in the 1950s and 1960s, a correlation that seemed to violate the neutrality theorems of classical monetary theory. Those neutrality theorems follow directly from the fact that a proportional rise in all prices, including those for all future state- and date-contingent commodities, leaves all agents' budget sets and thus their decisions unaltered. The decision rules in Keynes's system exhibited the same homogeneity of degree zero in prices as did those in the classical system. It was by withdrawing one equation (the labor supply schedule or the labor market equlibrium condition) and one variable (the money wage rate) that Keynes managed to render money nonneutral and fiscal policy immediately potent in its effects on output. This is the sense in which Keynes made a general theory: he withdrew restrictions imposed by the classical theory, giving his theory more latitude to fit the data. The Keynesian model was thus short one equation and one variable relative to the classical model. To close that gap, Keynesian models of the late 1960s incorporated some version of a Phillips curve as a "structural relation" to serve as a "law of motion" of the money wage rate. Adding the Phillips curve not only closed the Keynesian system by accepting the Phillips curve correlation as a "theory of wages" but also implied that the Phillips curve was exploitable by policymakers, who could buy a lower unemployment rate by accepting a little more inflation in wages and prices. In 1967, most macroeconomists probably accepted some version of the Keynesian system augmented with an exploitable Phillips curve.

But Friedman dissented. In his presidential address to the American

Economic Association (AEA), Friedman set forth a vision of how a complete macroeconomic model could reconcile the observed correlations between inflation rates and the unemployment rate with the hypothesis that the economy is in competitive equilibrium. Friedman maintained the assumption that markets clear and that agents' decision rules are homogeneous of degree zero in all prices. Friedman used the idea that when agents face intertemporal choice problems, the relevant price vector includes not just current prices but also (expectations about) future prices. If some disturbance to the system causes some component of the price vector to change (say, current prices) while other components remain fixed (say, expectations about future prices), then the conditions of the classical neutrality theorem are not met. Friedman argued that the trade-off between inflation and unemployment captured in the Phillips curve correlations represented the outcomes of experiments that had induced forecast errors or misperceptions in private agents' views about prices, thus rendering the classical neutrality theorems inapplicable. If the experiment under study were a sustained and fully anticipated inflation, Friedman asserted that there would be no effects on aggregate economic activity.

Friedman used a version of adaptive expectations together with this reasoning to argue that any trade-off between inflation and unemployment is at best temporary. Over time, the adaptive expectations hypothesis implied that people would catch on to a sustained increase in the rate of inflation, causing any effects induced by unexpected inflation to dissipate.[8]

On the basis of this reasoning Friedman predicted that the Phillips curve trade-off evident in the data from the 1950s and 1960s would vanish if a systematic attempt were made to exploit it. In the 1970s, the Phillips curve trade-off vanished from the data.

Friedman's AEA address was the opening shot of the "rational expectations revolution" in macroeconomics. Although Friedman didn't mention the phrase or use the concept in his address, the argument was just waiting to be completed and strengthened by adding the hypothesis of rational expectations. With adaptive expectations, Friedman's system was one in which the monetary policy authorities could only temporarily influence the rate of output or the real rate of interest. However, the monetary policy authority retained much power, and different policies would still have very different (and difficult to assess) implications for real variables, depending on the detailed dynamics of the system. But under rational expectations, the same economic structure would have the property that all equally well-understood monetary policies would have identical implications for real interest rates and rates of real economic activity.

In particular, in terms of the behavior of output and prices, a k-percent rule would be a good one.[9]

Friedman's AEA address on the natural-rate hypothesis, like his work on consumption, ventured far into new territory and, at some points, took the risk of expressing insights and making guesses about aspects of the theory that could not yet be fully articulated or completely laid out. Subsequent work on the natural-rate hypothesis has strengthened Friedman's original vision. In raising the possibility that the data could be rendered consistent with a dynamic model in competitive equilibrium, Friedman began a rebirth of equilibrium macroeconomics.

Frameworks and Rules for Macroeconomic Stability

Friedman has long advocated thinking about government macroeconomic policies as alternative rules to which government authorities might feasibly commit themselves. Friedman's consistent advocacy of "rules as opposed to discretion" and the particular simple mechanical rules that he recommended seemed odd during the high tide of IS-LM curves and of short-run "fine-tuning" in the 1960s. But work on dynamic macroeconomics since the late 1960s has led to increasing understanding and respect for Friedman's proposals.

Friedman's work on macroeconomic frameworks and policy rules has two enduring aspects. First, there is the methodological principle, which has become a foundation of modern dynamic macroeconomics, that the way to think about government policy is in terms of a rule (or decision rule or contingency plan) that spells out the government's actions across time and across contingencies. Unless this is done, one hasn't specified a policy proposal in enough detail that it can even be discussed or evaluated because the government's behavior in distant time periods and remote contingencies will influence today's behavior by private agents. Today, as a result of work in game theory and dynamic equilibrium theory, Friedman's point of view is routinely accepted.

Second, Friedman's analysis of alternative rules and mechanisms for selecting macroeconomic policies endures and underlies much contemporary work. At different times, Friedman advocated two comprehensive and simple plans for coordinating monetary and fiscal policies. (Feasibility requires that monetary and fiscal policy be coordinated because open market operations have revenue implications.) In 1948, Friedman advocated a coordinated scheme in which the Federal Reserve would permit no interest-bearing government debt to be placed with the public. The Federal Reserve's operating rule would simply be to monetize all interest-bearing government debt. Government deficits would lead to increases in the stock of currency plus reserves, while government surpluses would lead to reductions in that stock. This coordination scheme is simple and feasible (if government deficits aren't too large and persistent) and has the virtue of assigning responsibility for currency growth and inflation to its primary determinant, the federal deficit.

Then in 1960, Friedman advocated an alternative mechanism that, in a superficial sense, is the polar opposite of the 1948 mechanism. In 1960, he advocated that the Federal Reserve adopt a rule of increasing high-powered money by a constant k-percent a year (where k is a small number to accommodate growth in the economy). This rule has the effect of virtually permanently denying the fiscal authorities access to the printing press and is feasible only if the federal budget is close enough to balance in a present value sense. If committed to, the k-percent rule has the effect of forcing the fiscal authority to finance current deficits only by credibly promising future surpluses.

Friedman's k-percent rule was known to be a poor one in the context of the Keynesian macroeconometric models of the 1960s in that for those models one could apply optimal control theory and always find a much more complicated feedback rule that "looked at everything" and that gave better performance for real economic activity and prices. Even in the context of Friedman's AEA presidential address model with adaptive expectations, the policy authorities could always do better than to use Friedman's k-percent rule. However, if one substituted the hypothesis of rational expectations for adaptive expectations in Friedman's model, it turned out to imply that a k-percent rule performs at least as well as any other rule.

The Optimum Quantity of Money

When Friedman adopted the Chicago plan of banking reform, the plan passed down from Henry Simons and Lloyd Mints, he modified it in an important way. The original Chicago plan had called for a version of a k-percent rule, facilitated by the imposition of 100 percent reserves behind bank notes and deposits, as a way of separating the money and credit markets and of enforcing a government monopoly on the right to issue currency (and good substitutes for it). Friedman (1960) spotted a flaw in the original proposal that created a situation in which, owing to limitations on intermediation enforced by 100 percent reserves, government currency would be a low-yielding asset, creating inefficiencies and incentives to

avoid the restriction associated with a violation of the law of one price. To remedy this, Friedman proposed that the government pay interest on bank reserves at a market rate of interest. He pointed out that paying interest on reserves would have fiscal consequences and briefly mentioned two alternative schemes for financing the plan (through taxation or by having the government hold a portfolio of interest-bearing assets to back its currency).

In his work on the optimal quantity of money (1969) Friedman treated in more detail what is really an alternative version of an interest on reserves scheme. The optimal quantity of money problem is to find a set of coordinated monetary and fiscal policies that optimize the welfare of the representative consumer, taking as given the consumer's own optimizing behavior and, in particular, the consumer's optimizing responses to the government's behavior. Friedman reasoned that if nondistorting taxes were available, the optimal policy would be, insofar as possible, to satiate the system with real balances. This would be accomplished by generating a deflation that would make the real return on government currency equal to the rate of return on real assets of the same risk level as currency. The deflation would be generated by steadily withdrawing currency from the system through the imposition of nondistorting taxes. Economically, this scheme is equivalent with a scheme that pays interest on currency at the market rate of interest and finances the payments by nondistorting taxes.

Friedman's work on the optimum quantity of money was important both substantively and methodologically. Subsequent researchers William Brock, Bewley, and Townsend studied the optimum quantity of money to discover a string of insights about the features of economies needed to support a valued fiat currency. That work has taught us much about how the preferences and/or the endowment and technology pattern of a standard Arrow-Debreu general equilibrium model must be modified to support a valued currency. Thus, Brock (1974) modifies the standard utility function, while Bewley and Townsend modify things so as to shut down enough loan and insurance markets to permit government currency to play a consumption-smoothing role. Townsend (1980) and especially Bewley (1980) discovered deep links between the optimum quantity of money and the permanent income theory of consumption. Both Brock and Bewley discovered some existence problems that can occur if things are such that the demand for real balances becomes unbounded as the rate of return on currency approaches the return on other real assets. Finally, it was discovered that in those circumstances where a feasible tax plan exists to support an interest on reserves scheme or the optimum quantity of money, the tax rates and the price level in the

associated equilibrium are both indeterminate. This led to a modification of Friedman's plan to pay interest on reserves by Jean-Michel Grandmont (1985) and Hall (1983) that renders the price level unique.

Methodologically, Friedman's work on the optimum quantity of money stands as one of the first examples of using the method of studying optimal government macroeconomic policy by formulating it as a dynamic choice problem of a government that behaves as a "dominant player" against a collection of optimizing private agents who behave competitively. This structure is now standard and underlies a wide variety of dynamic optimal taxation problems that have become very important in research on macroeconomic policy. When one modifies Friedman's optimum quantity of money problem by specifying that the only taxes available to the government are distorting ones, as Guillermo Calvo (1978) did, one discovers a version of Finn Kydland and Edward Prescott's (1977) "time inconsistency" problem.

The Study of Monetary History

Friedman and Anna Schwartz's *Monetary History of the United States* (1963) was regarded as pretty much beside the point in the 1960s, when the center of the macroeconomics profession was putting its resources into constructing econometric models of the United States based mostly on quarterly data from the post–World War II period. I was taught in graduate school that the structure of the economy had evolved a great deal since 1900 and that it was also different during wars, so that old data and war periods were not useful for understanding the structure of the modern post–World War II U.S. economy. Given the objects that my teachers and other econometric model builders of the 1960s interpreted as "structural," namely, decision rules of private agents, their reluctance to use data from war periods and history was appropriate.

Friedman and Schwartz have to be regarded as going after bigger game than a particular collection of decision rules for private agents that seemed to be operating during the first two decades after World War II in the United States. One of the most interesting aspects of Friedman and Schwartz's study is the light it sheds on how the private economy adjusted to alternative environments, especially alternative monetary arrangements and alternative government operating rules. Today it is widely understood, as a result of work in applied economic dynamics and game theory, that what is important to know for evaluating alternative government policies is how private agents' decision rules or strategies will

respond to alternative government strategies. Friedman and Schwartz's monetary history gives us some observations on this dependence.

Another important aspect of Friedman and Schwartz's book was their insistence that much of the data be cast in the language of Arthur Burns and W. C. Mitchell (1946), with graphs of reference-cycle averages scattered throughout the book in place of the two-stage least-squares estimates that one expected of technically sophisticated authors in 1963. What seemed an anachronism in 1963 seems much more modern and defensible today, as the connection between Burns and Mitchell's work and statistical dynamic index or factor models has become clear.[10] In tying their method of presentation to that of Burns and Mitchell, Friedman and Schwartz assembled an impressive body of evidence that their money supply series is the hidden common factor underlying Burns and Mitchell's business cycle or that it is closely correlated with it. There is impressive evidence in favor of a one-dimensional (or at least a low dimensional) factor explanation of business fluctuations, much of the evidence having been organized by Burns and Mitchell. Friedman and Schwartz's evidence remains the most persuasive that has yet been assembled pointing to a business cycle whose impulses originate in monetary disturbances.

A variety of good recent papers on monetary theory, like Douglas Diamond and Phillip Dybvig's (1983) paper on banking panics, are built on observations and insights contained in Friedman and Schwartz.

Many very good researchers continue to pay Milton Friedman the compliment of thinking hard about issues that he posed, often in terms that he defined, and using methods that he invented or inspired.

Notes

1. Note how in the paper of Robert Lucas (1972), the agents in the economy, not only the economist who wants to understand the economy, solve a signal extraction problem.

2. Other workers like L. M. Koyck, H. Chenery, and A. W. Phillips had used the idea of "adaptive expectations." The term "adaptive expectations" was not used by Milton Friedman (1956) but was later coined by Kenneth Arrow and Marc Nerlove.

3. A conjecture recently explored and, in one case, confirmed by Thomas Sargent (1987).

4. A linear quadratic version of the William Brock-Leonard Mirman (1972) optimal stochastic growth model yields a version of Friedman's permanent income model in which adaptive expectations are optimal and the geometric distributed-lag decay parameter equals the representative consumer's discount factor. This

specification depends on the endowment shock process being a white noise. Sargent (1987) considers this example and how it confirms Friedman's (1963) conjecture.

5. The tax-smoothing model of Robert Barro (1979) can be viewed as an application of Friedman's permanent income model in which variables are simply renamed as follows: consumption in Friedman's model becomes tax collections in Barro's, labor income in Friedman's model becomes net of interest government expenditures in Barro's, consumers' nonhuman assets in Friedman's model become government debt in Barro's, and consumer's one-period utility function in Friedman's model becomes minus the government's one-period loss function in Barro's.

6. See John Taylor (1980a, 1980b) for examples of this change of emphasis even in the context of models having "sticky wages."

7. See Friedman's analysis of the economic effects of excise taxes, Friedman (1953).

8. Friedman also pointed out how Irving Fisher's theory of the relation between nominal interest rates and the rate of inflation was another aspect of a complete macroeconomic system in which there is a natural (equilibrium) rate of employment.

9. This was established in related contexts by Lucas (1972) and Sargent and Neil Wallace (1975). The theme of Friedman's AEA address is that the monetary authority has less power over real output and interest rates than had been ascribed to it in Keynesian models. Sargent and Wallace (1981) described a setting in which the monetary authority was less powerful than Friedman (1968) had left it and even less powerful than Sargent and Wallace (1975) had left it.

10. For example, see Sargent and Christopher Sims (1977).

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About Milton Friedman

Milton Friedman received the Nobel Prize in Economic Science in 1976 for his achievements in the fields of consumption analysis and monetary history and theory, and for his demonstration of the complexity of stabilization theory. He has been a Senior Research Fellow at the Hoover Institution for more than ten years. In 1987 the Institution celebrated his 75th birthday with the publication of *The Essence of Friedman*, a distillation of his works, available from the Hoover Institution Press.

About the Author

Thomas J. Sargent joined the Hoover Institution as a Senior Fellow in 1987. From 1971 to 1987 he taught at the University of Minnesota and had visiting positions at the University of Chicago, Harvard University, and Stanford University. Before 1971, he held positions at the University of Pennsylvania, Carnegie-Mellon University, and with the U.S. Army. He studies macroeconomics, monetary economics, and time series econometrics. He is the author of *Dynamic Macroeconomic Theory*, published by Harvard University Press in 1987, and is the editor (with Robert E. Lucas, Jr.) of *Rational Expectations and Econometric Practice*, published by the University of Minnesota Press in 1981.