Owning up to Uncertainty in Macroeconomics*

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**** Readers whose interests are primarily multidisciplinary may wish to concentrate on Sections 1 and 5, skimming only the first few pages introducing Sections 2, 3, and 4 and the last section (4) of 4.

"Indeed the historian of the modern world is tempted to reach the depressing conclusion that progress is destructive of certitude."

(Paul Johnson 1983, p. 697)

1. The Subject and its Interdisciplinary Background

This survey seeks to show what account is taken of uncertainty in contemporary macroeconomics. Before outlining its scope and content at the end of this section, it may be useful to provide some historical background on how the treatment of uncertainty, and the contexts in which it has been dealt with, have changed not only in economics but also in other disciplines. For it is difficult to gain perspective on the treatment of uncertainty in one discipline without comparing this with another.

Because of the element of deliberate choice and mutual awareness by the actors, the economic processes of society are not like physical processes. Nevertheless, certain basic changes in how uncertainty is viewed and hence represented in formal structures apply across several sciences, hard and soft. What Gordon Reece (1977, p. 11) wrote about physics since the 1920s may also apply to economics much more recently: Imperfection, inaccuracy, unpredictability, uncertainty and randomness have gradually been accepted into the discipline.

Uncertainty in a measure or value can arise on account of the dispersion of repeated occurrences in the face of the same prediction. This concept of uncertainty is statistical and the one most frequently meant here. Occasionally we will make use of a different, epistemological concept: uncertainty in the opposite sense from likelihood. Uncertainty, for instance about policy pronouncements, then becomes an inverse measure of belief in a single event being true or real. Sir Harold Jeffreys (1973, pp. 12-14) has identified the latter concept as involved in scientific inference from past to future observations and in the rational legitimization of beliefs.

The acceptance of either concept of uncertainty has been slow to spread to expositions and policy applications of macroeconomics. Except in the context of *multiplier uncertainty*, which expresses inability to predict the precise effects of economic policies, uncertainty is still rarely mentioned in all but the most advanced textbooks on macroeconomics such as Thomas Sargent's (1979). Robert Hall and John Taylor's (1986) recent undergraduate textbook is the first to have what amounts to an entire chapter devoted to (imperfect) information. This is a subject which, until some years ago, even economic theorists traditionally had banished to footnotes (in the judgement of Michael Rothschild and Joseph Stiglitz 1976, p. 629). The common teaching method of introducing shocks experimentally by displacing a variable or shifting a function and seeing how the model's solutions are changed is not normally presented as importantly involving uncertainty and the state of expectations. Even when shocks and disturbances are viewed as stochastic and taken as surprises, they are quickly decoded and given over to stabilization policy in standard treatments. In other words, disturbances arrive nicely identified and are then processed essentially without uncertainty about the model affected.

Macroeconomists could, and did, proceed to lay out the options relevant for stabilization policy even when the authorities' objective function was not fully revealed to them or if government preferences were known to be fuzzy or fickle. In doing so they intended to

alert politicians to the likely economic consequences of their actions so as first to clarify and then to improve their choices. Among economic advisers in and around governments, specificity was at such a premium that even multiplier and forecast uncertainty tended to be played down.

Until the late 1960s, and possibly longer, most macroeconomists felt comfortable in what has been called the Newtonian or Cartesian world of determinism. Long after the natural sciences had forsaken this world, the social sciences clung to the belief that the process of “scientific” discovery could only yield ever more refined certainties. Thus elements of knowledge would build on each other without being subject to dissipation by new discoveries or by phenomena that could not be accounted for within existing modes of analysis. In that earlier world of thought, aptly characterized by Orio Giarini (1982, p. 911), economic control was deemed not only possible but increasingly perfectible through research if only popular superstitions blocking its application could be overcome. We will quote three statements by Paul Samuelson, which may have represented the thinking of many macroeconomists at the time, to show that such convictions were, in fact, held. This preparatory segment then concludes by explaining why the possibilities of macroeconomic engineering are now viewed as so much smaller.

A few decades ago Samuelson wrote:

We no longer regard cyclical swings as immutable facts of nature, like the inevitable plagues that man could do nothing about before the age of penicillin, sulphur, medical care and public health. Fiscal and monetary policies can ameliorate, moderate, and perhaps even compensate fully for such tendencies toward sluggish investment opportunities. ([1962] 1963, p. 59)

From these remarks it will be clear that economic science is not only neutral as to the question of the desired rate of capital accumulation – it is also neutral as to the ability of the economy to realize any decided-on rate of capital formation. I repeat: With proper fiscal and monetary policies, our economy can have full employment and whatever rate of capital formation and growth it wants. ([1956] 1962, p. 41)

The real barrier to optimal fiscal policy is not procedural or administrative. It is ideological. If the American people, Congress, and the President all had a desire for the requisite pattern of expenditure and taxing – and the implied budget deficits (and surpluses!) – then without any structural reforms our present system could be more nearly optimally stabilizing. It is simply a matter of fact, though, that... [t]he American public simply cannot stomach budgetary deficits of the size sometimes needed for stability, high employment and growth. ([1962] 1963, p. 36)

Clearly the spirit of scientism, of ever more successful application of scientific management to the economy at large, gleams through these writings. It seemed that with expert management the “twilight of the business cycle” (Samuelson [1962] 1963, p. 27) might soon be turned into its total eclipse. Walter Heller (1966, p. 69) identified steady advances in fact-gathering, forecasting techniques, and business practice as helping in this regard. While problems arising from uncertainty in the private sector and from the vagaries of business and consumer confidence were not denied, they were viewed as challenges to stability that

could eventually be met. In fact, Keynesianism shared with more pervasively “planned” approaches the conviction that “indeterminacy and uncertainty arising in the private sector should be counteracted by political action” (Walter Weisskopf 1984, p. 359). As Keynesians, more than John Maynard Keynes ([1926] 1972; 1936, p. 382), had insisted, if the laws of markets and the force of competitive behavior did not suffice to establish order and acceptable levels of employment, then the government’s program would.

Confidence in the ability to overcome ignorance and crises through ever more refined scientific tuning of policy instruments was not limited to stabilization policy in the 1950s and 1960s. It also extended to the intersectoral and intertemporal allocation of resources through public investment and industrial policy and, more broadly, through planning for economic development in a mixed economy. Jan Tinbergen (1952, pp. 37-52) had conceived of a given allocation policy as controllable if only there existed instruments which were sufficient in number and in their potential range of variation and combination to cause the private and government sectors together to realize that policy. Kenneth Arrow and Mordecai Kurz still found this conception useful when they wrote:

It is possible to calculate what may be termed the *publicly optimal policy*, the policy with regard to all variables (in this case, public investment, private investment, and consumption) that would be adopted by a perfectly altruistic government with unlimited powers. (1970, p. 15)

Thus there was justice to G.L.S. Shackle’s (1973, p. 518) characterization that, “for a hundred years and more, economists have concerned themselves with a world where everything necessary can in principle be known, and where the only questions to be studied are how to work out this knowledge from the data of experience, and what practical commands to recognise in it.” This paper shows that research attitudes have been changing.

1.1. The Growing Acceptance of Uncertainty

Overconfidence in the government’s capabilities peaked in the “New Economics” of the 1960s (for a retrospective see Rudiger Dornbusch and Stanley Fischer 1978, pp. 297-330). Since then the rise in inflation and its subsequent stubbornness with respect to the policies of the 1970s, the still largely unexplained worldwide decline in the rate of growth of productivity that accompanied stagflation, and the failure of government-orchestrated development and control programs have had sobering effects in many countries. Keynes’ theories were applied, but found, some would say, extremely wanting (Michael Darby and James Lothian 1986, p. 13).

In the United States the sense of being in close control, particularly over real economic activity, crumbled when the tuning fork of policy activism, consisting of a stable Phillips curve and reliable policy multipliers, proved dissonant with subsequent experience. The most telling critique, that of Robert Lucas, noted that difficulties of observing the course of nature without disturbing it and of separating subject and object, already encountered in the natural sciences, were compounded in the social sciences. There calculating observers of a process also consciously participate, and thereby reshape it. “Given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant

to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models" (Lucas 1976, p. 41). In this way serious doubts were raised about the ability of economists to inform policymakers about the likely consequences of their actions through policy evaluations with econometric models.

The new classical economics went further. As portrayed by Bennett McCallum (1980, pp. 724-38) and summarized by Jerome Stein (1982, pp. 73-75), "[d]emand management policies cannot be expected to accelerate the return to full employment or capacity output" in the words of the latter (p. 75). Furthermore, the variance of price forecast errors and deviations from full employment will rise with the erratic component of changes in the money supply. Hence efficiency would call for abandoning vain attempts to manipulate the economy that inevitably raise discretionary disturbances in the new classical view.

Nevertheless, in René Passet's (1984, p. 378) excellent judgment, uncertainty, which asserts itself more and more in economic analysis, will no doubt for years to come be seen by many organs of state as that unbearable margin of free play that must, if possible, be reduced in the name of efficiency. On the other hand, many economists, starting with classical liberals, continue to view policy activism as a potential source of uncertainty, malign tutelage, and wasteful disturbance. Milton Friedman ([1951] 1966, pp. 117-32) already held this view when Keynesianism was still in its political ascendance. Subsequently disagreements arose on whether policy ineffectiveness or poor execution of policies from an economic viewpoint are to blame for the futility, or worse, of macroeconomic interventions. In either event, the confidence of macroeconomists in their ability to generate useful policy advice has declined and is now at low ebb.

This loss of access and external esteem may be damaging in that "[m]acroeconomic theory is ultimately justifiable by connection to policy analysis" (Christopher Sims 1986b, p. 126). The admission of greater uncertainty may also be necessary, however, to the extent "[e]conomists generally tend to put forward policy conclusions and forecasts as if they were surer of them than they ought to be, based on any objective evidence" (Sims 1986a, p. 8). Friedrich Hayek ([1974] 1978, pp.23-24) in his Nobel Memorial Lecture entitled *The Pre-
tence of Knowledge*, made much the same point.

In fact there are many sources of uncertainty, only a few of which will be enumerated here. For one, only a vanishingly small part of the objective world can be sampled and what can be measured is not all that is important. Then there is the uncertainty surrounding future variables. Expectations and beliefs about them, while important in many macroeconomic relations, can rarely be ascertained directly, and any survey evidence there is may be disputed (see, for instance, Michael Bryan and William Gavin 1986). Future variables are followed in order of potential importance by "notional" or "unconstrained" decision variables. Such variables could be observed over time only if constraints, including prior commitments which may result in a present disequilibrium, were no longer binding in the same way as before (Ray Fair 1984, pp. 20-23). They would surface if there is some institutional or regime change. A multiplicity of solutions may result unless there is a great deal of prior, and itself uncertain, structuring and judgement about relevant variables, coefficient constraints, and the absence of self-fulfilling expectations (McCallum 1983; Edwin Burmeister, Robert Flood, and Peter Garber 1983). Thus uncertainty is now recognized in many measures and values, forms and structures.

We may carry the last point one step further. Recent work by James Hamilton and Charles Whiteman (1985) suggests that observable implications of self-fulfilling expectations, such as bubbles or “sunspot” equilibria that exist only because they are arbitrarily created and temporarily sustained by faith in them, are difficult to extract from price data. The difficulty is that the joint hypothesis normally tested contains a wider range of possibilities and of relations between observables and unobservables than would be needed for identification. Such inability to discriminate between observationally equivalent possibilities, whose implications for government intervention and for the interpretation of price signals differ, is a common manifestation of uncertainty about structures or events. There is growing awareness that identifications that are conditional upon the correct model may exclude such ambiguities only by advance restrictions which have remained untested.

1.2. Statistical and Epistemological Uncertainty

Traditionally uncertainty has been attributed in economics not only to expectations, unobservables and the factor of choice but also to incompleteness of our knowledge of complex structures. If the latter were the main cause of uncertainty, as assumed in classical physics, economic developments could still be regarded as deterministic in principle (Niels Bohr [1949] 1958, p. 34; [1958] 1963, p. 2; Jeffreys 1973, p. 234). Even then one could not pretend to have penetrated to the point of having as yet obtained a complete description of all the factors relevant to a particular entity or to its behavior in the system investigated. Consequently, one had settled for statistical laws or probability estimates in the classical world of thought because there were no practical alternatives for obtaining useful predictions, and not because of irreducible uncertainty and randomness of the kind acknowledged in modern physics (see Lewis Feuer 1974, pp. 177-80). Since then the premise of randomness has proved more productive than the premise of certainty in a number of areas where statistical laws are no longer treated as awaiting replacement by an extension of determinism through scientific research.

Insights first developed in applied mathematics and physics also gradually made uncertainty be reckoned with in the biological and social sciences in a more fundamental way. For instance, wide classes of nonlinear difference and differential equations, that can be as pertinent for ecology as for economics, yield “turbulent” or chaotically unstable trajectories. Systems of such equations are used to establish critical values for policies to be stabilizing or to represent processes such as gradual stock adjustment in conjunction with other reactive processes. One immediate implication of nonperiodic behavior emphasized by Richard Day (1982) is that the future evolution of a model solution cannot be anticipated from its pattern in the past.

Even if the process generating the past data should take a series of irregular and non-recurring values that do not fit any pattern, it would be important to know what that process is. Provided there are no random errors attributable to outside disturbances, even chaotic time series would be determined solely by internal propagation that could be modified by policy. As William Brock (1986) has emphasized, however, deterministic chaos looks random to the naked eye. This makes it difficult in small data sets to distinguish such chaos from, say, a stable nonlinear system buffeted by exogenous shocks.

Doing so would be important for several reasons beyond ascertaining the existence of stable equilibria or limit cycles and the number of possible solutions. It is not sure that nothing at all can be done about the arrival rate and reception of external disturbances. Nevertheless, in the first instance, the government is bound to be much more helpless in the face of shocks classified as exogenous than of irregular movements resulting from known endogenous propagation mechanisms. Hence whether the government can expect to be able to stabilize the economy through built-in policy rules hangs in the balance. If so, such rules could narrow and "improve" the range of deterministic solutions of nonlinear systems (Jean-Michel Grandmont 1985). They could also be designed to provide "resilience" against intrinsically unpredictable fluctuations which can occur in the presence of parameter uncertainty even without exogenous, random shocks (Day and T.-Y. Lin 1986).

A reason for wanting to discriminate also between linear and nonlinear processes, the latter of which contain the possibility of chaos, derives from the dependence of behavior in nonlinear dynamics on initial conditions. If there are multiple solutions in the system, such dependence is likely even in the long run. Brock (1986, pp. 185-92) has summarized the evidence showing how common nonlinear data generation processes appear to be in economics. Any change in initial conditions may then put the future on a different track.

Jacques Monod (1970, p. 161) has emphasized the last point also for modern sciences that do not involve conscious choice. According to him, singular events, such as the origin of human kind, that could not have been grasped in advance even by the "demon" of Laplace because they had an extremely low probability of occurrence, can alter subsequent evolution in a manner not preconceived. Although biological nature tends to be invariant and faithfully replicative, it is the random copying errors, a few of which may turn out to be successes, which let the future be unexpectedly creative. There may be even more of this creativity in the social sciences where copying errors need not be random but can be due to planned innovation and to learning more from experience and the passage of time than the conclusion of one's fate in terms of survival, propagation, or extinction. While creativity may be due to an attempt to manage, i.e., "improve", the odds currently perceived, it also adds to uncertainty about what entries there will be in the catalogue of the future.

In economics, the notion that the list of Arrow-Debreu securities can be complete, so that its tree of sequential events contains all possible future commodities and contingencies right now in theory (Arrow [1953] 1971, pp. 121-33; Gerard Debreu [1953] 1959, pp. 98-102), if not in practice (Arrow 1970, p. 64), would be entirely at variance with this conception. As Manfred Neumann (1986) has hinted, the notion that the set of future possibilities is already closed and precise suffers from a number of deficiencies. It ignores inventiveness and the non-probabilistic possibility of original accidents in both nature and humans (John Hey 1985). It also ignores the fact that the definition of contingencies must be fuzzy: each has to apply over some discrete range of approximation or tolerance if their number is to be finite. Even then there is inexhaustibility, even in theory, as Werner Heisenberg ([1964] 1974, p. 105) has explained among others, so that the set of future contingencies can not be closed. Nevertheless uncertainty, just like knowledge, must be relative to something that is currently at least partially perceived; it has to be motivated and structured. Why and where do we think uncertainty arises and what difference does it make? What specific allowance or provision has been made for it in macroeconomics? We will address questions like these in the body of this paper.

1.3. Scope and Content of this Survey

With this background as introduction, it is now possible to outline the reach of this survey and what will escape its grasp. First a few words on terminology and scope of the subject. Baruch Berliner (1984, p. 381) has the term *uncertainty* cover everything other than complete certainty so that “[w]hatever is not certain is uncertain, whether it is nearly certain or very far from being certain.” If only things that are absolutely certain are to be excluded, almost all of economics remains, certainly much more than can possibly be handled in this survey. To illustrate: Even the most accurate data provide only limited transparency. For instance, price quotations in auction markets have at least peripheral elements of uncertainty in that it is rarely perfectly clear in advance, or independently of testing the market through offers of actual transactions, how much can be bought for how long and from whom at that price. Hence some degree of market uncertainty, as Jack Hirshleifer and John Riley (1979, pp. 1376-77) have called it, is ubiquitous when unobserved variables enter into contemplated tests of markets.

Moving to the opposite extreme by selecting uncertainty rather than certainty as the limiting case is equally unhelpful for delineating our scope. While the previous meaning would exclude almost nothing, this other meaning would exclude almost everything that is suitable for economic analysis, as Lucas ([1976] 1983, p. 9) and others (Arrow 1971, p. 17; Hirshleifer and Riley 1979, p. 1378) have pointed out. Uncertainty about events to come has been given such narrow usage most notably by Frank Knight (1921, pp. 197-232 and 255-61).

Clearly we do not accept either of these polar conceptions of the range to be covered by the term. Rather we will deal with uncertainty that is more than incidental or peripheral to macroeconomic phenomena on the one hand but not boundless or beyond prior structure, probability estimates, and learning on the other. We will also spotlight a middle range in other respects. That range, marked by Lucas (1975, p. 1138), lies between economic and econometric representations that imply that agents and markets foolishly waste information by not changing decision rules optimally and the opposite extreme of markets which rapidly transmit all information to all traders and result in a sequence of static general equilibria.

Within this range we will proceed in each section from the comparatively ascertainable, where uncertainty is taken to arise from known and uncomplicated origins or processes, to increasingly complex conceptions and consequences in particular areas. These areas are dealt with in successive sections starting with technical matters and then turning more to policy issues. Thus the next section (2) covers the basic concepts used in macroeconomics in a technical way by considering aggregation as both a drain and a font of uncertainty. The succeeding section (3) shows econometric procedures that have been applied to learn about the uncertain relations between these concepts. Relaxing the extreme information assumptions of the rational expectations hypothesis, it deals with techniques for updating model parameters with learning and discusses econometric problems posed by current and future expectations variables, multiple equilibria and by transitions between regimes. Section 4, less technically, focuses on representations and effects of variability in several sectors and in the economy as a whole. It also explores the standing of policy and technology surprises and the propagation of the resulting shocks under various models and indexation arrangements. Some concluding observations concerning the treatment of uncertainty in micro/macro relations and in asserting current states of information are attempted in the last section (5).

2. Uncertainty in Aggregation

The origins of uncertainty are sometimes believed to be known and sometimes not known; more often in economics uncertainty is simply disregarded. This applies especially to the basic building blocks of macroeconomics, which are aggregation functions and the resulting aggregates. Both Keynes and Milton Friedman, in the judgement of the latter (1976, p. 316), and many others building from “the top down” treat some aggregates as “objective” inputs for analysis. In fact, aggregates do not precede analysis and are not necessarily pre-given to it. None of them exists independently of definitional rules and a mathematical form for constructing it. Construction should be guided, ideally, by theoretical rationales that ensure compatibility with basic requirements of economic theory. For example, a twice continuously differentiable linear homogeneous aggregation function (yielding what is known as a “superlative” index or aggregate) could be consistent with basic tenets, such as diminishing marginal effect on utility or productivity (W. E. Diewert 1976; 1978; William Barnett *et al.* 1984), whereas a linear function, or a simple-sum aggregate, would not be.

In practice, theoretical requirements are often ignored and violated. As a result, aggregation raises uncertainty in some respects while it reduces it in others compared with the uncertainty surrounding the behavior of one of its imperfectly homogeneous elements. Probing more deeply into these possibilities of error early in this survey will make it easier to appreciate what can happen when data taken from the plane of actual decisions or individual tries are combined to form aggregates.

Several different types of aggregates are encountered in economic data bases and in the kind of weighing that leads to decision making. Accordingly, the rules of aggregation may differ. For instance, the median voter is found by solving for the limit of an integral while the mean of a probability distribution is the value of an indefinite integral whose discrete equivalent is a simple-sum aggregate divided by the number of cases. While different kinds of slating, filtering, data generation or screening may occur in the background, in each case fixed statistical “eligibility” rules are adopted which are based on the recognized franchise, accounting standards, or conventions. They yield aggregates that are verifiable, usually through the simple procedure of a “recount”, but of doubtful suitability for the analytical demands made on them. This is where uncertainty enters aggregation.

An opposite effect, toward reduced uncertainty, is attributed to the law of large numbers. From the microeconomic base of many tries, this law could raise the predictability of economic outcomes to the point of converting uncertainty about the outcome of individual events into asymptotic certainty about aggregates, i.e., averages of such events. For instance, if such events are independent with a coefficient of variation equal to x at the micro level, that coefficient would be reduced to $x/\sqrt{n}$ at the macro level when the number of contemporaneous elements in the aggregation is n . In applications, for instance to optimal inventory holding, this aggregation effect is known as the square-root law. Of course, in economics, complete independence of events is unlikely because there are people, and shared information systems, behind them.

Even if the square-root law applies and the estimated averages of stationary distributions reveal the population mean with growing precision as more observations are added, no information may be gained from increased sample size about the characteristics of individual elements relative to the original prior (Hayek [1974] 1978, p. 27). For example, assume

this prior was equiprobability of heads and tails in a toss of a coin with unknown bias, but a statistically significant bias is revealed when a large number of coins are tossed simultaneously. Then if bias in the aggregate is due to a few coins with strong bias in one direction dominating the outcome over more coins with weaker bias in the other direction, calling with the net bias would not be advised for arriving at the best estimate of the direction of the bias in a randomly selected coin.

Analogues of this argument are frequently found in critiques of “representative agent” models in economics that take no account of composition. David Betson and David Greenberg (1986), M.H. Pesaran, R.G. Pierse, and M.S. Kumar (1986) and Stewart Schwab (1986) have provided telling examples from the labor market. Real wages have been found sensitive to unemployment by demographic groups (Mark Mitchell *et al.* 1985) and at the industry level (Wilfred Beckerman and Tim Jenkinson 1986) even though there are no stable or significant relations between real wages and the business cycle at the aggregative level. Similarly, price flexibility appears in disaggregated statistics that does not appear from aggregate price level indexes (Dennis Carlton 1986). Hence aggregation can obscure the evidence we are interested in under some circumstances, while making it stand out more clearly under others.

The many types of aggregates that exist may crudely, but usefully for economics, be classified into three groups distinguishing cross-sectional, intertemporal, or organizational features as the dominant aspect of aggregation. Of course in the architecture of an economic system, all of these aggregates appear together in various configurations. Still it may be helpful to explain the uncertainties particular to each type of aggregate in turn before dealing jointly with their several dimensions.

2.1. Cross-Sectional Aggregates

If putting small pieces together to make something large is part of what gives macroeconomics its name, cross-sectional aggregates are the ones most commonly thought of in that discipline. Conceptually, this first type of aggregate is formed over distinct micro-level decision elements, such as households, and over object classes, such as currency and demand deposits which they hold. In actuality, no reports from the household sector are needed by government agencies to compile the statistics as simple dollar sums of the components which have been defined to constitute a particular aggregate such as money. We will next report on what the standards for this first type of aggregation should be and to what extent they have been found to be observed in the literature.

Simple-sum aggregation may be justifiable in equilibrium with perfect markets, particularly if hedonistic and productivity attributes can be separately priced and reflected in the definition of the items to be aggregated. Atomistic competition in which information is centrally revealed in Walrasian auction markets may be uncharacteristic of many areas of economic life; but where it exists, it prevents lasting differences between the marginal values of the same or similar products and resources in different uses. This would help greatly to simplify the problem and methods of aggregation.

Unfortunately, marginal valuations are frequently not uniform. Consider, for instance, what happens to the validity of inferring changes in capital services for use in production functions from changes in simple-sum quantity aggregates of the capital stock when marginal productivities, r , need not be equalized. The simple-sum aggregate is derived by adding statistical estimates of the (current replacement cost of the gross or net) stock of private (p) and government-owned (g) fixed nonresidential capital, so that this total stock, k , equals $k_p + k_g$. Then a Divisia index (see Barnett 1982), long recommended by Laurits Christensen and Dale Jorgenson (1969; 1970), Christensen, Jorgenson and Lawrence Lau (1973), and Jorgenson (1980) in similar contexts, would measure the rate of change in capital inputs consistently. It would do so by aggregating rates of change in the two quantity components weighted by the value shares, i.e., by their shares in the total return to capital, as shown below:

$$[r_p k_p / (r_p k_p + r_g k_g)] (\dot{k}_p / k_p) + [r_g k_g / (r_p k_p + r_g k_g)] (\dot{k}_g / k_g). \quad (1)$$

It is easy to see that this expression would be equal to $\dot{k}/k$, the rate of change in the simple quantity aggregate, only on two conditions: (a) $r_p = r_g$ or $k_p/k_p = k_g/k_g$. Since equal growth rates in the components would be fortuitous, only equality of the marginal rates of return r_p and r_g could validate the simplest form of aggregation. If rates of return also differed persistently between private industries, k_p/k_p might itself, of course, be an improper aggregate for use in an aggregate production function if growth is distributed unevenly over industries. This argument could be carried further to firms within industries and then to divisions of firms that are separate profit centers.

Quite generally, for factors i and j to form a consistent aggregate such that the set J , containing i and j is separable from factor h not in J , a weak separability condition (Trout Rader 1972, p. 216) must hold. As shown in eq. (2) below, it states that the ratio of the marginal rates of substitution, m , with the numeraire commodity, in this case h , should be independent of h . If this is so, then it will also be the case that the (R.G.D.) Allen (1960, pp. 503-05) partial elasticities of substitution, ς , with the excluded factor, h , are the same for each of the factors, i and j , included in J . Hence two equivalent conditions for i and j to form a consistent aggregates are:

$$\delta(m_i/m_j)/\delta h = 0 \quad i, j \in J; h \notin J, \quad (2)$$

and $\varsigma_{ih} = \varsigma_{jh}$.

Ernst Berndt and Christensen (1974) have analyzed whether these conditions are met for different types of labor so that labor inputs can be aggregated consistently over skill grades. Letting i represent blue-collar labor, j white-collar labor, and k capital, they found with manufacturing data going back to 1929 that the degree of substitution of i and j for k is very far from being the same. Instead, white-collar labor is complementary with capital in the previous study, or at least far less substitutable for capital than blue-collar labor (Daniel Hamermesh and James Grant 1979). By contrast, Carmel Chiswick (1985) has found that the long-run elasticity of substitution of physical capital for each of the two levels of human capital is much higher (about 2.5) than between capital and a single labor aggregate (less than unity). Continuing to subdivide, non-residential structures and equipment each are likely to relate differently to labor as a whole and to its major skill components. The same may be true for capital goods of different vintages, technology levels, or in sectors with different labor shares under all but improbable conditions (Murray Brown and Winston

Chang 1976; Diewert 1980). Energy, but not some other materials, may be a complement for capital and a substitute for labor (Berndt and David Wood 1975; Barry Field and Charles Grebenstein 1980). Hence, there may not be a consistent aggregate of any of the major factors of production, labor, capital and materials.

Berndt and Christensen (1974) and Finn Kydland (1984) have shown that the size of the errors introduced by ignoring this depends on the relation under investigation. Robert Allen and Diewert (1981) have characterized error bounds on price and quantity indexes under assumed conditions. The corollary of this is that when errors are reduced by defining the aggregates and the limits of aggregation in the manner most suitable for each purpose, the aggregates become specialized. Results obtained with them become difficult to compare within and across areas of application. James Tobin (1985, p. 36) has noted the ambiguities that may arise from the proliferation of constructs. Whether specialized or general, aggregation now raises uncertainties, quite the opposite of what the law of large numbers had promised.

Uncertainty in aggregation extends not only to products and factors but also to policy instruments. The notion of a single indicator of the thrust of fiscal policy, such as the change in the high-employment or middle-expansion budget surplus (see Frank de Leeuw and Thomas Holloway 1983, 1985) has already been abandoned for some time for many purposes as Alan Blinder and Stephen Goldfeld (1976) had advised. However, simple-sum aggregates of money are still in wide use. They are targeted by the monetary authorities, announced weekly amid suspense in financial markets, and used to forecast nominal GNP, although microfoundations for doing so are quite lacking (Arrow 1986, pp. S386-S387).

For forecasting purposes, the different components of monetary change have been weighted in some recent academic studies by the proportion of the total value of transactions to which each of the components may be thought to have contributed. In the rental cost formulation of Donal Donovan (1978), each proportion is represented by the share of the opportunity cost of a component of money in the total opportunity cost of all components that are credited with being money. The rate of opportunity cost, that is presumably compensated by the marginal value of transaction services, is the rate of return on a liquid non-monetary asset of negligible risk minus the explicit own rate of return on money. If the non-monetary asset selected were Treasury bills or Milton Friedman's traditional favorite, high-grade commercial paper, only deposit balances with lower rates of return could possibly be included in money. In recent years, Milton Friedman and Anna Schwartz (1982, p. 263) have advised finding a compact way to describe the whole structure of yields on non-monetary assets, rather than just on the one, or the elusive small set, that can be regarded as the closest substitute for money. Even so, certain high-yielding components of money could drop in or out of the definition depending on cyclical or other changes in relative interest rates.

Furthermore, the non-negativity constraint on opportunity cost does not settle what could possibly be included until the alternative asset has been defined. Such an asset would have approximately equal substitutability with all the components included in money if the sum of these components is to be jointly separable from the excluded asset. No asset is likely to meet these demanding requirements (Thomas Simpson and Patrick Parkinson 1984). There are also problems with technological advances that lower the cost of providing

transaction services and hence the opportunity cost of holding a particular component of money in a competitive banking system. Reducing the weight attached to changes in that particular component does not appear sensible because a reduction in the cost of transaction services should raise, not lower, the quantity of such services demanded from that component of money. For this reason Paul Spindt (1985) has experimented with turnover, rather than opportunity-cost, weighting of changes in money components. Even so he found that as the opportunity cost of holding bank liabilities with deregulated interest rates became less and less, the sophisticated aggregate behaved more and more like the narrowest concept of non-interest bearing money, including currency about whose turnover little is known. From tests of separability conditions, Apostolos Serletis and A. Leslie Robb (1986) also obtained no justification for broad money measures such as those officially emphasized once again by the Federal Reserve early in 1987.

It appears, therefore, that sophisticated aggregation procedures which are persuasive under some conditions may be unable to take account of others. Results can degenerate and fall victim to a change in circumstances. For instance, aggregation problems may hamper the ability to control nominal GNP by relying on any stable procedure for aggregating money or total nonfinancial debt (Simpson 1984; Stephen King 1986). Furthermore, policy-makers who are uncertain even about the policies they would follow contingent upon events compound uncertainty in the private sector. Kenneth Judd (1986) and Jonathan Skinner (1986) have explored this for fiscal policy. Beyond being unsure about how to fit means to ends in this and other areas, the policy goals themselves, of course, are frequently vague, and this may contribute to uncertainty about prospective reactions.

Far on the other side of this aggregation debate are those who believe not only that simple-sum monetary aggregates are meaningful in a country but that their rates of growth, weighted by GNP, should be combined for several major countries to achieve better control in each. Ronald McKinnon (1982; 1984) is the most prominent exponent of this view which implies that world money is a separable aggregate. If so, some major national moneys, no matter how heterogeneous internally, would be so highly substitutable for each other that they must also have similar substitutability with non-monetary assets issued by the major countries in their own or each other's currency. Several studies (see Dallas Batten and R. W. Hafer 1985) have indicated that these assumptions have no significant empirical support and that world money growth is not a good predictor of what happens to nominal GNP and inflation in each of the major countries. Dornbusch and Fischer (1986, p. 492) have characterized the addition of foreign variables to money demand equations as unpersuasive. Hence, contrary to McKinnon and Kong-Yam Tan (1983), domestic monetarism may not have become obsolete. However, both global and traditional domestic monetarism might gain by considering aggregation issues in terms somewhat less crude than whether, on the basis of ad hoc judgement, particular liabilities of financial institutions should be in or out of the definition of money at various times.

2.2. Intertemporal Aggregates

Except perhaps in two-period models, intertemporal calculations, whether connected with portfolio, consumption, or investment decisions, invariably employ some forms of aggregation over time. Certain prices, for instance, long-term interest rates, also involve

such aggregation (over short rates) in efficient markets. Similarly, contracts that fix terms over some period involve intertemporal aggregation of the tree of contingencies envisaged when they are entered into. To carry out intertemporal estimation may require assumptions about relevant time constraints or horizons, such as building, holding, or commitment periods and (useful) lifetimes. In addition, there must be rules for forecasting and discounting uncertain events over variable time horizons that can reach infinity in some models.

Contributions assessing substantive controversies that have arisen in this regard have appeared in a number of areas. Hall (1977), Burton Malkiel *et al.* (1979), and Kydland and Edward Prescott (1982) provide different intertemporal constructs of investment decisions and their implementation over time. John Judd and John Scadding (1982, pp. 1007-08), Gregory Mankiw and Lawrence Summers (1984), and John Campbell and Robert Shiller (1987) appraise long and short-run determinants of money demand, the term structure of interest rates, and the adequacy of present value models of valuation. Finally, Martin Feldstein (1982), Olivier Blanchard (1985), Jacob Frenkel and Assaf Razin (1986), and James Poterba and Summers (1986b) stand out from the many who have addressed the uncertain weighing of exposure to future taxes connected with the government's unsustainable rate of deficit finance.

In what follows we will deal more generally with uncertainty that may arise in intertemporal aggregation of data in some respects while being reduced by that very same aggregation in others. On the one hand uncertainty is introduced by the dependence of the construction of such data on uncertain prior assumptions about reaction or commitment times that have to do with the length of the observation period desired for the data. On the other hand, while priors are needed here also, uncertainty is reduced to the extent intertemporal aggregation helps discover systematic tendencies by raising the signal to noise ratio and allowing conclusions to be drawn with greater confidence. These opposing possibilities are illustrated by two types of data that are inevitably aggregated over time: flow data and data designed to reveal the behavior pattern of significant actors in the economy. Uncertainties arising in connection with the former type are discussed only briefly before turning to the latter.

The length of time period over which intertemporal aggregation is informative depends on what priors one has about the behavior involved. For instance, few would believe that it would be sensible to test the sensitivity of consumption to current income with daily data because it does not stand to reason that consumption would plummet when no income is earned on one's weekly days off. However, if a choice would have to be made between monthly, quarterly, and annual data, the decision could well turn more on the degrees of freedom readily afforded by a series than on principled considerations. Paul Newbold (1983, p. 159) has summarized what can happen when continuous processes are reduced to data sampled at administratively convenient points in time. For instance, time aggregation can induce spurious causality, making an inherently unidirectional relationship appear to exhibit feedback.

Priors are needed not only in data construction. They also determine whether it would be thought useful, for gauging future behavior, to observe the past behavior of an actor. If the attitude taken about the policy actions forthcoming at a particular juncture is that "anything is possible", there is zero precision, the inverse of an infinite variance, of prior

beliefs. Such an attitude would make the individual put the entire weight on current developments for gauging what might then follow. However, under less than complete discontinuity in the ways of the authorities, their past actions would retain some information value for prediction. How much value depends on priors about likelihood, rapidity, and frequency of a regime change and the ease and statistical confidence with which any such change can be detected amidst the “noise” accompanying its implementation. William Roberds (1987) has expanded on the importance of considering the probability of administration turnover in this connection.

Even if there is no obvious change in administration, there can be an inference problem. At first glance, the second type of aggregate, used to reveal lasting characteristics of actors, may be thought to involve little heterogeneity because it deals with aggregation of the track record of what could be considered the “same” agent. However, the concept of being the same is problematic in revealed-preference theory when spontaneous or endogenous changes in tastes are admitted (C. Christian von Weizsäcker 1971) or utility adapts as a result of new insights (Michael Cohen and Robert Axelrod 1984; Richard Cyert and Morris DeGroot 1986). Just as variables or patterns that require (artificial) intelligence to recognize are invariably fuzzy (for references to formal treatments of fuzzy variables, objectives, and logic see Janusz Kacprzyk 1986), there is a problem of identity in macroeconomics. Without addressing that problem it would be pointless to remark that “if all potential policymakers were the same, there would be nothing to learn from seeing their actions” (Robert Barro 1986b, p. 20). Is a regime change to be recognized by a change in the *modus operandi* or by a change in preferences or ends? How can any such change be inferred statistically? What if the change in the choice of means results from a change in the way in which the authorities view, or implicitly model, the economy? This would alter the constraints they perceive and hence their actions, but it would not necessarily affect their targets or the objectives to which they feel they can contribute. Furthermore, obfuscation to maintain the element of surprise may itself be the objective in games creating uncertainty about the authorities’ next move and true intentions. Experience values would then be difficult to derive from repeated observation of a given action or process.

Alternatively, the authorities may be myopically risk averse and repetitive so that their behavior pattern is easily figured from their record. Stein (1982, pp. 209-18) and a number of others (cited in Michael Bradley and Dennis Jansen 1986) have tried to show at various times that they could do this with the Federal Reserve. However, the role underlying the actions of a single entity can emerge ever more clearly from lengthening time series only if the systematic features of official behavior are in fact constant. Furthermore, constancy of method as well as purpose can be expected only if the degree of novelty or surprise from adopting a particular *modus operandi* is unrelated to its rationally expected success. Otherwise it is difficult to see how the authorities could acquiesce in losing effectiveness as their strategies are found out.

Taylor (1975) provides a systematic analysis of what intertemporal aggregation may achieve in revealing to the public methods and intentions pursued by the authorities. Before showing how Bayesian learning proceeds with lengthening time series, he explains that private agents face the need for such learning because the authorities disguise their systematic actions with “noise”. In addition, there is a temporary tradeoff between inflation

and unemployment that is characterized by an expectations-augmented Phillips curve, while a (quadratic) penalty applies to both inflation and allocatively excessive unemployment. Then the speed with which expected inflation catches up with actual inflation determines the size and duration of the net gains perceived by the authorities from using their control of the money supply to generate inflation surprises. These gains can arise from temporarily depressed after-tax real wages driving the unemployment rate below its high "natural" but tax-distorted level in a system in which wage rates for the period ahead are set on the basis of expected inflation. In a continuous-time model, an infinitely large adjustment rate of the expected rate of inflation to any difference between the actual inflation rate, $f(t)$, and the expected rate, $x(t)$, would keep any such difference infinitesimal at all times t . Hence the net value of inflation would necessarily be negative to the authorities.

However, in the absence of prior knowledge that a regime change is imminent, it would not necessarily be efficient for private agents to restrict attention to the latest data. Suspending prior beliefs is consistent with rational expectations in that it prevents a string of serially correlated expectational errors if a regime change is in fact occurring. Then if there are no long-term contracts that are renegotiated less frequently than monetary policy (Fischer 1977) and "if new policymakers take over monetary planning, and if the public is completely ignorant as to their objectives and puts no weight on past inflation policy, ...their monetary policy will be ineffective in changing unemployment" (Taylor 1975, p. 1020). In other words, the expected forecast error under the new regime, $E[f(t)dt - x(t)dt]$ over the time interval dt , would be zero because expectations lack conviction and are formed on the basis of no information other than $f(t)$. If the mean rate of money growth has, in fact, changed in a manner initially unknown to the public, sticking with any prior beliefs on the matter is prejudicial to learning as fast as possible what the new rate is. Bayesian estimators are biased unless the prior distribution is treated as noninformative, as it should be in this case. If the new policy is known to be characterized by a fixed rate of money growth, the very first observation under the new regime would give away the game; if implementation is noisy, $f(t)$ would still be the best guess of the new average rate of money growth which the authorities now have planned.

On the other hand, being ready to abandon all priors at the slightest provocation amounts to choosing a very low t -value for the significance test of the hypothesis that nothing fundamentally has changed. This increases the chance of being misled by noise in the early stages of the potentially new series and rejecting the hypothesis of "no change" which could, in fact, remain true. Thus the chance of type I error rises while that of type II declines with the loss of conviction. Matthew Canzoneri (1985) has shown that concerns about these different types of errors would also weigh on labor if it could collectively adopt a penalty scheme with which to confront the monetary authorities. Matters are even more difficult if workers, as in David Backus and John Driffill (1985), do not communicate to the authorities what this scheme is.

In this peculiar role assignment, labor is cast as so opposed to being thrown off its supply curve by inflation surprises, that it is willing to frustrate the authorities through increased unemployment later on should they dare. Now if the authorities pursue a noisy policy consistent with long-term price stability and try to accommodate shifts in money demand,

about which they alone have some knowledge, at the same time, money supply growth will appear quite erratic to private agents (Canzoneri 1985). Agents now must infer whether the changes in money supply growth observed contain only stabilizing and white noise variations, or variations spelling a return to inflation bias as well. In this, complete agnosticism about official intentions is uncalled for, perhaps even preposterous, particularly in democracies. Furthermore, in democracies, the authorities are not the only ones who can play, so that many games may be two-sided (Backus and Driffill 1985). European contributions, in particular, continue to emphasize that, instead of threatening to retaliate against inflation surprises engineered by the monetary authorities, organized labor may use political and economic threats of various kinds, some of which may kindle inflation of their own. A recent contribution by K. Blackburn and M. Christensen (1986) and the many references to the Scandinavian literature it contains provide examples of games in which more than one type of player can take initiatives.

Organized or not, the general public is not normally relieved of the task of filtering signals from noisy series or of deciding when to look out for a change in signals and when to expect a break of a size and duration sufficient to herald a new economic regime. Already at this stage of the survey it is clear, therefore, that without identifying content and strength, or mean and variance, of prior beliefs about a variable and the way it is handled by the authorities in at least some respects, uncertainty could be featureless and rational learning impossible to describe. Furthermore in this as in other respects, such as in selecting projects with uncertain returns (Raaj Sah and Stiglitz 1986), preferences regarding type I versus type II errors in society have much to do with its expected performance and decision structure.

One such structure has been developed by Taylor (1975) on the assumption that prior beliefs about money growth are given from time $t = 0$ with mean $x(0)$ and variance ζ_0^2 , so that they are held with invaring precision of $w = \zeta_0^2$. Nevertheless mathematical expectations do not stand still as experience begins to accumulate under the new regime. That regime aims for money growth (and inflation) of μ with an instantaneous precision of $y(t) = \zeta_t^2$ and cumulative precision of $z(t) = \int_0^t y(s) ds$. Although, unlike $y(t)$ and $z(t)$, μ is not known in advance to the public, it is the average money growth rate one would expect to observe with a variance that declines with the number of observations generated since $t = 0$. The inverse of this variance, $z(t)$, correspondingly increases with t . In Taylor's (1975, p. 1017) formula, reproduced below, this causes the systematic error in the inflation (and money growth) forecast, $E[f(t)dt - x(t)dt]$, to tend to zero as observations accumulate.

$$E[f(t)dt - x(t)dt] = [w/(w + z(t))][\mu - x(0)]dt \quad (3)$$

This result will be inevitable unless the new policy can never be found out because it is infinitely noisy or completely imprecise so that $y(t) = z(t) = 0$. However, such extreme noise in money growth rates will be discouraged by Jensen's inequality on the non-linear expectations-augmented Phillips curve raising the mean unemployment that is generated by wider symmetric scatter of money growth. On the other hand, if $w = 0$ because the agent has no confidence whatever in the predictive usefulness of any prior beliefs, he will eliminate any systematic error in the inflation forecast right away no matter how much the mean rate of money growth, $\mu - x(0)$, may have changed.

As Barro and David Gordon (1983a, 1983b) have pointed out, where there are no prior beliefs there is no reputation. In the first of a series of games between the monetary authorities and the public, they have the prior beliefs of economic agents oscillating with total confidence ($w \rightarrow \infty$) between the allocatively optimal inflation rate of zero and the time consistent (Kydland and Prescott 1977), noncooperative or Nash equilibrium rate. At that rate further inflation would be unattractive to the authorities even when they take the expected inflation rate as given and divorced from their actions. In this first game, reputations are easy to establish. The authorities need to do what they say only once--even if what they do is bad for private agents (the Nash inflation rate)--and be believed completely the next time if they announce (but never follow) a policy of zero inflation. The loss in credibility in the second period is then made up in the third and the game oscillates between "believe you" and "believe you not" without more memory or learning.

Regaining a reputation has been made harder in further games by Barro and David Gordon (1983a, 1983b) and higher penalties for official misbehavior, such as over 100% lagged indexing (Christopher Waller 1987), have been invoked also in subsequent contributions. It has since been pointed out by Alex Cukierman (1986) that this deterrence strategy may itself be lacking in credibility on account of free rider and other problems. Nevertheless, various proposed schemes of punishment have led to the lowest enforceable, or incentive-compatible inflation rate being cut down, at least in theory. Robert Townsend (1982) and Daniel Cohen and Phillipe Michel (1986b) have explored optimal precommitment and incentive compatibility further in this context. Taylor (1983) found the literature succeeding to such an extent already earlier that time inconsistency of the optimal policy of zero inflation (Kydland and Prescott 1977) no longer appeared as an attractive explanation for the failure to overcome inflation bias in government policies. However, in a recent evaluation, Kenneth Rogoff (1986) has concluded that it would be premature to dismiss time consistency as a major issue in the design of monetary policy institutions and in deciding on the constraints and rules to be placed on them.

This literature has shown that policy making cannot normally be treated as if it occurred in a historical vacuum, or as a comparative-static exercise entirely *de novo*. Rather, aggregation and retention of the track record contribute to the appraisal of regimes and their credibility. Institutional and private memory can keep the past alive in economic decisions in a way best explained in international lending to sovereigns (see, for instance, Herschel Grossman and John van Huyck 1986). Reputations can be acquired by providing reliable information about current intentions and difficulties as well as about future actions and conditional penalties or planned retaliations. Reputations may be built over time even if policymakers make noisily executed announcements as long as the official targets do not turn out to be biased forecasts (Cukierman and Allan Meltzer 1986). Such investments may have social value not only in that they lower the cost of acquiring information for others but also in that they reduce the social cost of enforcing announced policies and getting the desired results (for an example see Jeffrey Frankel and Gikas Hardouvelis 1985).

With stochastic disturbances of a continuing nature leading to a repeated game, the authorities will value their reputation inversely with their political discount rate (David Currie and Paul Levine 1986). Under some change in circumstances, instead of being maintained, reputations may then be traded on and depreciated; they can be used to deceive.

Secrecy can be so used if it is designed to impede the discovery of true intentions. This applies to government bodies as well as persons. At the very least there appears to be a bias in favor of information which is of value to the individual or unit precisely because it need not be made public (Stiglitz 1981, p. 245) and can be used to reap gains at the expense of the uninformed or those with incorrect prior information or beliefs (Hirshleifer 1971). Accordingly, the literature just surveyed was based on the premise of official secrecy or of situations in which discretionary actions speak louder than words.

Institutional defenses and theoretical justifications of the practice of secrecy in central banking have been reviewed already by Marvin Goodfriend (1986a) and Robert King (1986). Of course not all regime changes, such as the official suspension of commitments to maintain fixed exchange rates among the major currencies in February 1973 or the adoption of money-supply targeted operating procedures by the Federal Reserve in October 1979, were, or could be, secret. However, even here only time could tell what these changes would actually imply, for instance for domestic money growth. Hence even if the authorities dispensed with official secrecy and announced their plans of action as soon as they had been adopted, such announcements would not necessarily reduce uncertainty. Compared with secrecy they would do so only if the authorities deserve to be believed not only in the judgement of the representative individual but of all. In fact, as Roman Frydman and Edmund Phelps (1983, p. 6) have pointed out, an individual must not only know and believe the government announcement but must also know that other agents know and believe in the announced change in policy for a protracted period of disequilibrium to be avoided. Hence, how decision-making units are linked within a system, how they are selected (Rogoff 1985), and what screening devices they apply affects the errors within the system, as well as how these errors are aggregated. Sah and Stiglitz (1986) have described such features as basic to the architecture of the economic system. It is architectural issues and their relation to uncertainty to which we now turn.

2.3. Organizational Aggregates

The third type of aggregation occurs in organizations or in the process of deriving system solutions. Politically it rests on voting rules and other procedures for reaching decisions in committees or hierarchies within organizations and between them. Technically it involves procedures for combining the weighted contributions of several "levels", "factors" or "causes" to a decision sequence that produces some outcome or resolution.

Outcomes may cover a wide range. They may be as diverse as the determination of a dependent variable in a system on one side, and an election to office on the other. Considering the entire organization of the system from which individual results emerge, they may be called "particular", "organic", or "holistic" aggregates. Forming them involves uncertain processes of emergence and agency (representation) perhaps similar to those encountered in relating a U.S. president's program to the popular will. Considering also the uncertain interactions among subsystems, general systems theory (see, for instance, Kenneth Boulding 1972) and principal-agent theory (see Arrow 1985) could be relevant here, while use of game theory would be more appropriate for analyzing decision making in smaller groups in which power remains divided.

In politics and management, compromise outcomes tend to be less stable and predictable the greater the heterogeneity of interests and viewpoints from which they are wrung. It is impossible, not only for outsiders, to program all the games and decision elements along the multiple pathways leading to resolution inside and between particular organizations (Daniel Levinthal 1984). Hence the number of possible scenarios is large, and the sequence of outcomes correspondingly uncertain. A number of past attempts to map out systematic elements in this political aggregation process are of interest to macroeconomics (see, for instance, Richard Puckett 1984; Willem Buiter and Richard Marston, eds. 1985; James Griffin 1985; and Ronald Wintrobe and Albert Breton 1986). Nevertheless, the uncertainty that is implicit in the decision processes of complex organizations will not be dealt with further in this paper. Indeed, partly because these processes have proved so difficult to model, salient decisions of such organizations are frequently treated as exogenous inputs, or shocks, in economic models.

Even aggregates reached outside hierarchies or committees, such as flow measures which may have looked robust and unambiguous to the early Keynesians, increasingly have become objects of contention and doubt. There is a growing sense that the usefulness of any one construction will depend on what Sah and Stiglitz (1986) have called the architecture of the economic system. They show that how decision-making units are organized and their members and executives selected, what screening functions they apply to projects and ideas of uncertain merit or profitability, and how much they insure against mistakes of one type or another affects the errors within the system, as well as how these errors are combined, propagated, and compensated.

At the simplest level it even affects the correspondence between data, such as actual and potential output, which are frequently compared over business cycles. For instance, if a central bureaucracy, or some other organization with market power (Hall 1986a; 1986b), arranges matters in such a way that the prices of products are made to differ from their marginal costs, then factor-cost based and consumer-benefit based aggregations would not agree. Potential output, however, is factor-cost based. It purports to measure the level of output consistent with the natural degree of utilization of all resources, particularly labor, and not the maximum benefit, in terms of consumer valuations evidenced by output prices, that can be derived from such resource use (see Robert Gordon 1984b). Hence industrial organization matters to aggregate outcomes and how they are to be understood.

More broadly, the information content of aggregates is reduced whenever composition effects and relative standing matter and externalities arise from demonstration, imitation, and other invidious or solidaristic forms of interpersonal dependence. Dimensional compression has a cost. Robert Frank (1985) covers several of these points in his discussion of cooperative arrangements and institutions which may serve to raise the demand for contingent and "nonpositional" as opposed to "positional" goods, or for "insurance" versus "cars". Only the values of the latter type of goods depend strongly on how they compare with things visibly owned by others. As opposed to such interdependence, a polyarchy (Sah and Stiglitz 1986), in which decision makers undertake projects, ideas, or purchases independently and without consideration of rank or signals emitted from peers rather than

markets, would be aggregation's best friend in at least one respect. It would replace the complex games persons or organizations play with and upon each other with the Nash solutions characteristics of competitive markets in which all decisions are impersonal and unilateral.

On the other hand, informationally decentralized systems beyond those amenable to tâtonnement processes contain obstacles to rational learning and to the identification of average opinion that is to support market equilibria. These obstacles have proved difficult to overcome in the theoretical literature when it is impossible through communication to centralize dispersed information (Leonid Hurwicz 1972, p. 301; Geoffrey Philpotts 1972; Frydman 1983; Townsend 1983, esp. pp. 548-50). Similarly, heterogeneous information, for instance about the productivity of capital (Sanford Grossman and Laurence Weiss 1982), or agents that are heterogeneous in terms of their ability to process information (see John Haltiwanger and Michael Waldman 1985) have been found to lead to solutions different from those expected under the informational assumptions underlying macroeconomic applications of rational expectations. Hence how people, abilities, information flows and markets are organized can have a profound effect on the aggregate outcomes.

2.4. Value Dependence and the Several Dimensions of Aggregation

It was shown before that both prices and quantities enter as weights into the construction of any Divisia or other "superlative" index or aggregate compatible with economic theory. (Several such index forms are identified in Douglas Caves *et al.* 1982.) For this reason, no matter how physical the count intended, aggregation is quite literally not value free. Value dependence also enters into aggregation in a less mechanical way through a variety of insurance and risk sharing arrangements in society. These include fiscal equalization rules or constitutions adopted when individuals are uncertain about their future income positions (James Buchanan 1976; Hal Varian 1980; Georg Tillmann 1986) or about comparative capacities for satisfaction (Abba Lerner 1944, pp. 28-30). Together with a number of risk sharing devices in private markets, they create an intertemporal web of explicit and implicit contracts masterfully surveyed by Sherwin Rosen (1985). Few strands of this web are visible in high-frequency flow data or in stock data on assets and wealth.

For a simple illustration take compensation of employees. As reported in the U.S. income and product accounts, wage and salary disbursements account for 83 percent (1985) of this total and supplements to wages and salaries for the rest. Supplements, in turn are split about equally between employer contributions for social insurance and other labor income. Unlike other elements of compensation, other labor income has frequently involved tax shelters and this has contributed to heterogeneity of the value of different components to recipients. Functionally, supplements as a whole consist almost entirely of contributions to pension, profit-sharing, and other retirement benefit plans (53%), health insurance (32%), life insurance (2%), workers' compensation (6%), and unemployment insurance (6%). Lawrence Thompson (1983) has discussed many of the intertemporal, indeed intergenerational, issues that arise in the valuation of these supplements by individuals and in determining to what degree they are appropriable, at least notionally. Contributions for unemployment insurance, for instance, contain both a flat-tax component and an element of experience rating that might be thought of as prepayment, or, more likely, postpayment

for indemnities provided by the unemployment insurance system to employees and employers with unusually intermittent, cyclical, or seasonal work (James Adams 1985). Clearly, valuing such combined contributions as simply on a par with wage and salary disbursements would be arbitrary for the purpose of determining labor supply. The same holds for profits-related pay. Even regular wage and salary disbursements are thought to contain elements of insurance and risk sharing that dissociate the measured average wage rate from both the marginal product of labor and from the marginal rate of substitution between leisure and consumption (Rosen 1985, p. 1161; John Fay and James Medoff 1985).

Compared with piece rates, moral hazard and possible inefficiencies arise in all these “two-part variable tariff” (Rosen’s term 1985, p. 1159) arrangements, particularly when they are concluded in situations of bilateral monopoly (Hall and Edward Lazear 1984). The entire set of issues has been considered in depth by Stiglitz (1983), Arrow (1985), and Richard Arnott and Stiglitz (1985). Relevant portions have been dealt with in labor or product markets with asymmetric information by Joanne Salop and Steven Salop (1976), Jacques Drèze (1979), Milton Harris and Artur Raviv (1979), Sanford Grossman and Oliver (1983), Charles Schultze (1985), and Kurz (1986). Compared with a Walrasian auction system, the significance and steering function of prices and the determination of quantities change when there is a need for devising “agency” remuneration, offer, and insurance pricing schemes designed to elicit honest revelation of preferences and intentions for the present and the future. Aggregation simply on the basis of current cost, as in the case of employee compensation, is not likely to suit many analytical objectives. Employment relationships, like customer and other relationships, obviously have a number of dimensions and implied contract attributes.

For this reason, the dependence of data construction on the economic analysis intended is likely to grow in spite of the loss of comparability and replicability that extensive processing of data imposes. Before lamenting the increase in uncertainty about data that is bound to result from researchers’ exercise of judgement from case to case, it is well to remember that even so-called “hard” data, the simple-sum aggregates and indexes spurned by Irving Fisher (1922), may contain many errors. This has been pointed out most forcefully by Oskar Morgenstern (1950). There are several recently documented cases in point. Errors have been reported in conventional aggregates of money (David Pierce *et al.* 1981; John Boschen and Herschel Grossman 1982) and in the unemployment rate (Christina Romer 1986a; Michael Lovell 1986). The imaginary (“Martian”) global deficit on current account of close to \$100 billion in a recent year (1982), which arose upon summation of the individual country balances on a supposedly consistent basis, has also attracted much comment about how defective and misleading official statistics can be (see, for instance, Sven Grasmann 1983). Because of the likelihood that errors in components and between the two sides of transactions are to some degree offsetting, only a fraction of the sum of errors can be brought to light by double-entry controls in macroeconomic accounting.

This concludes our discussion of how aggregation may convert individual indeterminacy into statistical regularity on the one hand while making things that are definitive as particulars uncertain in combination on the other. We next survey econometric representations of how learning about the uncertain relations between aggregate data can proceed. The focus thus shifts from uncertain macroeconomic measures to uncertain structures in which they occur.

3. Uncertainty in Estimation

While older macroeconomic theories, such as Keynesian theories, paid little attention to how private agents utilize information, including information about the likely reactions of policymakers to developments in the private sector, newer theories have placed increasing emphasis on this aspect. However, few of them have as yet taken pains to model the process of learning. Neoclassical optimization and general equilibrium theory, for instance, commonly assumes that the parameters of preference, as well as technology and market prices, are known not just on a current basis but also as sequences of future contingencies, all of which are already perfectly well defined. This section surveys what basic approaches to learning about uncertain parameters, variables, and structures have been taken in econometrics when agents cannot be assumed to be endowed with as much certain prior information as various theories have presupposed.

Among the newer theories, the rational expectations hypothesis, by equating the average of subjective beliefs of agents about a state to the equilibrium consistent with economic theory, goes farthest in regarding agents as informed. Economic agents are thus held capable of combining data and theory in an optimal way to predict and influence future realizations of stochastic economic variables. This assumption is currently understood as extreme on two grounds. First, the economic data kept in the information set is neither complete nor free of error, and, second, theoretical knowledge of the laws of motion is at best imperfect when there is a need for learning. A multiplicity of equilibria and of transition paths among states can arise and leave uncertainty about the appropriateness of particular methods and solutions.

Economic decision making under uncertainty is inevitably based on expectations about the future. Hence it is important to know how the formation of these expectations is modelled. John Muth (1961) proposed a particular solution to this problem known as the rational expectations (RE) hypothesis. It postulates the equivalence of the average of the economic outcomes subjectively expected by individuals i , y_{it}^e , and the predicted outcomes of the relevant theory, $y_t|I_t$, conditional on the same information set available at time t , I_t , for the state of the economy, y_t . Stated formally :

$$\int_0^1 y_{it}^e di = y_t|I_t = E(y_t | I_t) \quad (4)$$

when the economic agents are indexed by i from a set of unit interval $[0,1]$. Essentially Muth replaced the requirement of perfect information in the classical approach with one of perfect ability in processing available information. Specifically he (1961, p. 316) assumed that the economic agent (1) maximizes the use of information, (2) knows the structure of the relevant system, and (3) makes a prediction not systematically different from the public prediction unless it is based on inside information.

Under the *RE* hypothesis, the prediction error, e_t , of the average expectation is equal to the random deviation of actuals from the predictions of the relevant theory,

$$e_t = y_t - \int_0^1 y_{it}^e di = y_t - y_t|I_t. \quad (5)$$

This implies that the economy is operating efficiently in the use of information such that the errors have zero expectation and are uncorrelated.

$$E[e_t | I_t] = 0$$

and

$$\int_0^1 E(y_{it}^e, e_t | I_t) di = E(y_{it} | I_t, e_t | I_t) = 0 \quad . \quad (6)$$

In other words, the average expectation about the state of the economy is an unbiased predictor of actual states and is orthogonal to the prediction error.

If the system tends to equilibrium, so that equilibrium is what must, on average, be rationally expected, it follows that

$$y_{it} = y^* \quad (7)$$

where y^* is an equilibrium solution of the relevant theory when expectations are modelled explicitly. New Classical economists have emphasized this identification.

On the other hand, if rational expectations are regarded as the outcome of some process of learning, asymptotic properties, such as convergence to rationality, and stability and uniqueness of equilibrium toward which the system may be tending are immediate concerns. Ronald Heiner (1983, 1985) has made the counter-intuitive statement that it is the uncertainty which prevents agents from successful optimization that makes their behavior more predictable due to limitations on the choice of actions. However, it can also be said that because uncertainty inhibits economic choice, it supports more frequent revision in plans as new information arrives. It therefore establishes a need for learning. Accordingly this section surveys econometric representations of systematic error learning behavior in a stochastic environment that may contain multiple equilibria, regime change, and latent variables.

3.1. Multiple Equilibria, Disequilibrium, and Switching Regimes

In theoretical approaches, economic agents can be represented abstractly as anonymous computers who execute programs with basic data on states,--prices and quantities,--according to encoded natures,--preference orderings and technologies,--under scarcity constraints. Under sufficient conditions the duality theorem guarantees the existence of an economically meaningful optimal solution which will eventually satisfy the system solution in the form of the fixed point. Competitive Walrasian general equilibrium has been considered the norm for these conditions. However, the basic data which constitute the economic environment is neither known with certainty nor fixed over time. Moreover decisions of households, firms or policymakers generate and encounter uncertainty due to both cross-market and intertemporal spillovers. Markets can be slow to clear when there is good reason for waiting and search, equilibrium solutions can become dispersed under imperfect information, and cyclical movements and rigid prices may result when market signals are unobservable. Thus, under uncertainty, the individually optimized solution may lead to a multiplicity of consistent solutions in macroeconomic aggregates as Richard Startz (1986) and Randall Wright (1986) have shown in a variety of situations.

When expectations about current endogenous variables appear in a rational expectations model, uniqueness of equilibrium is obtained unambiguously because rational expectations appear as a fixed point of a well defined mapping through cross-equation nonlinear parameter constraints (Lars Hansen and Sargent 1980; Fair and Taylor 1983). However, when expectations about future variables enter the model, a feedback from the future to the present causes rational expectations to be compatible with an infinity of solutions (George Evans 1985). In economic terms this means that “[m]any price distributions, each with a finite variance, may satisfy the self-fulfilling property of rational expectations” (Taylor 1977, p. 1377). In this situation, the rational expectations model can permit “irrational” expectations as shown by Sargent and Neil Wallace (1973) in the context of Cagan’s (1956) model of hyperinflation. The usual identification condition, of having no more expectations variables than exogenous variables in a model with current expectations, established in Kenneth Wallis (1980), will not hold in this situation.

Which solution will best fit the behavior of economic agents if models with future rational expectations generally have a large number of solutions? To show some of the choices that have been made, we will use a simple rational expectations model with future price expectations:

$$p_t = aE(p_{t+1} | I_t) + b x_t + v_t \quad (8)$$

A practical method of estimation proposed by McCallum (1976) was to take the exogenous variables, x_t , and the Box-Jenkins prediction of the price index p_{t+1} at time t as instrumental variables to estimate the parameters. This solution, while unique, is ad hoc unless it can acquire asymptotic justification as studied in Adrian Pagan (1984). Alternatively, if there are multiple but stationary solutions ($|a| > 1$ and x and v stationary with zero mean), predictive power can be a selection criterion. Taylor (1977) suggested minimum variance of the prediction error as a condition for choosing a single solution in stochastic macroeconomic models with RE. C. Gourieroux, J. Laffont, and A. Montfort (1982) examined other selection criteria, such as boundedness in mean or variance, asymptotic stationarity, and robustness. However, these are first of all statistical and not economic requirements because the stability of economic systems is examined independently of agents’ learning about changing structures.

Two papers by L. Broze, Gourieroux, and A. Szafarz (1985a, 1985b) linked the procedure of selecting the single most convincing solution with the revision processes by which economic agents update their expectations. Let ϵ_t^k be the difference between the two expectations of p_{t+k} formed respectively at time t and at time $t-1$:

$$\epsilon_t^k = E(p_{t+k} | I_t) - E(p_{t+k} | I_{t-1}), \quad (9)$$

so that ϵ_t^k represents the revision of the expectation of p_{t+k} between $t-1$ and t . Here ϵ_t^k is taken to be orthogonal to all past information such that for $k > 0$:

$$E(\epsilon_t^k | I_{t-1}) = 0 \text{ and } E(\epsilon_t^k | I_t) = \epsilon_t^k. \quad (10)$$

Hence the error made in predicting p_t k periods before t , e_t^k , is the sum of the revision process $\{\epsilon_t^k\}$ known as a martingale difference (ΔM) sequence:

$$\begin{aligned} e_t^k &= p_t - E(p_t | I_{t-k}) \\ &= \epsilon_t^0 + \epsilon_{t-1}^1 + \dots + \epsilon_{t-k+1}^{k-1} \end{aligned} \quad (11)$$

For $k = 1$ the general solution of model (8) then becomes:

$$p_{t+1} = (1/a) p_t + \epsilon_{t+1} - (b/a) x_t - (1/a) v_t. \quad (12)$$

The unobservable future expectation $E(p_{t+1} | I_t)$ is replaced by an arbitrary martingale difference process ϵ_{t+1} , and the rational expectations model is reduced to a rational expectations augmented dynamic model which becomes estimable with known error process.

The set of solutions in a more general simultaneous RE model can be described by a multidimensional prediction error revision process (Broze, Gourieroux and Szafarz 1985b). Instead of concentrating on the validity of cross-equation coefficient constraints, rationality is tested in these more general models by considering the use made of newly available information in updating expectations. For example, Peter Hartley (1983) examined the rationality of expectations about exchange rate movements when the monetarist model of exchange rate determination and the (Fisher-open) interest parity condition are used as the underlying structure. He found that expectations are formed rationally in the foreign exchange market in the sense that the exchange rate forecasting error is not systematically related to changes predicted by the model. These changes may differ from those implied by the forward premium or discount satisfying the interest parity condition to the extent there is "news" in the money sector. Obviously, however, testing theories that depend on quantification of time and content of news events presents ambiguities that may well permit multiple RE solutions.

Further cases of multiple solutions arise in disequilibrium situations that prevent markets from clearing in a Walrasian way. If, in the absence of a Walrasian auctioneer, agents perceive that they cannot complete their desired transactions, they may have to choose their demands and supplies by optimizing subject to expected quantity constraints and institutionalized rationing schemes on their trading activities. In this situation, the inflexibility of wages and prices becomes endogenous to the system, and rationality in the quantity-price adjustment will lead to various temporary equilibria under quantity rationing (Allan Drazen 1980; Jean-Pascal Benassy 1986).

Obviously demands and supplies at equilibrium will now depend on the rationing schemes. When quantity constraints are perceived or merely feared under some contingencies (Stephen Zeldes 1986), agents will modify their demands and supplies because they know that their effective demands and supplies could be restricted by specific rationing schemes (among them are uniform or proportional rationing or queuing). Nonetheless, except in cases where there is an incentive to overbidding under a manipulable rationing scheme, there exists an equilibrium (Grandmont 1977; Benassy 1982). With stochastic rationing, matters are more complicated. Thus Lars Svensson (1980) has found that effective demand is sensitive to the institutional set-up of rationing and how it is perceived to function under various contingencies.

Expectations about quantity constraints affect not only the markets in which constraints may occur but also other markets. Several price-quantity combinations can be consistent with temporary equilibrium under rationing in the presence of spillover effects. The leading case is the existence of Keynesian underemployment equilibrium where "[t]he impact of excess supply of commodities on labor demand removes the one-to-one classical relationship between real wage and employment" (Barro and Herschel Grossman 1971, p. 92).

In two-period markets, agents' expectations of future constraints induce "bootstraps" behavior in the, as yet, unconstrained market that makes future constraints more likely. Hence, in the judgement of J. Peter Neary and Stiglitz (1983, p. 210), intertemporal spillovers lead the possibility of there being multiple equilibria. The dynamics of the whole economic system could be influenced by the way people forecast the future. Taking account of this, Grandmont (1977) has recommended a time-dependent stochastic process where traders accumulate information over time.

Switches between macroeconomic disequilibrium regimes have also been studied (John Cuddington, Per-Olov Johansson, and Karl-Gustaf Löfgren 1984, pp. 213-35). The approach taken to identify disequilibrium regimes was to separate the sample into unobservable excess demand and supply regimes such that the observed quantities could be adjusted according to price-fixing or rationing information (Fair and Dwight Jaffee 1972). However, the same econometric technique can not be used in disequilibrium macroeconomic models because the spillover effects of quantity constraints in a multimarket setting require a simultaneous equation approach. Various combinations of excess demand and supply in goods and labor markets then characterize different regimes. Along these lines, Gourieroux, Laffont, and Monfort (1980) have studied a linear simultaneous equations model with endogenous switching of regimes. In this switching model, local stability of quantity adjustment processes is conditioned on the existence of well-defined reduced form coefficients representing spillover effects.

Disequilibrium macroeconomic regimes that explicitly consider rationing schemes among the domestic productive sectors have been studied empirically by P. Artus, G. Laroque, and G. Michel (1984). From the fact that the reduced form of the model varies with regime, they derived the probability that an observed labor input and total output configuration belongs to one of the four combinations of excess supply and excess demand possible in these two markets. They reported that rationing of demand has been an almost permanent feature of the French economy between 1968 and 1974, with Keynesian unemployment becoming dominant thereafter. A more disaggregated study of markets in disequilibrium, based on French micro-level survey data, has been conducted by M. Bouissou, Laffont and Q. H. Vuong (1986). They estimated a dynamic logit model of panel data with some macroeconomic conditioning variables. The resulting transition matrix associated with the four possible disequilibrium regimes shows that each regime has a high probability of persisting, with the Keynesian unemployment regime an absorbing state.

It is fair to conclude that low-frequency events, such as quasi-permanent disequilibrium regime changes, pose problems of multiplicity and hybridism that are difficult to sort out econometrically until well after the fact. That is true particularly if matters that are usually left unobserved in macroeconomic models, such as political organizations, and the legislation, regulations, and protection they have won, mark the stages of a disequilibrium process.

3.2. Updating Structural Knowledge during Transitions

If a multiplicity of equilibria, or disequilibrium regimes characterize actual economies, these economies will frequently be in a state of transition which economic agents may seek to monitor. How could information be acquired and used during this transition?

To concentrate on this question, we consider a simple linear model relating the value of a state variable y_t to a vector of variables x_t used by agents in forming a forecast of y_t . The reduced form of the relevant economic theory can then be represented as:

$$y_t = x_t' \beta + e_t. \quad (13)$$

In this standard regression equation, β is a vector of fixed coefficients and e_t is assumed to be a random disturbance with zero mean, constant variance of σ^2 and zero serial correlation. Underlying economic theory may require β to be related to another vector of economically more meaningful hyperparameters θ of smaller dimension via nonlinear coefficient constraints. In that case:

$$\beta = \beta(\theta). \quad (14)$$

Economic agents will choose the unrestricted least squares estimator $b = \hat{\beta}$ when forecasting is the purpose or constraint (14) is doubtful. They will choose the restricted nonlinear estimator $b = \beta(\hat{\theta})$ when testing economic theory is the purpose or when imposition of constraints can be expected to improve the efficiency of the estimator because knowledge of the constraints is sufficiently precise.

The agents form forecasts using the one-period ahead predictor:

$$y_{t+1|t} = E_t(y_{t+1}) = x_{t+1}' b_t \quad (15)$$

with b_t obtained either by standard least squares if the agents are classical econometricians, or by the matrix weighted mixing formula if agents are Bayesian econometricians. All classical econometricians obtain the same forecast from the same information set because their estimation and inference are based only on optimal use of the sample information available from period 1 to t , with nonsample information ignored as not objective.

If the agents are Bayesian econometricians, the information set of agent i , I_{it} , contains not only the historical data but also prior beliefs. Based on the observed realization $[Y_t X_t]$, the individual agent will revise his prior using the matrix-weighted average formula to obtain the posterior mean and precision of the coefficient estimates. The weights that the i th Bayesian agent employs to obtain the posterior mean are the precision matrices for prior beliefs and estimates from data samples. These two matrices are used to weight the coefficient representing the prior belief of individual i , b_i , and the sample specific least-squares value, b_t , respectively. The forecast of the Bayesian agents is indistinguishable from that of the classical agents only when the initial prior on b_i is either diffuse or not different from the sample value ($b_i = b_t$).

At the arrival of new data information at time $t + 1$, the agents are expected to process it optimally by the standard of their expectations generating process. The forecast error e_{t+1} caused by uncertain structural knowledge reflected in b_t at time t is used by economic agents in forming a new estimate, b_{t+1} , with improved knowledge about structure at time $t+1$. The coefficient b_{t+1} is then used in the next prediction whose error, e_{t+2} , will again help obtain a revised estimate of β , and so forth.

This updating procedure satisfies the orthogonality principle which states that the condition $E[x_{t+1}'(y_{t+1} - y_{t+1|t})] = 0$ or $E[y_{t+1} - E(y_{t+1}|I_t) | I_t] = 0$ uniquely determines $y_{t+1|t}$. This is true whether b_t is obtained from classical or Bayesian methods as long as the forecast error is orthogonal to the information set. In reality, however, x_{t+1} may well

include the lagged value of the state variable, y_t , and y_{t+1} may not be independent of economic agents' beliefs about β or of $y_{t+1}|t$. Under such circumstances, orthogonality may be violated, so that forecast errors are still correlated with given data information,

$$E_t[x'_{t+1} e_{t+1}] \neq 0 \quad (16)$$

and hence Muth rationality does not obtain.

The usual justification for the use of the RE hypothesis is that outside of RE equilibrium agents are systematically making mistakes. Hence they modify their expectations and behavior until systematic errors are eliminated. The constant parameter model satisfying nonlinear parameter constraints implied by the RE hypothesis is a correctly specified model which holds under RE equilibrium. However this model is misspecified outside of RE equilibrium when agents use the time-varying parameter model to update their forecasts. In updating the parameter estimators of a known functional form, agents use observations, such as previous forecast errors, which are endogenously determined. Consequently the RE equilibrium model is not the correct model for the data generating process describing the behavior of economic agents who cannot jump instantly from any state in which they may find themselves to RE equilibrium. Modification of structural knowledge during the transition to RE equilibrium has thus become a subject of increased study in stochastic macroeconomics, with RE equilibrium no longer viewed as a natural starting point.

3.3. *Learning Behavior in Stochastic Macroeconomics*

The literature on the transition to RE equilibrium can be divided into two classes as Lawrence Blume, Margaret Bray and David Easley (1982) have suggested. The first contains fully rational learning, that is, informationally demanding Bayesian approaches, and the second contains nonrational learning, that is, informationally less demanding classical approaches. We now discuss the latter type emphasizing for contrast, once again, the extreme information requirements of rational expectations.

As Taylor (1985, p. 418) has pointed out in his comprehensive portrayal, "the question of how agents learn about the economic environment that influences their behavior is rarely addressed in rational expectations research". Learning would seem necessary particularly since current macroeconomic models with rational expectations are much more complicated and informationally demanding than the most frequently cited single equation models: the single product cobweb model of Muth (1961) or the money market hyperinflation model of Phillip Cagan (1956). Not only current expectations, but also future expectations of endogenous variables, appear in RE models. Hence a large number of solutions can satisfy the RE equilibrium condition as noted before. Moreover the concept of RE equilibrium is crucially based on agents' perfect ability to use knowledge about structure and parameter values of the model to anticipate the levels of the state variables.

It is obvious that economic agents neither process every data nor review all theory that is relevant for their economic decisions. Even if pertinent raw information were free, they would not want to know the consequences of all possible actions because resources would have to be spent to absorb and to act on such information. Whether it is nevertheless useful to pretend, for the purpose of explaining economic phenomena such as price formation, that agents are complete information processors, "on average" without making systematic

mistakes, depends to some degree on how benefits and costs of being correctly informed rise as the time allowed to learn from new information is reduced to zero. The literature on "sunspot" equilibria (see Michael Woodford 1987) makes it difficult to visualize how such instant learning could ever be conclusive or instantly convergent because it is not clear, even in theory, what is relevant to economic outcomes. Events that objectively would have to be viewed as irrelevant, because no cause-and-effect relationship can be demonstrated outside of human consciousness, can nonetheless modify economic outcomes if, arbitrarily, they are believed to have that capacity. Additional complications in characterizing the behavioral science aspect of economics arise from a Nash equilibrium, an equilibrium reached without cooperation and specific knowledge of others beyond that reflected in market data, being attainable if utility depends only on one's own strategy and the integral of everybody else's (David Schmeidler 1973). Such conditions may not be fulfilled (John H. Kagel and Dan Levin 1986). Hence waiting for things to become clearer through additional observations releasing information may well be an individually optimal strategy in changing circumstances. Furthermore, the combination of such strategies over all individuals may well be capable of affecting market outcomes.

For these reasons, agents' subjective beliefs can differ for some time from the objective distribution of the state which would prevail in RE equilibrium. During the transition period, the learning procedure can make the sequence of actual outcomes dependent upon agents' initial parameter estimates. Where economic agents consistently update their knowledge about the structure, their knowledge is summarized in model parameters which are time-varying as in optimal control models with active learning (David Kendrick 1981; Nicholas Kiefer and Yaw Nyarko 1986).

Current research on the stability of RE equilibrium has been extended to the point that informationally demanding RE equilibria can be studied as limits of some learning procedures without explicit reference to the structural model. A surprising conclusion from this research is that learning based on a misspecified ad hoc prediction equation becomes rational asymptotically under less restrictive stability conditions than those typically encountered under RE. Bray and N. Savin (1986) have examined bounded rationality for price predictions from a cobweb model outside of RE equilibrium when economic agents use a regression model allowing parameter modification. The coefficients of this time-varying parameter model with learning are linear functions of the estimated regression parameters. Although the estimated model is misspecified in that the updated parameter is different from the RE augmented parameter, the average estimate under learning tends asymptotically toward RE equilibrium. C. Fourgeaud, Gourieroux, and J. Pradel (1986) obtained a similar result when the evolution of the forecasts is based on a misspecified auxiliary model but the rate of divergence is restricted. More fundamentally, Dimitris Margaritis (1986) has examined the stability of RE equilibrium in a more general situation by relating the asymptotic trajectories of a sequential learning algorithm to the solution of an ordinary differential equation. He found that, even if based on simple OLS estimation of a misspecified model, a learning procedure that revises the coefficient estimates used in forecasting each time a new data point is observed can eventually yield RE equilibrium as recognized earlier by Bray (1982). The message of this line of research is that a complicated macroeconomic

model with RE can be studied by a simple unrestricted reduced form model such as the vector autoregressions of Sims (1980). In such a model, time varying coefficients can reflect the learning procedure of economic agents.

Under RE equilibrium, public forecasts have no substantial effect (Muth 1961). Is this also true outside of RE equilibrium when economic agents are engaged in learning? Under learning, forecast errors are serially correlated over time and contemporaneously correlated over decision makers when unexpected once-and-for-all changes occur. According to Frydman (1982, p. 664), the convergence to RE equilibrium in decentralized markets could then be influenced significantly by social norms and information generated by institutions external to the market. Townsend (1983) has shown that serially uncorrelated economic shocks can induce rapid oscillations in forecasts and decision variables when agents forecast the forecasts of others about the propagation of economic shocks. Under Bayesian expectation revision mechanisms, Sanford Grossman, Richard Kihlstrom and Leonard Mirman (1977), Townsend (1978), and Blume and Easley (1982) have shown that agents are concerned with the expectations of all others. They modify their behavior depending on how they evaluate the beliefs of others and their own experiments. To the extent public forecasts affect this evaluation, they can influence the stability of RE equilibrium when economic agents are learning and presumably moving toward it.

In practice finding such an equilibrium is far from straightforward. It is usually true that even with the same data and an exact specification, different stochastic assumptions, and hence different econometric techniques, give different parameter estimates. Due to complex nonlinearity in parameters implied by RE equilibrium, extreme simplicity of the underlying theoretical model is required for RE augmented models to be empirically tractable. Even for a simple model, RE equilibrium is unique only under highly restrictive conditions which must be supported by exact priors. Such exactness of priors is difficult to derive from macroeconomic theory so that there is a conflict between economic and econometric requirements in this regard. For example, the structural parameter θ in equation (14) is identifiable from the reduced form parameter β in the reduced form equation (13) only when there is no feasible θ that is observationally equivalent and when a stable policy rule has been followed. In terms of the order condition for identifiability, this means that, given a just identified model, economic theory must be strong enough to assume away at least one exogenous variable for every exogenous variable added if the structural equation is to be estimable. This econometric requirement appears to contradict the common presumption that the economy is underidentified in general since everything is related to everything else.

One way of circumventing this dilemma is to give up the use of uncertain structural knowledge in model specification. Serious doubts about obtaining economically meaningful overidentifying restrictions led Sims (1980; 1982) to suggest vector autoregressions (VAR) as "the unstructured first-state models" (1980, p. 15). A Bayesian type tightness prior on the distributed lags was suggested to improve the prediction in Thomas Doan, Robert Litterman, and Sims (1984). Others have suggested ways of refining knowledge about structure. For instance, methods of obtaining more reliable overidentifying restrictions through data analysis have been motivated in Arnold Zellner (1979) and E. Malinvaud (1981). Criteria for model selection surveyed in Gregory Chow (1983, pp. 277-319) may be used to eliminate insignificant variables in the empirical model or to "edit" a VAR.

Still others have suggested mixtures of data based unrestricted, and more efficient restricted, reduced form estimators in learning about uncertain structural models (Malinvaud 1981; Jeong 1985; Esfandiar Maasoumi 1986). Using a mixture could be important in policy design under model uncertainty. Thus Robin Becker *et al.* (1986) combined rival macroeconomic model predictions using minimax criteria and obtained indications that the conduct of policy would thereby be improved. Peter Orazem and John Miranowski (1986) have extended such thinking to expectational regimes, suggesting that the weighted average of several regimes may ultimately prove to be a dominant empirical regime. Alternatively, one might start with a general model and progressively constrain the parameter space to get away from untested advance restrictions (Michael McAleer, Pagan and Paul Volker 1985). However, current econometric usage often remains dichotomized between unrestricted reduced forms for forecasting and restricted reduced forms for policy analysis, despite the advice of Leamer (1985a) and Sims (1986a) suggesting a more integrated approach.

Bayesian approaches also have difficulties to start with in that the prior weight matrix is arbitrary, either because agents may differ in their personal beliefs or because priors are impossible to assess without error. The same data available to agents do not necessarily lead agents to form the same opinion, and the dispersion of opinion can have important price consequences (Varian 1986). Leamer (1978; 1982; 1985b) demonstrated the sensitivity of inferences when variance bounds of the fixed prior mean are allowed to vary. Leamer and Leonard (1983) and Walter Krämer *et al.* (1985) proposed a methodology for reporting the fragility of regression estimates. Beyond this, Leamer's (1983a; 1983b) critique makes clear that because no econometric model can be considered as firmly given by theory, the usefulness of data in economics has to be established by taking careful account of the absence of completely defined models.

3.4. Latent Variables Models with Extended Learning

In recent years, macroeconomic theory has been communicated increasingly in the form of recommendations of improved econometric techniques. True to this pattern, current research in stochastic macroeconomics tends to adopt econometric techniques in describing the learning behavior of economic agents. These agents frequently can be understood to be in transition from macroeconomic disequilibrium to equilibrium and to update their knowledge about the structure of the system by studying their forecast errors upon arrival of newly available information. As a result they learn more about the latent variables of their concern and the uncertain structures which govern realizations of stochastic macroeconomic aggregates.

An econometric model appropriate for describing learning on the part of economic agents is the latent variables model with time-varying coefficients. The Kalman filters central to that model were developed in engineering to track the "state" of the system obtained from noisy measurements (R. Kalman 1960; Kلمان and R. Bucy 1961). Although Kalman filters can also have a Bayesian interpretation (Chow 1984; Y. Ho and R. Lee 1964), they are generally used to estimate a time-varying structure with minimum mean square error and to update estimates when new information becomes available. Their applicability to economic systems and econometrics has been surveyed in Michael Athans (1974), Robert Engle and Mark Watson (1985), and Andrew Harvey (1985). There are several

motivations for using time-varying parameter models. Here we will concentrate on two major objects of economic learning: parameters that are time varying due to the updating of coefficient estimates, and errors in variables that are due to unobservable expectations and other latent variables.

A structural model of changing coefficients can incorporate information on how agents learn about the new model such that the transition equation can represent the actual learning process. At the arrival of new information, agents would update the estimate of the time-varying structure. In this connection the rational expectations hypothesis can explain why adjustment of structural parameters should be provided for when there is an implied change in policy regime or in the likelihood that a particular rule will be followed. Other reasons for using time-varying parameter models are diagnostic. Thus misspecification of a regression model will generally lead to nonwhite residuals, and time variation of coefficients can be caused by misspecification.

The problems of unobservable and erroneously observed variables are becoming more important with the exploration of new areas of empirical research dealing with situations in which the data collected do not provide the information content required by economic theory. Some variables cannot be measured accurately or simply cannot be directly observed or measured at all. Permanent income and consumption, lifetime earnings, desired output and expectations variables are such examples. Insufficient information is the prime cause of the basic errors in variables problem (Zvi Griliches 1974; Dennis Aigner and Arthur Goldberger 1977; Aigner *et al.* 1984). Goldberger (1972) developed a structural equation method for estimating simultaneous equation models with latent variables. The basic idea behind his Linear Structural Relations is to compare a sample covariance matrix with the parametric structure imposed on it by the hypothesized model (Jerry Hauman 1977). However, application of this approach is limited to linear structures and not suitable for dynamic models because it assumes independence of successive observations.

Most of the econometric techniques surveyed in this section are compatible with agents who continuously update their knowledge about the structure of the economy by examining their forecast errors at the arrival of newly available information. When a priori information is not available from theory, direct learning from empirical macrodata is still possible. The typical shape of the majority of economic data studied by C.W.J. Granger (1966) and Sargent (1979) demonstrates the very high correlation between adjacent values of variable levels. Economic data frequently have a low-frequency component representing stable structural links and a high-frequency component representing serially or contemporaneously correlated error structures. Granger (1986) has suggested a framework for combining co-integration analysis of the long-run equilibrium relations provided by economic theory with error-correction modelling of the short-run dynamics revealed by time series analysis.

Path analysis, exogeneity, and superneutrality are examples of open data analysis independent of theory to gather information from the data about the unknown structure relating them (John Geweke 1984; 1986). Available information comes not only from observations but also from non-sample information. Current research on empirical modelling rules (David Hendry and Jean-François Richard 1982; Richard 1982; Hendry 1986), which has developed concepts like encompassing, data consistency and structural invariance, is designed to

refine learning about uncertain economic systems. Even so, knowledge of complicated macroeconomic stochastic processes is imperfect at the time of realization and will remain incomplete. The reason, as in physics, is that low-probability events will continue to occur and foil exhaustive learning about the state which the system is most likely to attain. In addition, human consciousness, behavioral interaction, and endogenous change can be persistent modifiers, defeating exact prior knowledge.

4. Uncertainty in Policy Formation

Uncertainty that provides a compelling reason for learning by the private sector also motivates policy by the public sector while at the same time limiting, or casting doubt on, what such policy can accomplish. To show that uncertainty can affect both content and dosage of what policymakers should do, we will first survey literature relating to the optimal choice and use of policy instruments in the presence of stochastic disturbances. These disturbances are then characterized further by sector of origin to weigh their past and prospective roles in economic fluctuations. Considered last are indexation schemes and the issue of policy activism to cope with shocks arising from various sources. Principally this section thus surveys contributions sharing Frank Knight's (1921, p. 259) conception that "[t]he fundamental uncertainties of economic life are the errors in predicting the future and in making present adjustments to fit future conditions". The usual reason for emphasizing uncertainty about the future is that there is far less knowledge about future shocks than about the significance of past shocks. This would be particularly true if these shocks are taken as exogenous, or identified with "innovations" or "surprise".

It is useful to pause briefly at this point to consider that what constitutes a shock or surprise, and how much an event contributes to either, depends on what has been left out of a model. The earliest Keynesian models of the consumption-driven multiplier applicable to changes in business investment treated such investment as autonomous and changes therein as shocks inducing a sequence of ripple effects. This example shows that shocks and surprises exist only relative to a model; whether they deserve these names depends on the aptness of the model's specification for identifying the expectational milieu actually prevailing.

It is futile to look for shocks that are entirely exogenous in principle, although it may well be acceptable to treat many of them as externally given in practice. An example may again help clarify the point. Even ignoring political crisis developments that might have served as the immediate trigger, the first oil price shock did not materialize all of a sudden in October 1973 but was preceded by a gathering worldwide inflationary boom and a falling dollar which were giving such a shock increasing likelihood. Subsequently, steps such as the gradual decontrol of energy prices, expansion of the strategic petroleum reserve, and emergency allocation agreements within the International Energy Agency have reduced vulnerability to OPEC actions. Hence any such action, upon repetition, would produce less shock. The upshot is that since shocks can not be quantified except in relation to the receiving system, and since that system can be managed or designed to avert or cushion shocks, shocks exist as part of the structure of that system and not entirely outside it. The degree of surprise they generate, if they occur and are processed under the normal rules for signal extraction, is inverse to their relative frequency and severity in the past.

In evaluating the stability of systems, and how it can be improved through policy rules, shocks frequently are introduced as arbitrary displacements of variables from equilibrium. These experimental displacements, while often designed to mimic error (co)variances and perturbations thought to have occurred across various sectors, appear exogenous to the system in that they have no identified internal cause. However, to the extent they have been calibrated on products of a particular estimation system, such as historical series of residuals, to avoid simulating a regime different from the one about which the data can instruct, the exogeneity of displacements is far from complete (Robert Gordon and Stephen King 1982, p. 207). Hence disturbances that are conditional upon the system by which they are identified, and vice versa, can not be recognized as entirely exogenous. Nor can they be imposed experimentally without prior restraints upon macro models incorporating policy-invariant laws of motion.

Until some years ago, this understanding frequently was still lacking in devising and evaluating stabilization policies with “fixed-effect” models. For economic advisers relying on such models, speeding up shock absorption and hastening the move, or return, toward desired, or inevitable, equilibrium levels of key variables remained a policy vocation (Franco Modigliani 1977, pp. 8-9). Technically, in models containing difference equations in discrete time or differential equations in continuous time, automatic stabilization’s success was measured by the reduction in the absolute size of the eigenvalues of the model (see, for instance, Malcolm Knight and Clifford Wymer 1978, pp. 768-73). Values of the roots closer to zero or reductions in the variance of the ultimate target variables (Chow 1981, pp. 131-45), achieved through building feedback mechanisms on to simultaneously estimated models, would produce faster dampening and more reliable parameter identification. The stabilization gains attributable to optimal control would then be determined through Monte Carlo experiments with randomly generated shocks, or by use of simulation experiments to improve on the historical record, very much like in physical control systems.

Prescott (1977) has reviewed the earlier state of this literature. He criticized its foundations because, unlike in chemistry or physics, control is being applied in economics not to a model of nature, but in confrontation with calculating agents exercising memory, learning, and reasoned foresight. Nevertheless, it is useful to show how uncertainty came to matter in behavioral and control specifications in at least those respects that have continued to draw attention. This will be done by first surveying how second moments, both variances and covariances, came to supplement the first moments of linear stochastic models in a variety of macroeconomic applications.

4.1. Measures of Variability for Modelling Economic Behavior and Control

Various uncertainties surrounding human existence and economic choice have long been analyzed by referring to statistical distributions. Some hazards, such as to life, although not completely beyond risk management and the play of incentives, are frequently treated as acts of God whose distribution can be obtained from the past record, albeit with some allowance for drifts. In such situations, means and variances of past outcomes can be related precisely to the demand for, and supply of, insurance. In other situations, moral hazard or costly pooling make self-insurance more likely. Examples are self-administered saving, inventories, and the holding of precautionary balances and reserves. The use of variability measures is immediately called for to explain such provisions.

For example, it is difficult to explain the demand for international reserves without having in mind an official role in smoothing the consequences for domestic absorption of disturbances arising in international trade and finance. The extent of the disturbances to be reckoned with has been approximated by the variance or standard deviation of export receipts or reserves, scaled by a country's gross domestic product (Robert Heller and Mohsin Kahn 1978, p. 630; Jacob Frenkel 1983, p. 69; José Lizondo and Donald Mathieson 1987). Under floating, standard deviations of trade-weighted real or nominal exchange rates have also been used to represent exchange rate uncertainty and its effect on trade (see Padma Gotur 1985; Sebastian Edwards 1987). Likewise the degree of variability of exports and of the terms of trade are importantly involved in determining the external credit worthiness of sovereign borrowers. Both their present and future dependence on such borrowing for smoothing absorption and the effect of adverse realizations on the cost of repudiation are functions of the degree of variability prevailing in external flows and price relations. A comprehensive review of this literature has been provided by Jonathan Eaton, Mark Gersovitz, and Stiglitz (1986).

Examples from other areas in which risk and diversification are central abound. Benjamin Friedman (1978; 1985) shows how the vast literature on portfolio characteristics and the resulting rate of return relationships between risky assets bear on the evaluation of macroeconomic developments and policy initiatives. For another example, the uncertainty raised by inflation has been studied not only by attempting to get at non-constant variances of inflationary expectations (Engle 1982) but also in a compositional setting. In it, the variance of relative prices is related to the level of general inflation, or, more perceptively, to the *unexpected* part of inflation or money growth generally obtained as univariate or vector autoregression residuals. The survey by Alex Cukierman (1983) and additional articles by Mario Blejer (1983) and George Katsimbris (1985) cover most of this literature and its techniques to date.

The conclusion that relative price variability increases with absolute inflation or its unanticipated part and that output variability rises also in the aggregate and between sectors is widely shared but not unanimous. Sanford Grossman, Oliver Hart, and Eric Maskin (1983) have identified the reverse possibility, that relative price variability may come first. For instance, the anticipation of greater relative demand shocks could lower employment under asymmetric information between employers and workers. The expected decline in future output would raise future prices and hence present prices in efficient markets, so that unanticipated inflation and inventory movements could be a consequence of increased relative price variability and not a cause. The hypothesis, that greater inflation uncertainty has detrimental effects on economic activity, first tested by Lucas (1973) with mixed results and elaborated in the Nobel lecture of Milton Friedman (1977), has also received some further support. The evidence linking inflation positively to inflation variability and thence negatively to output and employment has been described by Steven Holland (1984) and supplemented by Richard Froyen and Roger Waud (1985) and Holland (1986). Eugene Fama (1981) has used a similar approach to explain the negative relation between stock returns and inflation.

Recently this type of analysis has extended to the effect of inflation uncertainty on sectoral employment and real wage dispersion on the one hand (Ronald Ratti 1985) and on the demand for wage-price controls and indexation on the other (Cukierman and Leonardo Leiderman 1984; David Card 1986; Allan Drazen and Hamermesh 1986). More aggregative

studies on uncertainty about prospective inflation--revealed, for instance, by the dispersion of survey responses--and its effects on unemployment, real output, and hedging have been analyzed and extended by Donald Mullineaux (1980) and Laurence Kantor (1986). Another of Milton Friedman's (1984, p. 399) hypotheses, that exceptional volatility of monetary growth may have increased the degree of perceived uncertainty and thereby increased the demand for money earlier this decade, has also received some empirical support from Thomas Hall and Nicholas Noble (1987). They represented volatility by a rolling standard deviation constructed on eight consecutive observations of current and past rates of money growth. These examples may suffice to show that measures of variability have long been viewed as pertinent directly in some areas of economic inquiry.

Over the last twenty years, second moments have also become central to signal extraction and in taking stochastic macromodels beyond certainty equivalence. The simplest stochastic systems were linear and had only additive error terms associated with each equation which were contemporaneously and intertemporally uncorrelated. Such models could be solved by certainty equivalence, thereby reducing the stochastic control problem to one that was essentially deterministic (Robert Pindyck 1973, p. 38). William Brainard (1967, p. 413) has pointed out that this was because simple additive uncertainty with regard to policy actions leaves the higher moments of the distribution of the target variable unaffected by such actions. As a result, the policymaker was free to act on the basis of expected values alone. Thus certainty equivalence prevailed in systems with quadratic loss functions in the sense, explained by William Poole (1970, p. 207), that the optimal decision, though not expected disutility, is the same in the stochastic model as in the certainty model.

Brainard (1967) has shown that this changes as soon as multiplier uncertainty attaches to the use of policy instruments. He assumes the social objective is to maximize a quadratic expected loss function of the form $L = -E(Y - Y^*)^2$ on the output and income target Y^* . (This would be equivalent to minimizing expected loss defined as a positive, rather than negative, magnitude.) If the coefficient of variation of the policy multiplier is V and the optimal setting of the policy instrument under certainty is $P = g$ because $Y^* = E(Y)$, then it is $P^* = g/(1+V^2)$ under uncertainty. Hence uncertainty now makes a difference, one precisely equal to $P - P^*$, that is rising with V . The greater the uncertainty about the effect of an instrument, the less it should be used. For actual macroeconomic models, V is not normally known, but Fair (1980) has described a method of stochastic simulation for obtaining the asymptotic variances of impact and dynamic multipliers for such nonlinear models.

Stephen Turnovsky (1977) has elaborated on the inhibiting role of uncertainty, and A. Malliaris and W. Brock (1981, pp. 192-40) have summarized the point that less is done under uncertainty than certainty. In fact, it is a common result that the less clearly perceived the signal, the less it should serve as a basis for optimal action (see, for instance, Turnovsky 1986, pp. 18-19). However, we may note parenthetically that the fact that increased uncertainty always seems to have a chilling effect on the activities to which it attaches in macroeconomics is not necessarily shared with microeconomics. The opposite possibility, that activity or participation levels may be higher under uncertainty than certainty, has been identified by Thomas Rothenberg and Kenneth Smith (1971) for national income and by Eytan Sheshinski and Drèze (1976) for the number of firms in an industry. In empirical applications, tax loss offset provisions, capital gains taxation, limited liability, and

bankruptcy laws can be important in this context. Franz Hahn (1986, p. 585) has found, for instance, that rising uncertainty may increase credit demand enough to increase capital inputs over some range even though the credit supply schedule shifts up as well. Similarly, Joseph Zeira (1987, pp. 208-09) points to a number of microeconomic models showing that output price uncertainty may raise the rate of investment.

A second point of distinction between certainty and uncertainty solutions brought out by both Brainard (1967) and Poole (1970) is that, in general, it is optimal under uncertainty to use all instruments in a unique combination even if there is only one target variable. By contrast, any equivalent linear combination of policy instruments, each weighted simply by its per unit effect on the target, will do equally well under certainty. Hence if instrument use is "free", it is not crucial how "effective" the instrument is per unit of change. Instead what matters for stabilization purposes is its relative accuracy (McCallum 1986a, p. 23). Knowing the desired solution of the system at its optimum from the correct model, one can take an intermediate target associated with that solution, such as the interest rate, and use the money supply to hit it. Formally, this would involve a monetary policy that targets the interest rate. Alternatively one could target the money supply associated with the desired solution and let the interest rate fall in line. In an environment of certainty, the optimal solution is guaranteed to be attainable when prices are given. Which policy variable, or linear combination of variables, is assigned the task of shifting the linear system to its unique optimum is a matter of convenience and phrasing. Normally using more than one instrument per target would be logically, if not politically, redundant.

All this changes under uncertainty as may be worth showing with Poole's (1970) miniscale model, stripped to essentials. That model has been referred to again and again in subsequent literature on the choice of regulatory and policy instruments (e.g., Sargent and Wallace 1975; Michael Dotsey and Robert King 1986; Patrick Minford 1986; Ernst Baltensperger and Jean Dermine 1987), so that it merits more extended treatment. In it the negative loss function, L , is maximized subject to an IS and LM constraint with the price level fixed and a money supply function whose coefficients c_0 and c_1 are to be determined. With the IS disturbance u , the money demand disturbance v , and perfect control over money supply M_g , the model, in which, all coefficients except possibly c_1 are defined positive, is one of:

$$\begin{aligned} \text{Max. } L &= -E(Y - Y^*)^2 \\ \text{s.t. } Y &= a_0 - a_1 r + u \\ M_d &= b_0 + b_1 Y - b_2 r + v \\ M_g &= c_0 + c_1 r \end{aligned} \tag{17}$$

Now the optimal solution for c_0 would help achieve exactly the same money supply as in the system ignoring uncertainty. The policy coefficient c_1 could be set to zero or any other value in the certainty system, and c_0 would be adjusted accordingly to keep the money supply consistent with the desired solution for Y and hence r . Under uncertainty, the choice of c_1 ceases to be inconsequential. Rather its optimal value, c_1^* , depends on the variance and covariance if u and v as shown below.

$$c_1^* = (a_1 \sigma_v^2 + (a_1 b_1 - b_2) \sigma_{uv} - b_1 b_2 \sigma_u^2) / (b_1 \sigma_u^2 + \sigma_{uv}) \tag{18}$$

Clearly if all the shocks come from the side of money demand, so that $\sigma_{uv} = \sigma_u^2 = 0$, c_I^* should be set equal to infinity, meaning that money supply should be governed by an interest rate target. In other words, the money supply should vary as necessary to keep the interest rate at $r^* = (a_0 - Y^*)/a_I$. On the other hand, if all the shocks come from the IS side, so that $\sigma_{uv} = \sigma_v^2 = 0$, c_I^* should be set equal to $-b_2$. Here a rise in the interest rate due not to a jump in money demand but to an expansionary IS disturbance should be reinforced by monetary contraction, rather than be offset through faster growth in the money supply as before.

The two extremes identified are therefore (1) that the money supply reacts positively and so much to a change in the interest rate as in effect to peg that rate at the level consistent with the certainty solution, and (2) that it reacts negatively to keep, say, a rise in the interest rate induced by an expansionary IS shock from creating any excess supply of money at the original level of income. In between these hypothetical extremes the actual size of the variances and the covariance of the disturbance terms and the slopes of the IS and LM schedules will determine c_I^* as the solution, given by eq. (18), to the signal extraction problem facing the authorities.

Obviously any change in c_I , whether induced by a change in the variance-covariance structure of the disturbances or arbitrarily decided on by the authorities, will change the reduced form of system (17). Hence the model positively discourages policy evaluations of the kind that would be subject to the Lucas (1976) critique. On the other hand, since the model is specified in real terms, with the authorities accorded control over the real money supply, it can not be used to demonstrate policy-ineffectiveness propositions advanced or examined by Lucas (1972), Sargent (1973), Sargent and Wallace (1975), and McCallum (1980).

Rather than allowing prices to be determined within it, it might be more instructive for our purposes to update Poole's (1970) model in another respect by including the unexpected component of money supply, or, more precisely, of excess money supply or $-v$, in the IS equation. If this were done by adding $-a_2v$ to the first equation of system (17), to obtain an "upper triangular" error structure, the solution for c_I^* would become vastly more complicated, as shown in eq. (18a) below.

$$c_I^* = [a_2(b_2 - a_1b_1 - a_2b_1b_2)\sigma_v^2 + a_1\sigma_v^2 - b_1b_2\sigma_u^2 + (a_1b_1 - b_2 + 2a_2b_1b_2)\sigma_{uv}] + [a_2(a_2b_1 - 1)\sigma_v^2 + b_1\sigma_u^2 + (1 - 2a_2b_1)\sigma_{uv}] \quad (18a)$$

It is, in general, impossible to prejudge from this equation how increasing a_2 would affect c_I^* . The reason is that the greater the direct contractive effect of an unexpected increase in money demand on output, the greater the possibility that the interest rate falls. Such an unusual situation would require c_I^* to be negative so as to call forth the additional money supply and the further decline in interest rates needed for stabilization.

For the public, eq. (18a) might be of little help. Unless they knew the objective function of the authorities together with the model and its coefficients and hence also knew the variance-covariance matrix of the estimated residuals, they would not be able to infer c_I^* . Furthermore, prior knowledge of the error structure would be essential for deciding whether eq. (18), eq. (18a), or yet some other equation is to be relied upon. Buiter (1983, p. 211) has suggested, for instance, that the authorities may take interest rate movements as indicative of IS shocks. If one ignores Goodfriend's (1986b) point that aggregate income

is not contemporaneously observable, the authorities may 'lean against the wind' even in a model without interest rates by entering $\underline{u}$ with a negative coefficient in the money supply function. Making this addition to the LM sector in Poole's updated system without eliminating ν from the IS equation would destroy the triangular structure of the error terms. This would leave c_1^* , and the distinction between expected and unexpected money and output, statistically undetermined. The data can not unambiguously reveal either if the authorities do not tip their hand.

To know what rule and calibration to adopt should the authorities decide to endogenize the money supply, they themselves would have to solve a signal extraction problem. The strength of Poole's original model is to show this well before Lucas (1976), building on earlier work by Muth (1960), posed signal extraction problems as commonplace for individuals to solve. Baltensperger and Dermine (1987) have shown that such a problem arises whenever the authorities set out to modify the impacts of stochastic disturbances by policy rules or regulations. They may do so because there is inadequate information to allow fine-tuning in response to each of the different types of disturbances distinguished below.

4.2. Policy Surprises and Other Macroeconomic Disturbances

Classifying shocks by sector of origin is tricky and uncertain. For instance, if an earthquake in California led to a run on its local banks because of feared loss of collateral and loan quality, were all the resulting economic disturbances attributable to real shocks? Was everything that followed attributable to the propagation mechanism? Robert King and Charles Plosser (1986) have explained that if real disturbances are strictly temporary, all of the serial correlation in time series is due to the internal propagation mechanism. But what if the run had spread to other states out of any proportion or fixed relation to the underlying cause? After all, before establishment of the U.S. Federal Deposit Insurance Corporation, bank runs could be triggered at times by a change in perceptions; self-fulfilling rumors could get started on very little hard news.

Although government deposit insurance has limited the negative externalities of real shocks (Robert Gordon ed. 1986, p. 25), it remains hard to conceive of real shocks without a financial counterpart, as Benjamin Friedman (1986) has pointed out. Conversely, several writers, identified by Otto Eckstein and Allen Sinai (1986, p. 59), have viewed credit crunches and financial crises as a by-product of the real cycle that simultaneously occurs. Fischer Black (1986, p. 538) has cast doubt on the feasibility of characterizing the quality of news independently of the market's reaction when unanticipated shifts in tastes and technology may be the information. Michael Bruno and Jeffrey Sachs (1982; 1985) and Olivier Blanchard and Watson (1986, p. 133) have noted that it is difficult to observe supply shocks without seeing them intertwined with aggregate demand shocks. Likewise, Mark Rush (1986) and others he cites find unexpected monetary shocks quite insufficient by themselves to explain the U.S. experience of depression during the 1930s. Thus, in any major disturbance worthy of macroeconomic note a number of things tend to happen, though not necessarily in a sequence so inevitable that it could be tightly ordered from cause to effect. Furthermore, the frequency and severity of disturbances (how often aerialists fall off the high wire) are not independent of the safety nets in place.

A related complication is that the propagation system is transformed under the influence of past and statistically expected shocks. Its safety devices are designed to cope

with a number of shocks to degrees depending on what damage they might cause and what it costs to reduce the welfare losses otherwise expected. This partial endogeneity of the propagation mechanism and the indexation arrangements it contains has been pointed out by Drazen and Hamermesh (1986) and Kantor (1986); it is further explored later in this survey. Conversely, the observability of shocks depends on the shock-absorption facilities in place as G. Worswick (1969) explained already much earlier. Hence both the persistence of the original disturbances and the propagation mechanism combine to determine the persistence of macroeconomic fluctuations in ways difficult to disentangle (Campbell and Mankiw 1987).

Areas in which defining shocks is especially problematic relate to policy, particularly if policy is to a large extent an open book by the time it is about to be adopted in representative democracies. Minford (1986, p. 6) has explained that the "islands" story--so called because individuals are allocated to local markets and can not obtain current aggregate information, not even on prices, across islands--will not wash in highly developed countries that do not practice willful deception with statistics. Secondly, shocks measured by flows or changes in stocks are more ambiguous than shocks measured by prices. This will be shown briefly before proceeding to the monetary and fiscal disturbances attaching to macroeconomic policies.

If the surprise content of the policies adopted this period is small with regard to the expectations formed at the beginning of this period, but large with regard to the expectations for this period formed several periods ago, then the time structure and duration of commitments between then and now determines how surprises matter and what echo they have in staggered contracts (see Zarnowitz 1985, pp. 567-68 for the main sources). It also becomes clear that surprises attach not to the actions themselves but to low expectations about them. It is possible to speak of shocks, such as the first (1973) or second (1979) oil shocks, without qualification only if the lack of forecasting ability is time-invariant as the event approaches. This is likely to be true, almost by definition, for shocks measured by abrupt jumps in the prices of storable commodities, commodities traded on futures markets, or financial assets, but not self-evident for shocks measured by quantities or flows.

In efficient markets abrupt jumps implying abnormal returns,--windfall gains or losses,--simply would not occur in the absence of news. Frenkel (1981, p. 673) has stressed the importance of news in the foreign exchange markets by calculating that the variances of monthly exchange rates exceed the variances of monthly forward premia by a factor larger than 20. Craig Hakkio and Douglas Pearce (1985, p. 635) have addressed the problem of defining and quantifying news independently of the market's reaction thereto. They did so by using survey data of the weekly money growth expected by money market participants and contrasting the mean of expected growth with actual money growth. They reported that exchange rate responses are often completed within 20 minutes of the public announcement of unexpected changes in the money supply.

Such a high response speed to the release of new information is supportive of the efficient markets hypothesis, even while new doubts have arisen on other grounds. Among them are serial correlation of asset returns (Fischer and George Pennachi 1985) and of valuation errors (Shiller 1984; Summers 1986). In addition, there has been a growing literature on price signals that, on the one hand, are muffled by insufficient volatility of output

prices in relation to marginal costs (Hall 1984; Mark Bills 1987; and Dennis Carlton 1986) and, on the other, scrambled by excess volatility in capital asset prices in relation to the variability of future returns and their discount rates (Shiller 1981; Marjorie Flavin 1983; Terry Marsh and Robert Merton 1986; Shiller 1986). Nevertheless, if one is willing to assume efficiency, auction markets are ideally suited to transmit news through price signals. For this reason, supply side economists (e.g., Robert Mundell 1983) have called for using gold price movements to signal inflation so that money supply growth can be interpreted by reference to changes in the price of gold and be directed toward gold price stabilization.

Meltzer (1986) has summarized the arguments against (1) letting the money supply be controlled by the requirement to stabilize the dollar price of gold and (2) defining monetary control in terms other than its quantity. In fact, most economists continue to treat monetary instability as equivalent to innovations in the money supply. As well illustrated by Blanchard and Watson (1986), money supply that is not predicted by its own past history and that of output, price, and an index of fiscal policy is unexpected. To get to the innovation, one would first have to decide whether unexpected money could be a function of unexpected developments in other variables. Sargent (1973; 1976a; 1976b) and Currie (1985, p. 289) have explained that this general manner of proceeding is attractive from the viewpoint of rational expectations because "[i]t cuts through the problem of having two distinct models – one for how the economy works and the other for how people form expectations – by assuming that people form their expectations on the basis of knowledge of the true structure of the economy". Since this is the structure that is estimated, expectations are unbiased and efficient predictors for that structure, but not necessarily optimal unless the theory underlying the structure is correct and the lag function of the policy processes unchanging.

Buiter (1983) has shown that the zero restrictions that must be imposed to distinguish anticipated and unanticipated policy actions are themselves untestable. The reason is that several different sets of such restrictions are compatible with a full error variance-covariance matrix of the reduced form, so that econometrically the hypotheses reflected in constraining different sets of coefficients to zero are indistinguishable. Because of this observational equivalence, it is not possible to test simultaneously both the validity of a model and how the surprises, left by the constrained expectational structure of that model, work within it. Wallis (1980) has attributed this inconclusiveness in part to failure to distinguish an underlying economic structure, albeit one incorporating the rational expectations hypothesis, from a forecasting scheme relevant for particular exogenous or policy processes and changing when they do. McCallum (1980, p. 723) and Chow (1981, pp. 225-64) have examined the feasibility of making the required distinction.

Alternatives to the tenuous procedures of decomposing quantities of money growth into anticipated and unanticipated components are increasingly being suggested, for instance, by Dennis Hoffman and Don Schlagenhauf (1985) and by James Hamilton (1985; 1987). These alternatives focus on identifying unanticipated changes in the general price level and in nominal and real interest rates with the aid of efficient markets theory. For policy analysis and decomposition of the sources of disturbances a complication is that relative price surprises are not exclusively, or in the case of real interest rates on variable-rate instruments, even predominantly, attributable to surprises in monetary policy, except in the

short run (Shiller 1980; Hoffman and Schlagenhauf 1985). René Stulz (1986) has deduced some systematic relations between monetary policy uncertainty and both the level and variability of the real interest rate, but these relations are conditioned on the covariance between money and output growth. Furthermore, as Frederic Mishkin (1982) and the literature on the money supply announcement puzzle summarized by Bradford Cornell (1983) and extended by Jeremy Siegel (1985) make clear, the changes in interest rates associated with surprise announcements can go either way. The sign depends on the expectations of future policy actions and on the relative size of monetary and real disturbances. The information equivalent to that supplied by credit crunches also can not always be read from the money supply numbers alone. Credit crunches are quite clearly indicative of unanticipated developments that have led to balance-sheet and cash flow disequilibria under precommitments making the credit demands of business highly interest-inelastic in the short run. Hence they are complex cyclical phenomena (Eckstein and Sinai 1986).

It could be useful to compare the dozens of statistical attempts to extract money surprises or “purely nominal” shocks from the same historical data series and to examine the correlation between the many alternative estimates all claiming to have identified unexpected money. Of course, this could be interesting only if nominal shocks are important and their effects persistent in the United States as they could be, for instance, if firms set their price and output for a period and then let the market determine sales (Willard Witte and Jagdeep Bhandari 1985). Fischer Black (1986, p. 539) has doubted that such shocks can amount to much under any circumstances because he regards monetary policy as almost completely passive. This view has antecedents in Sims (1983) and King and Plosser (1984). Boschen (1985) and Martin Eichenbaum and Kenneth Singleton (1986) also rule out incomplete information about money growth as part of the explanation for monetary business cycles. Furthermore, Black (1986, p. 537) has found little in models of the U.S. economy to persuade him that “shifts in the general price level or in the level of government spending are large enough or powerful enough or unanticipated enough to cause significant business cycles”. He therefore discounts not only monetary but also fiscal shocks. Alan Stockman (1986a) has provided empirical support for this view.

It is interesting to recall that in some of the original attempts to obtain money surprises as a residual from a single equation involving lagged money growth and a few other terms, fiscal surprises were implicitly excluded. This was done in Barro (1977, p. 104; 1978, p. 551) by including the deviation of the actual current level of federal government spending from its recent normal level among the explanators used to obtain the regression prediction identified as the anticipated rate of money growth. Only much later, after Barro (1979; 1980) had developed tax smoothing as the intertemporal efficiency principle that should guide the choice of tax versus debt finance of government expenditures, did fiscal surprise in the form of “public debt shocks” appear. In one of Barro’s (1986a) recent works it did so mainly to be dismissed as unimportant, or perhaps quite absent, in President Reagan’s first term, considering how changes in the federal government’s debt held by the public have behaved before over business cycles and phases of military build-up. Using the temporary defense emergencies of previous decades to suppress surprise about the deficits of the U.S. government in recent years shows how arbitrary, or ill-founded, the measurement of fiscal surprises, or their absence, may be.

A fiscal index that measures the effect of fiscal policy on aggregate demand at given interest rates has been provided by Blanchard and Watson (1986, pp. 149-56) based on earlier work by Blanchard (1985). In it, tax and spending components are weighted by the effect on aggregate demand per unit of fiscal change. This is comparable to the International Monetary Fund's multilateral exchange rate index (see Jacques Artus and Anne McGuirk 1981) weighting particular exchange rates by the sensitivity to rate changes exhibited by trade, and not simply by the amount of trade or the bilateral trade volume associated with a particular exchange rate. To be able to conduct such elasticity weighting requires, of course, a model prior to the measure, an issue addressed in a more fundamental way by Prescott (1986). Treating their composite fiscal index, once derived, as simply a measure, Blanchard and Watson (1986) regress it on past values of itself and of output, price, and money to obtain the unexpected fiscal component. This component is judged to qualify as a fiscal surprise to the extent it is not "explained" by simultaneous quarterly realizations of unexpected output or price changes. The latter have preassigned coefficients which are to represent automatic or built-in fiscal responses to unexpected developments in the respective sectors.

Overall the impression is that constructions of fiscal surprises, while less plentiful and more laborious than those of money surprises, have remained just as idiosyncratic. Unwilling to accept someone else's construction of policy surprise, each researcher has tended to conjure up his own, with damage to the credibility of the entire enterprise. Furthermore, basic issues of measuring the magnitudes relevant for policy analysis have remained just as vexing, but just as frequently ignored, on the fiscal as on the monetary side, as Robert Eisner (1986) has shown.

From their decomposition of eight-quarter forecast errors for GNP, Blanchard and Watson (1986, p. 146) have concluded that fluctuations in the U.S. economy during the period 1950-82 were due, in roughly equal parts, to fiscal, money, demand and supply shocks, both large and small. King and Plosser (1986) have emphasized that such decompositions are very brittle. In his excellent survey, Zarnowitz (1985, pp. 544-58) has discussed many earlier, more theoretical, decompositions still emphasizing policy effects. By contrast, Kydland and Prescott (1982), Prescott (1986), and Black (1986, pp. 538-39) hold unanticipated shifts in tastes and technology--"many small things that are difficult to measure and essentially impossible to control,"--and not policy shifts, responsible for the business cycle. Black (1986) justifies this view by pointing to the fact that the costs of shifting real resources are clearly large while the costs of putting inflation adjustments in contracts or of publicizing changes in the money stock or the price level seem low. Hence if such adjustments are comparatively rare in the U.S. economy, the benefits of having them must also be low (McCallum 1986b). Observing the changing patterns of indexation might therefore provide information on the extent of the disturbances anticipated from various quarters and the costs and benefits of modifying their impact through indexation. This is subject to which we now turn.

4.3. Indexation as a Way of Absorbing Uncertainty

The purpose of indexation schemes is to hold someone or something harmless for some, but not normally all, consequences of accidents. Because such arrangements insulate against both windfall gains and losses associated with recurring, albeit individually

unexpected, developments, they go beyond insurance to stabilization. Indexation can substitute at least partly for firm policy rules or operating targets. If set in advance or by a formula that, unlike in Joshua Aizenman and Frenkel (1986, p. 318), does not involve reacting to (currently unobservable) disturbances, these targets may do at least as well as indexing. Provided the targets are completely credible, they may be superior under most contingencies, although complete stochastic dominance over indexing is unlikely. The extent to which (a) wages that are indexed to various measures and (b) monetary targeting rules may achieve comparable stabilization under various circumstances has been examined by Aizenman and Frenkel (1986) and Turnovsky (1987).

Both rules and indexation are of overriding concern to those, like Lucas (1980a, p. 206), who view policy analysis as most importantly and necessarily involving choice among alternative stable, predictable policy rules minimizing, though never entirely eliminating, the role of discretionary economic management. A secondary reason for the emphasis on constitution rather than discretion is that a strong constitution ruling economic conduct may cope with the many small perturbations that are difficult to identify. Discretion is to handle only the large shocks of manifest origin, the likes of "Penn Central and Franklin National" as Poole (paraphrased in Fischer ed. 1980, p. 243) once put it. Richard Startz (1986) also reached the conclusion that fiscal policy should be used actively only to counteract large shocks.

Taylor (1986, p. 155) has defined rules not laconically, as in constitutions, but broadly as in contingency plans that describe how policy will react to future events. Then policy is all about rules which forward-looking agents must seek to know. One may add that the application of such conditional rules, which requires matching up prespecified contingencies with real life events, is an art and a question of imagery and appearance as well as of fathoming the uncertain causes of events. Contingencies can easily be misdiagnosed and shocks misinterpreted when they occur.

Karl Brunner (1981) has given additional reasons for finding far less conditional rules preferable to activist adjustment of the policy instruments. They are (1) that diffuse uncertainty about the correct representation of the economic process precludes the clever adjustment of a policy regime to a given structure (p. 34) and (2) that even if the authorities have an informational advantage, they will have incentives to trade-off degrees of achievable stabilization for political and personal benefits of various kinds (p. 37). For at least some of these reasons, we will focus on indexation and rules, rather than discretionary policies, in what follows, although the search for rationales for policy activism is far from over, as the review essays by Steve Davis (1986) and Mankiw (1986b) may indicate.

Although deindexation is now frequently advocated as part of government stabilization programs in Latin America and Europe, many of those who favor government by rules have also favored indexation in the past. An impressive roster of economists advocating escalator clauses since just after the Napoleonic Wars has been furnished by Herbert Giersch (1974, pp. 4-5) and Milton Friedman (1974, pp. 46-61). They regarded escalator clauses as holding out much promise of both reducing the harm done by inflation and facilitating the ending of inflation. In addition to wages and salaries, indexation has been used in money and capital transactions, royalties, rents and leases, social insurance, life insurance policies, tax provisions, and income accounting based on replacement cost. Applied to several of the last items, indexation may put destabilizing mechanisms in place in countries that have little

alternative to linking money growth to the budget deficit (Fischer 1983). Similarly, Domingo Cavallo (1983) has warned that mandatory indexation that includes only particular groups can intensify inflation because of the distributional non-neutralities involved. Voluntary indexation, on the other hand, serves mainly to reduce transaction costs otherwise associated with frequent recontracting in nominal magnitudes. Its chief purpose is to deal efficiently with anticipated inflation--to reduce the inconvenience and distortions of having long-term relationships covered by short-term contracts (Vincent Crawford 1982)--and not to make ex post adjustments between expectation and facts. Cavallo (1983, p. 319) supports this last point by noting that, together with indexation, long-term contracts usually include reopening clauses which can be triggered by drastic changes in the general economic situation.

From the viewpoint of the economy as a whole, large "real" shocks would constitute such drastic events that should lead to the suspension of indexation. At the very least, small countries in which nominal wages are indexed on the general price level or where the nominal exchange rate is depreciated in line with the difference between domestic and foreign inflation should make provision for exceptions in indexation arrangements. To obtain the flexibility in real wages and real exchange rates required to counter fluctuations in export earnings, Richard Marston (1984b) and Daniel Gros (1986) have proposed a mixed scheme in which an index of export earnings is added to price level change and inflation differentials in the indexation formula. Edwards (1987) has found that the real exchange rate is considerably affected by nominal disturbances and overshooting in the short run, something that can be counteracted in the small open economy by fixing the exchange rate with a major international partner and letting the money supply be governed by the need to defend fixed rates (Marston 1984a). However, as Turnovsky (1976, p. 45) has also pointed out, the relative stability of output under fixed and flexible exchange rates in the face of various random shocks depends crucially upon the source of these disturbances. In the short run, output will always be more stable under flexible rates if the stochastic disturbances are either in exports or in foreign output prices.

Indexation can be hedged not only by, in effect, putting it out of action as needed to cope with real disturbances, but also by having less than 100% indexation to start with. Jo Anna Gray (1983) has shown that how much less depends on the prevalence of non-monetary compared with monetary disturbances or uncertainty. We may note parenthetically that the microeconomic analogue worked out by Mitchell Polinsky (1986) is that sellers would prefer spot price contracts with respect to production cost uncertainty and fixed price contracts with respect to demand uncertainty. Alan Stockman (1986b) has shown that buyers may have the same preference in the absence of complete asset markets, thereby supporting a degree of price stickiness for utility maximization on insurance grounds. The non-monetary shock Gray focuses on is a relative demand shock that is industry-specific as opposed to a monetary shock to aggregate demand that affects all industries equally. Blinder and Mankiw (1984) and Marston and Turnovsky (1985b) concentrate instead on relative supply shocks with "island" or firm-specific productivity disturbances. Here again partial, rather than full, indexation turns out to be optimal. A simpler demonstration at the most aggregative level with one supply and one demand disturbance process, by Gary Fethke (1985), finds the optimal indexation coefficient from a regression of output innovations on

price level innovations. These innovations are generated either just by differencing or by a three-variable vector autoregression involving short lags of output, price level, and money supply. One plus the regression coefficient, which would be zero in the absence of supply disturbances and a negative fraction otherwise, would be the estimate of the optimal degree of wage indexation.

Aizenman and Frenkel (1985) have found that a rise in the variance of the monetary shock and an increase in the elasticity of labor supply raise the optimal degree of wage indexation. The degree of policy uncertainty can therefore influence the degree of indexation. Conversely what policy can do depends on the prevailing degree of indexation and, more broadly, on the entire system of contracts prevailing in an economy (Benassy 1985). The question of how individuals can index to neutralize the effects of policy, addressed in depth by Robert King (1982), can therefore be turned around to ask how policymakers are constrained by existing forms of contracting.

One of the easiest ways to introduce the reverse perspective is Gordon's (1984a) or, similarly, Fischer's (1985) showing of how labor market arrangements constrain the ability of monetary authorities to respond to supply shocks. If rates of nominal wage change are inertial, so that they depend only on their past value, full monetary accommodation is optimal because it would succeed in lowering real wages to their new equilibrium level. There would be no need for increased unemployment to inform labor about the change in production possibilities. On the other hand, with complete indexation of wage changes to current changes in the price level there is no change in nominal GNP that will maintain full employment. The economy will be thrown into disequilibrium until the indexation mechanism, and perhaps the labor supply curve, if that curve is not independent of the perceived technological opportunity set, are reset to take account of the new realities. Partly forward-looking agents, as in Taylor (1980), should be able to calculate the future consequences of maintaining high indexation parameters in the face of a permanent supply shock once such a shock has been clearly identified (Gordon 1984a, p. 41).

International extensions of the modelling of given degrees of indexation and how they bear of the processing of various shocks in industrial countries are found in Gilles Oudiz and Sachs (1984, pp. 9-16). Since the U.S. economy has frequently been described as having very low degrees of wage indexation compared, at least, with Western European countries (William Branson and Julio Rotemberg 1980; Sachs 1983; Fethke 1985; Blanchard and Summers 1986), accommodation of the 1973-74 and 1979-80 oil price shocks might have been indicated. Of course, there remain wide disagreements on this score and about the subsequent disinflation, as Cagan and William Fellner (1983), George Perry (1983), Marston and Turnovsky (1985a), and Gordon (1985) have indicated.

Having touched on actual conditions in major countries, we will close by returning to a theoretical island group with its archipelago economy, as Blinder and Mankiw (1984) have called it. Suppose the economy of each of five islands conforms to a different model. One island instantly adjusts to clear markets, and another sets the money wage in advance but allows management the right to determine employment effort thereby exposing employment and output to unanticipated changes in demand and in productivity. One more indexes the real wage without nominal rigidities, and yet another does so by fixing both the money wage and prices beforehand. In this fourth island, firms agree to supply whatever

quantity is demanded at the predetermined price level, and workers agree to produce this quantity at the predetermined real wage. One last, presumably poorly inhabited, island fixes only prices beforehand, again with the output supply commitment of the previous island but without the commitment of workers to go off their full-information supply function when unanticipated disturbances occur.

Blinder and Mankiw (1984) explain that this archipelago economy cannot really be aggregated. At any one point in time, some labor markets may be on their notional supply curves, some may be on their notional demand curves, some may be on both, and some may be on neither. Furthermore, policies which are optimal for one type of island may not be optimal for another type of island that handles contracts differently. Similarly, Cukierman (1980) has found that the effects of wage indexation in the face of various shocks depend on whether the labor contract employment rule reflects mostly the demand or the supply of labor. Hence the absorption of uncertainty through *ex post* adjustments mandated under indexation arrangements may succeed only under specialized circumstances and initial conditions.

4.4. Summary

This section started by surveying how measures of variability have gradually come to accompany expected values in modelling behavior and in deriving stabilization rules under uncertainty. Coefficients, such as marginal propensities, that might once have been thought of as revealing behavior now appear more often as tuners set to extract signals from high-frequency series, normally prices, about what is happening to low-frequency series, normally flows which can not be monitored at continuous rates. Coefficients designed to elicit this economic intelligence are ratios whose numerator appears, say, as the covariance of a currently observed innovation or error with the sum of all errors. The variance that remains in the absence of cross-correlations is then divided by the sum of the variances of all errors, some of which are not currently observed, to determine the strength of the signal to be extracted. Certainty equivalence is lost in such applications as it is in simple control models as soon as parameter uncertainty is admitted.

In attempting to decode disturbances, little attention has been given in the literature surveyed here to how the construction of the model acting as receiver or monitor can bias and distort the signals picked up. The interdependence of the method of observation and what is observed, long recognized in (quantum) physics, is not often appreciated in economics or taken into account in joining apparently contradictory evidence to a deeper understanding of disturbance origin and propagation. Hence estimates of the various shocks and their contribution to economic fluctuations can differ greatly among researchers. However, it appears that policy shocks that were regarded as the main trouble in much of the research of the 1970s are frequently held of less importance than real shocks in the 1980s. Part of the change in emphasis may have been prompted by the growing realization that one would expect more private insurance and indexation arrangements to evolve to counter at least nominal policy shocks if they really imposed significant welfare losses in free economies.

The duality between rules and indexation implies a dynamic interplay between policy and indexation. The latter can be used to reduce certain forms of policy to irrelevance; in other cases policy can take advantage of certain forms of nominal contracting and straggling for which adequate microeconomic explanations may nevertheless be found (Fethke

and Andrew Policano 1986; 1987). Marston (1984b, p. 300) is surely right in reminding us that indexation is no panacea. Instead, an indexation rule that is preferable for some disturbances will exacerbate the effects of others. Indeed something like (Charles) Goodhart's Law (see Paul Evans 1985), according to which tightening monetary control by a specific measure lessens the relationship between that measure and what the monetary authorities care about, may be at work in indexation. Just when mandatory or voluntarily introduced indexation would appear to have neutralized a disturbance prevalent in the past, a new source of disturbance could come to the fore, with the result that there is little or no gain in stability overall. A possible reason for this is not, of course, that nature plays against successful applications of human intelligence, but that the manifestations of disturbances, and their income distribution effects, change as different forms of contracting are adopted.

5. Closing Observations on Microfoundations and Information

The Royal Astronomer of Scotland, Malcolm Longair (1986, p. 3), in a much noted lecture on the communication of science, thought it worth clearing up the misconception that the typical scientist agonizes in everyday research about the fundamentals of the discipline. If a concern with some basic issues should nevertheless have touched the present survey, the concern was prompted by widespread disillusionment with the treatment of uncertainty and learning in macroeconomics. "Foundations of sand" is alleged to be what the discipline stands on in the judgement of some of those who pride themselves in being hard scientists. A former director of the division of reactor development in the (U.S.) Atomic Energy Commission (Lawrence Hafstad 1982) is among them. Currie (1985, p. 285) cites another severe critic, an eminent British biologist, as lambasting macroeconomists not so much for their wrongness "as their pretensions to rightness that have brought economic predictions and the theory that underlies them into well-deserved contempt".

Perhaps "the dogmatic self-assurance and asseverative confidence" attributed to macroeconomists further by Sir Peter Medawar are a less valid grievance now than they would have been in the 1960s. For most of that decade the leading Keynesian economists in or around government felt capable of bringing on the twilight of the business cycle and the eclipse of macroeconomic instability, to use the language of heavenly accomplishment favored by the luminaries of the time. Such high expectations have not been fulfilled, and promises have been withdrawn to be replaced by faintly worded, minimalist opinions (see, for instance, Sargent 1984, p. 414). It has even been suggested by Romer (1986b) that correct empirical evidence is lacking that would support the presumption that the severity of economic fluctuations is less on this side than on the other side of the Great Depression. Romer's conclusion, that the standard view of higher prewar volatility of GNP is spurious, has since been refuted by Nathan Balke and Gordon (1986) who defend prior findings by J. Bradford DeLong and Summers (1986) in this respect. Earlier, Lucas (quoted in Arjo Klammer 1984, pp. 55-56) had already rated what he regards as the inappropriately titled Keynesian "revolution" more a political than a scientific event.

Considering some of the unguarded claims about the inevitable effects of policies that have been made since that earlier revolution by monetarists, supply-side economists, and every other school that has received political articulation, it is unclear how much scientific perspective has been won. Lucas (1980a) and Sims (1986a) have been among those charging that macroeconomists have continued to pretend to far more certain knowledge than they

have any scientific basis for. It is quite doubtful that macroeconomics has established “secure bases from which exploration could start in new directions,” as Debreu (1984, p. 275) has claimed for the axiomatization of economic theory elsewhere. Instead, schools of macroeconomists rise by discrediting others, perhaps too totally. Unlike physicists who reconceptualize only very carefully when prodded by puzzles otherwise unaccountable, macroeconomists do not thrive on constructive conservation. Frank Hahn, in the foreword of a text by Pierre-Yves Hénin (1986), has criticized them for this. The thought, common in the natural sciences, that almost every time-tested paradigm or basic conceptualization of complex processes retains at least some restricted milieu and circumstance under which it may have a cognitive advantage because the force of the old induction relative to the old evidence is untouched (Tony Lawson 1985, p. 911), has not made much headway in economics. When staked in the political arena, claims to macroeconomic knowledge still tend to be overreaching and exclusive. As a result, “as an advice-giving profession we are in way over our heads” (Lucas 1980a, p. 209), treating admissions of uncertainty and diverse possibilities as something to be avoided because it might not be viewed as constructive.

Attitudes and practices, particularly macroeconometric practices surveyed in Section 3, have been changing in this regard, and there is more appreciation that models of economic behavior may not simply be right or wrong, but differently conditioned. Still macroeconomists may not quite have absorbed the type of lessons (James Clerk-) Maxwell brought to physics well over a century ago. The change in basic conceptions then occurring led from the caloric theory of heat as an indestructible fluid to the notion that heat is indeed destroyed in conversion to mechanical work but that it is impossible to convert a given amount of heat completely into mechanical work. The puzzle posed for determinism by the irreversibility contained in the second law of thermodynamics was followed by other puzzles in the theory of gases. We will use one of them, albeit as laymen, to reflect on the consequences of uncertainty about the objects of aggregation and how these consequences change when going from the natural sciences to those involving human consciousness and calculation.

5.1. Substantive and Nonsubstantive Micro-Macro Relations under Uncertainty

As already touched on in the first section (1) of this survey, in the systems of Newton and Laplace and then (William) Hamilton, certainty was presumed to govern physical relations. By a solution of the equations of motion they meant that all the positions or coordinates of the particles are known for all time. At least through the middle of last century, determinism at the micro level was taken for granted even when statistical laws, and not deductions from Newtonian equations for the countless constituents, were used to characterize the behavior of macroscopic aggregates. This began to change in the late 1860s when Maxwell discovered randomness as basic to physics. Specifically he found that in gas, heat is no more than a (non-normal) frequency distribution of the random velocities of the atoms of the gas whose individual speeds are impossible to predict. After Maxwell, if one chose any particle at random from the gas one could no longer assume that there was a way to establish what its velocity should be. Determinism at the micro level had broken down, to be replaced by statistical laws.

What could this narration, compressed from Longair (1986), imply for our understanding of what could be meant by the microfoundations of macroeconomics? Much of what passes for such foundations uses the construct of the representative individual, firm, or

agent in utility or profit maximization models. Necessary conditions under which it is possible to treat aggregate behavior as if it were the outcome of the decisions of a single maximizing entity, conditions sought by Angus Deaton and John Muellbauer (1980, p. 148), do not solve any problem of aggregation but trivialize it. Thomas Stoker (1986) has shown that such conditions are unlikely to be met. Indeed Arrow (1986, p. S390) finds the "homogeneity assumption...especially dangerous. It denies the fundamental assumption of the economy, that it is built on gains from trading arising from individual differences." Models of representative principals may have some use in specifying the objective function of governments concerned with the median voter, or of benevolent governments or political agents subsuming the representative citizen's criterion (see Cohen and Michel 1986a, p. 9). In other macroeconomic applications, being representative means very little, unless everything such an amorphous entity does is perfectly correlated with what everybody else does. Hence this figment does not normally establish microfoundations-- only micro analogies as if nothing changed going from micro to macro. Furthermore, for any agent to be recognizably representative, all of them must have utility functions which are known to principals so that they can be played on, for instance in eliciting labor supply and effort. Such assumptions further suppress uncertainty.

Used to dodge the charge of being based on arbitrary, ad hoc relationships, representative-agent models themselves contain a great deal of arbitrariness in the way the optimization problem is posed. Turnovsky (1985, p. 168) has remarked on the shifting of arbitrariness to different points in the analysis, and Mankiw (1986a) has questioned the use of the construct of the representative consumer when exposure to shocks is the same for all *ex ante*, but shocks actually are concentrated *ex post* among a few. Lucas (1980b, p. 710) has offered some provocative questions to show how little is learned in this way about aggregates. How a monkey that has not been fed for a day will react to a banana tossed into its cage is a question we can answer from previously established knowledge. But is such knowledge helpful for the way an entire society of monkeys react to changes in their environment? How, for instance, will five monkeys that have not been fed for a day react to one banana thrown into their cage? This, Lucas explains, is an entirely different question, on which the knowledge of preferences (each monkey wants as much of the banana as he can get) and technology (banana consumption in total cannot exceed unity) gives us scarcely a beginning. Lucas (1986) and Arrow (1986, p. S387) have given other illustrations of how little rationality assumptions by themselves can yield in a world of many actors.

After the representative agent, another common way of providing microfoundations is to assume that individuals can be characterized by stable differences in tastes and endowments. In that case the behavioral qualities of the aggregate become functions of its composition. This assumption is more general than that of the representative agent since being homogeneous is but a limiting case of being rigidly heterogeneous. What is as yet rarely considered is that there may be inherent randomness, imprecision and indeterminacy in human behavior and in the impulses and objectives that guide it. The flicker noise that then occurs is sometimes described as non-epistemic uncertainty; it is not noise that is just a stand-in for missing knowledge about explanatory variables or about elements that are difficult to quantify. We return briefly to the contrast with physics to explain how uninformative a particle could be and how it could appear differently in economics.

In physics, heat, on account of conductivity, is a quality of aggregates, but within the aggregate environment of mean velocity, any particle changes velocity randomly and cannot be labelled a fast or slow mover categorically. Each particle could be any other but is quite unlikely to behave like any other at a given point in time. Hence it is unclear what could be meant by microfoundations. Since it would be pointless to attempt to anticipate a particle's next move, the behavior of the aggregate cannot possibly be deduced from laws governing the micro units.

Starting with the closest possible replication of this instance of randomly heterogeneous representative agents in economics, we can trace precisely how replacing physical particles with calculating human beings affects micro-macro relations. Goodfriend's (1986b) recent work on aggregation bias is well suited for this demonstration because it deals with randomly heterogeneous agents, thereby replicating the environment of Maxwell's gases in an important respect. We will consider just one signal extraction problem which a total of $i = 1 \dots n$ such agents face. They are, reasonably enough, assumed capable of contemporaneously observing only their individual income y_t^i and not aggregate income, y_t , at time t . But they have good reason to want to infer the latter as Goodfriend shows.

Agent i 's income, y_t^i is generated as the sum of an average aggregate component, y_t/n , and a relative income component, u_t^i , such that:

$$y_t^i = y_t/n + u_t^i \text{ where } \sum_{i=1}^n u_t^i = 0. \quad (19)$$

Like the gas particles, agents are anonymous in that the relative income generating process is assumed to be identical across agents, implying ex ante equality of the income distribution each period ahead. The agents are, therefore, randomly heterogeneous representative agents without any lasting class standing; each incurs random windfall gains or losses that leave no residue from period to period. Aggregate and relative income innovations, which are e_t and u_t^i respectively, are uncorrelated by construction. The individual income forecast error is decomposed into the sum of these two types of errors such that:

$$\eta_t^i = y_t^i - E_{t-1}^i y_t^i = e_t/n + u_t^i. \quad (20)$$

Now assume (detrended) aggregate income is a (0, 1, 0) ARMA process, i.e., a random walk. Then the best forecast at time $t-1$ of income y_t^i for any individual i , $E_{t-1}^i y_t^i$ is y_{t-1}/n . When an individual observes his current income deviating from y_{t-1}/n , there is the problem of inferring how much of the error η_t^i is permanent (associated with the aggregate income innovations e_t) and how much is transitory (associated with temporary deviations, u_t^i , in the individual's income position from the common mean). The way to find out one and hence the other is to regress e_{t-j} on $n\eta_{t-j}^i$ for the past ($j > 0$) so as to obtain the current expectation of e_t from:

$$E_t^i e_t = \Omega(n\eta_t^i), \text{ where } \Omega = \sigma_e^2/(\sigma_e^2 + n^2 \sigma_u^2). \quad (21)$$

In the least-squares estimator, σ_e^2 is the step-ahead variance of (detrended) income or the variance of income change, while σ_u^2 is the variance of individual income deviations from the mean which is the same for all i .

Once the optimal contemporaneous allocation of unexpected changes in current individual income has been made in this familiar way between changes in aggregate and in relative income, something else is revealed by the passage of time that is not as familiar according to Goodfriend (1986b): Last period's estimate of its aggregate income will be revised to the extent errors are revealed when the information on last period's aggregate income becomes available this period. Each individual's forecast is optimal, hence rational and unbiased, and forecast errors are serially uncorrelated at the micro level. Nevertheless, given any nonzero random aggregate income innovation, that innovation will be systematically underforecasted. Except when agents are rigidly rather than randomly heterogeneous, so that absolute income differences remain fixed between them, possibly at zero, and σ_a^2 equals zero, Ω will necessarily be less than 1 in equation (21). Because of the forecast error correction that then ensues next period, aggregate consumption is not a random walk, even if aggregate income is. Simply because aggregate income is not currently observable, the reaction to any nonzero realization of e_t is dragged out over two periods. Empirical work by Edgar Weissenberger (1986) tends to support this conclusion. Hall's (1978) famous result, that consumption is a random walk when the rates of subjective time preference and real interest are equal, can therefore be overturned by a slight change in information structure.

Being explicit about the uncertainty faced by the subjects of aggregation turns out to be important to what the procedure yields. Micro was shown to be relevant for macro in the above experiment that otherwise came as close to Maxwell's environment as one can come in economics. Alan Nelson (1984) has commented that seeking to retrofit microrelationships to macrotheory by imposing restrictions on the former to suit the latter would stand these foundation procedures on their head. Benoit Mandelbrot (1963, p. 440) once made a similar point by noting that when the law of Boyle (about constancy of the product of absolute pressure and volume of a gas) was found to differ from facts (particularly in the neighborhood of condensation points), the physicists simply invented the concept of a "perfect gas", that is, a body that follows perfectly Boyle's law. Blinder (1987) has pointed to physics, chemistry and medicine to argue that good science need not always be built up from solid microfoundations. Hence, dispensing with such foundations may be preferable to retrofitting them to empirical regularities that have been formulated or tested directly at the macro level. It may also be preferable to creating puzzles at that level by starting with unrealistic premises, if nothing apt seems tractable, just to have microfoundations to boast of.

5.2. *Uncertainty of Inference and Prerequisites for Processing Information*

The inference problem just discussed helps bring out another point. Using a coefficient such as Ω in signal extraction implies a statement of prior beliefs. One of these beliefs is that least squares rather than, say, least absolute error estimation (see Andrew Weiss 1986) should be used in the optimal forecast, presumably because the subjective cost of forecast errors and the associated objective function are taken to be quadratic. Then there is the implied belief that past variances, specifically, the ratio of aggregate to relative income disturbance measures, will remain unchanged. Otherwise Bayesian or some other procedures would have to be specified to update or modify the signal extraction coefficient, Ω , as new evidence accumulates. One might even follow Zellner (1986, p. 3) and consider that anticipated and unanticipated changes in variances and covariances might have to be

distinguished because they could have different impacts on behavior. Indeed, Poterba and Summers (1986a) have already identified, and added to, literature distinguishing such changes in examining the effects of volatility shocks on the stock market.

All the judgements, beliefs, and anticipations involved in reasoning about future events and their distributions in this way are based on priors. Now if the “true” economic model is not known or is changing, priors can get in the way and prevent errors in expectations from being serially uncorrelated and orthogonal to all underlying conditioning variables (Benjamin Friedman 1979). Nevertheless, priors are indispensable for the orientation of decisionmakers and their ability to be informed by events.

“There is today a strong consensus that there is no macroeconomic consensus” (Blinder 1986, p. 209). It is equally apparent that economists’ own views of the best model approximating economic behavior have evolved over time, and the views of households and businesses have almost certainly changed as well. Moreover, in modern nature sciences, models are viewed as providing more or less useful hints of reality under specified conditions, not the whole reality or definitive truth. For all these reasons, the assumption commonly made in new classical economics, that there is a “true” economic model and one that is sufficiently unchanging for people’s priors to have long been grounded in it, does not come from “science” or “rationality”. It also does not square with the facts as macroeconomists have experienced them. Hence the choice of priors, instead of being a rather effortless exercise of acknowledging what has long been driving the economy, becomes a complex and unfinished search for more or less useful starting assumptions pointing in different directions.

A basic point that arose in several different contexts in this survey thus deserves to be underscored. Just as it is not clear what is meant by microfoundations of macroeconomics in the abstract, without specifying the randomness and cognitive abilities of the micro units, it is not clear what is meant by “the current state of information” including the correct model. Taking that state as given, ahead of any analysis and without specifying prior beliefs, their distribution, and the procedure used for acquiring information is potentially contradictory. What constitutes information and how news is processed depends on priors. Conversely, information is likely to be unusable if there are no priors and none are being formed.

Priors can only be generated through learning or experience acquisition processes. First of all, as Hahn (1984, p. 82) has put it, the argument that rational expectations are justified because rational agents will learn what is the case is ill founded in theory unless it has also been shown that agents *could* learn. An even stronger condition must be met to show that agents *would* learn. It needs to be explained why anyone would work hard to produce informative priors individually rather than defer to impulse, habit, prejudice or “group-think”. Seeking, organizing, and evaluating information takes effort and self-discipline before it can lead to anything approaching what variously has been called calculative, intentional or procedural rationality (see Amitai Etzioni 1986, p. 19). Herbert Simon (1986) and Arrow (1986, p. S388) have stressed that *substantive* rationality of the choices actually made, particularly global consistency, is even more demanding on individuals, albeit sterile (devoid of implications) in aggregates. Etzioni (1986) has conceived of rationality not as a useful starting assumption but as a painfully acquired product requiring continuous maintenance expenditures. Hence the facility with which we posit expectations being conditioned

on all information available through time t , while keeping silent on prior beliefs and their appropriate generation, is another device used to hide multiple possibilities and uncertainty, in this case about the conduct of inference and the process of learning.

This too is beginning to change in macroeconomics following advances in econometrics and in the microeconomics of information. It is possible that from a fuller appreciation of uncertainty and the need to account for it in the process of making decisions a more credible and cumulative macroeconomics may yet emerge. Perhaps hopeful for this, several economists, among them Brunner and Meltzer (eds. 1984, p. 1), have identified the integration of uncertainty into the type of models used by macroeconomists as a major area of professional interest in the years ahead.

REFERENCES

- ADAMS, JAMES D. "Permanent Differences in Unemployment and Permanent Wage Differentials", *Quart. J. Econ.*, Feb. 1985, 100 (1), pp. 29-56.
- AIGNER, DENNIS J. AND GOLDBERGER, ARTHUR S. *Latent variables in socio-economic models*. Amsterdam: North-Holland, 1977.
- AIGNER, DENNIS J. ET AL. "Latent Variable Models in Econometrics", in ZVI GRILICHES AND MICHAEL D. INTRILIGATOR, eds., 1984, pp. 1321-93.
- AIZENMAN, JOSHUA, AND FRENKEL, JACOB A. "Optimal Wage Indexation, Foreign Exchange Intervention, and Monetary Policy", *Amer. Econ. Rev.*, June 1985, 75(3), pp. 402-23.
- AIZENMAN, JOSHUA, AND FRENKEL, JACOB A. "Supply Shocks, Wage Indexation, and Monetary Accommodation", *J. Money, Credit, Banking*, Aug. 1986, 18(3), pp. 304-22.
- ALLEN, R.G.D. *Mathematical analysis for economists*. London: Macmillan, 1960.
- ALLEN, ROBERT C. AND DIEWERT, W. ERWIN. "Direct Versus Implicit Superlative Index Number Formulae", *Rev. Econ. Statist.*, Aug. 1981, 63(3), pp. 430-35.
- ARNOTT, RICHARD J. AND STIGLITZ, JOSEPH E. "Labor Turnover, Wage Structures and Moral Hazard: The Inefficiency of Competitive Markets", *J. Labor Econ.*, Oct. 1985, 3(4), pp. 434-62.
- ARROW, KENNETH J. "The Organization of Economic Activity: Issues Pertinent to the Choice of Market Versus Nonmarket Allocation", in *Public expenditure and policy analysis*. Eds.: ROBERT H. HAVEMAN AND JULIUS MARGOLIS. Chicago: Markham, 1970, pp. 59-73.
- ARROW, KENNETH J. *Essays in the theory of risk-bearing*. Chicago: Markham, 1971.
- ARROW, KENNETH J. "The Economics of Agency", in *Agency: the structure of business*. Eds.: JOHN W. PRATT AND RICHARD ZECKHAUSER. Cambridge, MA: Harvard Business School Press, 1985, pp. 1183-95.
- ARROW, KENNETH J. "Rationality of Self and Others in an Economic System", *J. Bus.*, Oct. 1986, 59(4, Part 2), pp. S385-S399.
- ARROW, KENNETH J. AND KURZ, MORDECAI. *Public investment, the rate of return, and optimal fiscal policy*. Baltimore: Johns Hopkins U. Press for Resources for the Future, Inc., 1970.
- ARTUS, JACQUES R. AND MCGUIRK, ANNE KENNY. "A Revised Version of the Multilateral Exchange Rate Model", *Int. Monet. Fund Staff Pap.*, June 1981, 28(2), pp. 275-309.

- ATHANS, MICHAEL. "The Importance of Kalman Filtering Methods for Economic Systems", *Ann. Econ. Soc. Measure.*, Jan. 1974, 3(1), pp. 48-64.
- BACKUS, DAVID AND DRIFFILL, JOHN. "Rational Expectations and Policy Credibility Following a Change in Regime", *Rev. Econ. Stud.*, April 1985, 52(2), pp. 211-21.
- BALKE, NATHAN S. AND GORDON, ROBERT J. "The Estimation of Prewar GNP Volatility 1869-1938". NBER Working Paper no. 1999, Aug. 1986.
- BALTENSPERGER, ERNEST AND DERMINE, JEAN. "Banking Deregulation and Financial Stability, A European Regulatory Perspective", *Econ. Policy*, April 1987, 4, pp. 64-95.
- BARNETT, WILLIAM A. "Divisia Indices", in *Encyclopedia of statistical sciences*, 2. Eds.: NORMAN JOHNSON AND SAMUEL KOTZ. NY: John Wiley, 1982, pp. 412-15.
- BARNETT, WILLIAM A.; OFFENBACHER, EDWARD K. AND SPINDT, PAUL A. "The New Divisia Monetary Aggregates", *J. Polit. Econ.* Dec. 1984, 92(6), pp. 1049-85.
- BARRO, ROBERT J. "Rational Expectations and the Role of Monetary Policy", *J. Monet. Econ.*, Jan. 1976, 2(1), pp. 1-32.
- BARRO, ROBERT J. "Unanticipated Money Growth and Unemployment in the United States", *Amer. Econ. Rev.*, Mar. 1977, 67(2), pp. 101-15.
- BARRO, ROBERT J. "Unanticipated Money, Output, and the Price Level in the United States", *J. Polit. Econ.*, Aug. 1978, 86(4), pp. 549-80.
- BARRO, ROBERT J. "On the Determination of the Public Debt", *J. Polit. Econ.*, Oct. 1979, 87(5), pp. 940-71.
- BARRO, ROBERT J. "Federal Deficit Policy and the Effects of Public Debt Shocks", *J. Money, Credit, Banking*, Nov. 1980, 12(4, Part 2), pp. 747-62.
- BARRO, ROBERT J. "Deficits Since World War II", *Scand. J. Econ.*, 1986a, 88(1), pp. 195-222.
- BARRO, ROBERT J. "Reputation in a Model of Monetary Policy with Incomplete Information", *J. Monet. Econ.*, Jan. 1986b, 17(1), pp. 3-20.
- BARRO, ROBERT J. and GORDON, DAVID B. "Rules, Discretion and Reputation in a Model of Monetary Policy", *J. Monet. Econ.*, July 1983a, 12(1), pp. 101-21.
- BARRO, ROBERT J. and GORDON, DAVID B. "A Positive Theory of Monetary Policy in a Natural Rate Model", *J. Polit. Econ.*, Aug. 1983b, 91(4), pp. 589-610.
- BARRO, ROBERT J. and GROSSMAN, HERSCHEL I. "A General Disequilibrium Model of Income and Employment", *Amer. Econ. Rev.*, Mar. 1971, 61(1), pp. 82-91.
- BATTEN, DALLAS AND HAFER, R.W. "Money, Income and Currency Substitution: Evidence from Three Countries", *Fed. Res. Bank St. Louis Rev.*, May 1985, 67(5), pp. 27-35.
- BECKER, ROBIN G. ET AL. "The Simultaneous Use of Rival Models in Policy Optimization", *Econ. J.*, June 1986, 96(382), pp. 425-48.
- BECKERMAN, WILFRED AND JENKINSON, TIM. "Disaggregative Versus Aggregative Wage Equations". Instit. Econ. Statis. Applied Econ. Disc. Paper no. 5. Oxford: U. of Oxford, Apr. 1986.
- BENASSY, JEAN-PASCAL. *The economics of market disequilibrium*. NY: Academic Press, 1982.

- BENASSY, JEAN-PASCAL. "A Non-Walrasian Model of Employment with Partial Price Flexibility and Indexation", in *Issues in contemporary macroeconomics and distribution*. Ed.: GEORGE R. FEIWEL. Albany, NY: State U. of NY Press, 1985, pp. 184-96.
- BENASSY, JEAN-PASCAL. *Macroeconomics: An introduction to the non-Walrasian approach*. NY: Academic Press, 1986.
- BERLINER, BARUCH. "Some Thoughts on Uncertainty, the Transfer of Knowledge and Insurability", *The Geneva Pap. on Risk and Insurance*, Oct. 1984, 9(33), pp. 380-95.
- BERNDT, ERNST R. AND CHRISTENSEN, LAURITS R. "Testing for the Existence of a Consistent Aggregate Index of Labor Inputs", *Amer. Econ. Rev.*, June 1974, 64(3), pp. 391-404.
- BERNDT, ERNST R. AND WOOD, DAVID O. "Technology, Prices and the Derived Demand for Energy", *Rev. Econ. Statist.*, Aug. 1975, 56(3), pp. 259-68.
- BETSON, DAVID A. AND GREENBERG, DAVID. "Labor Supply and Tax Rates: Comment", *Amer. Econ. Rev.*, June 1986, 76(3), pp. 551-56.
- BILS, MARK. "The Cyclical Behavior of Marginal Cost and Price". *Amer. Econ. Rev.*, Dec. 1987, 77(5) pp. 838-55.
- BLACK, FISCHER. "Noise", *J. Finance*, July 1986, 41(3), pp. 529-43.
- BLACKBURN, K. AND CHRISTENSEN, M. "Macroeconomic Policy Games and Reputational Equilibria in a Contracting Model". Dept. of Econ. Disc. Papers in Econ. and Econometrics no. 8621. Southampton: U. of Southampton, 1986.
- BLANCHARD, OLIVIER J. "Debt, Deficits, and Finite Horizons", *J. Polit. Econ.*, Apr. 1985, 93 (2), pp. 223-47.
- BLANCHARD, OLIVIER J. AND SUMMERS, LAWRENCE H. "Hysteresis and the European Unemployment Problem", *NBER Macroeconomics Annual*, 1986, 1, pp. 15-78.
- BLANCHARD, OLIVIER J. AND WATSON, MARK W. "Are Business Cycles All Alike?" in ROBERT J. GORDON, ed., 1986, pp. 123-56.
- BLEJER, MARIO I. "On the Anatomy of Inflation: The Variability of Relative Commodity Prices in Argentina", *J. Money, Credit, Banking*, Nov. 1983, 15(4), pp. 469-82.
- BLINDER, ALAN S. "Keynes after Lucas", *Eastern Econ. J.*, July/Sept. 1986, 12(3), 209-16.
- BLINDER, ALAN S. "Keynes, Lucas and Scientific Progress", *Amer. Econ. Rev.*, May 1987, 77(2), pp. 130-36.
- BLINDER, ALAN S. AND GOLDFELD, STEPHEN M. "New Measures of Fiscal and Monetary Policy, 1958-73", *Amer. Econ. Rev.*, Dec. 1976, 66(5), pp. 780-96.
- BLINDER, ALAN S. AND MANKIW, N. GREGORY. "Aggregation and Stabilization Policy in a Multi-Contract Economy", *J. Monet. Econ.*, Jan 1984, 13(1), pp. 67-86.
- BLUME, LAWRENCE E.; BRAY, MARGARET M. AND EASLEY, DAVID. "Introduction to the Stability of Rational Expectations Equilibrium", *J. Econ. Theory*, Apr. 1982, 26(2), pp. 313-17.
- BLUME, LAWRENCE E. AND EASLEY, DAVID. "Learning to Be Rational", *J. Econ. Theory*, Apr. 1982, 26(2), pp. 340-51.

- BOHR, NIELS. *Atomic physics and human knowledge*. NY: Wiley, 1958.
- BOHR, NIELS. *Essays 1958-1962 on atomic physics and human knowledge*. NY: Interscience Publishers, a Division of John Wiley, 1963.
- BOSCHEN, JOHN F. "Employment and Output Effects of Observed and Unobserved Money Growth", *J. Money, Credit, Banking*, May 1985, 17(2), pp. 153-63.
- BOSCHEN, JOHN F. AND GROSSMAN, HERSCHEL I. "Tests of Equilibrium Macroeconomics Using Contemporaneous Monetary Data", *J. Monet. Econ.*, Nov. 1982, 10(3), pp. 309-33.
- BOUISSOU, M. B.; LAFFONT, J. J. AND VUONG, Q. H. "Disequilibrium Econometrics on Micro Data", *Rev. Econ. Stud.*, Jan. 1986, 53(1), pp. 113-24.
- BOUILDING, KENNETH E. "Economics and General Systems", in *The relevance of general systems theory*. Ed.: ERVIN LASZLO. New York: George BRAZILLER, 1972, pp. 77-92.
- BRADLEY, MICHAEL D. AND JANSEN, DENNIS W. "Federal Reserve Operating Procedure in the Eighties: A Dynamic Analysis", *J. Money, Credit, Banking*, Aug. 1986, 18(3), pp. 323-35.
- BRAINARD, WILLIAM. "Uncertainty and the Effectiveness of Policy", *Amer. Econ. Rev.*, May 1967, 57(2), pp. 411-25.
- BRANSON, WILLIAM H. AND ROTEMBERG, JULIO J. "International Adjustments with Wage Rigidities", *Europ. Econ. Rev.*, May 1980, 13(3), pp. 309-32.
- BRAY, MARGARET. "Learning, Estimation, and the Stability of Rational Expectations", *J. Econ. Theory*, Apr. 1982, 26(2), pp. 318-39.
- BRAY, M. M. AND SAVIN, N.E. "Rational Expectations Equilibria, Learning, and Model Specification", *Econometrica*, Sept. 1986, 54(5), pp. 1129-60.
- BROCK, WILLIAM A. "Distinguishing Random and Deterministic Systems: Abridged Version", *J. Econ. Theory*, Oct. 1986, 38(4), pp. 168-95.
- BROWN, MURRAY AND CHANG, WINSTON W. "Capital Aggregation in a General Equilibrium Model of Production", *Econometrica*, Nov. 1976, 44(6), pp. 1179-1200.
- BROZE, L.; GOURIEROUX, C. AND SZAFARZ, A. "Solutions of Linear Rational Expectations Models", *Econometric Theory*, Dec. 1985a, 1(3), pp. 341-68.
- BROZE, L.; GOURIEROUX, C. AND SZAFARZ, A. "Reduction and Identification of Simultaneous Equations Models with Rational Expectations". CEPREMAP Disc. Paper no. 8601, Paris, Dec. 1985b.
- BRUNNER, KARL. "The Case Against Monetary Activism", *Lloyds Bank Rev.*, Jan. 1981, 139, pp. 20-39.
- BRUNNER, KARL AND MELTZER, ALLAN H., eds. *Essays on macroeconomic implications of financial and labor markets and political processes*. Carnegie-Rochester Conf. Publ. Pol., vol. 21. Amsterdam: North-Holland, Autumn 1984.
- BRUNO, MICHAEL AND SACHS, JEFFREY D. "Input Price Shocks and the Slowdown in Economic Growth: The Case of U.K. Manufacturing", *Rev. Econ. Stud.*, Special Issue 1982, 49(5), pp. 679-705.
- BRUNO, MICHAEL AND SACHS, JEFFREY D. *Economics of worldwide stagflation*. Cambridge, MA: Harvard U. Press, 1985.

- BRYAN, MICHAEL F. AND GAVIN, WILLIAM T. "Models of Inflation Expectations Formation: A Comparison of Household and Economist Forecasts", *J. Money, Credit, Banking*, Nov. 1986, 18(4), pp. 539-44.
- BUCHANAN, JAMES M. "Taxation in Fiscal Exchange", *J. Pub. Econ.*, July-Aug. 1976, 6(1,2), pp. 17-29.
- BUITER, WILLEM H. "Real Effects of Anticipated and Unanticipated Money: Some Problems of Estimation and Hypothesis Testing", *J. Monet. Econ.*, Mar. 1983, 11(2), pp. 207-24.
- BUITER, WILLEM H. AND MARSTON, RICHARD C., eds. *International economic policy coordination*. London: Cambridge U. Press, 1985.
- BURMEISTER, EDWIN; FLOOD, ROBERT P. AND GARBER, PETER M. "On the Equivalence of Solutions in Rational Expectations Models", *J. Econ. Dynam. Control*, May 1983, 5(2/3), pp. 311-21.
- CAGAN, PHILLIP. "The Monetary Dynamics of Hyperinflation", in *Studies in the quantity theory of money*. Ed.: MILTON FRIEDMAN. Chicago: U. of Chicago Press, 1956, pp. 25-117.
- CAGAN, PHILLIP AND FELLNER, WILLIAM. "Tentative Lessons from the Recent Disinflationary Effort", *Brookings Pap. Econ. Act.*, 1983, 2, pp. 603-10.
- CAMPBELL, JOHN Y. AND MANKIW, N. GREGORY. "Permanent and Transitory Components in Macroeconomic Fluctuations", *Amer. Econ. Rev.*, May 1987, 77(2), pp. 111-17.
- CAMPBELL, JOHN Y. AND SHILLER, ROBERT J. "Cointegration and Tests of Present Value Models". *J. Polit. Econ.*, Oct. 1987, 95(5), pp. 1062-88.
- CANZONERI, MATTHEW B. "Monetary Policy Games and the Role of Private Information", *Amer. Econ. Rev.*, Dec. 1985, 75(5), pp. 1056-70.
- CARD, DAVID. "An Empirical Model of Wage Indexation Provisions in Union Contracts", *J. Polit. Econ.*, June 1986 94(3, Part 2), pp. S144-S175.
- CARLTON, DENNIS W. "The Rigidity of Prices", *Amer. Econ. Rev.*, Sept. 1986, 76(4), pp. 637-58.
- CAVALLO, DOMINGO F. "Comments on Indexation and Stability from an Observer of the Argentinean Economy", in RUDIGER DORNBUSH AND MARIO HENRIQUE SIMONSEN, eds., 1983, pp. 318-20.
- CAVES, DOUGLAS W.; CHRISTENSEN, LAURITS R. AND DIEWERT, W. ERWIN. "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity", *Econometrica*, Nov. 1982, 50(6), pp. 1393-1414.
- CHISWICK, CARMEL U. "The Elasticity of Substitution Revisited: The Effects of Secular Changes in Labor Force Structure", *J. Labor Econ.*, Oct. 1985, 3(4), pp. 490-507.
- CHOW, GREGORY C. *Econometric analysis by control methods*. NY: John Wiley, 1981.
- CHOW, GREGORY C. *Econometrics*. New York: McGraw-Hill, 1983.
- CHOW, GREGORY C. "Random and Changing Coefficients Models", in ZVI GRILICHES AND MICHAEL D. INTRILIGATOR, eds., 1984, pp. 1213-45.
- CHRISTENSEN, LAURITS R. AND JORGENSON, Dale W. "The Measurement of U.S. Real Capital Input, 1929-1967", *Rev. Income and Wealth*, Dec. 1969, 15(4), pp. 293-320.

- CHRISTENSEN, LAURITS R. AND JORGENSEN, DALE W. "U.S. Real Product and Real Factor Inputs", *Rev. Income and Wealth*, Mar. 1970, 16(1), pp. 19-50.
- CHRISTENSEN, LAURITS R.; JORGENSEN, DALE W. AND LAU, LAWRENCE J. "Transcendental Logarithmic Production Functions", *Rev. Econ. Statist.*, Feb. 1973, 60(1), pp. 28-45.
- COHEN, DANIEL AND MICHEL, PHILIPPE. "Dynamic Consistency of Government's Behavior: A User's Guide". CEPREMAP Disc. Paper no. 8605, Paris, Feb. 1986a.
- COHEN, DANIEL AND MICHEL, PHILIPPE. "How Should Control Theory be Used by a Time-Consistent Government?" Université de Paris I - Panthéon-Sorbonne Paper, Paris, rev. Oct. 1986b.
- COHEN, MICHAEL D. AND AXELROD, ROBERT. "Coping with Complexity: The Adaptive Value of Changing Utility", *Amer. Econ. Rev.*, Mar. 1984, 74(1), pp. 30-42.
- CORNELL, BRADFORD. "The Money Supply Announcements Puzzle: Review and Interpretation", *Amer. Econ. Rev.*, Sept. 1983, 73(4), pp. 644-57.
- CRAWFORD, VINCENT P. "Long-Term Relationships Governed by Short-Term Contracts". Int. Centre for Econ. and Related Disciplines, London School of Economics, Theoretical Econ. Disc. Paper no. 82/59, 1982.
- CUDDINGTON, JOHN T.; JOHANSSON, PER-OLOV AND LÖFGREN, KARL-GUSTAF. *Disequilibrium macroeconomics in open economies*. Oxford: Basic Blackwell, 1984.
- CUKIERMAN, ALEX. "The Effects of Wage Indexation on Macroeconomic Fluctuations: A Generalization", *J. Monet. Econ.*, Apr. 1980, 6(2), pp. 147-70.
- CUKIERMAN, ALEX. "Relative Price Variability and Inflation: A Survey and Further Results", in *Variability in employment, prices, and money*. Carnegie-Rochester Confer. Publ. Pol., vol. 19. Eds.: KARL BRUNNER AND ALLAN H. MELTZER. Amsterdam: North-Holland, Autumn 1983, pp. 103-57.
- CUKIERMAN, ALEX. "Central Bank Behavior and Credibility: Some Recent Theoretical Developments", *Fed. Res. Bank St. Louis Rev.*, May 1986, 68(5), pp. 5-17.
- CUKIERMAN, ALEX AND LEIDERMAN, LEONARDO, "Price Controls and the Variability of Relative Prices", *J. Money, Credit, Banking*, Aug. 1984, 16(3), pp. 271-84.
- CUKIERMAN, ALEX AND MELTZER, ALLAN H. "The Credibility of Monetary Announcements", in *Monetary Policy and Uncertainty*, Ed.: MANFRED J.M. NEUMANN. Baden-Baden, Germany: Nomos, 1986, pp. 39-67.
- CURRIE, DAVID. "Macroeconomic Policy Design and Control Theory – A Failed Partnership?" *Econ. J.*, June 1985, 95(378), pp. 285-306.
- CURRIE, DAVID AND LEVINE, PAUL. "Credibility and Time Inconsistency in a Stochastic World". Disc. Paper no. 94. London: Centre for Econ. Pol. Research, Feb. 1986.
- CYERT, RICHARD M. AND DEGROOT, MORRIS H. *Bayesian analysis and uncertainty in economic theory*. Totowa, NJ: Rowman and Littlefield, 1986.
- DARBY, MICHAEL R. AND LOTHIAN, JAMES R. "Economic Events and Keynesian Ideas: the 1930s and the 1970s". NBER Working paper no. 1987, July 1986.

- DAVIS, STEVE J. "Does Search Theory Provide a Micro Foundation for Keynesian Models and a Rationale for Policy Activism? A Review of Peter Diamond's Wicksell Lectures", *J. Monet. Econ.*, Sept. 1986, 18(2), pp. 209-16.
- DAY, RICHARD H. "Irregular Growth Cycles", *Amer. Econ. Rev.*, June 1982, 72(3), pp. 406-14.
- DAY, RICHARD H. AND LIN, T.-Y. "Irregular Fluctuations and Comparative Policy Dynamics in the Keynesian Regime". MRG Working Paper no. M8604. Los Angeles: U. of Southern Cal., Dept. of Econ., Jan. 1986.
- DEATON, ANGUS AND MUELLBAUER, JOHN. *Economics and consumer behavior*. Cambridge: Cambridge U. Press, 1980.
- DEBREU, GERARD. *Theory of value*. NY: John Wiley, 1959.
- DEBREU, GERARD. "Economic Theory in the Mathematical Mode", *Amer. Econ. Rev.*, June 1984, 74(3), pp. 267-78.
- DE LEEUW, FRANK AND HOLLOWAY, THOMAS M. "Cyclical Adjustment of the Federal Budget and Federal Debt", *Surv. Curr. Bus.*, Dec. 1983, 63(12), pp. 25-40.
- DE LEEUW, FRANK AND HOLLOWAY, THOMAS M. "The Measurement and Significance of the Cyclically Adjusted Federal Budget and Debt", *J. Money, Credit, Banking*, May 1985, 17(2), pp. 232-42.
- DELONG, J. BRADFORD AND SUMMERS, LAWRENCE H. "The Changing Cyclical Variability of Economic Activity in the United States", in ROBERT J. GORDON, ed., 1986, pp. 679-719.
- DIEWERT, W.E. "Exact and Superlative Index Numbers", *J. Econometrics*, May 1976, 4(2), pp. 115-45.
- DIEWERT, W.E. "Superlative Index Numbers and Consistency in Aggregation", *Econometrica*, July 1978, 46(4), pp. 883-900.
- DIEWERT, W.E. "Aggregation Problems in the Measurement of Capital", in *The measurement of capital*. Ed.: DAN USHER. Chicago: U. of Chicago Press, 1980, pp. 333-528.
- DOAN, THOMAS; LITTERMAN, ROBERT AND SIMS, CHRISTOPHER. "Forecasting and Conditional Projection Using Realistic Prior Distributions", *Econometric Reviews*, 1984, 3(1), pp. 1-100.
- DONOVAN, DONAL J. "Modeling the Demand for Liquid Assets: An Application to Canada", *Int. Monet. Fund Staff Pap.*, Dec. 1978, 25(4), pp. 676-704.
- DORNBUSCH, RUDIGER AND FISCHER, STANLEY. *Macroeconomics*. NY: McGraw-Hill, 1978.
- DORNBUSCH, RUDIGER AND FISCHER, STANLEY. "The Open Economy: Implications for Monetary and Fiscal Policy", in ROBERT J. GORDON, ed., 1986, pp. 459-501.
- DORNBUSCH, RUDIGER AND SIMONSEN, MARIO HENRIQUE, eds. *Inflation, debt, and indexation*. Cambridge, MA: MIT Press, 1983.
- DOTSEY, MICHAEL AND ROBERT G. KING. "Informational Implications of Interest Rate Rules", *Amer. Econ. Rev.*, Mar. 1986, 76(1), pp. 33-42.

- DRAZEN, ALLAN. "Recent Developments in Macroeconomic Disequilibrium Theory", *Econometrica*, Mar. 1980, 48(2), pp. 283-306.
- DRAZEN, ALLAN AND HAMERMESH, DANIEL S. "Inflation and Wage Dispersion". NBER Working Paper no. 1811, Jan. 1986.
- DRÈZE, JACQUES H. "Human Capital and Risk-Bearing", *The Geneva Pap. on Risk and Insurance*, June 1979, 4(12), pp. 5-22.
- EATON, JONATHAN; GERSOVITZ, MARK AND STIGLITZ, JOSEPH E. "The Pure Theory of Country Risk", *Europ. Econ. Rev.*, June 1986, 30(3), pp. 481-513.
- ECKSTEIN, OTTO AND SINAI, ALLEN. "The Mechanisms of the Business Cycle in the Postwar Era", in ROBERT J. GORDON, ed., 1986, pp. 39-105.
- EDWARDS, SEBASTIAN. "Real Exchange Rate Variability: An Empirical Analysis of the Developing Countries Case", *Int. Econ. J.*, Spring 1987, 1(1), pp. 91-106.
- EICHENBAUM, MARTIN AND SINGLETON, KENNETH J. "Do Equilibrium Real Business Cycle Theories Explain Postwar U.S. Business Cycles? *NBER Macroeconomics Annual*, 1986, 1, pp. 91-135.
- EISNER, ROBERT. *How real is the federal deficit?* NY: Free Press, 1986.
- ENGLE, ROBERT F. "Autoregressive Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation", *Econometrica*, July 1982, 50(4), pp. 987-1007.
- ENGLE, ROBERT F. AND WATSON, MARK W. "Applications at Kalman Filtering in Econometrics". Paper presented at the 5th World Congress of the Econometric Society, Cambridge, MA, August 1985.
- ETZIONI, AMITAI. "Rationality is Anti-Entropic", *J. Econ. Psychology*, Mar. 1986, 7(1), pp. 17-36.
- EVANS, GEORGE. "Expectational Stability and the Multiple Equilibria Problem in Linear Rational Expectations Models", *Quart. J. Econ.*, Nov. 1985, 100(4), pp. 1217-33.
- EVANS, PAUL. "Money, Output and Goodhart's Law: The U.S. Experience", *Rev. Econ. Statist.*, Feb. 1985, 67(1), pp. 1-8.
- FAIR, RAY C. "Estimating the Uncertainty of Policy Effects in Nonlinear Models", *Econometrica*, Sept. 1980, 48(6), pp. 1381-91.
- FAIR, RAY C. *Specification, estimation, and analysis of macroeconomic models*. Cambridge, MA: Harvard U. Press, 1984.
- FAIR, RAY C. AND JAFFEE, DWIGHT T. "Methods of Estimation for Markets in Disequilibrium", *Econometrica*, May 1972, 40(3), pp. 497-514.
- FAIR, RAY C. AND TAYLOR, JOHN B. "Solution and Maximum Likelihood Estimation of Dynamic Nonlinear Rational Expectations Models", *Econometrica*, July 1983, 51(4), pp. 1169-85.
- FAMA, EUGENE F. "Stock Returns, Real Activity, Inflation, and Money", *Amer. Econ. Rev.*, Sept. 1981, 71(4), pp. 545-65.
- FAY, JON AND MEDOFF, JAMES L. "Labor and Output Over the Business Cycle: Some Direct Evidence", *Amer. Econ. Rev.*, Sept. 1985, 75(4), pp. 638-55.

- FELDSTEIN, MARTIN. "Government Deficits and Aggregate Demand", *J. Monet. Econ.*, Jan. 1982, 9(1), pp. 1-20.
- FETHKE, GARY. "The Conformity of Wage-Indexation Models with «Stylized Facts»", *Amer. Econ. Rev.*, Sept. 1985, 75(4), pp. 856-69.
- FETHKE, GARY AND POLICANO, ANDREW. "Will Wage Setters Ever Stagger Decisions?" *Quart. J. Econ.*, Nov. 1986, 101(4), pp. 867-77.
- FETHKE, GARY AND POLICANO, ANDREW. "Monetary Policy and the Timing of Wage Negotiations", *J. Monet. Econ.*, Jan. 1987, 19(1), pp. 89-105.
- FEUER, LEWIS S. *Einstein and the generations of science*. NY: Basic Books, 1974.
- FIELD, BARRY C. AND GREBENSTEIN, CHARLES. "Capital-Energy Substitution in U.S. Manufacturing", *Rev. Econ. Statist.*, May 1980, 62(2), pp. 207-12.
- FISCHER, STANLEY. "Long-Term Contracts, Rational Expectations, and the Optimal Money Supply Rule", *J. Polit. Econ.*, Feb. 1977, 85(1), pp. 191-205.
- FISCHER, STANLEY. ed. *Rational expectations and economic policy*. Chicago: U. of Chicago Press, 1980.
- FISCHER, STANLEY. "Indexing and Inflation", *J. Monet Econ.*, Nov. 1983, 12(4), pp. 519-41.
- FISCHER, STANLEY. "Supply Shocks, Wage Stickiness, and Accommodation", *J. Money, Credit and Banking*, Feb. 1985, 17(1), pp. 1-15.
- FISCHER, STANLEY AND PENNACCHI, GEORGE. "Serial Correlation of Asset Returns and Optimal Portfolios for the Long and Short Term", NBER Working Paper no. 1625, June 1985.
- FISHER, IRVING. *The making of index numbers*. Boston: Houghton Mifflin, 1922.
- FLAVIN, MARJORIE A. "Excess Volatility in the Financial Markets: A Reassessment of the Empirical Evidence", *J. Polit. Econ.*, Dec. 1983, 91(6), pp. 929-56.
- FOURGEAUD, C.; GOURIEROUX, C. AND PRADEL J. "Learning Procedures and Convergence to Rationality", *Econometrica*, July 1986, 54(4), pp. 845-68.
- FRANK, ROBERT H. "The Demand for Unobservable and Other Nonpositional Goods", *Amer. Econ. Rev.*, March 1985, 75(1), pp. 101-16.
- FRANKEL, JEFFREY A. AND HARDOUVELIS, GIKAS A. "Commodity Prices, Money Surprises, and Fed Credibility", *J. Money, Credit, Banking*, Nov. 1985, 17(4, part 1), pp. 425-38.
- FRENKEL, JACOB A. "Flexible Exchange Rates, Prices and the Role of «News»: Lessons from the 1970s", *J. Polit. Econ.*, Aug. 1981, 89(4), pp. 665-705.
- FRENKEL, JACOB A. "International Liquidity and Monetary Control", in *International money and credit: the policy roles*. Ed.: GEORGE M. VON FURSTENBERG, Washington, D.C.: Int. Monet. Fund, 1983, pp. 65-109.
- FRENKEL, JACOB A. AND RAZIN, ASSAF. "Fiscal Policies in the World Economy", *J. Polit. Econ.*, June 1986, 94(3, Part 1), pp. 564-94.
- FRIEDMAN, BENJAMIN M. "Crowding Out or Crowding In? Economic Consequences of Financing Government Deficits", *Brookings Pap. Econ. Act.*, 1978, 3, pp. 593-641.

- FRIEDMAN, BENJAMIN M. "Optimal Expectations and the Extreme Information Assumptions of Rational Expectations Macromodels", *J. Monet. Econ.*, Jan. 1979, 5(1), pp. 23-41.
- FRIEDMAN, BENJAMIN M. "The Substitutability of Debt and Equity Securities", in *Corporate capital structures in the United States*. Ed.: BENJAMIN M. FRIEDMAN. Chicago: U. of Chicago Press, 1985, pp. 197-233.
- FRIEDMAN, BENJAMIN M. "Money, Credit, and Interest Rates in the Business Cycle", in ROBERT J. GORDON, ed., 1986, pp. 395-438.
- FRIEDMAN, MILTON. *Essays in positive economics*. Chicago: U. of Chicago Press, 1966.
- FRIEDMAN, MILTON. "Monetary Correction", in *Essays on inflation and indexation*. By HERBERT GIERSCHE *et al.* Washington, D.C.: Amer. Enterprise Instit. Publ. Pol. Research, Domestic Affairs Study 24, Oct. 1974, pp. 25-61.
- FRIEDMAN, MILTON. "Comments on Tobin and Buiter", in *Monetarism*. Ed.: JEROME L. STEIN. Amsterdam: North-Holland, 1976, pp. 310-17.
- FRIEDMAN, MILTON. "Inflation and Unemployment", *J. Polit. Econ.*, June 1977, 85(3), pp. 451-72.
- FRIEDMAN, MILTON. "Lessons from the 1979-82 Monetary Policy Experiment", *Amer. Econ. Rev.*, May 1984, 74(2), pp. 397-400.
- FRIEDMAN, MILTON AND SCHWARTZ, ANNA J. *Monetary trends in the United States and the United Kingdom: their relation to income, prices, and interest rates, 1967-1975*. Chicago: U. of Chicago Press, 1982.
- FROYEN, RICHARD T. AND WAUD, ROGER N. "Demand Variability, Supply Shocks and the Output-Inflation Tradeoff", *Rev. Econ. Statist.*, Feb. 1985, 67(1), pp. 9-15.
- FRYDMAN, ROMAN. "Towards an Understanding of Market Processes: Individual Expectations, Learning and Convergence to Rational Expectations Equilibrium", *Amer. Econ. Rev.*, Sep. 1982, 72(4), pp. 652-68.
- FRYDMAN, ROMAN. "Individual Rationality, Decentralization, and the Rational Expectations Hypothesis", in *Individual forecasting and aggregate outcomes*. Eds.: ROMAN FRYDMAN AND EDMUND S. PHELPS. London and New York: Cambridge U. Press, 1983, pp. 97-122.
- FRYDMAN, ROMAN AND PHELPS, EDMUND S. "Introduction", in *individual forecasting and aggregate outcomes*. Eds.: ROMAN FRYDMAN AND EDMUND S. PHELPS. London and New York: Cambridge U. Press, 1983, pp. 1-30.
- GEWEKE, JOHN. "Inference and Causality in Economic Time Series Models", in ZVI GRILICHES AND MICHAEL D. INTRILIGATOR, eds., 1984, pp. 1101-44.
- GEWEKE, JOHN. "The Superneutrality of Money in the United States: An Interpretation of the Evidence", *Econometrica*, Jan. 1986, 54(1), pp. 1-21.
- GIARINI, ORIO. "Uncertainty from Newton to Heisenberg: A New Paradigm in Economics", in *Geld, Banken und Versicherungen*, Band 2/1982. Eds.: HERMANN GÖPPL AND RUDOLF HENN. Karlsruhe, Germany: Verlag Versicherungswirtschaft, 1983, pp. 903-22.
- GIERSCHE, HERBERT. "Index Clauses and the Fight Against Inflation", in *Essays on inflation and indexation*. By HERBERT GIERSCHE *et al.* Washington, D.C.: Amer. Enterprise Instit. Publ. Pol. Research, Domestic Affairs Study 24, Oct. 1974, pp. 1-23.

- GOLDBERGER, ARTHUR S. "Structural Equation Methods in the Social Sciences", *Econometrica*, Nov. 1972, 40(6), pp. 979-1001.
- GOODFRIEND, MARVIN. "Monetary Mystique: Secrecy and Central Banking", *J. Monet. Econ.*, Jan. 1986a, 17(1), pp. 63-92.
- GOODFRIEND, MARVIN. "Information – Aggregation Bias: The Case of Consumption". Fed. Reserve Bank of Richmond Paper, Aug. 1986b.
- GORDON, ROBERT J. "Supply Shocks and Monetary Policy Revisited", *Amer. Econ. Rev.*, May 1984a, 74(2), pp. 38-43.
- GORDON, ROBERT J. "Unemployment and Potential Output in the 1980s", *Brookings Pap. Econ. Act.*, 1984b, 2, pp. 537-64.
- GORDON, ROBERT J. "Understanding Inflation in the 1980s", *Brookings Pap. Econ. Act.*, 1985, 1, pp. 263-99.
- GORDON, ROBERT J., ed. *The American business cycle: continuity and change*. Chicago: U. of Chicago Press, 1986.
- GORDON, ROBERT J. AND KING, STEPHEN R. "The Output Cost of Disinflation in Traditional and Vector Autoregressive Models", *Brookings Pap. Econ. Act.*, 1982, 1, pp. 205-42.
- GOTUR, PADMA. "The Effects of Exchange Rate Volatility on Trade: Some Further Evidence", *Int. Monet. Fund Staff Pap.*, Sept. 1985, 32(3), pp. 475-512.
- GOURIEROUX, C.; LAFFONT, J.J. AND MONFORT, A. "Disequilibrium Econometrics in Simultaneous Equations Systems", *Econometrica*, Jan. 1980, 48(1), pp. 75-96.
- GOURIEROUX, C.; LAFFONT, J.J. AND MONFORT, A. "Rational Expectations in Dynamic Linear Models: Analysis of the Solutions", *Econometrica*, Mar. 1982, 50(2), pp. 409-25.
- GRANDMONT, JEAN-MICHEL. "Temporary General Equilibrium Theory", *Econometrica*, Apr. 1977, 45(3), pp. 535-72.
- GRANDMONT, JEAN-MICHEL. "On Endogenous Competitive Business Cycles", *Econometrica*, Sept. 1985, 53(5), pp. 994-1045.
- GRANGER, C.W.J. "The Typical Spectral Shape of an Economic Variable", *Econometrica*, Jan. 1986, 54(1), pp. 150-61.
- GRANGER, C.W.J. "Developments in the Study of Co-integrated Economic Variables", *Instit. Econ. Statist. Applied Econ. Disc. Paper no. 3*. Oxford: U. of Oxford, Jan. 1986.
- GRASSMAN, SVEN. "Comments", in *International money and credit: the policy roles*. Ed.: GEORGE M. VON FURSTENBERG. Washington, D.C.: Int. Monet. Fund, 1983, pp. 248-52.
- GRAY, JO ANNA. "Wage Indexation, Incomplete Information, and the Aggregate Supply Curve", in RUDIGER DORNBUSCH AND MARIO HENRIQUE SIMONSEN, eds., 1983, pp. 25-45.
- GRIFFIN, JAMES M. "OPEC Behavior: A Test of Alternative Hypotheses", *Amer. Econ. Rev.*, Dec. 1985, 75(5), pp. 954-63.
- GRILICHES, ZVI. "Errors in Variables and Other Unobservables", *Econometrica*, Nov. 1974, 42(6), pp. 971-98.

- GRILICHES, ZVI AND INTRILIGATOR, MICHAEL D., eds. *Handbook of econometrics*. Amsterdam: North-Holland, vol. II, 1984.
- GROS, DANIEL. "Wage Indexation and the Real Exchange Rate in Small Open Economies: A Study of the Effects of Fluctuations in Export Earnings", *Int. Monet. Fund Staff Pap.*, Mar. 1986, 33(1), pp. 117-38.
- GROSSMAN, HERSCHEL I. AND VAN HUYCK, JOHN B. "Sovereign Debts as a Contingent Claim: Excusable Default, Repudiation, and Reputation". Dept. of Econ. Working Paper no. 85-17. Providence, RI: Brown U., rev. Aug. 1986.
- GROSSMAN, SANFORD J. AND HART, OLIVER D. "An Analysis of the Principal-Agent Problem", *Econometrica*, Jan. 1983, 51(1), pp. 7-45.
- GROSSMAN, SANFORD J.; HART, OLIVER D. AND MASKIN, ERIC S. "Unemployment with Observable Aggregate Shocks", *J. Polit. Econ.*, Dec. 1983, 91(6), pp. 907-28.
- GROSSMAN, SANFORD J.; KIHLSSTROM, RICHARD E. AND MIRMAN, LEONARD J. "A Bayesian Approach to the Production of Information and Learning by Doing", *Rev. Econ. Stud.*, Oct. 1977, 44(3), pp. 533-47.
- GROSSMAN, SANFORD J. AND WEISS, LAURENCE. "Heterogeneous Information and the Theory of the Business Cycle", *J. Polit. Econ.*, Aug. 1982, 90(4), pp. 699-727.
- HAFER, R. W., ed. *The monetary versus fiscal policy debate: lessons from two decades*. Totowa, NJ: Rowman and Allanheld, 1986.
- HAFSTADT, LAWRENCE. *Foundations of sand: a hard look at the soft sciences*. [s. l.]: HMM, Inc., Centreville, MD: Distribution by Corsica Bookshop, 1982.
- HAHN, FRANK. *Equilibrium and macroeconomics*. Cambridge, MA: MIT Press, 1984.
- HAHN, FRANZ. "On Structural Stability of a Nonlinear Credit Market Model under Uncertainty", *Jahrb. f. Nationalök. u. Stat.*, Nov. 1986, 201(6), pp. 572-88.
- HAKKIO, CRAIG S. AND PEARCE, DOUGLAS K. "The Reaction of Exchange Rates to Economic News", *Econ. Inquiry*, Oct. 1985, 23(4), pp. 621-36.
- HALL, ROBERT E. "Investment, Interest Rates, and the Effects of Stabilization Policies", *Brookings Pap. Econ. Act.*, 1977, 1, pp. 61-103.
- HALL, ROBERT E. "Stochastic Implications of the Life-Cycle Permanent Income Hypothesis: Theory and Evidence", *J. Polit. Econ.*, Dec. 1978, 86(6), pp. 971-87.
- HALL, ROBERT E. "The Inefficiency of Marginal Cost Pricing and the Apparent Rigidity of Prices", NBER Working Paper no. 1347, May 1984.
- HALL, ROBERT E. "Chronic Excess Capacity in U.S. Industry", NBER Working Paper no. 1973, July 1986a.
- HALL, ROBERT E. "Market Structure and Macroeconomic Fluctuations", *Brookings Pap. Econ. Act.*, 1986b, 2, pp. 285-322.
- HALL, ROBERT E. AND LAZEAR, EDWARD P. "The Excess Sensitivity of Layoffs and Quits to Demand", *J. Labor Econ.*, Apr. 1984, 2(2), pp. 233-57.
- HALL, ROBERT E. AND TAYLOR, JOHN B. *Macroeconomics*. NY: W. W. Norton, 1986.

- HALL, THOMAS E. AND NOBLE, NICHOLAS R. "Velocity and the Variability of Money Growth: Evidence from Granger-Causality Tests", *J. Money, Credit, Banking*, Feb. 1987, 19(1), pp. 112-16.
- HALTIWANGER, JOHN AND WALDMAN, MICHAEL. "Rational Expectations and the Limits of Rationality: An Analysis of Heterogeneity", *Amer. Econ. Rev.*, June 1985, 75(3), pp. 326-40.
- HAMERMESH, DANIEL S. AND GRANT, JAMES. "Econometric Studies of Labor-Labor Substitution and their Implications for Policy", *J. Human Res.*, Fall 1979, 14(4), pp. 518-42.
- HAMILTON, JAMES D. "Uncovering Financial Market Expectations of Inflation", *J. Polit. Econ.*, Dec. 1985, 93(6), pp. 1224-41.
- HAMILTON, JAMES D. "Monetary Factors in the Great Depression", *J. Monet. Econ.*, March 1987, (19)2, pp. 145-69.
- HAMILTON, JAMES D. AND WHITEMAN, CHARLES H. "The Observable Implications of Self-Fulfilling Expectations", *J. Monet. Econ.*, Nov. 1985, 16(3), pp. 353-73.
- HANSEN, LARS PETER AND SARGENT, THOMAS J. "Formulating and Estimating Dynamic Linear Rational Expectations Models", *J. Econ. Dynam. Control*, Feb. 1980, 2(1), pp. 7-46.
- HARRIS, MILTON AND RAVIV, ARTUR. "Optimal Incentive Contracts with Imperfect Information", *J. Econ. Theory*, Apr. 1979, 20(2), pp. 231-59.
- HARTLEY, PETER R. "Rational Expectations and the Foreign Exchange Market", *Exchange rates and international macroeconomics*. Ed.: JACOB A. FRENKEL. Chicago: U. of Chicago Press 1983, pp. 153-77.
- HARVEY, ANDREW C. "Applications of the Kalman Filter in Econometrics", Pap. presented at 5th World Congress of Econometric Society, Cambridge, MA, Aug. 1985.
- HAUSMAN, JERRY A. "Errors in Variables in Simultaneous Equation Models", *J. Econometrics*, May 1977, 5(3), pp. 389-401.
- HAYEK, FRIEDRICH A. *New studies in philosophy, politics, economics and the history of ideas*. Chicago: U. of Chicago Press, 1978.
- HEINER, RONALD A. "The Origin of Predictable Behavior". *Amer. Econ. Rev.*, Sept. 1983, 73(4), pp. 560-95.
- HEINER, RONALD A. "Origins of Predictable Behavior: Further Modeling and Applications", *Amer. Econ. Rev.*, May 1985, 75(2), pp. 391-96.
- HEISENBERG, WERNER. *Across the frontiers*. [A collection of speeches and essays by WERNER HEISENBERG.] Tr.: PETER HEATH. NY: Harper and Row, 1974.
- HELLER, ROBERT H. AND KHAN, MOHSIN S. "The Demand for International Reserves Under Fixed and Floating Exchange Rates", *Int. Monet. Fund Staff Pap.*, Dec. 1978, 25(4), pp. 623-49.
- HELLER, WALTER W. *New dimensions of political economy*. NY: W.W. Norton, 1966.
- HENDRY, DAVID F. "Empirical Modelling in Dynamic Econometrics", Inst. Econ. Statist., Applied Econ. Disc. Paper no. 1, Oxford U., Jan. 1986.
- HENDRY, DAVID F. AND RICHARD, JEAN-FRANCOIS. "On the Formulation of Empirical Models in Dynamic Econometrics", *J. Econometrics*, Oct. 1982, 20(1), pp. 3-33.

- HÉNIN, PIERRE-YVES. *Macrodynamics: fluctuations and growth*. London and NY: Routledge & Kegan Paul, 1986.
- HEY, JOHN D. "The Possibility of Possibility", *J. Econ. Stud.*, 1985, 12(1/2), pp. 70-88.
- HIRSHLEIFER, JACK. "The Private and Social Value of Information and the Reward to Inventive Activity", *Amer. Econ. Rev.*, Sept. 1971, 61(4), pp. 561-74.
- HIRSHLEIFER, J. AND RILEY, JOHN G. "The Analytics of Uncertainty and Information – An Expository Survey", *J. Econ. Lit.*, Dec. 1979, 17(4), pp. 1375-1421.
- HO, Y. C. AND LEE, R. C. K. "A Bayesian Approach to Problems in Stochastic Estimation and Control", *IEEE Trans. Automatic Control*, 1964, AC-9, pp. 333-39.
- HOFFMAN, DENNIS L. AND SCHLAGENHAUF, DON E. "Real Interest Rates, Anticipated Inflation, and Unanticipated Money: A Multi-Country Study", *Rev. Econ. Statis.*, May 1985, 67(2), pp. 284-96.
- HOLLAND, STEVEN A. "Does Higher Inflation Lead to More Uncertain Inflation?" *Fed. Res. Bank St. Louis Rev.*, Feb. 1984, 66(2), pp. 15-26.
- HOLLAND, STEVEN A. "Estimates of the Long-Term Real Effects of Inflation Uncertainty". Working Paper in Econ. no. E-95-86. Lexington, KY: U. of Kentucky, rev. Sept. 1986.
- HURWICZ, LEONID. "On Informationally Decentralized Systems", in *Decision and organization: A volume in honor of Jacob Marschak*. Eds.: C.B. McGUIRE AND ROY RADNER. Amsterdam: North-Holland, 1972, pp. 297-336.
- JEONG, JIN-HO "Lower Risk Reduced Form Estimation and Forecasting Based on Finite Observations and Uncertain Structural Specifications in a Linear Simultaneous Equation Model". Ph. D. thesis. Bloomington, IN: Indiana U., 1985.
- JEFFREYS, SIR HAROLD. *Scientific inference*. Cambridge: Cambridge U. Press, 3rd ed. 1973.
- JOHNSON, PAUL. *Modern times: the world from the twenties to the eighties*. NY: Harper & Row, 1983.
- JORGENSEN, DALE W. "Accounting for Capital", in *Capital, efficiency, and growth*. Ed.: GEORGE M. VON FURSTENBERG. Cambridge, MA: Ballinger, 1980, pp. 251-319.
- JUDD, JOHN P. AND SCADDING, JOHN L. "The Search for a Stable Money Demand Function: A Survey of the Post-1973 Literature", *J. Econ. Lit.*, Sept. 1982, 20(3), pp. 993-1023.
- JUDD, KENNETH L. "The Macroeconomic Effects of Uncertain Fiscal Policy", Center for Math. Stud. in Econ. and Management Sci. Dis. Pap. No. 682. Evanston, IL: Northwestern U., rev. Feb. 1986.
- KACPRZYK, JANUSZ. "A 'Down-to-Earth' Managerial Decision Making via a Fuzzy-Logic-Based Representation of Commonsense Knowledge", in *Artificial intelligence in economics and management*. Ed.: L. F. PAU. Amsterdam: North-Holland, 1986, pp. 57-64.
- KAGEL, JOHN H. AND LEVIN, DAN. "The Winner's Curse and Public Information in Common Value Auctions", *Amer. Econ. Rev.*, Dec. 1986, 76(5), pp. 894-920.
- KALMAN, R. E. "A New Approach to Linear Filtering and Prediction Problems", *J. Basic Eng.*, Trans. ASME, Ser. D, 1960, 82(1), pp. 34-45.

- KALMAN, R. E. AND BUCY, R. S. "New Results in Linear Filtering and Prediction Theory", *J. Basic Eng.*, Trans. ASME, Ser. D, 1961, 83(3), pp. 95-103.
- KANTOR, LAURENCE G. "Inflation Uncertainty and Real Economic Activity: An Alternative Approach", *Rev. Econ. Statist.*, Aug. 1986, 58(3), pp. 493-500.
- KATSIMBRIS, GEORGE M. "The Relationship Between the Inflation Rate, Its Variability, and Output Variability: Disaggregated International Evidence", *J. Money, Credit, Banking*, May 1985, 17(2), pp. 179-88.
- KENDRICK, DAVID. *Stochastic control for economic models*. NY: McGraw-Hill, 1981.
- KEYNES, JOHN MAYNARD. "The end of laissez-faire", [1926] in *The collected writings of John Maynard Keynes*, IX. London: Macmillan, St. Martin's Press, 1972, pp. 272-94.
- KEYNES, JOHN MAYNARD. *The general theory of employment, interest and money*. NY: Harcourt, Brace and Co., 1936.
- KIEFER, NICHOLAS M. AND NYARKO, YAW. "Optimal Control of an Unknown Linear Process with Learning". Dept. of Econ. Working Paper no. 370. Ithaca, NY: Cornell University, 1986.
- KING, ROBERT G. "Monetary Policy and the Information Content of Prices", *J. Polit. Econ.*, Apr. 1982, 90(2), pp. 247-79.
- KING, ROBERT G. "Secrecy, Speculation and Policy", Rochester Center for Econ. Research Working Paper no. 52, rev. Aug. 1986.
- KING, ROBERT G. AND PLOSSER, CHARLES I. "Money, Credit, and Prices in a Real Business Cycle", *Amer. Econ. Rev.*, June 1984, 74(3), pp. 363-80.
- KING, ROBERT G. AND PLOSSER, CHARLES I. "Nominal Surprises, Real Factors and Propagation Mechanisms". Rochester Center for Econ. Research Working Paper no. 50, July 1986.
- KING, STEPHEN R. "Monetary Transmission: Through Bank Loans or Bank Liabilities?" *J. Money, Credit, Banking*, Aug. 1986, 18(3), pp. 290-303.
- KLAMER, ARJO. *Conversations with economists*. Totowa, NJ: Rowman and Allanheld, 1984.
- KNIGHT, FRANK H. *Risk, uncertainty and profit*. NY: Houghton Mifflin, 1921.
- KNIGHT, MALCOLM D. AND WYMER, CLIFFORD R. "A Macroeconomic Model of the United Kingdom", *Int. Monet. Fund Staff Pap.*, Dec. 1978, 25(4), pp. 742-78.
- KRÄMER, WALTER ET AL. "Diagnostic Checking in Practice", *Rev. Econ. Statist.*, Feb. 1985, 57(1), pp. 118-23.
- KURZ, MORDECAI. "On Asymmetric Information, Unemployment and Inflexible Wages", in *Equilibrium analysis: essays in honor of KENNETH J. ARROW*, vol. II. Eds.: WALTER P. HELLER; ROSS M. STARR AND DAVID A. STARRETT. NY: Cambridge U. Press, 1986, pp. 219-49.
- KYDLAND, FINN E. "Labor-Force Heterogeneity and the Business Cycle", in KARL BRUNNER AND ALLAN H. MELTZER, eds., Autumn 1984, pp. 173-208.
- KYDLAND, FINN E. AND PRESCOTT, EDWARD C. "Rules Rather Than Discretion: The Inconsistency of Optimal Plans", *J. Polit. Econ.*, June 1977, 85(3), pp. 473-91.

- KYDLAND, FINN E. AND PRESCOTT, EDWARD C. "Time to Build and Aggregate Fluctuations", *Econometrica*, Nov. 1982, 50(6), pp. 1345-70.
- LAWSON, TONY. "Uncertainty and Economic Analysis", *Econ. J.*, Dec. 1985, 95(308), pp. 909-28.
- LEAMER, EDWARD E. *Specification searches: ad hoc inference with nonexperimental data*. NY: John Wiley, 1978.
- LEAMER, EDWARD E. "Sets of Posterior Means with Bounded Variance Priors", *Econometrica*, May 1982, 50(3), pp. 725-36.
- LEAMER, EDWARD E. "Let's Take the Con Out of Econometrics", *Amer. Econ. Rev.*, Mar. 1983a, 73(1), pp. 31-43.
- LEAMER, EDWARD E. "Model Choice and Specification Analysis", in ZVI GRILICHES AND MICHAEL D. INTRILIGATOR, eds., 1983b, pp. 285-331.
- LEAMER, EDWARD E. "Vector Autoregressions for Causal Inference?" in *Understanding monetary regimes*. Carnegie-Rochester Conf. Publ. Pol., vol 22. Eds.: KARL BRUNNER AND ALLAN H. MELTZER. Amsterdam: North-Holland, Spring 1985a, pp. 255-303.
- LEAMER, EDWARD E. "Sensitivity Analysis Would Help", *Amer. Econ. Rev.*, June 1985b, 75(3), pp. 308-13.
- LEAMER, EDWARD E. AND LEONARD, HERMAN. "Reporting the Fragility of Regression Estimates", *Rev. Econ. Statist.*, May 1983, 65(2), pp. 306-17.
- LERNER, ABBA P. *The economics of control*. NY: Macmillan, 1944.
- LEVINTHAL, DANIEL. "A Survey of Agency Models of Organizations". Technical Report no. 443. Stanford, CA: Instit. for Math. Stud. in the Soc. Sci., Mar. 1984.
- LIZONDO, JOSÉ SAUL AND MATHIESON, DONALD J. "The Stability of the Demand for International Reserves", *J. Int. Money Finance*, 1987, 6, forthcoming.
- LONGAIR, MALCOLM S. "From Quarks to Quasars - What Everyone Really Ought to Know". Britannica Award Lecture, Royal Museum of Scotland, Edinburgh, October 14, 1986.
- LOVELL, MICHAEL C. "A Quick Fix for the Unemployment Estimate", *Brookings Pap. Econ. Act.*, 1986, 2, pp. 521-32.
- LUCAS, ROBERT E., JR. "Expectations and the Neutrality of Money", *J. Econ. Theory*, Apr. 1972, 4(2), pp. 103-24.
- LUCAS, ROBERT E., JR. "Some International Evidence on Output - Inflation Tradeoffs", *Amer. Econ. Rev.*, June 1973, 63(3), pp. 326-34.
- LUCAS, ROBERT E., JR. "An Equilibrium Model of the Business Cycle", *J. Polit. Econ.*, Dec. 1975, 83(6), pp. 1113-44.
- LUCAS, ROBERT E., JR. "Econometric Policy Evaluation: A Critique", in *The Phillips curve and labor markets*. Carnegie-Rochester Conf. Publ. Pol., vol. 1. Eds.: KARL BRUNNER AND ALLAN H. MELTZER. Amsterdam: North-Holland, 1976, pp. 19-46.
- LUCAS, ROBERT E., JR. "Rules, Discretion, and the Role of the Economic Advisor", in STANLEY FISCHER, ed., 1980a, pp. 199-210.

- LUCAS, ROBERT E., JR. "Methods and Problems in Business Cycle Theory", *J. Money, Credit, Banking*, Nov. 1980b, 12(4, Part 2), pp. 696-715.
- LUCAS, ROBERT E., JR. "Understanding Business Cycles", in *Theory, policy, institutions: papers from the Carnegie-Rochester conferences on public policy*. Eds.: KARL BRUNNER AND ALLAN H. MELTZER. Amsterdam: North-Holland, 1983, pp. 1-23.
- LUCAS, ROBERT E., JR. "Adaptive Behavior and Economic Theory", *J. Bus.*, Oct. 1986, 59(4, Part 2), pp. S401-S426.
- MAASOUMI, ESFANDIAR. "Reduced Form Estimation and Prediction from Uncertain Structural Models: A Generic Approach", *J. Econometrics*, Feb. 1986, 31(1), pp. 3-29.
- MALINVAUD, E. "Econometrics Faced with the Needs of Macroeconomic Policy", *Econometrica*, Nov. 1981, 49(6), pp. 1363-75.
- MALKIEL, BURTON G.; VON FURSTENBERG, GEORGE M. AND WATSON, HARRY S. "Expectations, Tobin's 'Q' and Industry Investment", *J. Finance*, May 1979, 34(2), pp. 549-61.
- MALLIARIS, A.G. AND BROCK, W.A. *Stochastic methods in economics and finance*. Amsterdam: North-Holland, 1981.
- MANDELBROT, BENOIT. "New Methods in Statistical Economics", *J. Polit. Econ.*, Oct. 1963, 71(5), pp. 421-40.
- MANKIW, N. GREGORY. "The Equity Premium and the Concentration of Aggregate Shocks". NBER Working Paper no. 1788, Jan. 1986a.
- MANKIW, N. GREGORY. "Issues in Keynesian Macroeconomics: A Review Essay", *J. Monet. Econ.*, Sept. 1986b, 18(2), pp. 217-23.
- MANKIW, N. GREGORY AND SUMMMERS, LAWRENCE H. "Do Long-Term Interest Rates Overreact to Short-Term Interest Rates?" *Brookings Pap. Econ. Act.*, 1984, 1, pp. 223-42.
- MARGARITIS, DIMITRIS. "Least Squares Learning and Convergence to Rational Expectations", Dept. of Econ. Disc. Pap. no. 86-03. Vancouver: U. of British Columbia, Feb. 1986.
- MARSH, TERRY A. AND MERTON, ROBERT C. "Dividend Variability and Variance Bounds Tests for the Rationality of Stock Market Prices", *Amer. Econ. Rev.*, June 1986, 76(3), pp. 483-98.
- MARSTON, RICHARD C. "Exchange Rate Unions as an Alternative to Flexible Rates: The Effects of Real and Monetary Disturbances", in *Exchange rate theory and practice*. Eds.: JOHN F.O. BILSON AND RICHARD C. MARSTON. Chicago: U. of Chicago Press, 1984a, pp. 407-37 and pp. 441-42.
- MARSTON, RICHARD C. "Real Wages and the Terms of Trade: Alternative Indexation Rules for an Open Economy", *J. Money, Credit, Banking*, Aug. 1984b, 16(3), pp. 285-301.
- MARSTON, RICHARD C. AND TURNOVSKY, STEPHEN J. "Imported Materials Prices, Wage Policy, and Macro-Economic Stabilization", *Can. J. Econ.*, May 1985a, 18(2), pp. 273-84.
- MARSTON, RICHARD C. AND TURNOVSKY, STEPHEN J. "Macroeconomic Stabilization through Taxation and Indexation: The Use of Firm-Specific Information", *J. Monet. Econ.*, Nov. 1985b, 16(3), pp. 375-95.
- McALEER, MICHAEL; PAGAN, ADRIAN P. AND VOLKER, PAUL A. "What Will Take the Con Out of Econometrics?" *Amer. Econ. Rev.*, June 1985, 75(3), pp. 293-307.

- McCALLUM, BENNETT T. "Rational Expectations and the Estimation of Econometric Models: An Alternative Procedure", *Int. Econ. Rev.*, June 1976, 17(2), pp. 484-90.
- McCALLUM, BENNETT T. "Rational Expectations and Macroeconomic Stabilization Policy: An Overview", *J. Money, Credit, Banking*, Nov. 1980, 12(4, Part 2), pp. 716-46.
- McCALLUM, BENNETT T. "On Non-Uniqueness in Rational Expectations Models: An Attempt at Perspective", *J. Monet. Econ.*, Mar. 1983, 11(2), pp. 139-68.
- McCALLUM, BENNETT T. "Monetary versus Fiscal Policy Effects: A Review of the Debate", in R. W. HAFER, ed., 1986a, pp. 9-29.
- McCALLUM, BENNETT T. "On 'Real' and 'Sticky-Price' Theories of the Business Cycle", *J. Money, Credit, Banking*, Nov. 1986b, 18(4), p. 397-414.
- McKINNON, RONALD I. "Currency Substitution and Instability in the World Dollar Standard", *Amer. Econ. Rev.*, June 1982, 72(3), pp. 320-33.
- McKINNON, RONALD I. *An international standard for monetary stabilization*. Washington, D.C.: Institute for Int. Econ. distrib. by MIT Press, 1984.
- McKINNON, RONALD I. AND TAN, KONG-YAM. "Currency Substitution and Instability in the World Dollar Standard: Reply", *Amer. Econ. Rev.*, June 1983, 73(3), pp. 474-76.
- MELTZER, ALLAN H. "Some Evidence on the Comparative Uncertainty Experienced under Different Monetary Regimes", in *Alternative monetary regimes*. Eds.: COLIN D. CAMPBELL AND WILLIAM R. DOUGAN. Baltimore: Johns Hopkins U. Press, 1986, pp. 122-53.
- MINFORD, PATRICK. "Rational Expectations and Monetary Policy". Centre for Econ. Pol. Research Disc. Paper no. 104, London, Apr. 1986.
- MISHKIN, FREDERIC S. "Monetary Policy and Short-Term Interest Rates: An Efficient Markets – Rational Expectations Approach", *J. Finance*, Mar. 1982, 37(1), pp. 63-72.
- MITCHELL, MARK L.; WALLACE, MYLES S. AND WARNER, JOHN T. "Real Wages Over the Business Cycle: Some Further Evidence", *Southern Econ. J.*, Apr. 1985, 51(4), pp. 1162-73.
- MODIGLIANI, FRANCO. "The Monetarist Controversy or, Should We Foresake Stabilization Policies?" *Amer. Econ. Rev.*, Mar. 1977, 67(2), pp. 1-19.
- MONOD, JACQUES. *Le hasard et la nécessité*. Paris: éditions du Seuil, 1970.
- MORGENSTERN, OSKAR. *On the accuracy of economic observations*. Princeton, NJ: Princeton U. Press, 1950.
- MULLINEAUX, DONALD J. "Unemployment, Industrial Production, and Inflation Uncertainty in the United States", *Rev. Econ. Statist.*, May 1980, 62(2), pp. 163-69.
- MUNDELL, ROBERT A. "International Monetary Reform: The Optimal Mix in Big Countries", in *Macroeconomics, prices, and quantities*. Ed.: JAMES TOBIN. Washington, D.C.: Brookings, 1983, pp. 285-93.
- MUTH, JOHN F. "Optimal Properties of Exponentially Weighted Forecasts". *J. Amer. Statist. Assoc.*, June 1960, 55(290), pp. 299-306.
- MUTH, JOHN F. "Rational Expectations and the Theory of Price Movements", *Econometrica*, July 1961, 29(3), pp. 315-35.

- NEARY, J. PETER AND STIGLITZ, JOSEPH E. "Toward a Reconstruction of Keynesian Economics: Expectations and Constrained Equilibria", *Quart. J. Econ.*, 1983, 98 Suppl., pp. 199-228.
- NELSON, ALAN. "Some Issues Surrounding the Reduction of Macroeconomics to Microeconomics", *Philosophy of Science*, Dec. 1984, 54(4), pp. 573-94.
- NEUMANN, MANFRED J. M. "[Review of] Hahn, Frank H., *Equilibrium and macroeconomics*", *Weltwirtsch. Arch.*, 1986, 122(2), pp. 398-400.
- NEWBOLD, PAUL. "Discussion of Paper by D. F. Hendry and J.-F. Richard", *Int. Statist. Rev.*, Aug. 1983, 51(2), pp. 157-60.
- ORAZEM, PETER AND MIRANOWSKI, JOHN. "An Indirect Test for the Specification of Expectation Regimes", *Rev. Econ. Statist.*, Nov. 1986, 68(4), pp. 603-09.
- UDIZ, GILLES AND SACHS, JEFFREY. "Macroeconomic Policy Coordination Among the Industrial Economies", *Brookings Pap. Econ. Act.*, 1984, 1, pp. 1-64.
- PAGAN, ADRIAN. "Econometric Issues in the Analysis of Regressions with Generated Regressors", *Int. Econ. Rev.*, Feb. 1984, 25(1), pp. 221-47.
- PASSET, RENÉ. "The Paradigms of Uncertainty", *The Geneva Pap. on Risk and Insurance*, Oct. 1984, 9(33), pp. 370-79.
- PERRY, GEORGE L. "What Have We Learned about Disinflation?" *Brookings Pap. Econ. Act.*, 1983, 2, pp. 587-602.
- PESARAN, M. H.; PIERSE, R. G. AND KUMAR, M. S. "On the Problem of Aggregation in Econometrics". Temi di discussione del Servizio Studi no. 67. Rome: Banca d'Italia, July 1986.
- PHILPOTTS, GEOFFREY. "Vote Trading, Welfare, and Uncertainty", *Can. J. Econ.*, Aug. 1972, 5(3), pp. 358-72.
- PIERCE, DAVID A. ET AL. "Uncertainty in the Monetary Aggregates: Sources, Measurement and Policy Effects", *J. Finance*, May 1981, 36(2), pp. 507-15.
- PINDYCK, ROBERT S. *Optimal planning for economic stabilization*. Amsterdam: North-Holland, 1973.
- POLINSKY, A. MITCHELL. "Fixed Price Versus Spot Price Contracts: A Study in Risk Allocation". NBER Working Paper no. 1817, Jan. 1986.
- POOLE, WILLIAM. "Optimal Choice of Monetary Policy Instruments in a Simple Stochastic Macro Model", *Quart. J. Econ.*, May 1970, 84(2), pp. 197-216.
- POTERBA, JAMES M. AND SUMMERS, LAWRENCE H. "The Persistence of Volatility and Stock Market Fluctuations", *Amer. Econ. Rev.*, Dec. 1986a, 76(5), pp. 1142-51.
- POTERBA, JAMES M. AND SUMMERS, LAWRENCE H. "Finite Lifetimes and the Effects of Budget Deficits on National Savings". Working Paper no. 434. Cambridge, MA: MIT Dept. of Econ., Dec. 1986b.
- PRESCOTT, EDWARD C. "Should Control Theory Be Used for Economic Stabilization?" in *Optimal policies, control theory and technology exports*. Carnegie-Rochester Confer. Publ. Pol., vol. 7. Eds.: KARL BRUNNER AND ALLAN H. MELTZER. Amsterdam: North-Holland, 1977, pp. 13-38.

- PRESCOTT, EDWARD C. "Theory Ahead of Business Cycle Measurement", in *Real business cycles, real exchange rates and actual policies*. Carnegie-Rochester Confer. Publ. Pol., vol. 25. Eds.: KARL BRUNNER AND ALLAN H. METZLER. Amsterdam: North-Holland, Autumn 1986, pp. 11-44.
- PUCKETT, RICHARD S. "Federal Open Market Committee Structure and Decisions", *J. Monet. Econ.*, July 1984, 14(1), pp. 97-104.
- RADER, TROUT. *Theory of microeconomics*. NY: Academic Press, 1972.
- RATTI, RONALD A. "Sectoral Employment Variability and Unexpected Inflation", *Rev. Econ. Statist.*, May 1985, 57(2), pp. 278-83.
- REECE, GORDON. "In Praise of Uncertainty", in *The uncertainty principle and foundations of quantum mechanics*. Eds.: WILLIAM C. PRICE AND SEYMOUR S. CHISSICK. London and NY: John Wiley, 1977, pp. 7-12.
- RICHARD, JEAN-FRANCOIS. "Exogeneity, Causality, and Structural Invariance in Econometric Modelling", in *Evaluating the reliability of macroeconomic models*. Eds.: GREGORY C. CHOW AND P. CORSI. NY: Wiley, 1982, pp. 105-18.
- ROBERDS, WILLIAM. "Models of Policy Under Stochastic Replanning", *Int. Econ. Rev.*, 1987, 28, forthcoming.
- ROGOFF, KENNETH. "The Optimal Degree of Commitment to an Intermediate Monetary Target", *Quart. J. Econ.*, Nov. 1985, 100(4), pp. 1169-89.
- ROGOFF, KENNETH. "Reputational Constraints on Monetary Policy". NBER Working paper no. 1986, July 1986.
- ROMER, CHRISTINA. "Spurious Volatility in Historical Unemployment Data", *J. Polit. Econ.*, Feb. 1986a, 94(1), pp. 1-37.
- ROMER, CHRISTINA. "Is the Stabilization of the Postwar Economy a Figment of the Data?" *Amer. Econ. Rev.*, June 1986b, 76(3), pp. 314-34.
- ROSEN, SHERWIN. "Implicit Contracts: A Survey", *J. Econ. Lit.*, Sept. 1985, 23(3), pp. 1144-75.
- ROTHENBERG, THOMAS J. AND SMITH, KENNETH R. "The Effect of Uncertainty on Resource Allocation", *Quart. J. Econ.*, Aug. 1971, 85(3), pp. 440-59.
- ROTHSCHILD, MICHAEL AND STIGLITZ, JOSEPH E. "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information", *Quart. J. Econ.*, Nov. 1976, 90(4), pp. 629-49.
- RUSH, MARK. "Unexpected Money and Unemployment 1920 to 1983", *J. Money, Credit, Banking*, Aug. 1986, 18(3), pp. 259-74.
- SACHS, JEFFREY. "Real Wages and Unemployment in the OECD Countries", *Brookings Pap. Econ. Act.*, 1983, 1, pp. 255-89.
- SAH, RAAJ KUMAR AND STIGLITZ, JOSEPH E. "The Architecture of Economic Systems: Hierarchies and Polyarchies", *Amer. Econ. Rev.*, Sept. 1986, 76(4), pp. 716-27.
- SALOP, JOANNE AND SALOP, STEVEN. "Self-Selection and Turnover in the Labor Market", *Quart. J. Econ.*, Nov. 1976, 90(4), pp. 619-27.

- SAMUELSON, PAUL A. "Public Responsibility for Growth and Stability", in *The goal of economic growth: sources, costs, benefits*. Ed.: EDMUND S. PHELPS. NY: W. W. Norton, 1962, pp. 38-42.
- SAMUELSON, PAUL A. *Stability and growth in the American economy*. (Second) Wicksell Lectures 1962. Stockholm: Almqvist & Wiksell, 1963.
- SARGENT, THOMAS J. "Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment", *Brookings Pap. Econ. Act.*, 1973, 2, pp. 429-72.
- SARGENT, THOMAS J. "A Classical Macroeconometric Model for the United States", *J. Polit. Econ.*, April 1976a, 84(2), pp. 207-37.
- SARGENT, THOMAS J. "The Observational Equivalence of Natural and Unnatural Rate Theories of Macroeconomics", *J. Polit. Econ.*, June 1976b, 84(3), pp. 631-40.
- SARGENT, THOMAS J. *Macroeconomic theory*. Orlando, FL: Academic Press, 1979.
- SARGENT, THOMAS J. "Autoregressions, Expectations, and Advice", *Amer. Econ. Rev.*, May 1984, 74(2), pp. 408-15.
- SARGENT, THOMAS AND WALLACE, NEIL. "Rational Expectations and the Dynamics of Hyperinflation", *Int. Econ. Rev.*, June 1973, 14(2), 328-50.
- SARGENT, THOMAS AND WALLACE, NEIL. "'Rational' Expectations, the Optimal Monetary Instrument, and the Optimal Money Supply Rule", *J. Polit. Econ.*, Apr. 1975, 83(2), pp. 241-54.
- SCHMEIDLER, DAVID. "Equilibrium Points of Nonatomic Games", *J. Statis. Physics*, April 1973, 7(4), pp. 295-300.
- SCHULTZE, CHARLES L. "Microeconomic Efficiency and Nominal Wage Stickiness", *Amer. Econ. Rev.*, Mar. 1985, 75(1), pp. 1-15.
- SCHWAB, STEWART. "Is Statistical Discrimination Efficient?" *Amer. Econ. Rev.*, Mar. 1986, 76(1), pp. 228-34.
- SERLETIS, APOSTOLOS AND ROBB, A. LESLIE. "Divisia Aggregation and Substitutability Among Monetary Assets", *J. Monet, Credit, Banking*, Nov. 1986, 18(4), pp. 430-46.
- SHACKLE, G.L.S. "Keynes and Today's Establishment in Economic Theory: A View", *J. Econ. Lit.*, June 1973, 11(2), pp. 516-19.
- SHESHINSKI, EYTAN AND DRÈZE, JACQUES H. "Demand Fluctuations, Capacity Utilization, and Costs", *Amer. Econ. Rev.*, Dec. 1976, 66(5), pp. 731-42.
- SHILLER, ROBERT J. "Can the Fed Control Real Interest Rates?" in STANLEY FISCHER, ed., 1980, pp. 117-60.
- SHILLER, ROBERT J. "Do Stock Prices Move Too Much to Be Justified by Subsequent Changes in Dividends?" *Amer. Econ. Rev.*, June 1981, 71(3), pp. 421-36.
- SHILLER, ROBERT J. "Stock Prices and Social Dynamics", *Brookings Pap. Econ. Act.*, 1984, 2, pp. 457-98.
- SHILLER, ROBERT J. "The Marsh-Merton Model of Managers' Smoothing of Dividends", *Amer. Econ. Rev.*, June 1986, 76(3), pp. 499-503.

- SIEGEL, JEREMY J. "Money Supply Announcements and Interest Rates: Does Monetary Policy Matter?" *J. Monet. Econ.*, Mar. 1985, 15(2), pp. 163-76.
- SIMON, HERBERT A. "Rationality in Psychology and Economics", *J. Bus.*, Oct. 1986, 59(4, Part 2), pp. S209-S224.
- SIMPSON, THOMAS D. "Changes in the Financial System: Implications for Monetary Policy", *Brookings Pap. Econ. Act.*, 1984, 1, pp. 249-65.
- SIMPSON, THOMAS D. AND PARKINSON, PATRICK M. "Some Implications of Financial Innovations in the United States". Staff Studies no. 139, Washington, D.C.: Board of Governors of the Fed. Res. Syst., Sept. 1984.
- SIMS, CHRISTOPHER A. "Macroeconomics and Reality", *Econometrica*, Jan. 1980, 48(1), pp. 1-48.
- SIMS, CHRISTOPHER A. "Policy Analysis with Econometric Models", *Brookings Pap. Econ. Act.*, 1982, 1, pp. 107-52.
- SIMS, CHRISTOPHER A. "Is There a Monetary Business Cycle?" *Amer. Econ. Rev.*, May 1983, 73(2), pp. 228-33.
- SIMS, CHRISTOPHER A. "Are Forecasting Models Usable for Policy Analysis?" *Fed. Res. Bank Minneapolis Quart. Rev.*, Winter 1986a, 10(1), pp. 2-16.
- SIMS, CHRISTOPHER A. "[Review of] *Specification, Estimation, and Analysis of Macroeconometric Models* by RAY C. FAIR", *J. Money, Credit, Banking*, Feb. 1986b, 18(1), pp. 121-26.
- SKINNER, JONATHAN, "The Welfare Cost of Uncertain Tax Policy". NBER Working Paper no. 1947, June 1986.
- SPINDT, PAUL A. "Money is What Money Does: Monetary Aggregation and the Equation of Exchange", *J. Polit. Econ.*, Feb. 1985, 93(1), pp. 175-204.
- STARTZ, RICHARD: "Monopolistic Competition as a Foundation for Keynesian Macroeconomic Models". NBER Conf. on Keynesian and Classical Economics After 50 Years Paper, Cambridge, MA, May 2, 1986.
- STEIN, JEROME L. *Monetarist, Keynesian and new classical economics*. NY: New York University Press, 1982.
- STIGLITZ, JOSEPH E. "Pareto Optimality and Competition", *J. Finance*, May 1981, 36(2), pp. 235-51.
- STIGLITZ, JOSEPH E. "Risk, Incentives and Insurance: The Pure Theory of Moral Hazard", *The Geneva Pap. on Risk and Insurance*, Jan. 1983, 8(26), pp. 4-33.
- STOCKMAN, ALAN C. "Sector Disturbances, Government Policies, and Industrial Output in Seven European Countries", Rochester Center for Econ. Research Working Paper no. 41, Apr. 1986a.
- STOCKMAN, ALAN C. "Price Contracts, Output, and Monetary Disturbances". NBER Working Paper no. 1960, June 1986b.
- STOKER, THOMAS M. "Simple Tests of Distributional Effects on Macroeconomic Equations", *J. Polit. Econ.*, Aug. 1986, 94(4), pp. 763-95.
- STULZ, RENÉ M. "Interest Rates and Monetary Policy Uncertainty", *J. Monet. Econ.*, May 1986, 17(3), pp. 331-47.

- SUMMERS, LAWRENCE H. "Does the Stock Market Rationally Reflect Fundamental Values?" *J. Finance*, July 1986, 41(3), pp. 591-601.
- SVENSSON, LARS E. "Effective Demand and Stochastic Rationing", *Rev. Econ. Stud.*, Jan. 1980, 47(2) pp. 339-55.
- TAYLOR, JOHN B. "Monetary Policy During a Transition to Rational Expectations," *J. Polit. Econ.*, Oct. 1975, 83(5), pp. 1009-21.
- TAYLOR, JOHN B. "Conditions for Unique Solutions in Stochastic Macroeconomic Models with Rational Expectations", *Econometrica*, Sept. 1977, 45(6), pp. 1377-87.
- TAYLOR, JOHN B. "Aggregate Dynamics and Staggered Contracts", *J. Polit. Econ.*, Feb. 1980, 88(1), pp. 1-23.
- TAYLOR, JOHN B. "Comments on 'Rules, Discretion and Reputation in a Model of Monetary Policy' by ROBERT J. BARRO AND DAVID B. GORDON"; *J. Monet. Econ.*, July 1983, 12(1), pp. 123-25.
- TAYLOR, JOHN B. "Rational Expectations Models in Macroeconomics", in *Frontiers of economics*. Eds.: KENNETH J. ARROW AND SEPPO HONKAPOHJA. Oxford: Basil Blackwell, 1985, pp. 391-425.
- TAYLOR, JOHN B. "An Appeal for Rationality in the Policy Activism Debate", in R. W. HAFER, ed., 1986, pp. 151-63.
- THOMPSON, LAWRENCE H. "The Social Security Reform Debate", *J. Econ. Lit.*, Dec. 1983, 21(4), pp. 1425-67.
- TILLMAN, GEORG. "Insurance Aspects of Taxation." SFB 303 Discussion Paper A-75. Bonn, Germany: (RFW) University Bonn, 1986.
- TINBERGEN, JAN. *On the theory of economic policy*. Amsterdam: North-Holland, 1952.
- TOBIN, JAMES. "Neoclassical Theory in America: J.B. Clark and Fisher", *Amer. Econ. Rev.*, Dec. 1985, 76(6), pp. 28-38.
- TOWNSEND, ROBERT M. "Market Anticipations, Rational Expectations, and Bayesian Analysis", *Int. Econ. Rev.*, June 1978, 19(2), pp. 481-94.
- TOWNSEND, ROBERT M. "Optimal Multiperiod Contracts and the Gain from Enduring Relationships under Private Information", *J. Polit. Econ.*, Dec. 1982, 90(6), pp. 1166-86.
- TOWNSEND, ROBERT M. "Forecasting the Forecasts of Others", *J. Polit. Econ.*, Aug. 1983, 91(4), pp. 546-88.
- TURNOVSKY, STEPHEN J. "The Relative Stability of Alternative Exchange Rate Systems in the Presence of Random Disturbances", *J. Money, Credit, Banking*, Feb. 1976, 8(1), pp. 29-50.
- TURNOVSKY, STEPHEN J. *Macroeconomic analysis and stabilization policy*. NY: Cambridge U. Press. 1977.
- TURNOVSKY, STEPHEN J. "Domestic and Foreign Disturbances in an Optimizing Model of Exchange-Rate Determination", *J. Int. Money Finance*, Mar. 1985, 4(1), pp. 151-71.
- TURNOVSKY, STEPHEN J. "Supply Shocks and Optimal Monetary Policy", NBER Working Paper no. 1988, July 1986.

- TURNOVSKY, STEPHEN J. "Optimal Monetary Policy and Wage Indexation Under Alternative Disturbances and Information Structures", *J. Money. Credit, Banking*, May 1987, 19(2), pp. 157-80.
- TURNOVSKY, STEPHEN J. AND D'OREY, VASCO. "Monetary Policies in Interdependent Economies with Stochastic Disturbances: A Strategic Approach", *Econ. J.*, Sept. 1986, 96(383), pp. 696-721.
- VARIAN, HAL R. "Redistributive Taxation as Social Insurance", *J. Pub. Econ.*, Aug. 1980, 14(1), pp. 49-68.
- VARIAN, HAL R. "Differences of Opinion in Financial Markets". Eleventh Annual Econ. Pol. Confer. Paper. St. Louis, MO: Fed. Res. Bank St. Louis, Nov. 14-15, 1986.
- VON WEIZSÄCKER, CARL CHRISTIAN. "Notes on Endogenous Change of Tastes", *J. Econ. Theory*, Dec. 1971, 3(4), pp. 345-72.
- WALLER, CHRISTOPHER J. "Reputation Building in a Monetary Policy Game". *J. Macroeconomics*, Summer 1987, 9(3), forthcoming.
- WALLIS, KENNETH A. "Econometric Implications of the Rational Expectations Hypothesis", *Econometrica*, Jan. 1980, 48(1), pp. 49-73.
- WEISS, ANDREW. "A Comparison of Ordinary Least Squares and Least Absolute Error Estimation". MRG Working Paper no. M8648. Los Angeles: U. of Southern Cal., Dept. of Econ., Dec. 1986.
- WEISSENBERGER, EDGAR. "Consumption Innovations and Income Innovations: The Case of the United Kingdom and Germany", *Rev. Econ. Statist.*, Feb. 1986, 68(1), pp. 1-8.
- WEISSKOPF, WALTER A. "Reflections on Uncertainty in Economics", *The Geneva Pap. on Risk and Insurance*, Oct. 1984, 9(33), pp. 335-60.
- WICKENS, M. R. "The Estimation of Linear Models with Future Rational Expectations by Efficient and Instrumental Variable Methods". Disc. Paper no. 111. London: Centre for Econ. Pol. Research, June 1986.
- WINTROBE, RONALD AND BRETON, ALBERT. "Organizational Structure and Productivity", *Amer. Econ. Rev.*, June 1986, 76(3), pp. 530-38.
- WITTE, WILLARD E. AND BHANDARI, JAGDEEP S. "Monetary Disturbances, Inventory Fluctuations and the Level of Sales: A Theoretical and Empirical Analysis", *Southern Econ. J.*, Apr. 1985, 51(4), pp. 1151-61.
- WOODFORD, MICHAEL. "Three Questions about Sunspot Equilibria as an Explanation of Economic Fluctuations". *Amer. Econ. Rev.*, May 1987, 77(2), pp. 93-98.
- WORSWICK, G.D.N. "Fiscal Policy and Stabilization in Britain", *J. Money, Credit, Banking*, Aug. 1969, 1(3), pp. 474-95.
- WRIGHT, RANDALL. "Job Search and Cyclical Unemployment", *J. Polit. Econ.*, Feb. 1986, 94(1), pp. 38-55.
- ZARNOWITZ, VICTOR. "Recent Work on Business Cycles in Historical Perspective: A Review of Theories and Evidence", *J. Econ. Lit.*, June 1985, 23(2), pp. 523-80.
- ZEIRA, JOSEPH. "Investment as a Process of Search", *J. Polit. Econ.*, Feb. 1987, 95(1), pp. 204-10.

- ZELDES, STEPHEN P. "Optimal Consumption with Stochastic Income: Deviations from Certainty Equivalence", Center for Financial Research Paper no. 20-86. Philadelphia: Wharton School of U. of PA, rev. Aug. 1986.
- ZELLNER, ARNOLD. "Statistical Analysis of Econometric Models", *J. Amer. Statis. Assoc.*, Sept. 1979, 74(367), pp. 628-51.
- ZELLNER, ARNOLD. "Discussion of 'Risk and the Economy: A Finance Perspective' by K. C. CHAN AND RENÉ M. STULZ". Eleventh Annual Econ. Pol. Confer. Paper. St. Louis, MO: Fed. Res. Bank St. Louis, Nov. 14-15, 1986.