Commentary on Chapter 9

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- How do rational economic agents identify and react to major changes in their economic environment?
- How do econometricians identify and conduct inference in the presence of such structural changes?
- What are the causes and mechanisms of such structural changes?

Finding answers to these questions has been a robust research enterprise in economics in the past decade, and James Hamilton has been a prolific and insightful contributor to this literature, as evidenced by his latest work in this volume. Here, I provide some comments to elucidate two broad themes. First, I discuss in some detail the Lucas critique, which stresses the links between rational expectations and structural change and is the impetus underlying Hamilton's work in this volume. Second, I discuss a few aspects of the specific regime-switching model that Hamilton popularized in his earlier work and that he uses here so effectively.

The Lucas Critique

Lucas (1976) criticized traditional macroeconometric models for their failure to account explicitly for agents' expectations of future variables. He argued that the coefficients of the behavioral equations of these models depended, in part, on the parameters describing the formation of agents' expectations; furthermore, under rational expectations, the expectations parameters reflect agents' understanding of the underlying economic structure. Accordingly, if there were a structural change in the laws of motion for the exogenous variables, the coefficients of the models' equations could not be expected to remain stable. The basic thrust of the Lucas critique—that the coefficients of reduced-form models are not invariant to structural changes—had been acknowledged well before 1976. As Lucas points out, Marschak (1953) and Tinbergen (1956) raised similar criticisms. However, Lucas's version of this critique, which stressed the crucial role of expectations, was widely viewed as a devastating indictment of traditional consumption, wage-price, and investment equations.

Lucas's charge that the coefficients of most empirical models were reduced-form, "shallow" parameters that were subject to change resulted in a major reorientation of econometric modeling. The subsequent research program of rational expectations econometrics has attempted to estimate the underlying parameters of taste and technology governing objective functions. In particular, much research has focused on the estimation of the stochastic first-order conditions for optimal choice by a rational, forward-looking representative agent. Indeed, this "Euler equation" modeling strategy has dominated empirical work in consumption (following Hall, 1978) and investment (following Abel, 1980).

Although Euler equations have become a very popular approach, there has been surprisingly little examination of their empirical adequacy and, in particular, their structural stability. For modeling investment spending, many authors have estimated the first-order conditions of the firm's intertemporal optimization problem given production and adjustment cost functions, and they generally view the resulting estimates as shedding light on stable "deep" parameters. To provide some specification tests of this investment Euler equation, Oliner, Rudebusch, and Sichel (1995, 1996) examine its structural stability. There are two different types of tests available in the literature that they employ.

First, there are *split-sample* tests that separate the whole sample into two parts and compare model parameters estimated from each part. The simplest split-sample test for structural stability is the usual F-test for structural change in a linear regression discussed by Chow (1960). The general case for this type of test is described in Andrews and Fair (1988). These tests assume that if structural change has occurred, it took place on a known breakpoint date. However, recent advances have been made in split-sample testing for structural change at an unknown breakpoint. In particular, Andrews (1993) describes the distribution of the maximum value of a *sequence* of test statistics from all possible breakpoints.

Second, there are *subsample* tests (often called "recursive" tests in the literature) that are based on the sequence of model estimates obtained by starting with a small set of observations and progressively enlarging the estimation sample one observation at a time. (Dufour, 1982, provides a useful survey.) This sequence of subsample estimates provides direct evidence concerning parameter drift and out-of-sample forecast performance.

Oliner, Rudebusch, and Sichel (1995, 1996) find that both types of tests indicate that the standard investment Euler equation exhibits substantial parameter instability. This is not an indictment of the Lucas critique but is instead an indication of the adequacy of the Euler equation response to that critique.

It is one thing to detect structural change empirically; it is a separate enterprise to explain that change. The source of much of the structural instability exhibited by empirical equations is often unclear. For example, whether indeed the instability demonstrated by a traditional accelerator investment equation reflects the response of expectations of rational agents (as in Lucas's critique) or some other model misspecification has not been determined.

Regime-Switching Models

In Hamilton's example, the application of the Lucas critique implies that the equation that appears to adequately describe rational agents' money demand during a zero-inflation regime breaks down with a change in the policy regime. The reduced form relationship between prices and money changes from one regime to the other. What is unsatisfactory about this analysis, as pointed out by Hamilton as well as Sims (1982) and fully developed by Cooley, LeRoy, and Raymon (1984) and by LeRoy's work in this volume, is that it has the rational agents treat the structural change as a change in a parameter. That is, the change is treated as unforeseen and permanent. More plausibly in most cases, the object that changes should be treated as a variable and incorporated in the model. Hamilton provides a useful example of how a change in policy can be incorporated as a probabilistic element in a larger model. In his model, the agent with rational, or model-consistent, expectations correctly recognizes and takes into account the probability that the policy regime may change.

Of course, not all potential structural changes can be fruitfully incorporated into a complete, all-encompassing model that is understood by rational agents. Indeed, an interesting literature has developed that continues to treat the structural change as an unforeseen, permanent parameter shift. However, this literature is sensible because it relaxes the assumption of the rationality of the economic agents and introduces explicitly the notion that some learning about the new structure must take place. For example, Sargent (1993) provides a useful introduction to the literature and centers his analysis on the "bounded rationality" of agents with respect to structural change. Thus, rather than treating a change in a parameter as something rational agents seamlessly adapt to (as did Lucas), the literature with learning permits agents to slowly adjust their behavior to new situations in which their previous experience is not entirely informative. For example, understanding the economic actions of those in the newly emerging market economies of Eastern Europe, who face unprecedented changes, realistically requires an understanding of transitional learning dynamics.

In any case, to return to Hamilton's analysis, where there is an explicit process generating the structural change, the next question he addresses is how to conduct an econometric analysis of the changes in regime. Hamilton's model in this paper is based on his pioneering work examining series whose time-series dynamics depend on an unobservable state that is governed by a first-order Markov process. There have been numerous applications of this specific regime-switching model—perhaps the best known is the use in a business-cycle context for dating turning points between recessions and expansions.[1]

One shortcoming of almost all of these applications is that they make no attempt to statistically test the hypothesis of regime switching against the hypothesis of a constant structure. The infrequency of testing for regime switching reflects the difficult, nonstandard econometrics involved. The difficulty lies in the Markov probabilities governing the transition, which are not identified under the hypothesis that there is no regime switching. Hansen (1992) proposes a valid but computational burdensome test. Diebold and Rudebusch (1994) describe and implement a closely related but tractable test, and they find striking support for a two-state regime switching process governing business cycles.

Finally, with respect to "explaining" regime switching, Diebold and Rudebusch (1994) survey some interesting models that can be construed as supporting regime switching in a business-cycle context. These are models in which there is a "strategic" element to an agent's economic actions. These strategic elements or externalities can arise, for example, in a model of search; in essence, search is more desirable when other agents are also searching because it is likely to be more productive. These externalities can produce multiple equilibria, and the dynamic transition between these equilibria may be fruitfully modeled by a regime-switching model.

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Note

1. Note that Hamilton's process can be used in real time by an agent to discern turning points. A different real-time procedure to uncover turning points that also treats expansions and contraction as different probabilistic objects is analyzed in Diebold and Rudebusch (1989, 1991).

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