

Complex Economic Dynamics. Volume 1. An Introduction to Dynamical Systems and Market Mechanisms.



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less profitably, I suggest, of Gadamer). In the social sciences, the New School sociologist Alfred Schutz must also be given great credit. Substantively, the new ideas on equilibrium and equilibration can be traced to the later Hayek and Lachmann (as influenced by Shackle, and, dare I say it, by Hayek's nemesis, Keynes). These ideas involve, *first*, a loosening of the concept of equilibrium to make it more nearly compatible with "real time" (i.e., time associated with change) and "radical uncertainty" (i.e., uncertainty that goes beyond risk), and, *second*, a realization that markets do not always conveniently move toward overall equilibrium (Ch. Eight). Vaughn is very favorably disposed to this reviewer's own work (O'Driscoll and Rizzo 1985) so I cannot pretend to be objective about this last chapter of her book.

My main criticisms of the book are three. First, Vaughn underplays the radical nature of Israel Kirzner's entrepreneurial critique of neoclassical economics and his contribution to Austrian theory. I do not think it is accurate to think of it as a "supplement to neoclassical economics" even a "vital" one. The implications are more far-reaching than that. Second, her analysis of the equilibration debate among Austrians is not always as accurate and rigorous as it could be. Third, she might have paid more attention to the interface between Austrian debates and those among neoclassical economists. This would have garnered a still-wider audience for her book. Overall, however, Vaughn has written an outstanding work in the history of economic thought, the philosophy and sociology of science, and on those fundamental issues of economics in which every economist should be interested.

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C Mathematical and Quantitative Methods

Complex economic dynamics. Volume 1. An introduction to dynamical systems and market mechanisms. By RICHARD H. DAY. Cambridge and London: MIT Press, 1994. Pp. xxiv, 309. \$37.50. ISBN 0-262-04141-3. JEL 95-0048

Richard Day has worked for more than 30 years studying economic change. He was well positioned to incorporate into economics the revolution of thought that was taking place in the previously staid field of differential equations. Mathematicians discovered that even very simple models could display extremely complicated dynamics. The importance of this work burst into popular consciousness, Day notes, with the stock market crash of 1987. Now that the fad has faded, Day presents this timely work to survey the landscape.

The author has divided his work on complex dynamics into two parts, micro and macro, with the latter looking at issues of economic growth, cycles, and development. This volume includes introductory material on dynamics, statistics, and analysis of the market mechanism.

The first three chapters are a self-contained section of motivating material. Chapter 1 defines complex dynamics as either non-periodic fluctuations, overlapping waves, or structural change. This definition is quite broad and includes chaotic dynamics as a sub-field. In this taxonomy, balanced growth or stationary states are labelled, somewhat misleadingly, as simple dynamics.

Day's guiding dynamic principle is that "the way things are . . . determines the way things change." The notion of path dependence threatens many cherished economic assumptions. Econometricians cannot rely on stationarity. Microeconomists must grapple with increasing returns. Day's book tries to explain these "qualitative attributes of economic data . . ."

Chapter 2 illustrates the genericity of his dynamic principle by showing how it arises even in simple examples. A first order difference equation with a quadratic form is derived as an example of Walrasian price adjustment. For different choices of initial conditions, a wide range of dynamic behavior

can follow. This basic idea forms the core of Chapter 10 devoted to tâtonnement processes.

Methodological issues are developed in Chapter 3. Day explains very clearly the principles of causation and shows how nonlinear systems can lead to a causal effect reversal.

The second section contains six chapters of mathematical background for analyzing complex dynamics. Chapter 4 contains some fairly standard material on dynamical and semi-dynamical systems. Chapter 5 on dynamical systems is among the most complete discussions of one dimensional dynamics available in the economics literature. The theorems of Li-Yorke and Svarokovskii are developed to demonstrate the existence of periodic and aperiodic trajectories. Some basic material on stability is also presented.

Day calls state dependent dynamics multiphase and devotes two chapters to it (6 and 9). He analyzes these systems in a novel way using qualitative histories, a nonparametric classification of the trajectory into regimes.

Chaos gets a very thin Chapter 7 of its own, but it clearly lurks in the background in several other chapters. Day defines chaos in the manner of Li and Yorke. A dynamical system on the unit interval that has a periodic solution of order 3 can be shown to have periodic solutions of any integer order. A further implication is the existence of aperiodic "chaotic" trajectories that always diverge, but also remain bounded on the same compact set. A shortcoming of this chapter is that these methods are not extended to higher dimensional systems. There is no discussion, for example, of the Lyapunov exponent, an ergodic measure of the rate at which trajectories diverge. An interested reader would be wise to supplement this reading with Brock and Malliaris (1989) or Guckenheimer and Holmes (1983).

Day introduces the use of statistical averages (ergodic theory) to analyze aperiodic behavior, and discusses this approach in detail in Chapter 8.

Hence the irony of chaotic dynamics: predictability over short intervals, unpredictability over longer ones, yet the system produces long run stable time averages. This sounds like a perfectly adequate description

of the weather, but it remains an open question for economics. Day makes the claim that there is very little evidence for simple dynamics in economic data.

This raises the unanswered question of whether economic systems have any deep structure at all.

The economic modeling in the last section of three chapters constitutes the bulk of Day's original contribution. He provides a number of interesting applications of the theory developed in the first two sections. In addition to the tâtonnement examples, there is a stock market model and a generalization of the cobweb model. A good step for researchers following Day's path would be to try to calibrate some of these models to show that complex dynamics is not only possible, but likely.

This book synthesizes the fruits of several decades of research. Although Day's summation comes in the second volume, he clearly believes that complex dynamics are at the core of the economic paradigm. I, for one, see this book as part of that foundation.

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- Identification problems in the social sciences*. By CHARLES MANSKI. Cambridge and London: Harvard University Press, 1995. Pp. x, 172. \$29.95. ISBN 0-674-44283-0. JEL 95-0885

The received literature in the social sciences treats the *identification problem* as an aspect of parameter estimation. (For example, Amemiya's *Advanced Econometrics* defines identifiability as "existence of a consistent estimator.") Manski opposes this focus on point estimation. He suggests that "Identification is not an all-or-nothing proposition. Weaker and more plausible assumptions often suffice to bound parameters in informa-