Chapter 9

Diffusion of Innovations Under Conditions of Uncertainty: A Stochastic Approach

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9.1 Introduction

The diffusion of innovations is at the core of the pattern of technological change. Many attempts to explain and describe this process have been undertaken during the last decade and a vast bibliography of publications on this subject is presented in Rogers, 1962 and 1983; and Rogers and Shoemaker, 1971. The theory of innovation is an important part of economic and social science, and is both conceptual and formal. Their unity is a necessary premise for the success of any scientific theory.

Currently, researchers are aware of some mismatch between the conceptual and formal sides of innovation theory. The conceptual part draws increasing attention to the hidden mechanisms of technological change. The problems of uncertainty and unevenness of innovations are at the center

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of current conceptual discussions. Economists argue about the relationships between ruptures and continuity in long-term technological change, and instability and consistency of technological trajectories during the different phases of an innovation's life cycle. A classification of innovations and some important new concepts, which reflect the technological pattern of change [technological and techno-economic paradigms, technological trajectories (Dosi, 1984; Perez, 1983; Freeman, 1987), radical, basic, incremental, process, and product innovations, having different diffusion regularities] were recently introduced into economic theory. These *conceptual innovations* have not yet been adopted by the formal side of innovation theory.

The majority of the present mathematical models treat the diffusion of innovations in a traditional way as a deterministic process, which can be described by means of differential equations or logistic curves. This approach has been quite successful as many studies have shown. Without questioning the usefulness of this approach, we must emphasize that the hypothesis about the deterministic character of innovation diffusion is appropriate only for the growth and maturity phases of the innovation life cycle under stable conditions. In this chapter we present another approach to innovation diffusion modeling which considers uncertainty and random fluctuations within the process. We consider a simple model that enables us to trace the influence of innovators and imitators on the final market share. It is worth mentioning that this approach for describing competing technologies, based on the generalized urn scheme, was proposed by Brian Arthur (1983).

We concentrate our analysis here on the early stage of innovation diffusion, when the costs and benefits of a new technology are not clear and the trajectory is fluctuating. This phase is not considered by the traditional deterministic approach because of the uncertainty and instability.

The early phases of radical innovation diffusion are characterized by the two important features which are often missed in diffusion models: (1) the instability of the present development and the uncertainty of the future evolution trajectory, and (2) the existence of different alternative technologies, which compete for the potential adopters. The random fluctuations play an important role in this phase and must be taken into consideration.

9.2 Formulation of the Problem

According to the Schumpeterian theory of innovation, innovation diffusion is a process of cumulative growth of imitators, which introduces the innovation