Chapter LVIII
Modeling an Artificial Stock Market

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ABSTRACT

This chapter presents an artificial stock market created to analyze market dynamics from the behavior of investors. It argues that information—delivered by financial intermediaries as rating agencies and considered as cognitive institution—directs the decisions of investors who are heterogeneous agents endowed with capabilities of learning in a changing environment. The objective is to demonstrate that information influences market dynamics as it allows the coordination of the decisions of investment in the same direction: information is a focal point for investors and contributes to generate a speculative dynamic on the market.

INTRODUCTION

Since their creation, stock markets have always experienced an alternation of phases of financial bubbles and crashes, the last important one being the bubble observed on the American and European stock markets between 1990 and 2000. The aim of the chapter is precisely to focus on the dynamic of prices to try to understand the phenomenon of financial bubble on stock markets.

The purpose is in fact to consider the emergence of a dynamic of stock prices as the result of investors' behaviors. On the one hand, we refer to the works that analyze economy as an *evolving complex system* (Arthur, Holland, LeBaron, Palmer, & Tayler, 1997): a market is a complex system in permanent evolution, whose product is explained by the numerous processes of interactions between its components. On the other hand, we consider market dynamics and stock prices as the consequence of the confrontation and evolution of investors' heterogeneous representations (Keynes, 1936; Kirman, 1997, 1999; Orléan, 1999; Tordjman, 1997).

To analyze the decisions of investors and their opinions about market dynamics, we propose an artificial model created thanks to the techniques of data-processing simulation, and more precisely to classifiers systems. These techniques allow apprehending an emergent dynamic as the result of the interactions between the decisions of investors composing the market.

Our model refers to the work of Arthur et al. (1997), known as the Santa Fe Artificial Stock Market, in which investors have to optimize the allocation of their portfolios between two kinds of assets: a stock and a bond. In this model, investors: (1) are characterized by a function of utility, (2) do not communicate, (3) form expectations according to a self-referential process, and (4) test different models of representation selecting only the ones that have generated profits in the past. The results of Arthur et al. (1997) notably demonstrate that when investors test few models, the market finally reaches an equilibrium state, whereas the market is characterized by a more complex dynamic when they explore several models of representation. Our artificial model differs from the work of Arthur et al. (1997) in the sense that: (1) investors do not optimize the value of their portfolios but are characterized by a "satisficing" behavior (Simon, 1979); (2) it allows testing the influence of institutions on financial markets and more precisely the impact of different kind of information on investors' representations; and (3) from a technical point of view, it is innovative because the model introduces two classifier systems as decision engines for each artificial investor.

Our work is original in the sense that it allows understanding behaviors according to the nature of the informational signals provided to investors. We consider two kinds of information: an *endogenous* one, representing information produced in the financial sphere and resulting from the interactions between inves-

tors; and an *exogenous* one, indicating information produced outside the market by financial intermediaries such as rating agencies or financial analysts. Thanks to this typology of information, we obtain two kinds of results. In simulations with endogenous signal, investors manage to coordinate their decisions: the stock market quickly converges towards a stationary state, whereas when investors dispose of exogenous information, the market is not characterized any more by a stable state but by the emergence of a financial bubble.

Finally, the model highlights the power of information in the orientation of market dynamics. We demonstrate that information polarizes the anticipations formed by investors with different representations on their environment: information directs the evolution of the market in the sense that it generates a financial bubble and is a framework for individual action.

A JUSTIFICATION OF THE ARTIFICIAL MODEL

The objective consists of modeling the emergence of a collective dynamic on the stock market starting from an analysis of investors' decisions. Data-processing simulation is mobilized as it allows analyzing the decision-making process of agents in situations of uncertainty by considering that they do not make optimal decisions but adapt their decisions to the changes of their environment. Generally, simulation is a relevant tools as soon as the market is characterized by an alternation of phases—in other words, when it is a question of analyzing a dynamic and an open system (Lane, 1993). Simulation allows studying a global dynamic without providing an analytical representation of it, and accounts for the emergence of a global phenomenon and for the adaptation of agents to this phenomenon.

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