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Trading strategies, feedback control and market dynamics

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Abstract

Markets have internal dynamics leading to stylized facts, such as fat-tails in price fluctuations and long-run memory. In this paper, we use a nonequilibrium price formation rule to explore feedback effects in trading strategies and market dynamics. By interpreting trading strategies as a feedback controller, we show that (a) trend followers can lead to oscillatory phenomena, and (b) adaptation mechanisms are necessary in order prices track values.

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1. Introduction

In the last few years, Econophysics has raised as an alternative scientific methodology to understand the highly complex dynamics of real financial and economic systems. Journal papers (mainly in Physica A) and international meetings have widespread the main ideas and results which, in several cases, are difficult to reconcile with rational expectations and some other traditional economic-theory assumptions. In a first stage, Econophysics focused on describing statistical facts of most common financial and economic indices [1]. Empirical modeling has been also explored to obtain a close description of clustering volatility phenomena. Two recent books [2,3] describe in an elegant way the application of statistical physics methodologies to elucidate the

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underlying mechanisms leading to commonly complex behavior of price and index fluctuations. Fundamental problems pertain to the existence or not of long-, medium- or/and short-range power-law correlations in various economic systems, to the presence of financial cycles and also to economical considerations, such as economic policy [4]. The desire to understand the physical mechanisms of market dynamics has lead to several new strands of modeling, including evolutionary game theory [5,6] and agent-based approaches (for a review see [7]). The aim of agent-based models is to capture complex adaptive/learning behavior using realistic market structures and agent strategies [8]. An elegant and simple theoretical framework for agent-based models has been reported by Farmer [9], where a simple reasonable model retaining the main dynamical and psychological characteristics of real markets is presented.

Departing from Farmer’s modeling framework, this paper explores links between feedback and common trading strategies in the price formation process. By interpreting trading strategies as a feedback controller, we show that (a) trend followers can lead to oscillatory phenomena, and (b) adaptation mechanisms are necessary in order prices track values. As we did in the pertinent oral contribution at International Econophysics Conference-2000 in Bali, we intend to show that feedback is a mechanism agents use for strategy design. Being a central concept in systems and control theory, feedback may be a useful concept to understand certain mainstream mechanisms of market evolution.

2. A price formation model

Main modeling ideas used in this paper have been borrowed from Farmer [9]. To this end, only market orders are considered. This means that transactions are made immediately at the best available price. There are two types of financial agents. The first type of agents are *directional traders*, which buy and sell by placing market orders. The second type of agents are *market makers*, filling all the orders at a price $p(t)$ whose dynamics are driven by the net order of the directional traders. Buying drives the price up, and selling drives it down. The market impact function ϕ is the procedure that the market maker uses to set prices, which, in turn defines a price formation rule relating the net order to the new price.

Let there be N directional traders, labeled by the subscript i , holding $x_i(t)$ shares at time t . The order $w_i(t)$ of the i th trader is determined from position $x_i(t)$ via the relationship

$$w_i(t) = \dot{x}_i(t) , \tag{1}$$

where $\dot{x}_i(t) \stackrel{def}{=} dx_i/dt$. By assuming that positions and orders are anonymous, the market maker bases price formation only on the net order $W(t)$, which is given by $W(t) = \sum_{i=1}^N w_i(t)$. If the instantaneous return $r(t)$ is defined as $r(t) = \dot{p}(t)$, the algorithm the market maker uses to compute the fill price $p(t)$ for the net order $W(t)$ is a risk-neutral increasing function of W : $\dot{p} = \Phi(W)$ with $\Phi(0) = 0$. In general, $\Phi(W)$ is a nonlinear, possibly noncontinuous, function of W . As a first approach, let us consider a first-order

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