Microsimulation of Markets and Endogenous Price Bubbles

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Extended Abstract

Difficulties

Two complex processes combine to make understanding even the qualitative nature of market movements an extraordinarily challenging problem: To begin with, economic actions are those of human beings, capable of cumulative learning, as well as irrational behavior. Furthermore, these actions are interconnected by institutions, such as auctions, to form nonlinear dynamical systems which are themselves subject to discontinuous and chaotic behavior.

In response, economic theory has attempted to deal with these two difficulties with two remarkable constructs: First, the rational expectations hypothesis circumvents the problem of detailed modeling of human behavior by assuming an overall rationality that leads to efficient markets. Second, economic theory centers attention on equilibria, or small, linearized excursions from equilibria, and generally avoids the difficult job of analyzing large-scale dynamic behavior.

The particular problem of explaining large, sudden and seemingly endogenous price movements like the 1987 U.S. stock market crash presents a theoretical framework based on an efficient market hypothesis and equilibria with something of a crisis. A large literature has thus grown to deal with the general issue of price bubbles, sometimes embracing them within conventional theoretical systems, and sometimes not. (For a balanced sample of recent thinking, see [7].)

The approach described here attempts to deal with the difficulties mentioned above by simulating economies at the agent level. Our hope is that it can complement (but in no way replace) theoretical explanatory methods.

Microsimulation of markets

By *microsimulation* we mean simulation in which every atomic action in an economy is represented. This includes not only bids to buy, offers to sell, and actual exchanges of commodities, but also production, consumption, storing of inventories, and implementation of particular auction mechanisms for clearing the market each trading period. This represents an attempt to construct an economic model — albeit imperfect and highly idealized — that is complete down to all individual actions. The approach is close in spirit to the recent work reported in [1, 2, 3, 4], but is unique in its reduction of all elements of an economy to atomic actions.

A key consequence of including production and consumption is that it then becomes possible to define very precisely a working notion of *fundamental value*. This is a consequence of the facts that

consumption is assumed known and fixed, and production decisions are a direct, known function of price. The fundamental value is defined to be the price that leads to a long-term balance between production and consumption. Having a definition of fundamental value for a commodity then allows us to define a price bubble as a large or sustained discrepancy between the market price and this fundamental value.

Groundwork

Earlier work [5] describes an artificial economy with two commodities, *gold* and *food*, a periodic sealed-bid auction, and with two kinds of agents. The *regular agents* are invested with no foresight or intelligence and just produce and consume. Their production decisions are based on the most recent market price, and their consumption rate is fixed. The second kind of agents are *value traders* (or fundamentalists) who buy and sell using their own estimates of fundamental value. It is shown in [5] that even if all the intelligence is thus concentrated in the value traders, their intertemporal arbitrage stabilizes the market price and leads to efficient allocation of skills.

The more recent work in [6] adds a third kind of agent: *trend traders*, who react to their own estimates of trend rather than fundamental value. The results show that when the fundamental value is exogenously ramped up and down by adjusting production skills, inflationary price bubbles form and burst on rising value, and deflationary bubbles form and recover on falling value.

In the work described here, we deal again with a two-commodity artificial economy with production and consumption, but with some of the trend traders made more prone to buy and sell (more "jumpy"), and with an infusion of additional gold (the numeraire). The result is that price bubbles form endogenously, without the additional impetus of an exogenously ramped fundamental value. We briefly describe below a typical example of a simulation exhibiting endogenous price bubbles.

Endogenous price bubbles

The illustrative case described here has 25 regular traders, 25 value traders, and 25 trend traders. Of the trend traders, every fifth can be made "jumpy," in the sense that the margins that trigger his bidding are much smaller than the others. Value traders begin operations at trading period 500, and trend traders begin at trading period 1000. Starting at trading period 3000, every fifth trend trader is made jumpy by changing his margins. Also beginning at trading period 3000, 10 units of gold are given to every trend trader every 50 trading periods.

Figure 1 shows the formation of four cycles of "boom and bust." Each inflationary bubble is followed by a short interval of correction (with higher volatility than normal), then by a deflationary bubble, and then by a recovery to normal behavior. Figure 2 shows a closeup of one of the boom-bust cycles. This example illustrates a secondary inflationary bubble after recovery. More detailed analysis of this behavior and further results will be included in a full version of this paper.

The role of microsimulation

Simulation provides a new and potentially powerful tool for experimenting with economic models. It replaces the utility function and rational expectations hypothesis with algorithms for individual behavior, and replaces equilibrium analysis with dynamic simulation. The goal at this point is typically qualitative, phenomenological insight into complex economic phenomena — as opposed to quantitative modeling with predictive value.

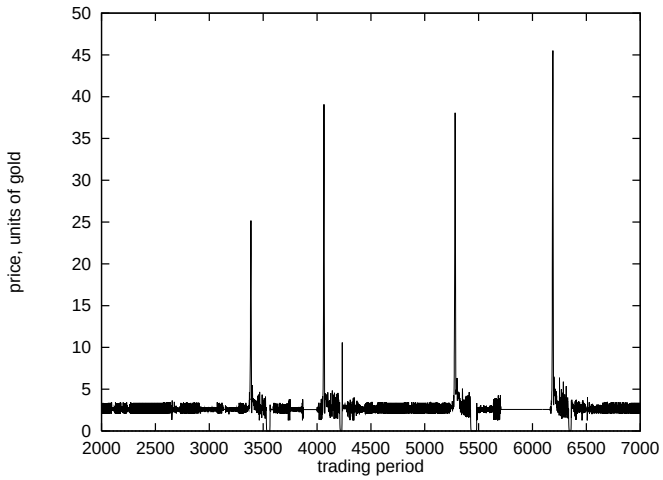

Fig 1. Market price history in a simulation with jumpy traders, illustrating bubbles and crashes.

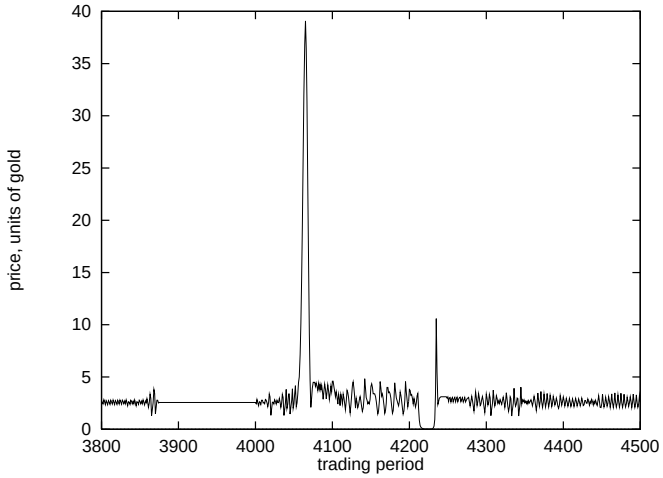

Fig. 2. Closeup of Fig. 1, showing a bubble followed by a crash.

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