

# **Bubbles, Crashes, and Online Auctions — Roles for Agent-Based Simulation**

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# **The huge challenges in understanding markets in general**

- . Systems of interaction are dynamic, complex, non-linear, high-dimensional**
- . Behavior is important**

## **The Copouts:**

- . Equilibrium theory**
- . Rational expectations**

## **The Tools:**

- . Theory: armchair and mathematical**
- . Experiment**
- . Simulation**

# **Part I: Price Bubbles**

## **The Classic Picture, a la Mackay (1841)**

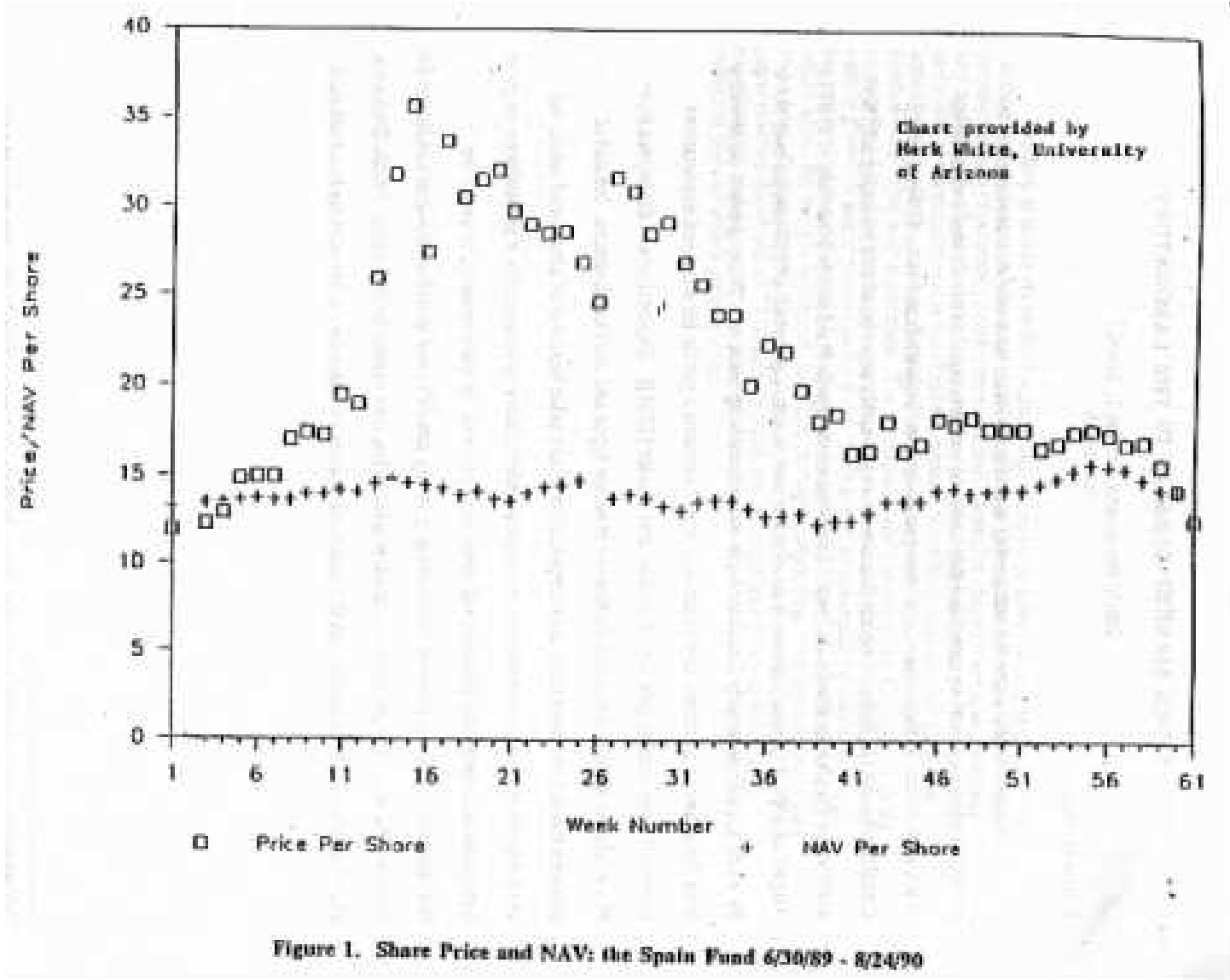
**The mania forms the bubble...**

**Nobles, citizens, farmers, mechanics, seamen, footmen, maid-servants, even chimney-sweeps and old clotheswomen, dabbled in tulips. People of all grades converted their property into cash, and invested it in flowers. Houses and lands were offered for sale at ruinously low prices, or assigned in payment of bargains made at the tulip-mart. Foreigners became smitten with the same frenzy, and money poured into Holland from all directions.**

**The bubble bursts...**

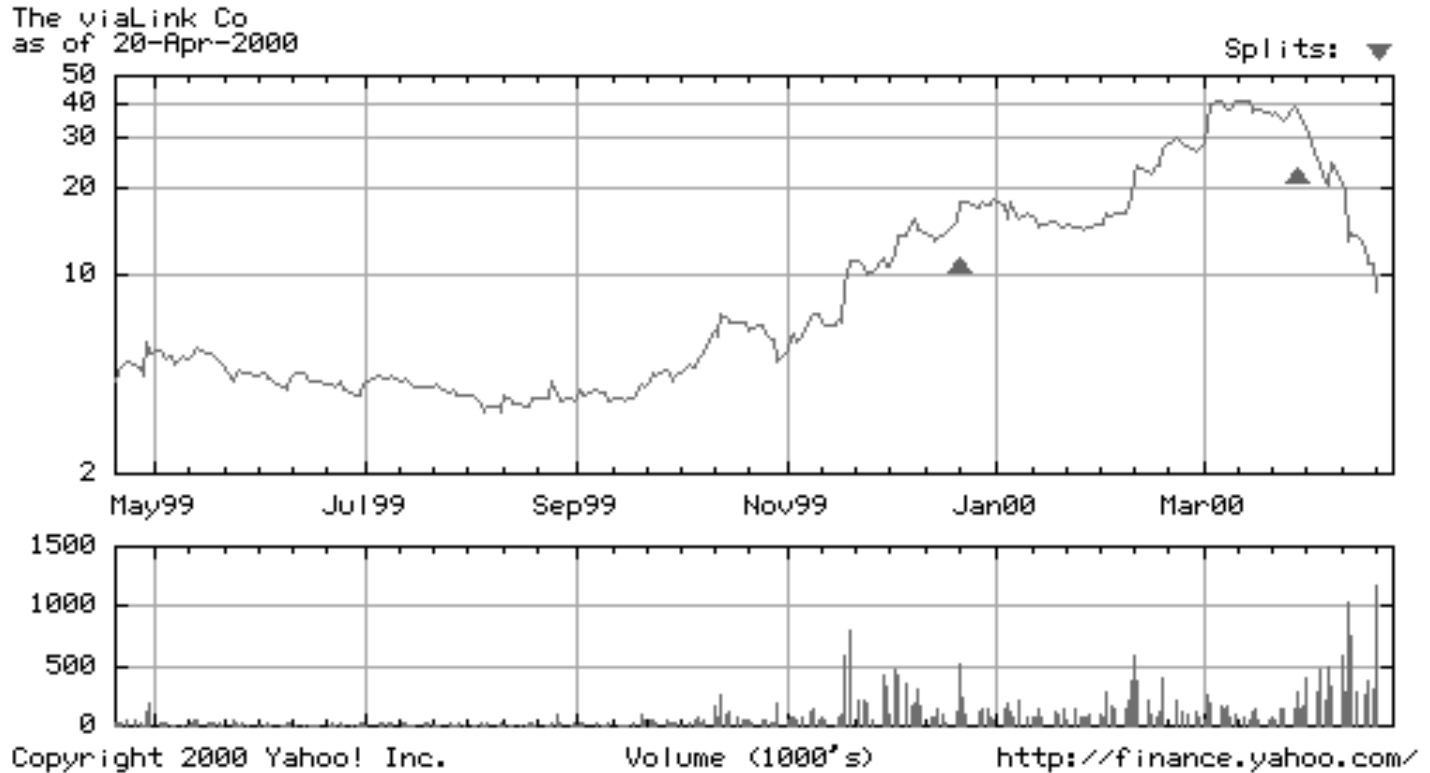
**At last, however, the more prudent began to see that this folly could not last for ever. Rich people no longer bought the flowers to keep them in their gardens, but to sell them again at cent per cent profit. It was seen that somebody must lose fearfully in the end. As this conviction spread, prices fell, and never rose again. Confidence was destroyed, and a universal panic seized upon the dealers.**

# A real example



— from “Stock Market Bubbles in the Laboratory,” D. P. Porter & V. L. Smith, preprint, May 1994.

# A more recent example?



— viaLink Co, as of 20-April-2000, from Yahoo

The rate of growth between Sep99 and Mar00 is 40:1 per year.

# The classical (repeatable) experiment of Porter and Smith

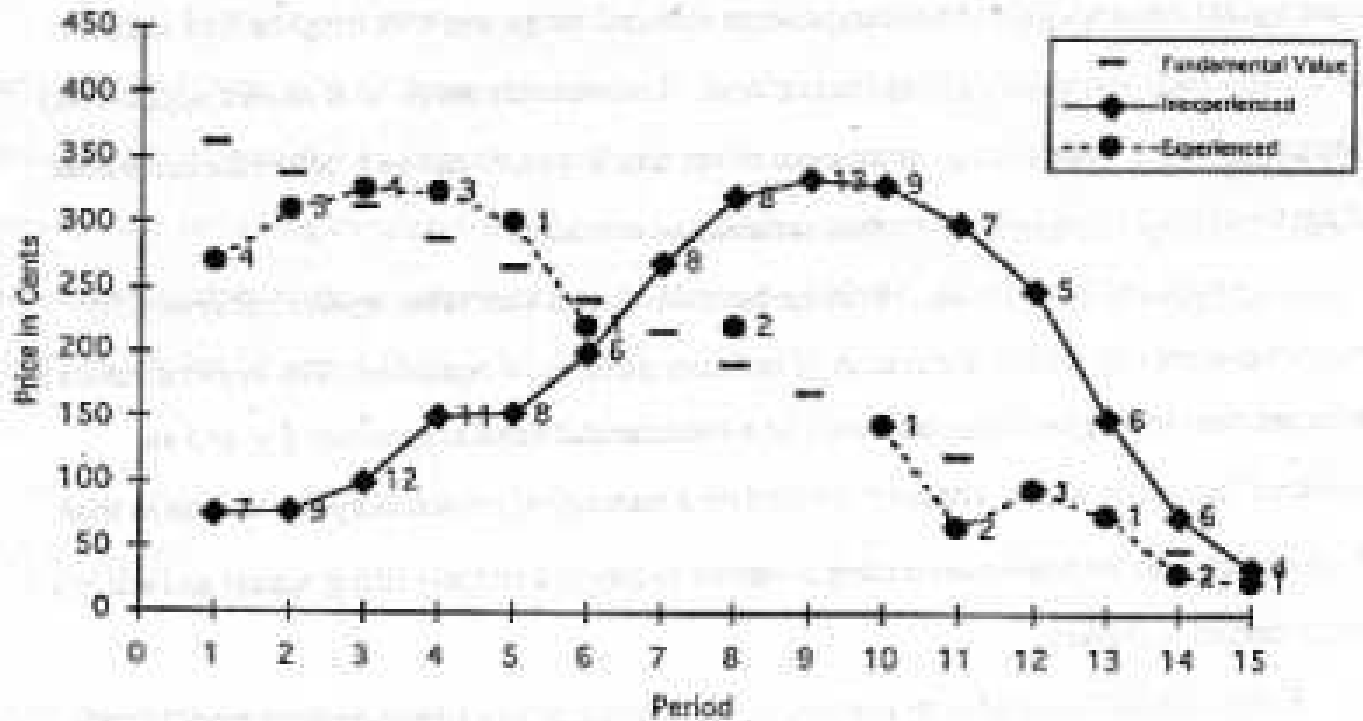


Figure 2. Mean Contract Price and Total Volume

— from “Stock Market Bubbles in the Laboratory,” D. P. Porter & V. L. Smith, preprint, May 1994.

## **Some work from various directions**

- **Laboratory experiment:**

- **Porter & Smith (ca. 1993 and before)**

- **Aggregate differential equations:**

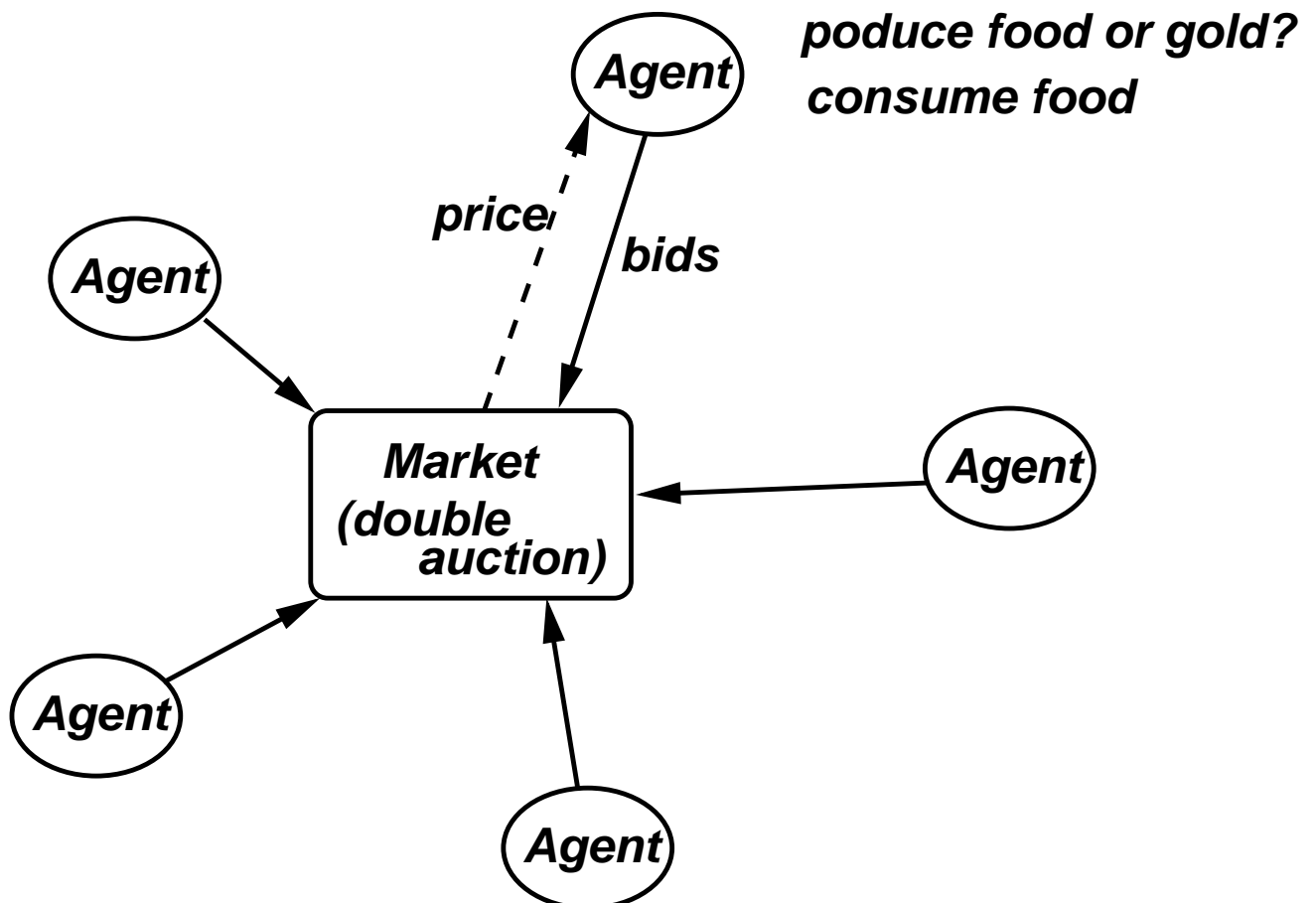
- **Caginalp & Balenovitch (1993)**
- **Youssefmir, Huberman, Hogg (1994)**

- **Agent-based simulation:**

- **Rust, Miller, and Palmer (1993)**
- **Steiglitz, Honig, Cohen, Shapiro (1993 –)**
- **Levy, Oersky, Solomon (1995)**
- **Andreoni and Miller (1995)**
- **Youssefmir, Huberman, Hogg (1996)**
- **Arthur, Holland, LeBaron, Palmer, Taylor (1996)**
- **Bak, Paczuski, and Shubik (1996)**
- **Brock and Hommes (1996)**
- **LeBaron, Arthur, and Palmer (1999)**

## Market Simulation:

- a simulated market with production-consumption
- exchange mediated by sealed-bid double auction
- heterogeneous traders

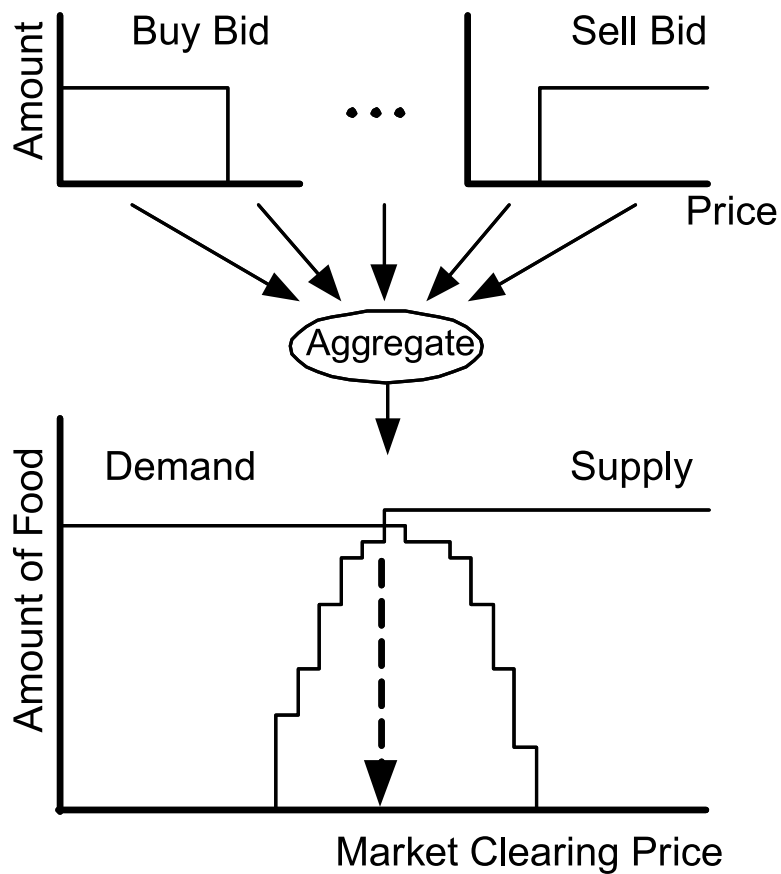


**A minimal market**



# Auction:

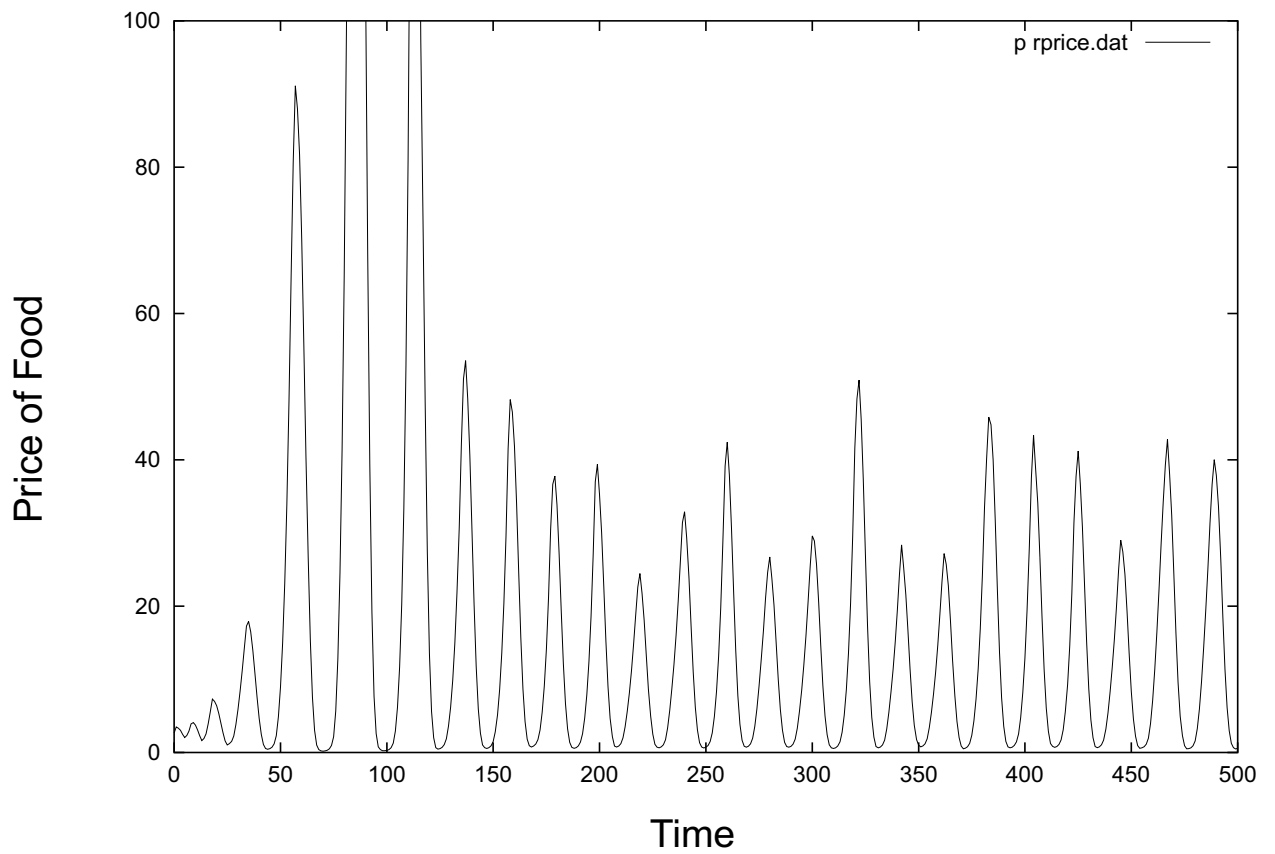
Each trading period the central auctioneer clears the market.



## Typical system parameters

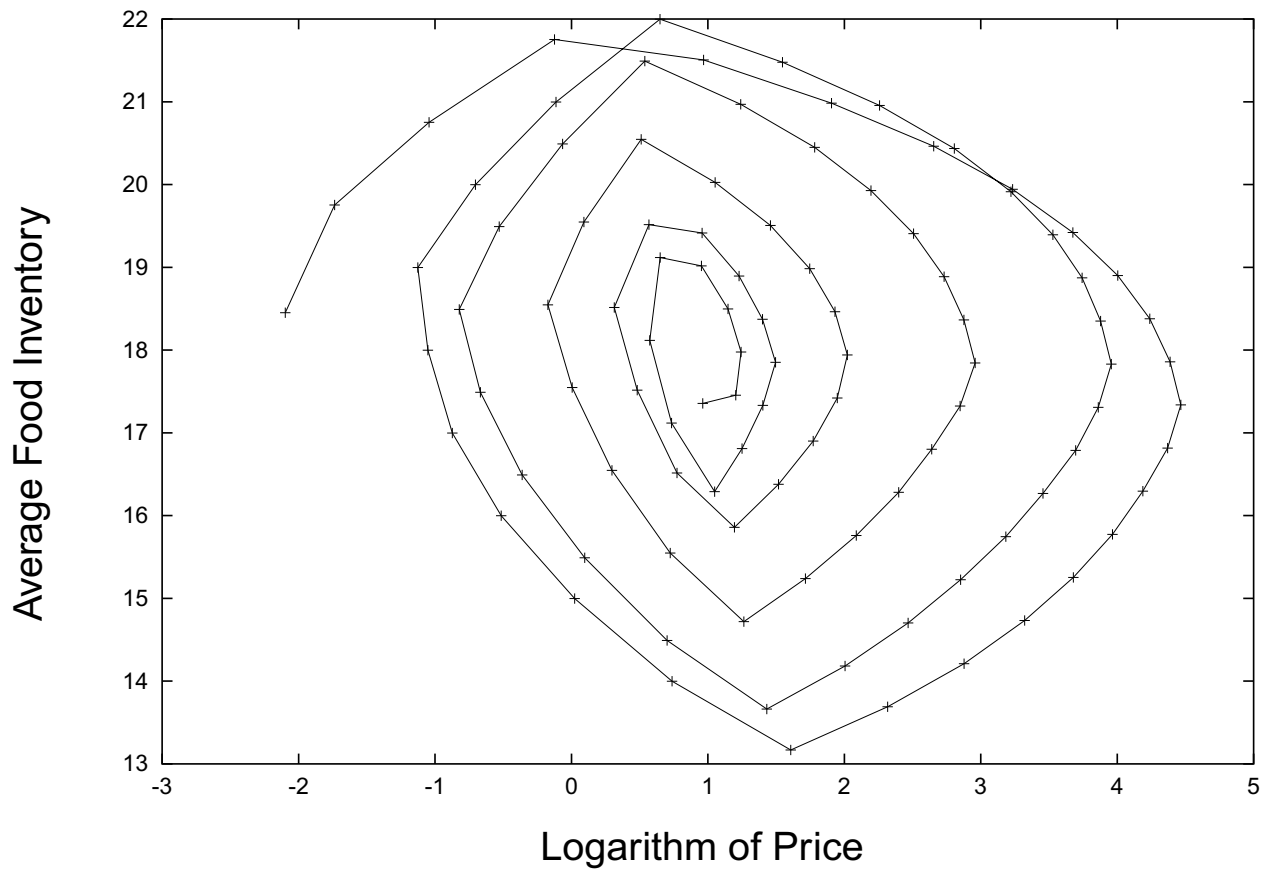
- two commodities: food, gold
- 25 regular agents, 25 value traders, 25 trend traders
- regular agents consume 1 unit of food per trading period
- endowed food skills distributed uniformly in  $[1.25, 1.75]$
- endowed gold skills distributed uniformly in  $[3,4]$
- trader decision margins
- trader smoothing time constants and estimation algorithms
- bidding function

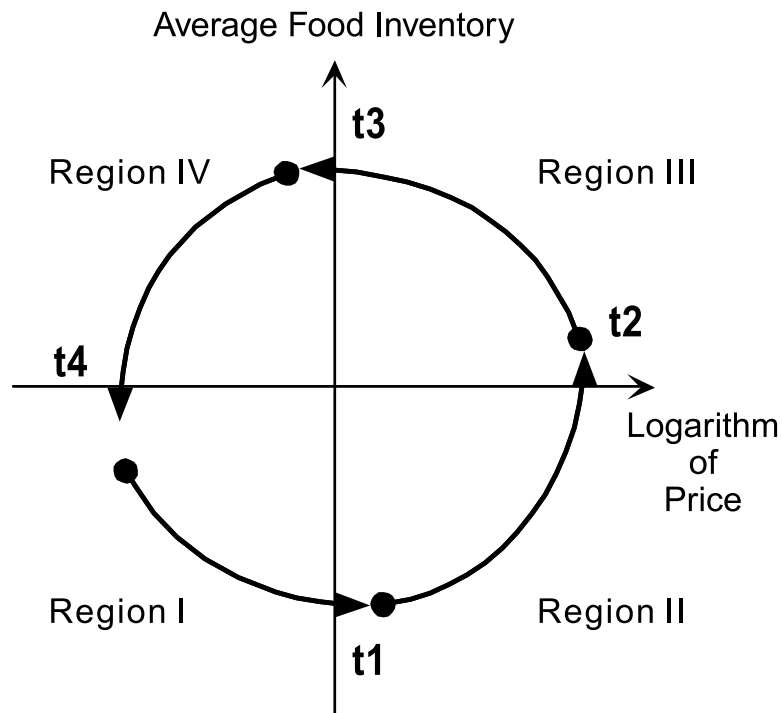
# The price oscillates violently:



**Why?**

# Inventory v. log-price plane

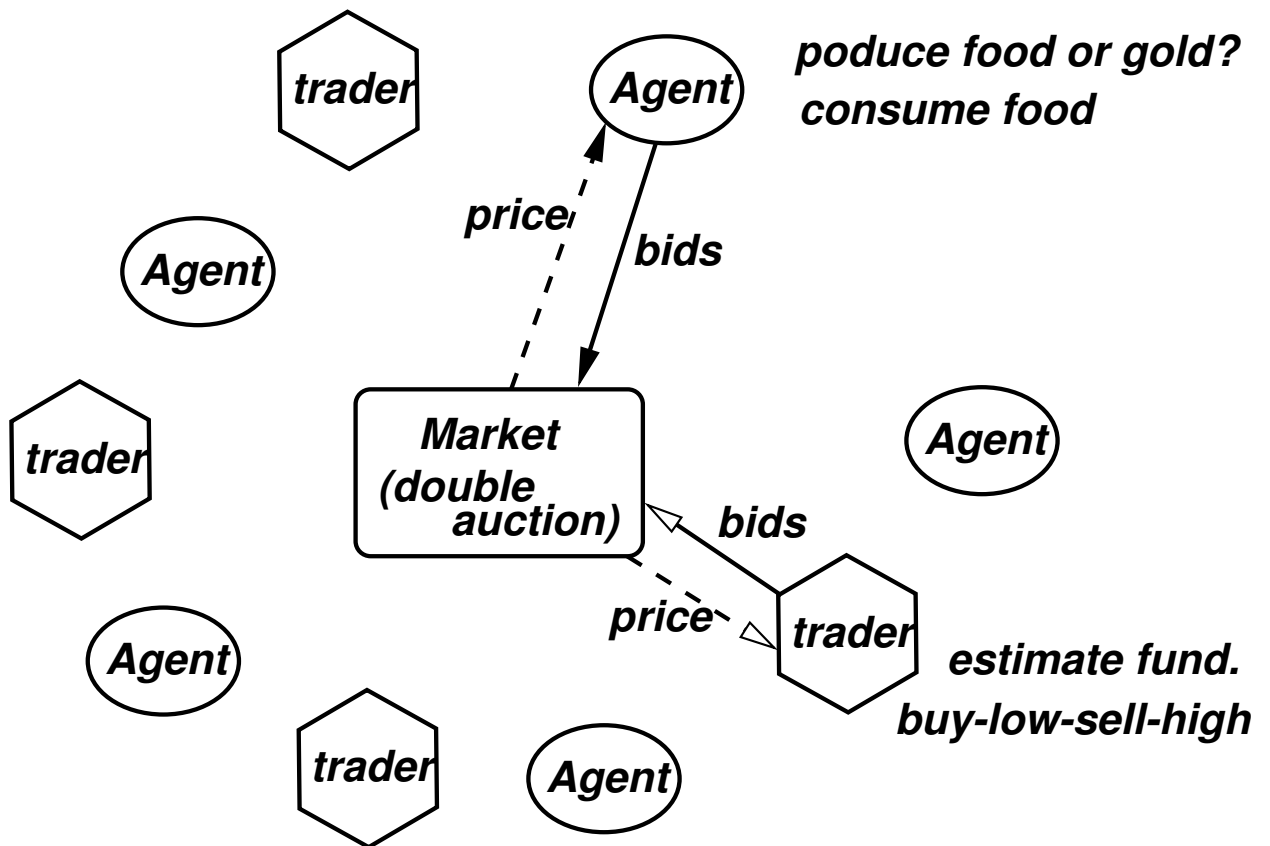




- In region I, the low price prevents agents from producing food and the resulting deficiency of food causes the price to rise.
- In region II, when the price gets high enough, agents begin to produce food, but the price keeps rising since there still isn't enough food to satisfy demand.
- In region III, agents now have enough food and the price begins to fall. However they continue to produce food because the price remains high for a time.
- In region IV, agents stop producing food because the price finally becomes low. But the price continues to fall because of food surplus.

It is therefore the delay between the price movement and the size of the food inventory that brings the system into oscillation, as in the cobweb model [?].

# Introduction of value traders:

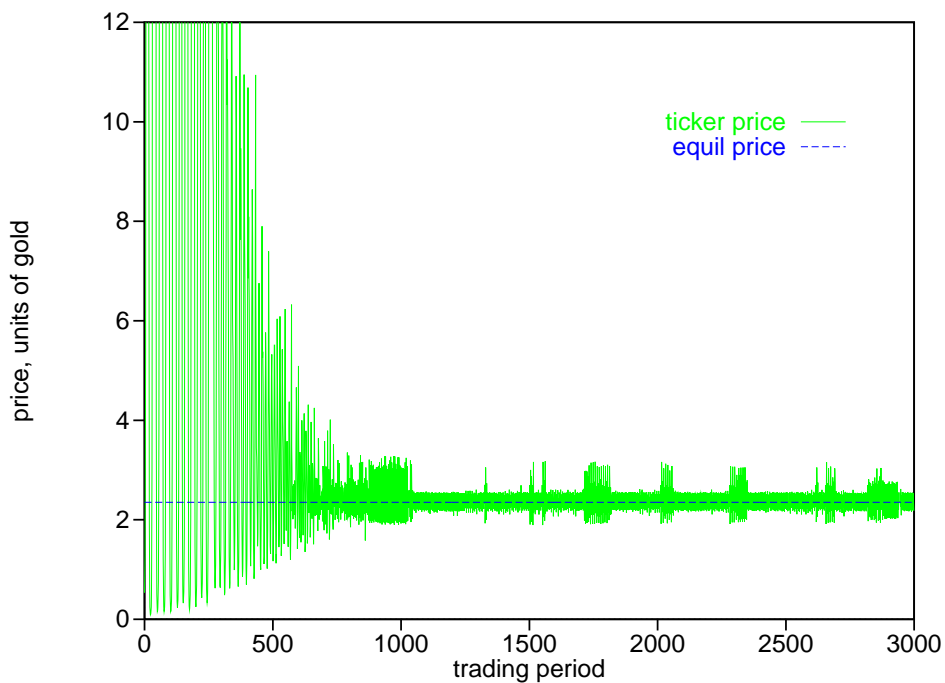


# Value Traders: The introduction of foresight

- Each estimates “fundamental value” using adaptive expectations:

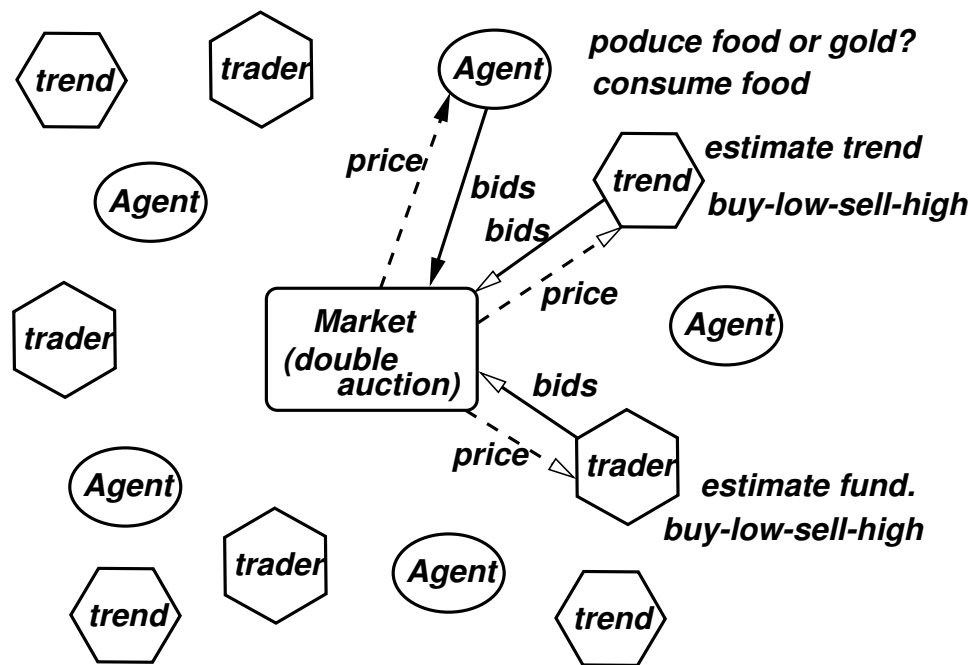
$$P_{\text{new}} = a \cdot P_{\text{old}} + (1-a) \cdot P_{\text{new}}$$

- Each tries to buy-low-sell-high



# Trend Traders: The introduction of foresight

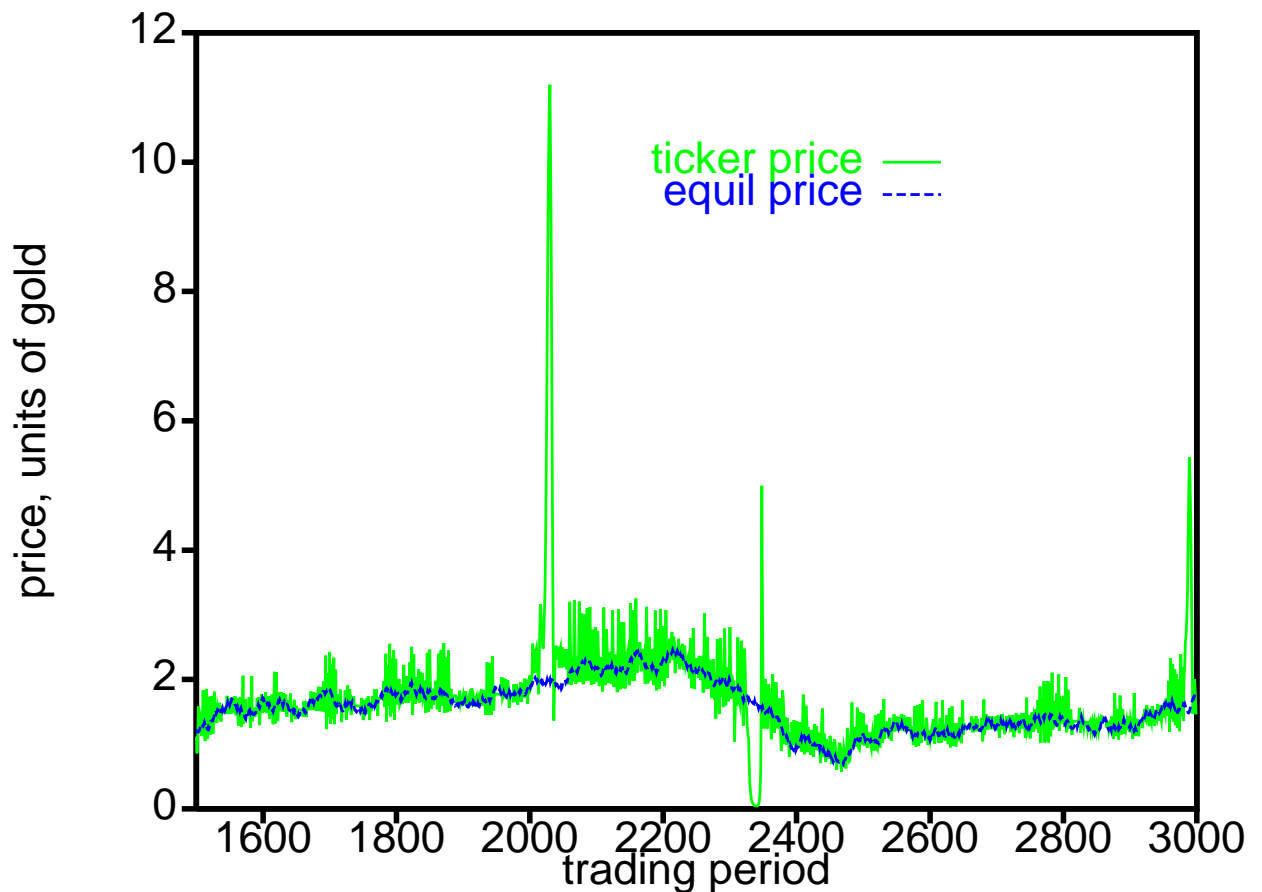
- . Each estimates “trend” also using
- . Each tries to buy-low-sell-high



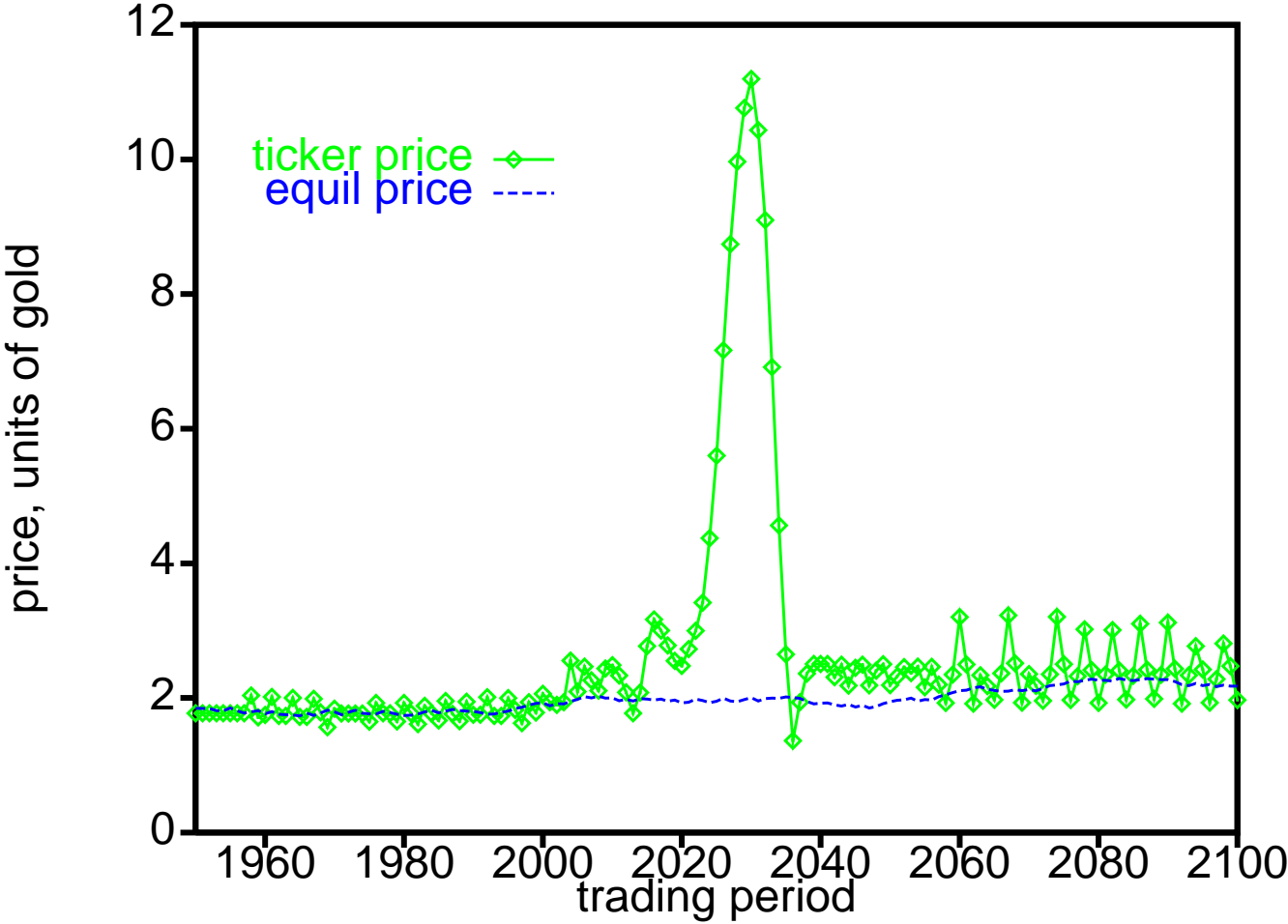


## Introducing Trend Traders:

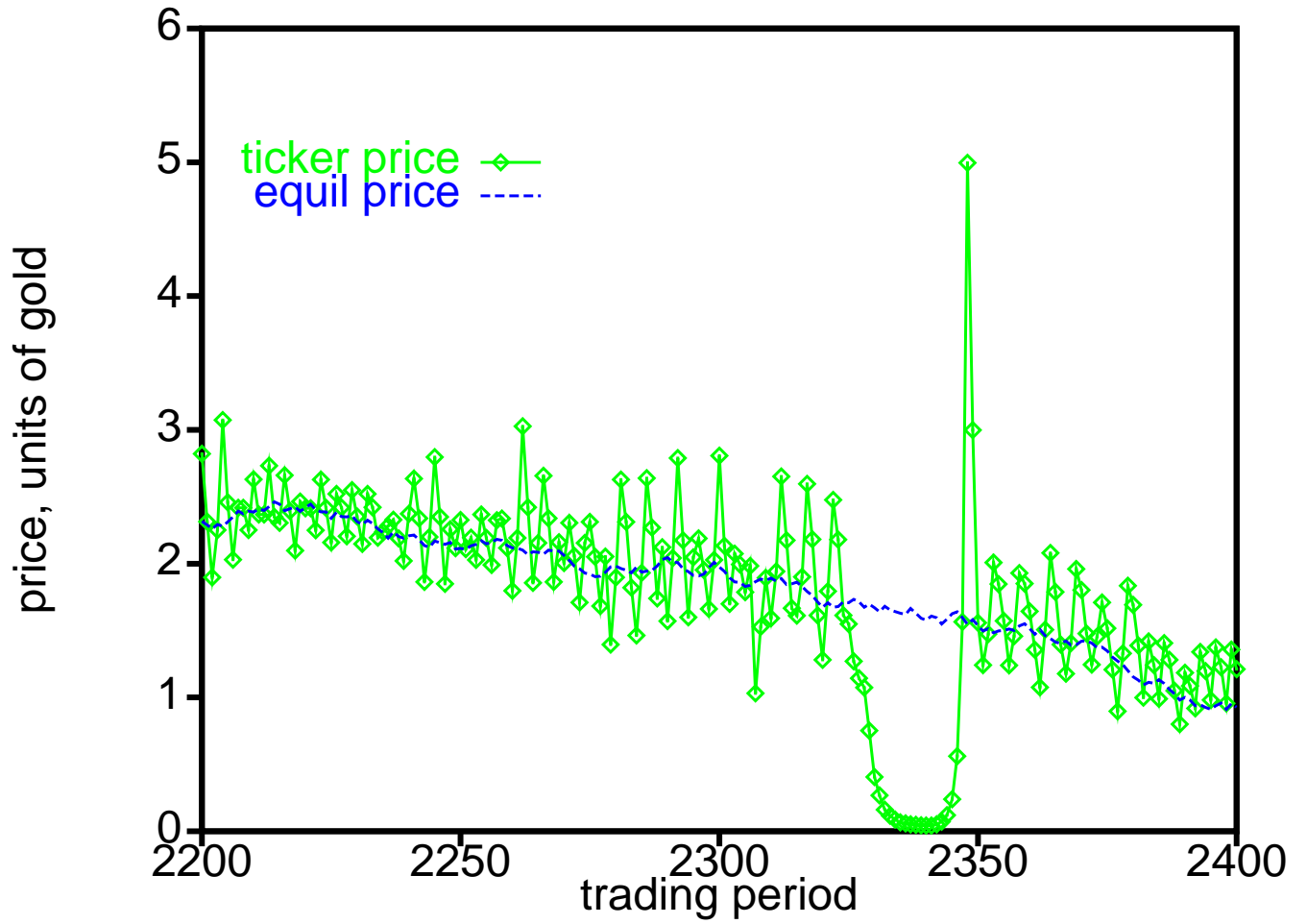
**Random variation in fundamentals is needed to give the trend traders some potential profit**



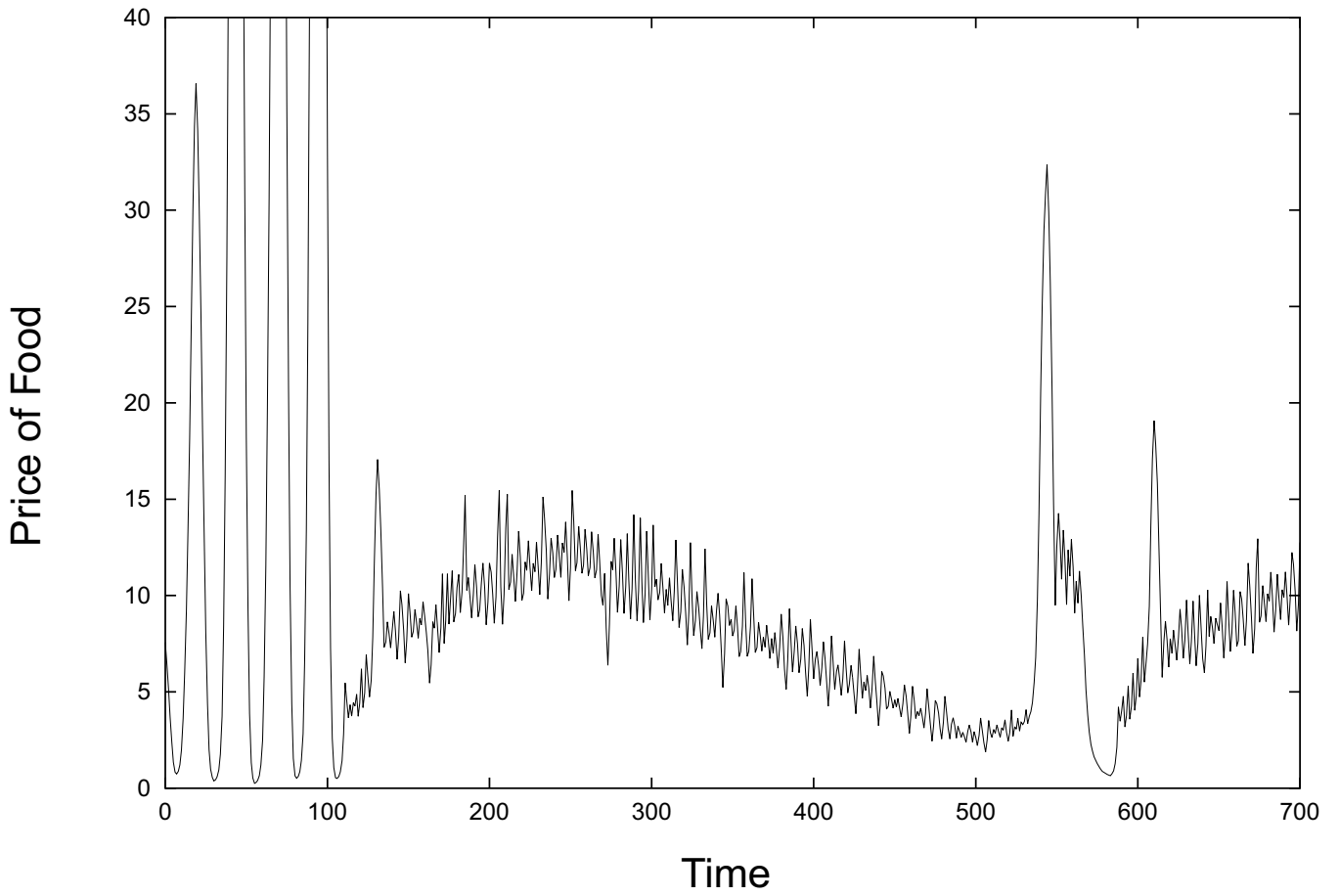
# Closeup of + bubble:



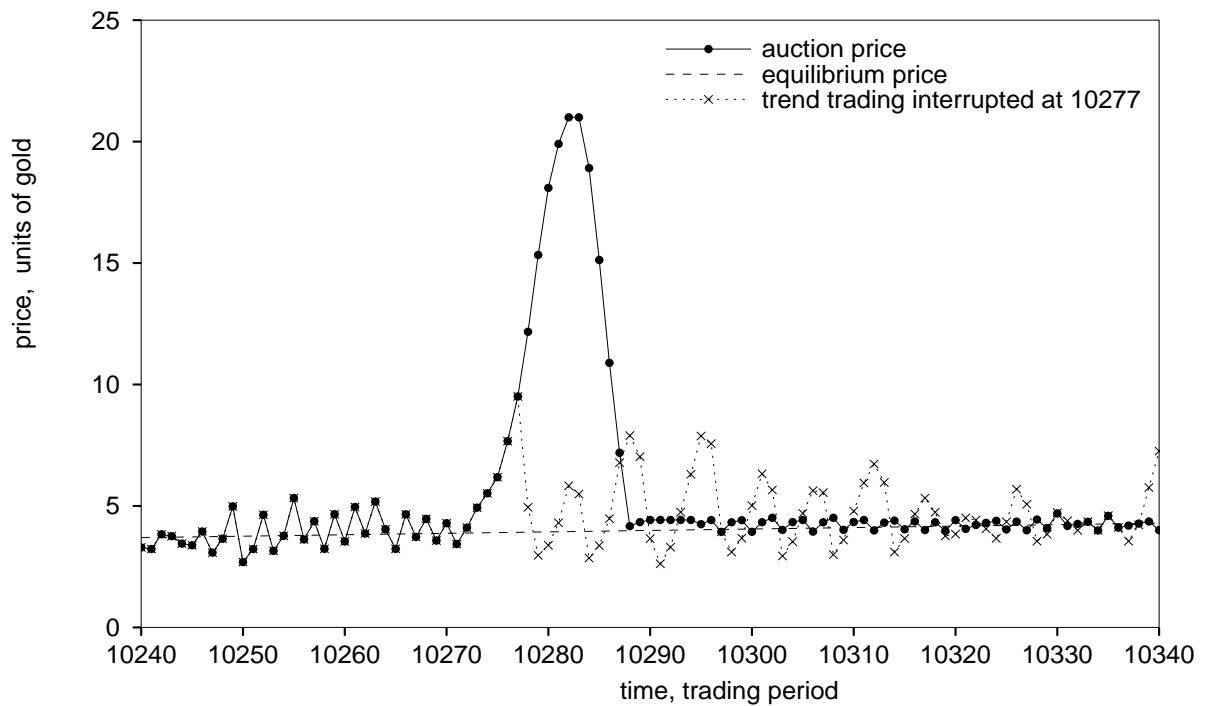
# Closeup of – bubble:



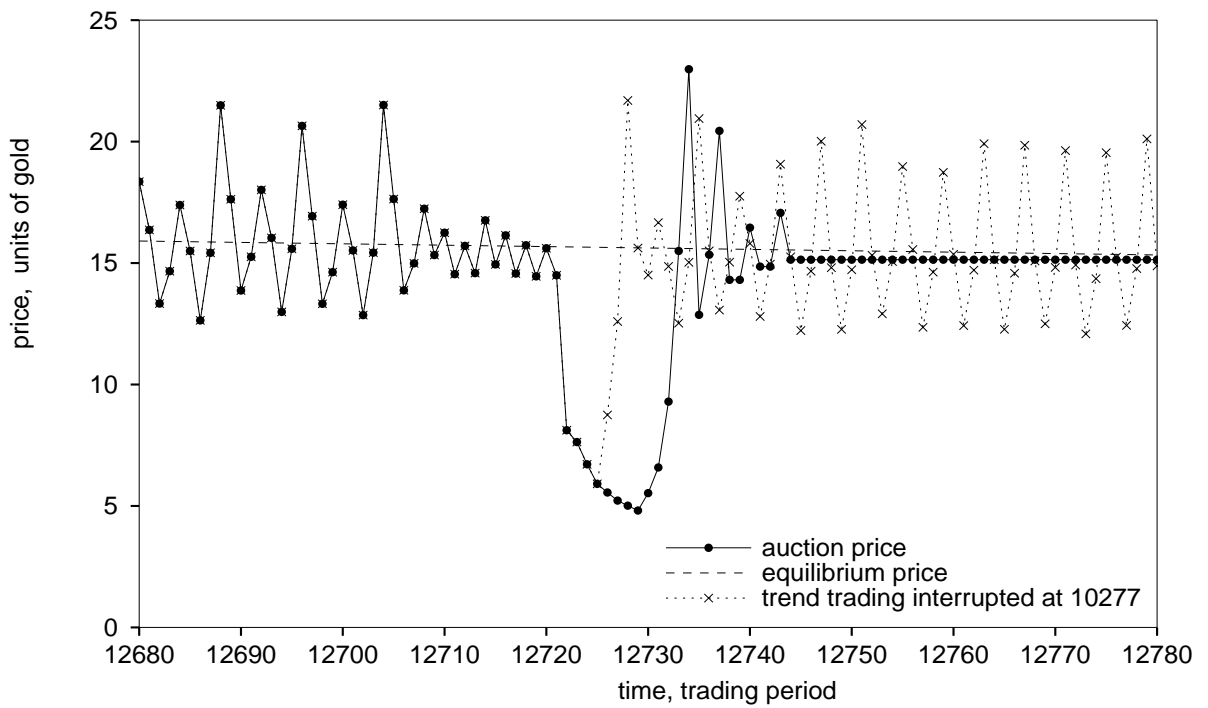
## Another example, with overshoot return:



# Circuit-breaker; removing trend traders during + bubble



# Circuit-breaker; removing trend traders during – bubble



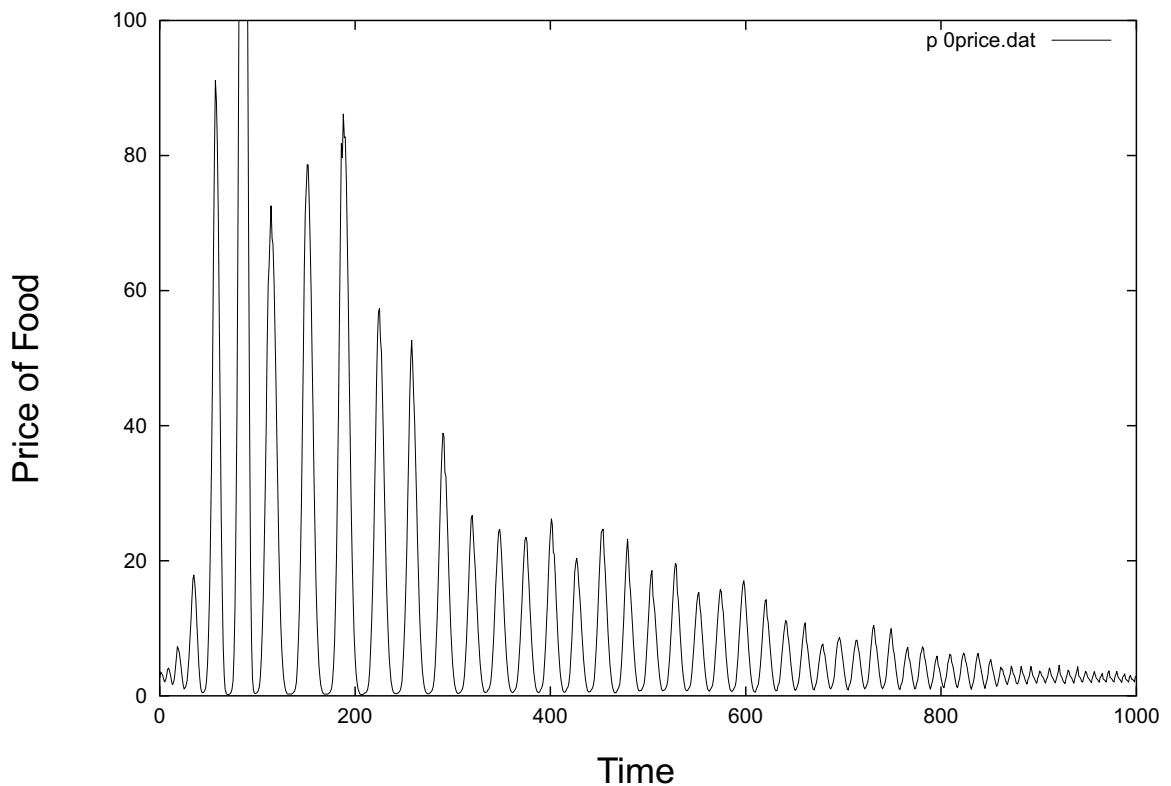
# Effects of Price Signal Choices on Stability (with H. Mizuta, IBM Tokyo)

Suppose we supply some information to the myopic agents: the average of all bids in the order book, and remove traders.

$P_0$  = average bid prices in the order book of the auctioneer

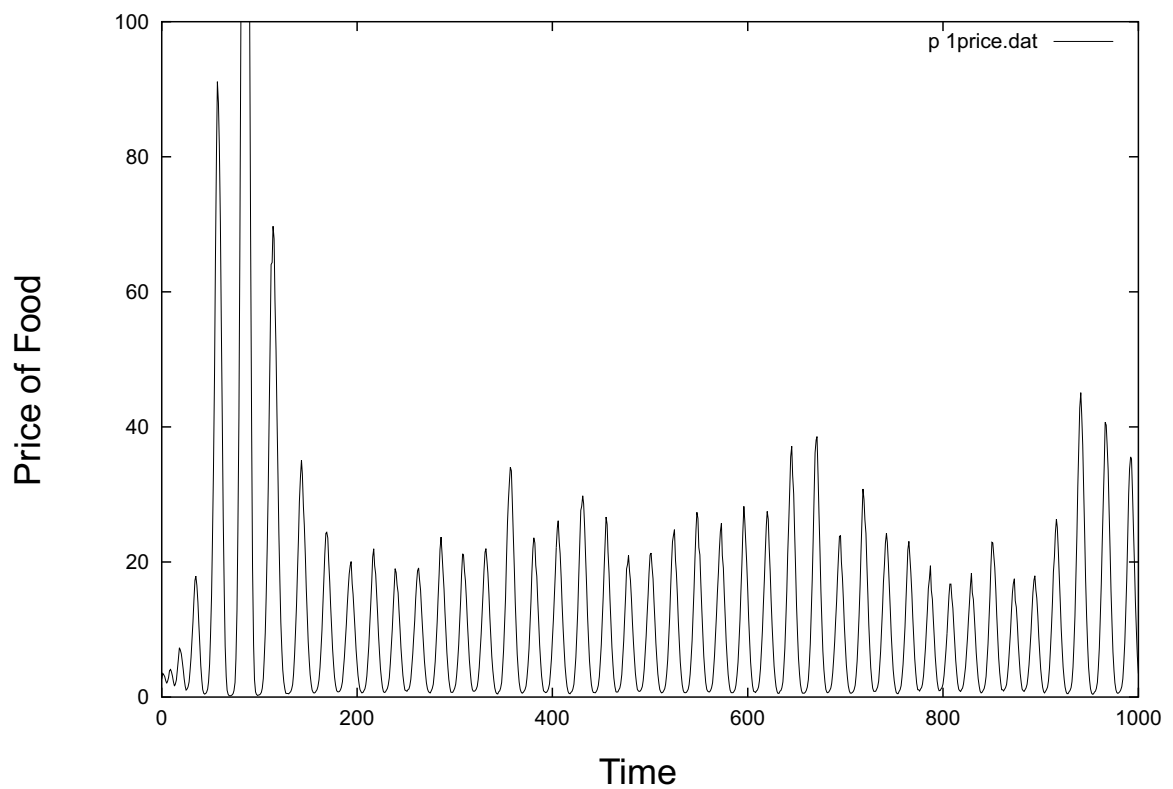
Intuitively, this reveals information about supply and demand not in the ticker price signal.

The result shows some stabilization:



# Suggests weighting bid prices by amount

**P1 = average bid prices in the order book of the auctioneer,  
weighted by amount offered/desired for trade**

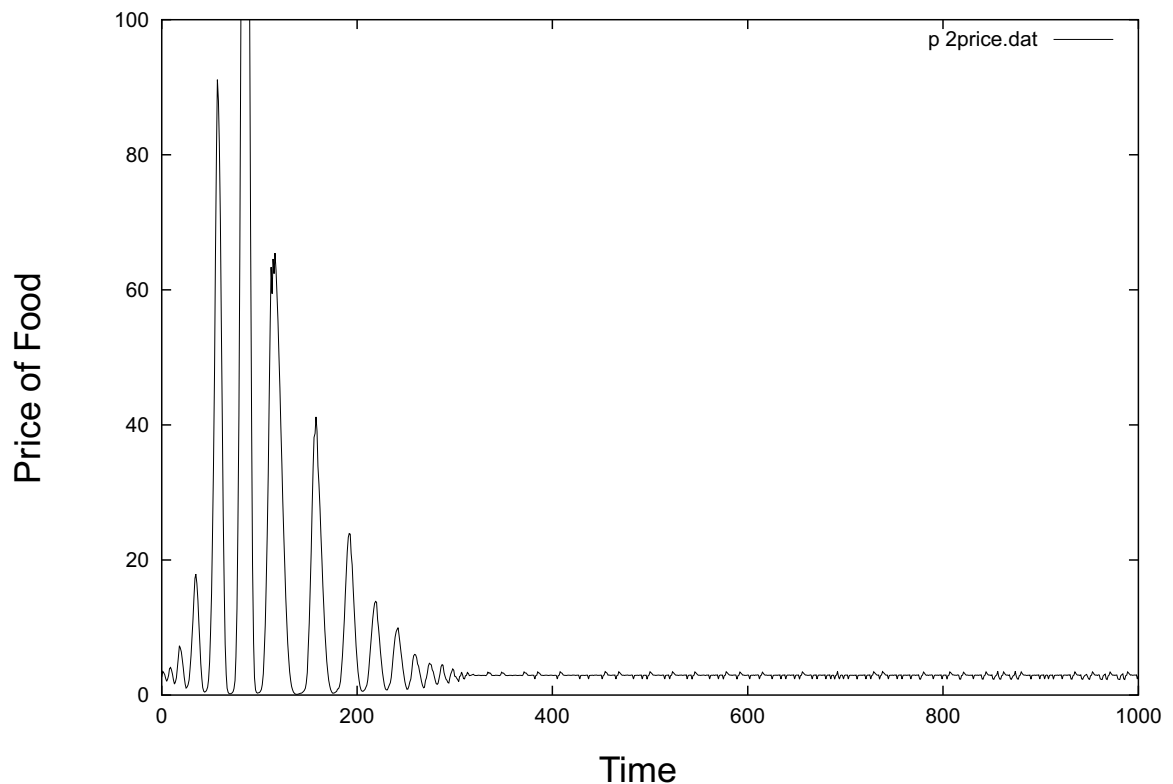


**Worse!**



# Try weighting bid prices by inverse amount

**P2 = average bid prices in the order book of the auctioneer,  
inversely weighted by amount offered/desired for trade**



**Very Stable — without traders!**

## **What does Simulation Offer?**

**A supplement to theory, laboratory experiments, econometrics:**

- . allows “play” to stimulate ideas**
- . forces us to specify everything, including human/bot behavior**
- . suggests hypotheses, alternate mechanisms**
- . provides a tool for experimentation with new ideas**
- . predicts behavior of markets with bots**

## **Limitations**

- . inevitably simplified versions of reality**
- . many, many dimensional and very complex behavior, easy to get lost**