

Title: A look at some models

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Abstract: The NASDAQ Model
The Partecon Model

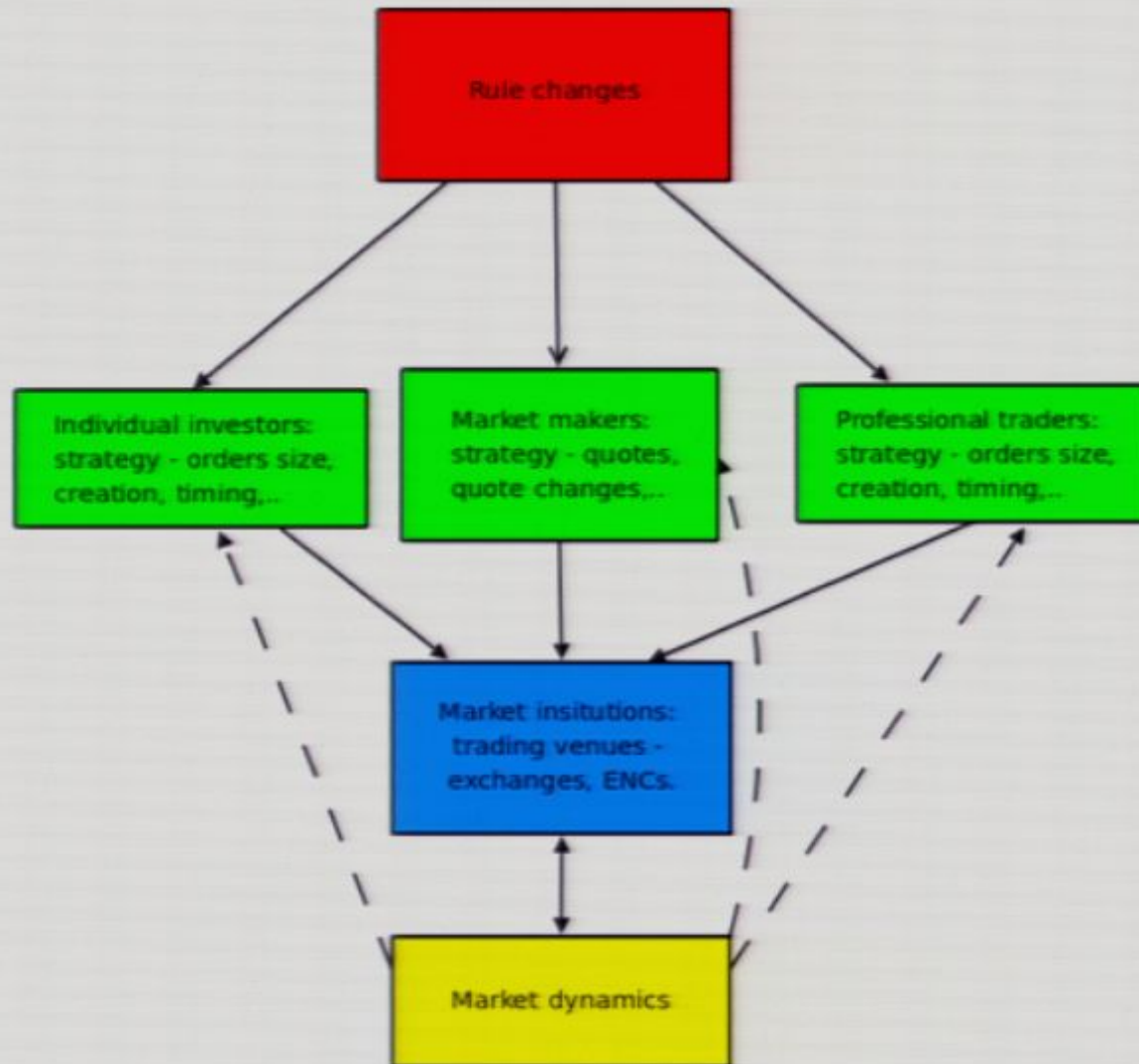
Problem Statement

- Nasdaq had to consider decimalization and its impacts in 1998.
- How reducing the tick size may affect the market behavior? Why should it have any effect?
 - How a change to decimals can be modeled?
 - What is the mechanism through which changed tick size would affect the market?
 - Via individual market participants (agents) decisions?
 - Via changes to market infrastructure– order matching?
 - Given specific mechanisms, what other (second order?) effects may occur?

Goals

- Investigate effects of possible policy and environment changes:
 - Ex: Evaluate the effects of changing the tick size (decimalization) and of parasitism
- Evaluate the influence of market rules and structure on market dynamics and strategies
- Demonstrate that that simulated market participants and aggregate market parameters are “sufficiently similar” to those in the real world to validate model empirically

Problem Architecture



Model Implementation

Construct and analyze an agent-based model of the market:

- Populate with agents (investors and market makers).
- Simulate market infrastructure and rules.
- Calibrate with the actual stock market data:
 - To ensure that the simulated distribution of trade sizes, volumes, prices and other statistical parameters is similar to that observed in the real world.
 - To simulate real-world behaviors of and interactions of market makers and investors using data sets of historical quotes and trades.
- Design it to reflect the look and feel of the then existing Level 2 Nasdaq system.

Philosophical Observations

- By definition, almost tautologically, the world is an agent-based system.
- The question is what predictive power such a representation has? For what kinds of problems?
- What are the theoretical reasons for agent-based representation to work?
- Crucial differences from existing approaches:
 - Modeling processes and mechanisms, rather than the outcomes and states.
 - Focus on emergent behaviors – potentially, counter intuitively, invalidating the initial model.
- Nasdaq decimalization study: an empirical example.
 - Study done during 1998-2000.
 - Decimalization occurred in April 2001.

Agent Details

- Market makers
- Investors
- Market Agent Features:
 - Autonomous
 - Adaptive/handcrafted strategies
 - Various levels of sophistication/adaptability/
access to information

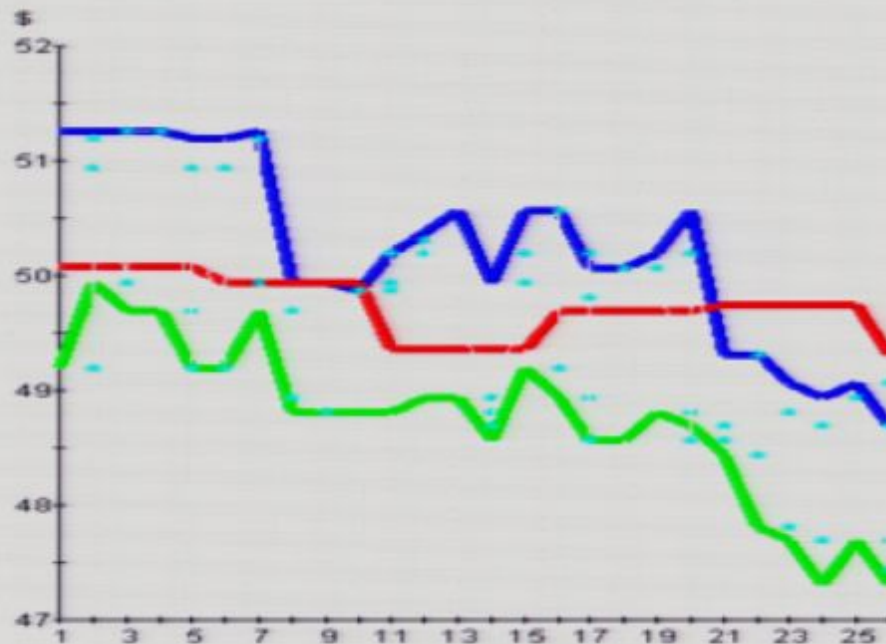
Simulation Basics

- Market agents are trading in a single stock
- Investors have a price target which follows a Poisson process, random walk, *etc.*
- Investors:
 - Receive noisy information about this target
 - Decide whether to trade by
 - Comparing this target with available price
 - Incorporating market trends
 - Performing sophisticated technical trading, *etc.*
- Market makers:
 - Receive buy and sell orders
 - Must learn how to set their quotes profitably

Investor – Market Maker Interaction and Parasitism

Parasitic strategy:

- Attempts to undercut the current bid/offer by a small increment (tick size)
- Is not a major source of liquidity for the market



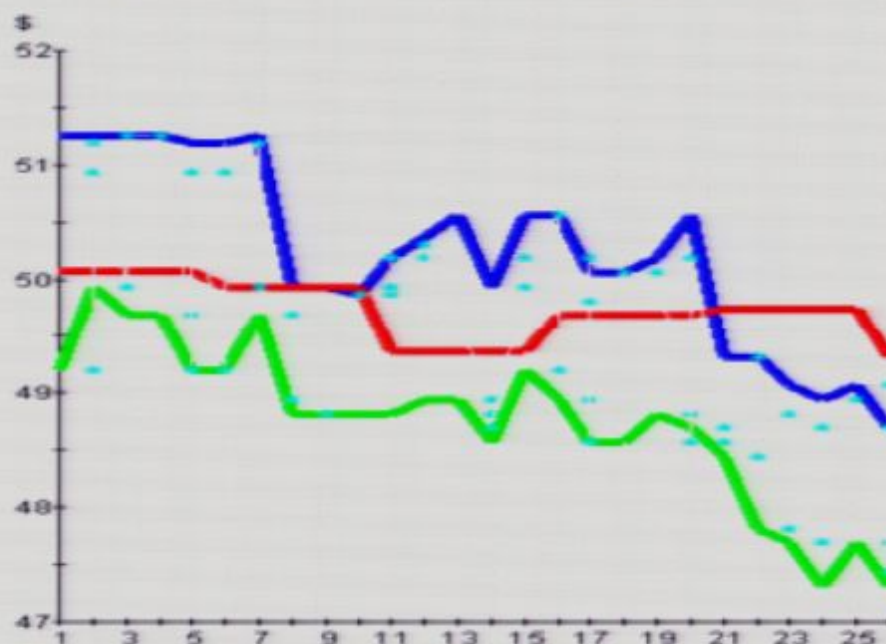
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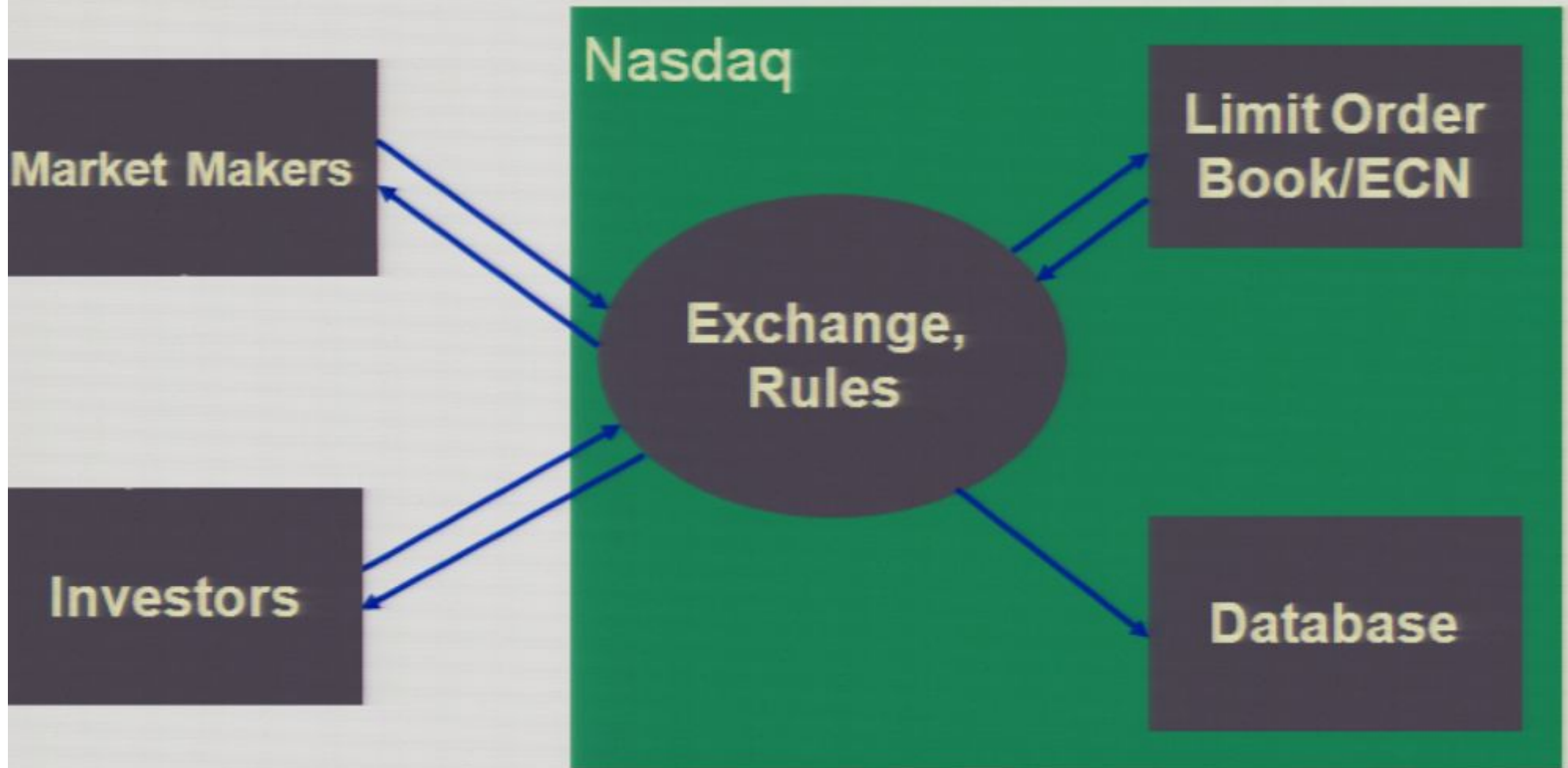
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Model Structure



Model Features

- Trading in:
 - Market orders
 - Limit orders
 - Negotiated orders
- Market rules/parameters:
 - Order handling rules
 - Tick size, etc.
- Market agents' modes of interaction:
 - Quote Montage
 - ECNs
 - Limit order books
 - Preferencing, etc.

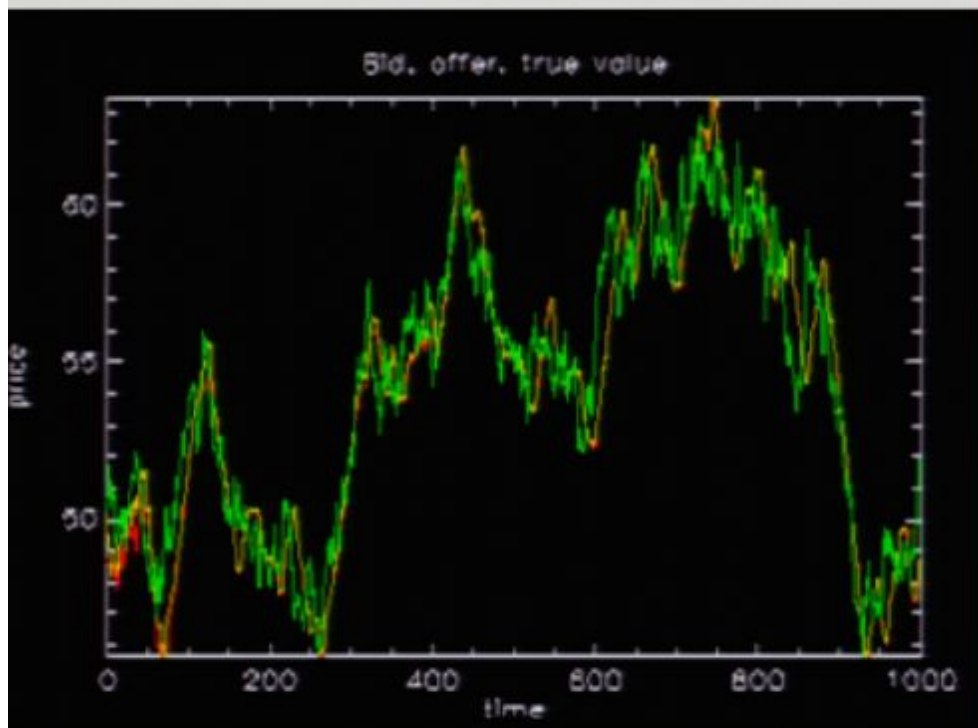
Model Calibration

- Calibrated the model to
 - Individual strategies
 - Aggregate market parameters
- Simulated strategies are able to replicate the real-world ones (with precision up to 60-70%)
- Created self-calibrating software to use data as it comes in

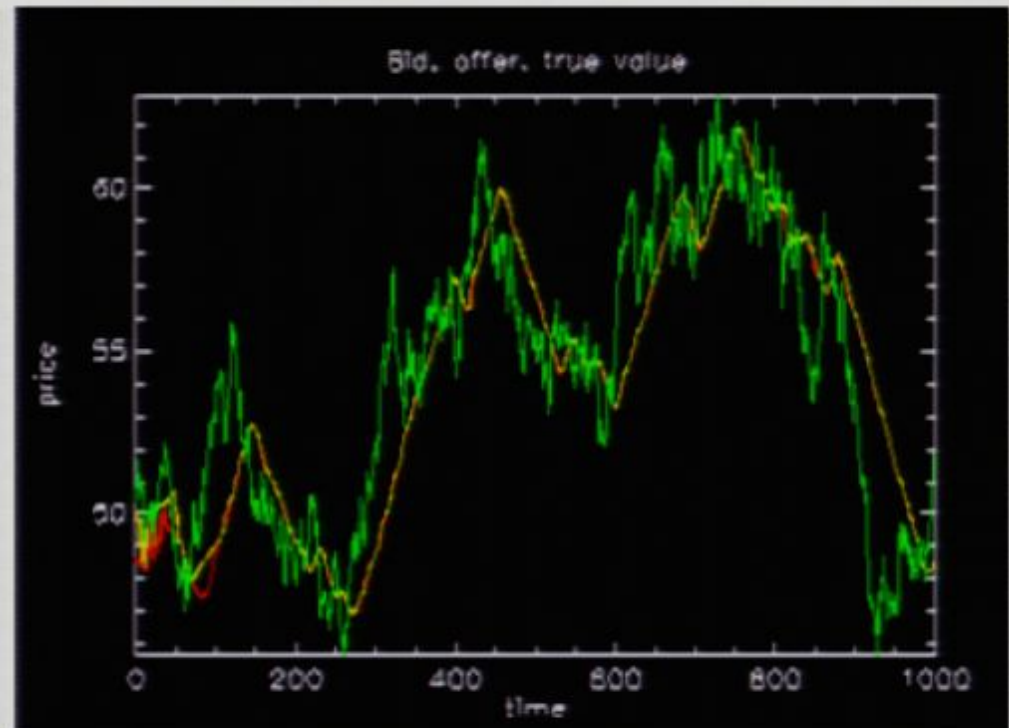
Questions Investigated

- Effects of tick-size changes and parasitism
- Market dynamics effects:
 - Presence and origin of “fat tails”
 - Spread clustering and its causes
- Effects of market maker and investor learning and strategy evolution

Tick Size Effects, Many Parasites



Tick size 1/16



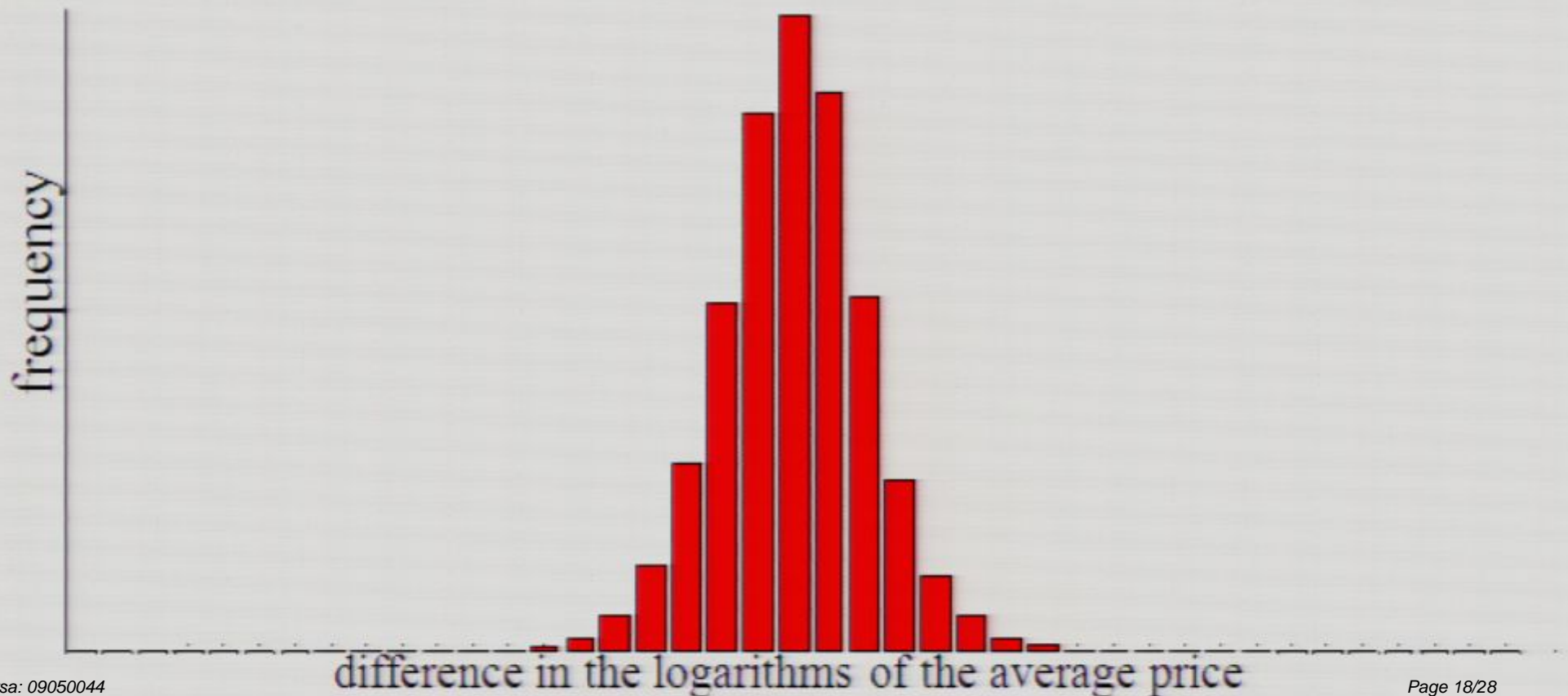
Tick size 1/100

Fat Tail Results

- “Fat tails”:
 - A large probability of extreme events by comparison with a Gaussian distribution
- Origins are uncertain
 - Herd effects, other?
- Our model generates fat tails with no herd effects

Time Correlations and Fat Tails

The fat tails seem to disappear when the data points are taken far apart (50 periods here)



Why Fat Tails in the Simulation?

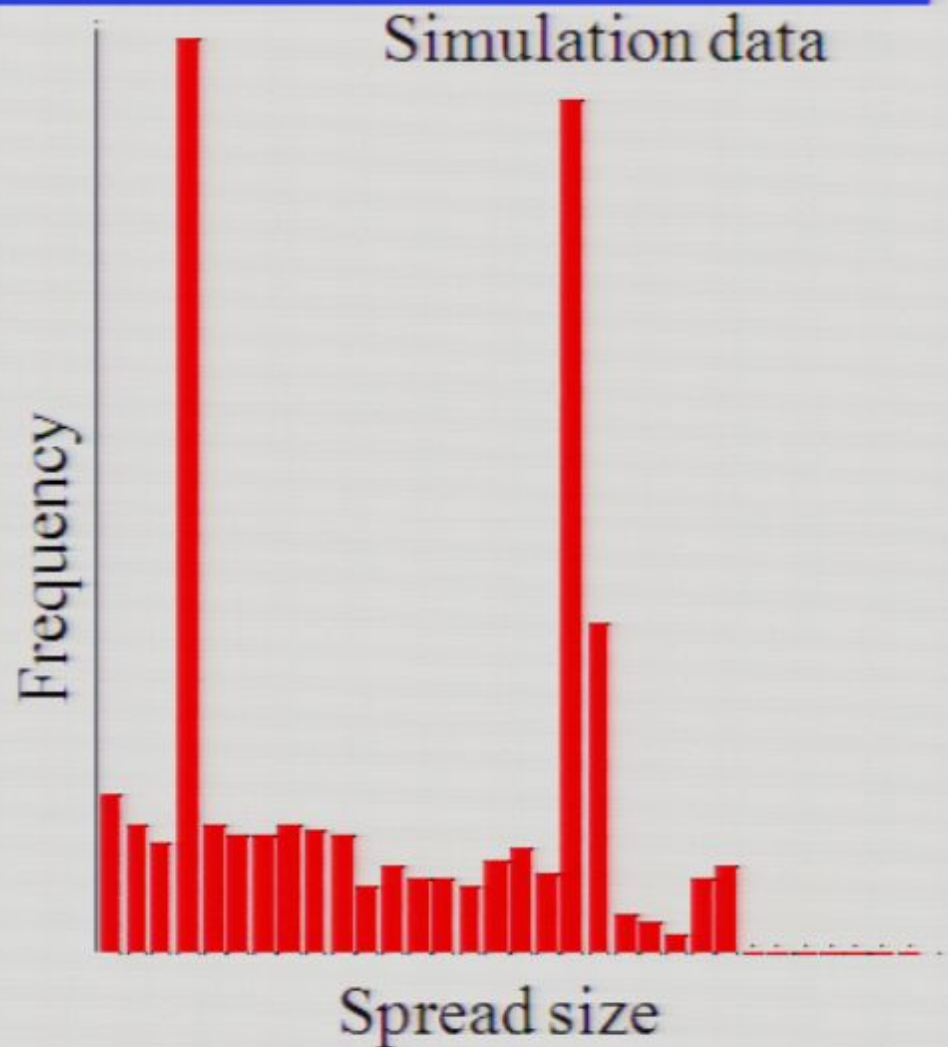
- Possible explanations:
 - Interaction and self-interaction through price
 - Existence of spread
 - Memory of traders, investors, etc.
- No explicit “herd” effects included

Spread Clustering

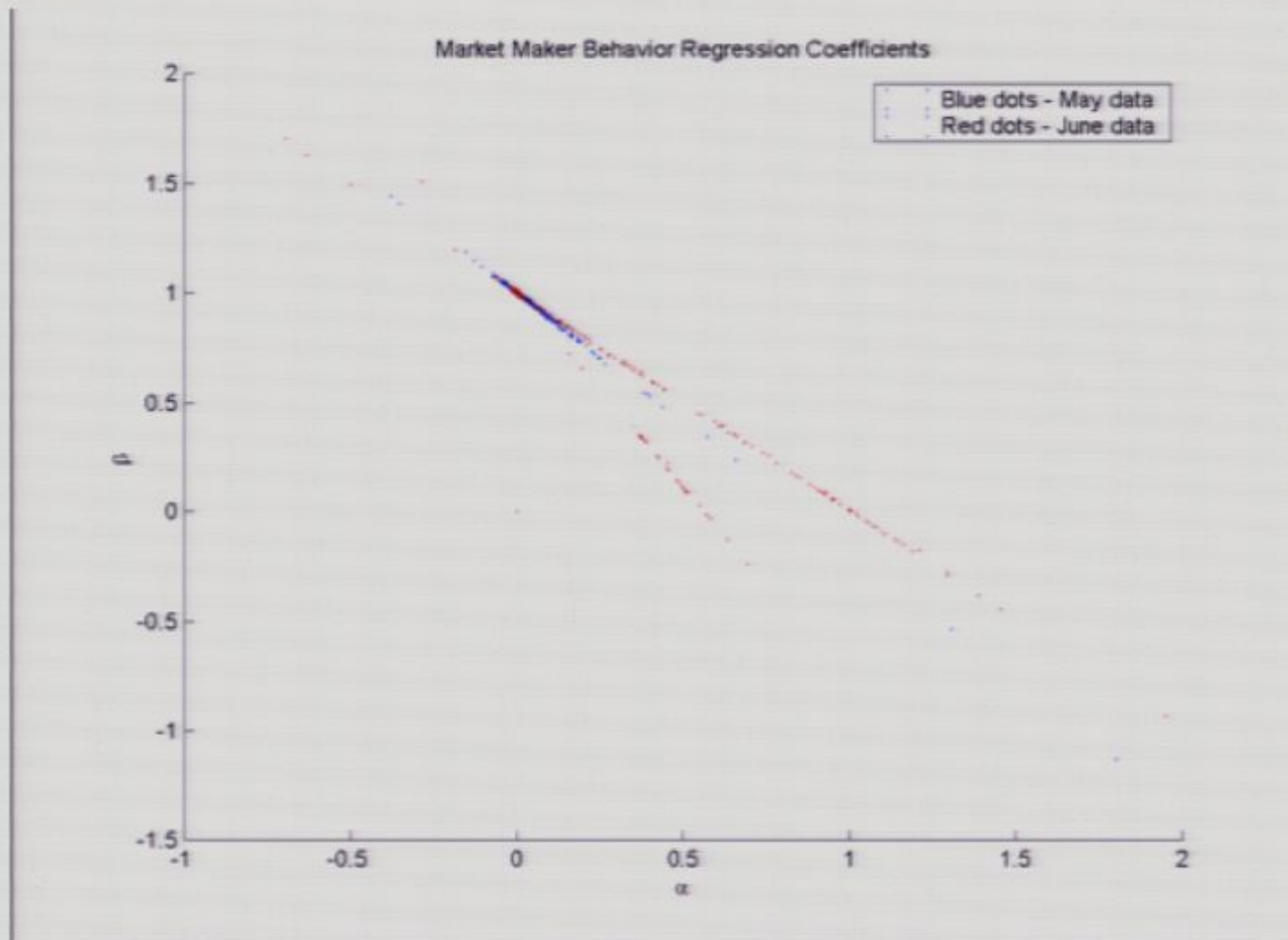
- Nasdaq dealers collusion accusations - Christie and Schulz (1994)
- SEC investigation into quoting behavior on Nasdaq (1996) and subsequent settlement
- Clustering in various financial markets - Hasbrouck (1998)

Spread Clustering

- Spread = difference between smallest offer and largest bid
- Spread clustering occurs when some spread values occur much more frequently than others



Phase Transitions



Summary of Findings

1. Decimalization (tick size reduction) will negatively impact the price discovery process.
2. Ambiguous investor wealth effects may be observed. (Investors' average wealth may actually decrease in the simulation, but the effect is not statistically significant).
3. Phase transitions will occur in the space of market-maker strategies.
4. Spread clustering may be more frequent with tick size reductions.
5. Parasitic strategies may become more effective as a result of tick size reductions.
6. Volume will increase, potentially ranging from 15% to 600%.

Comparisons with Data

Tick size was officially reduced from a $1/16^{\text{th}}$ to \$.01 (in phases) in March, 2001.

Nasdaq economists captured actual data from this transition and put the findings in their Economic Research study report.

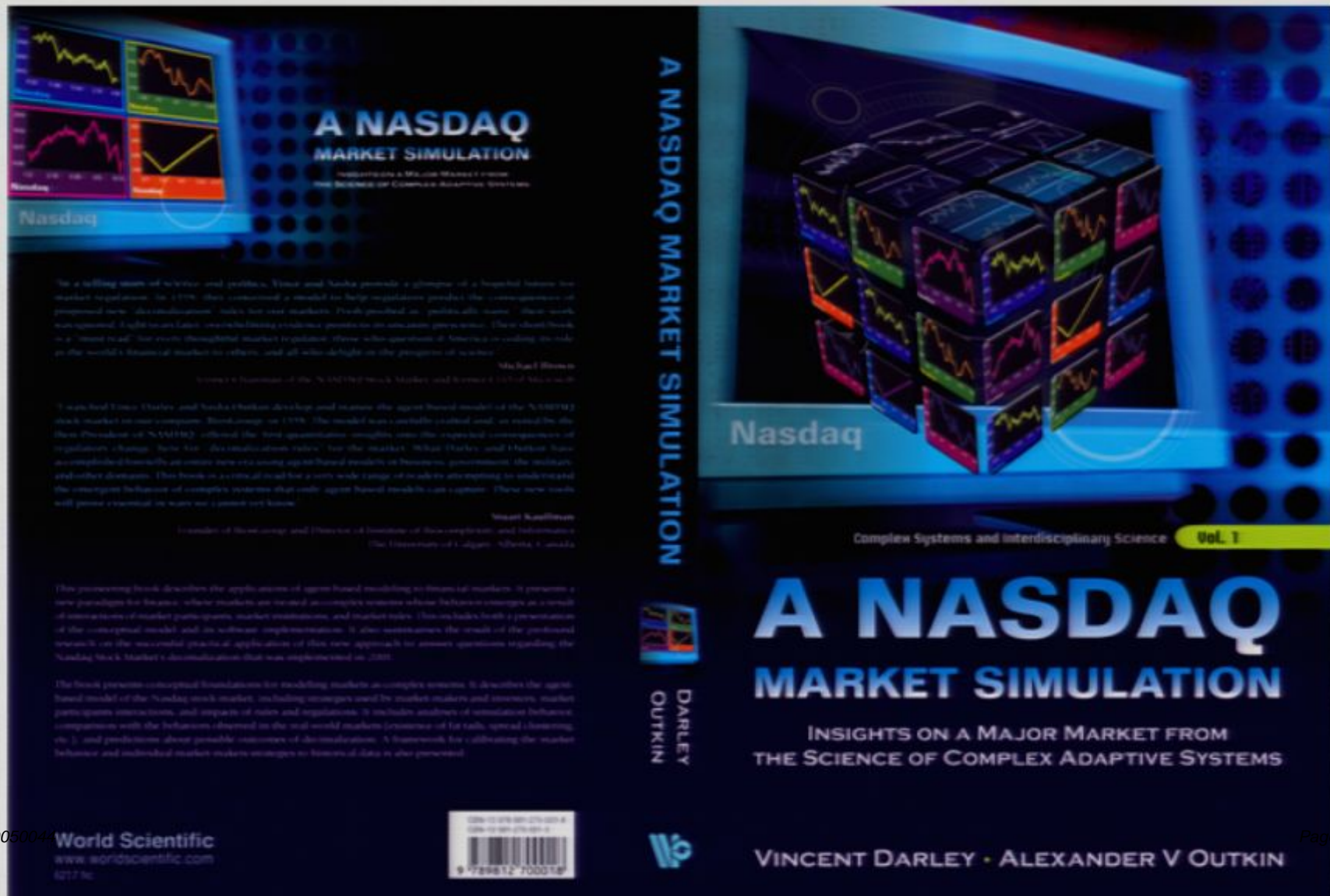
BiosGroup compared our model's results with the findings from the Nasdaq report.

Comparisons with Data (Cont.)

5 of the 6 likely outcomes actually occurred.

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Nasdaq Book



Future Directions

- Best features of ABMs combined with best features of more traditional approaches.
 - ABMs to explain / derive parameters of stochastic processes in finance. For example, what features of agents / institutions give rise to specific market behaviors?
- How strongly macro laws are coupled with the micro laws?
 - Is it possible to have the same macro behaviors when micro behaviors are different?

Longer-Term Effects

- Not only the participants strategies change, but the market institutions change as the result.

