Master's Thesis

Modelling and analysis of a financial market with slow and fast trading agents acting on time-delayed market information

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Background and motivation

A few fact about modern financial markets:

- Humans trade against software algorithms (the machines)
- Humans are slow but complex, whereas algorithms are fast, but (relatively) simple
- Fast crashes (flash crashes) has become a problem in recent years

Related work

Models for human/machine system must be developed.
Previous work:

Analysis of market data Works analyzing real market data for flash crashes and

Models of markets Works that divide agents into two groups: **slow** and **fast** traders

All discovered works in the field are recent (published 2013, or yet unpublished).

Key ideas in proposed model

Delayed market information All information exchanged between agents and the market is delayed

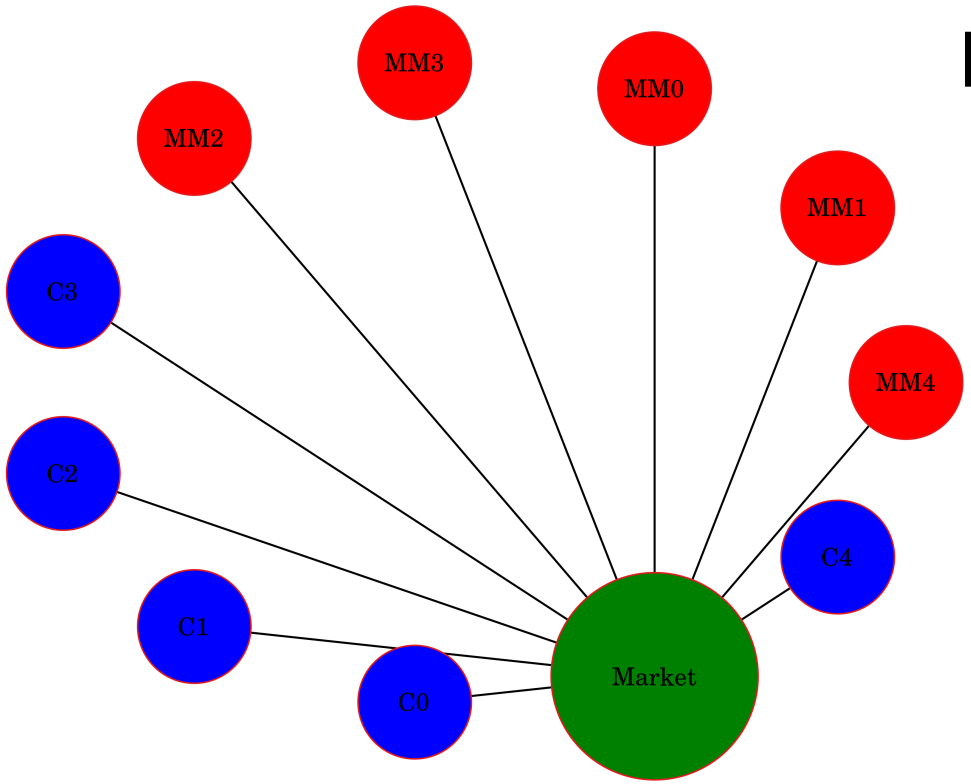
Agents with arbitrary time delays Agents are not just *fast* or *slow*, but have **arbitrary** delays

Research goal

Impact of agent speed on market behavior

Investigate how the behavior (e.g. stable, crash, etc.) of a simulated financial market changes when the latency of the traders change

Market model



Model components:

- Market
- Stock
- Agents
- Messages (orders, cancellations, receipts, etc.)

Messages are passed between agents and the market.

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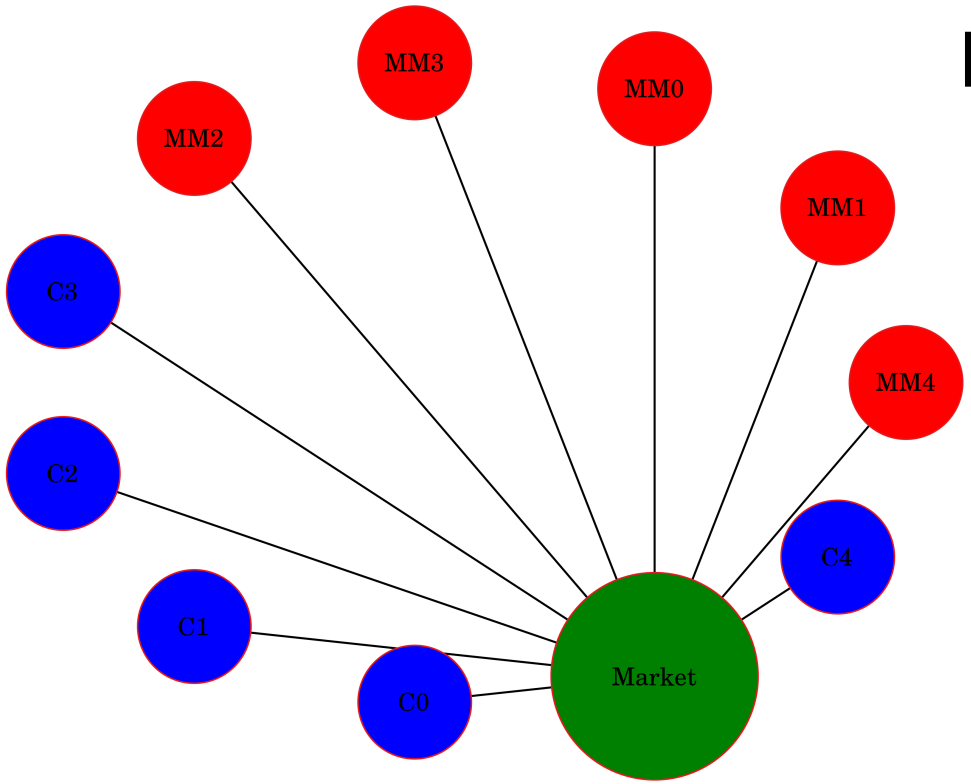

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Messages are delayed

Information travels from agents to market in different kinds of messages

- Market information
- Orders
- Receipts
- Cancellations

All messages have a non-zero travel time

Stock

A single stock is traded at the market.

Fundamental price The "*true*" value of the stock

Traded price The price at which the stock is currently traded

Agents

- Slow traders
- Fast traders (High Frequency Traders)
  - Market makers
  - Simple chartists

Slow traders

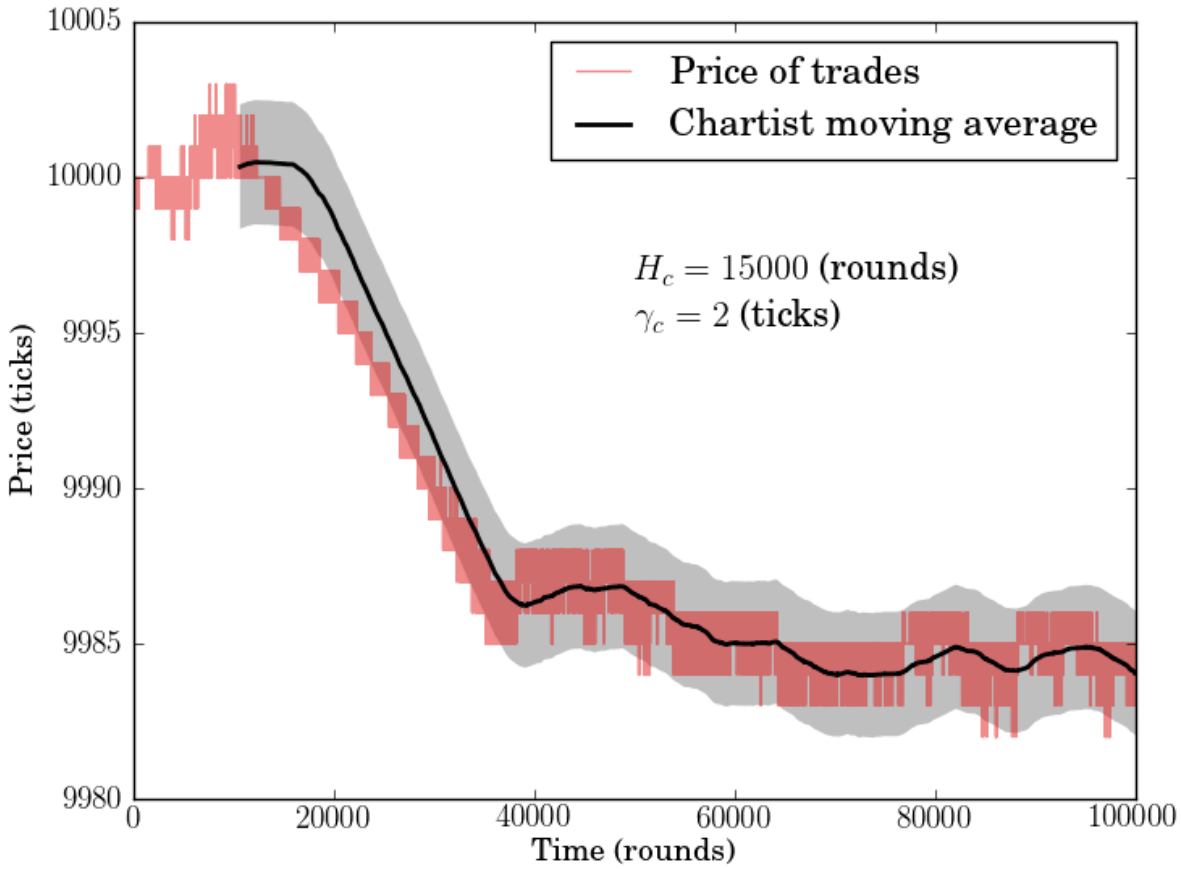
Slow traders model human traders

They know the **true** value of the fundamental, *but with a large delay*

The slow traders submit orders in order to *move the trade price towards the true price*.

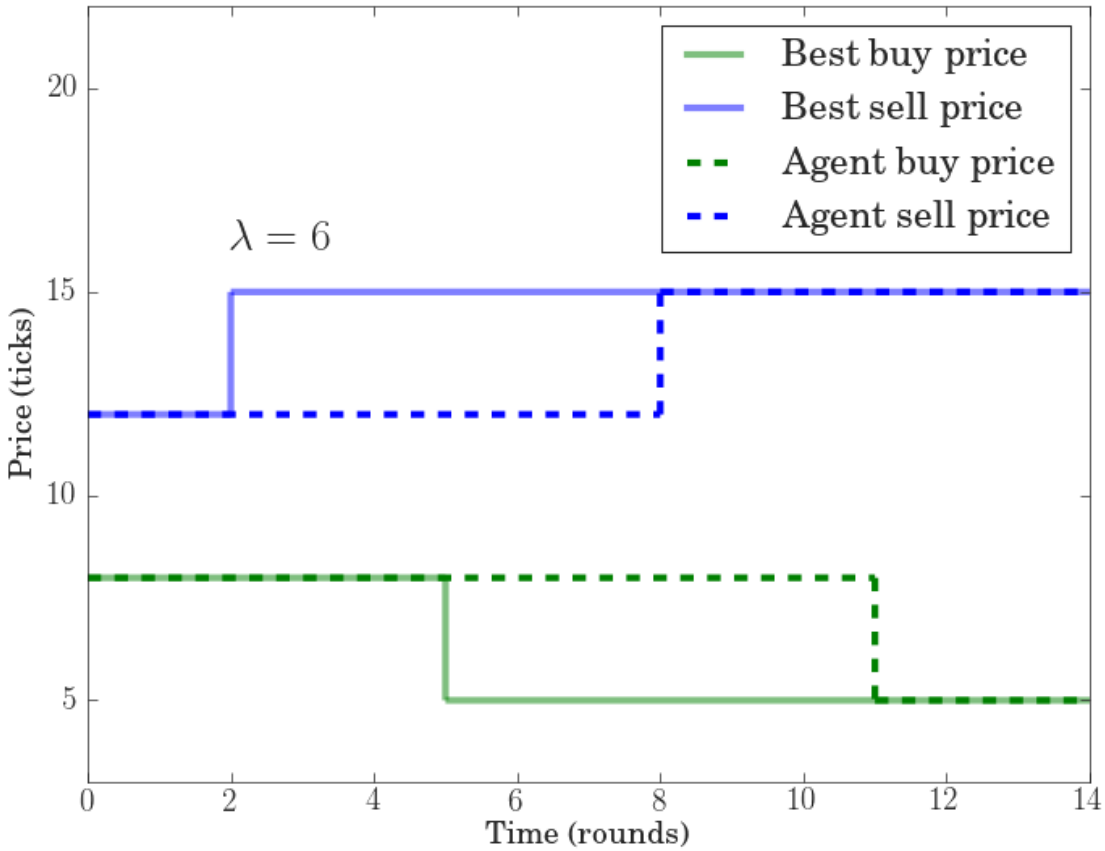
Fast trader: simple chartist

The chartists use a simple moving average strategy:



Market maker case

Market makers try to keep constant orders at both sides of the book.

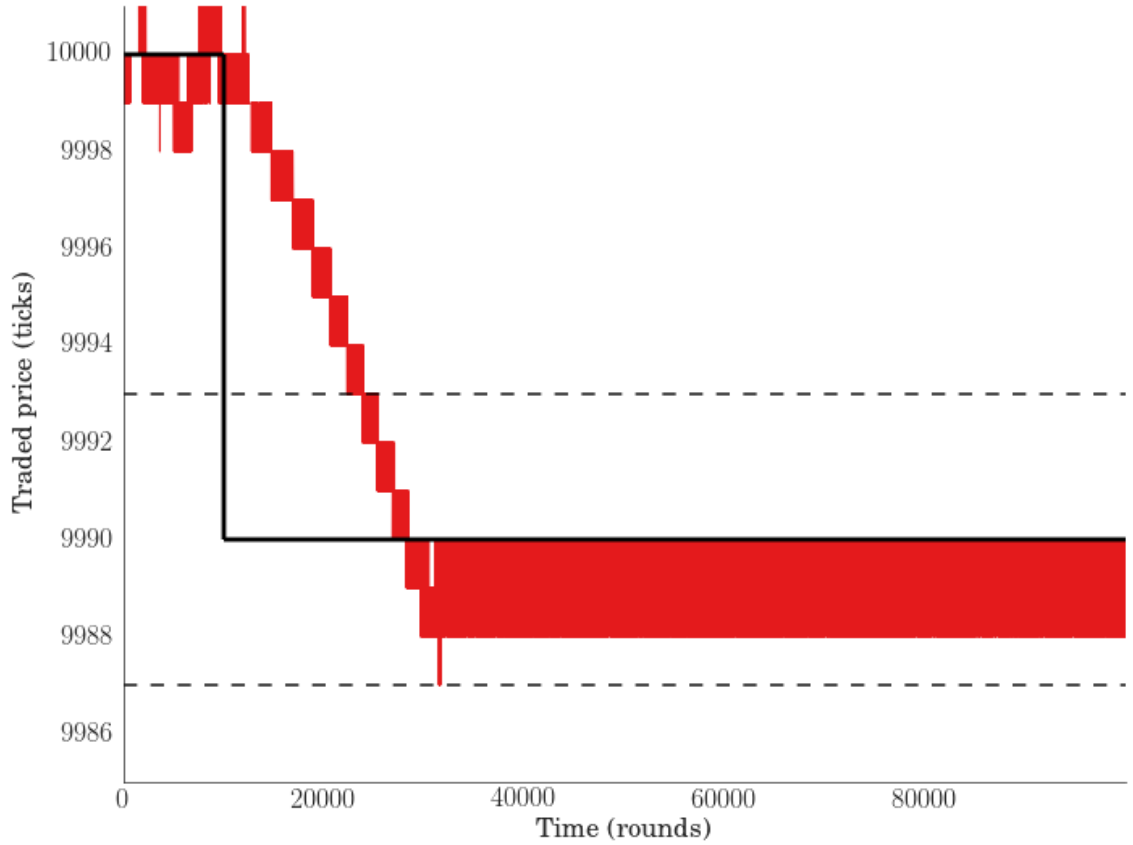


Model recap

- *Any* exchange of information between the market and agents is time delayed.
- Agent speeds are *quantitative* (e.g., 11 rounds or 23 rounds), instead of *qualitative* (slow or fast) as in previous models

Simulating bad news

How does the market react when the true price of the stock suddenly drops?



Exploring model behavior with inverse simulation

A genetic algorithm was used to find parameters causing **stable markets**. Four measures for model fitness were defined:

Overshoot Used to find **market crashes**

Response time Used to measure market reaction speed to bad news

Price flickering Standard deviation of trade prices)

Time to become stable the traded price must stay within a certain range of the true price)

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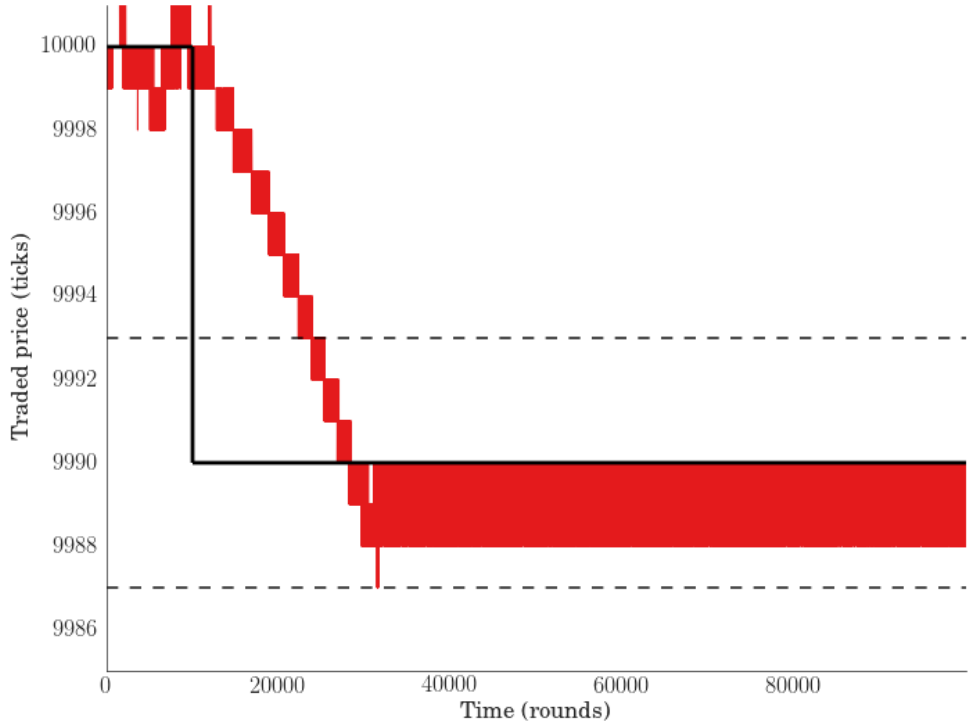
Stable market

Stable markets are found by minimizing all four fitness measures



Small overshoot, little price flickering

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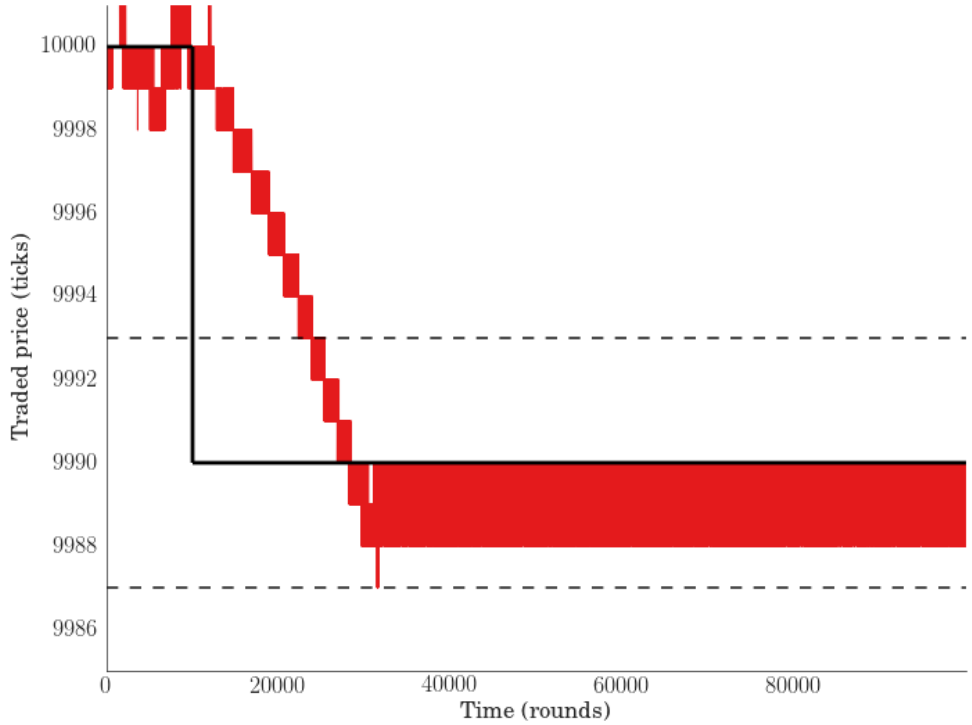

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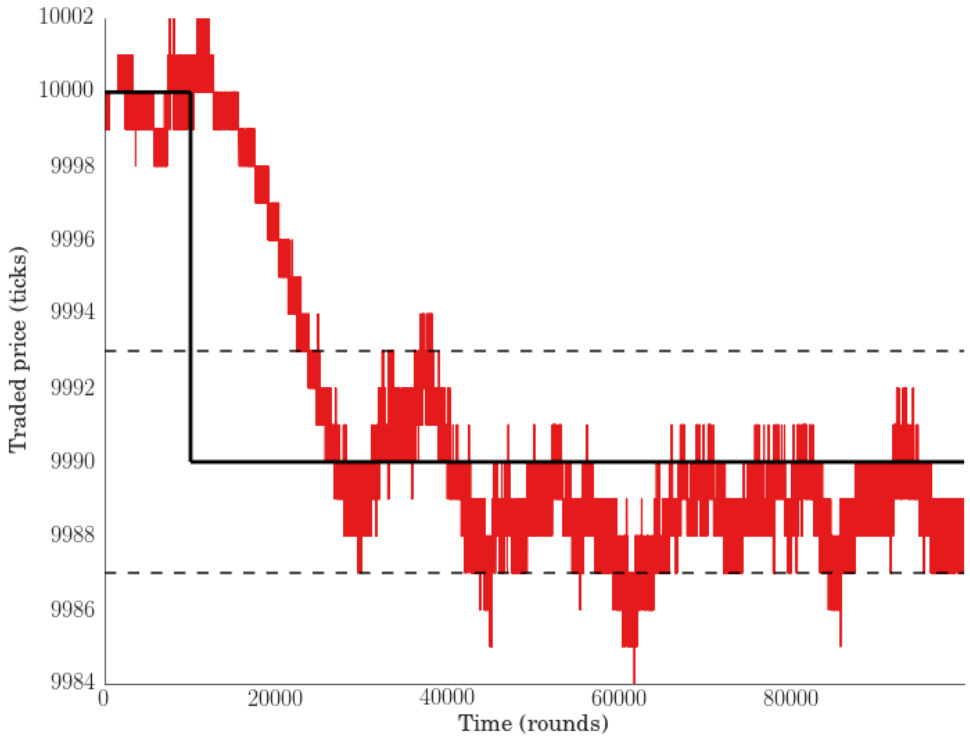
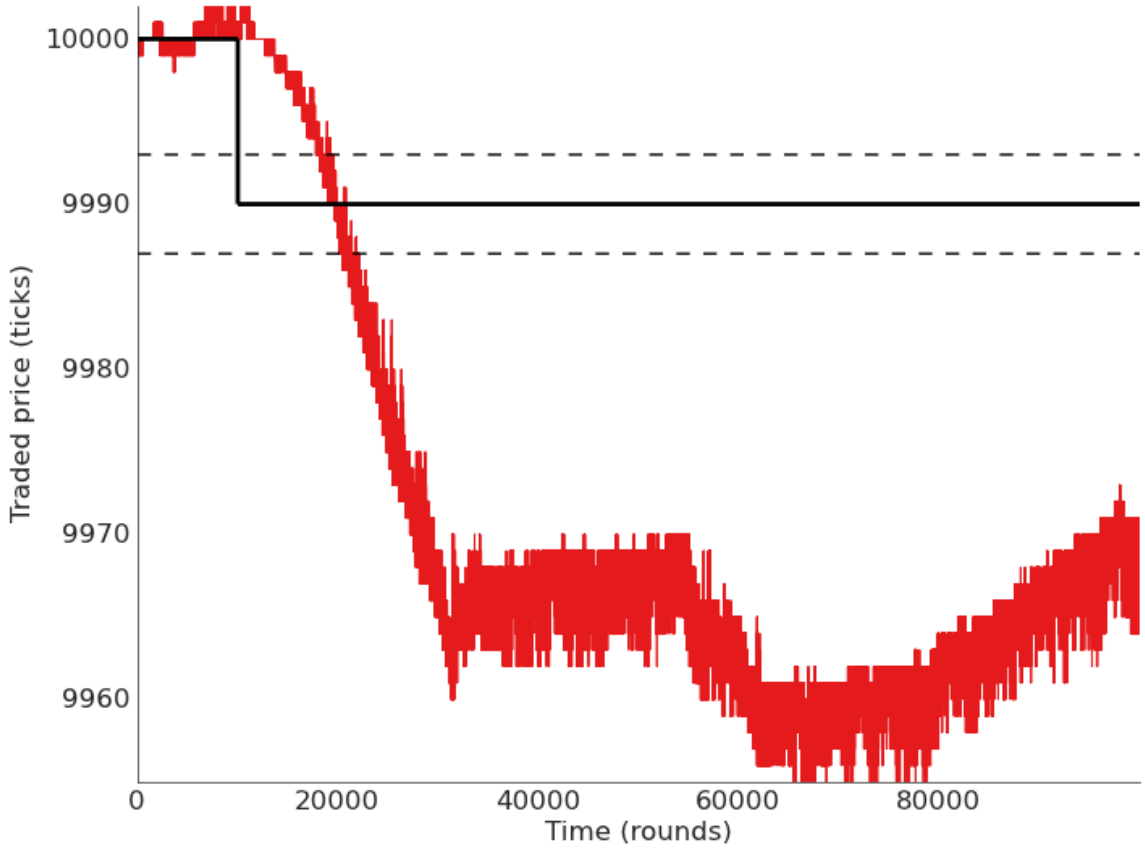
Market with large price flicker



Small overshoot but large price flickering.

Market crash

Crashing markets can be found by maximizing the overshoot.



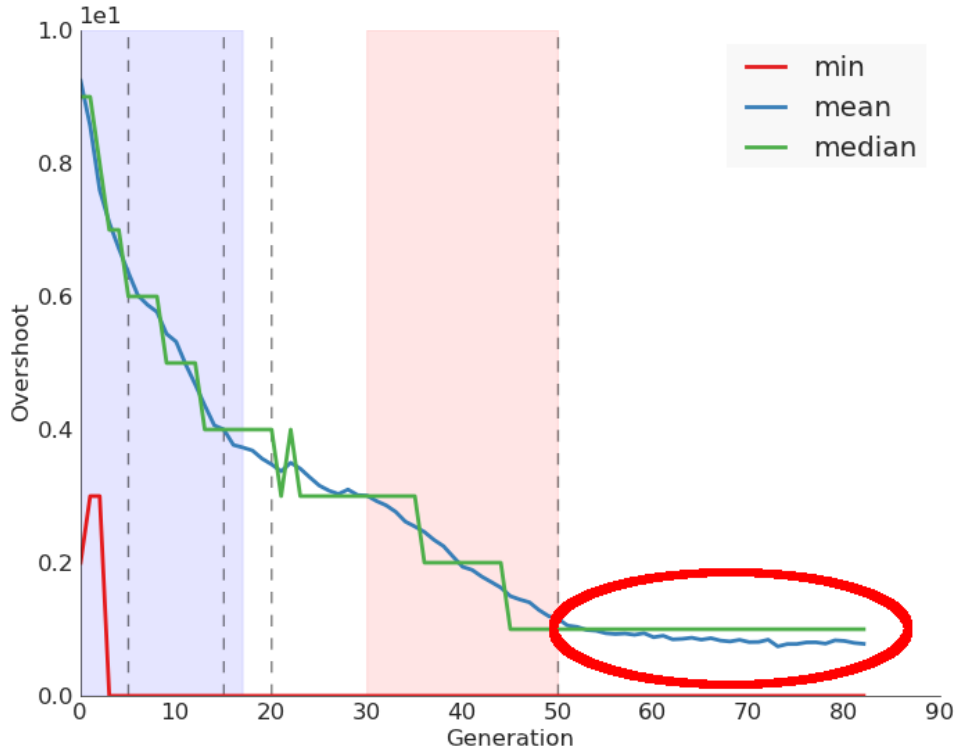
Speed/stability trade-off

- Stable markets are slow
- Slow markets are stable

What parameters cause this behavior?

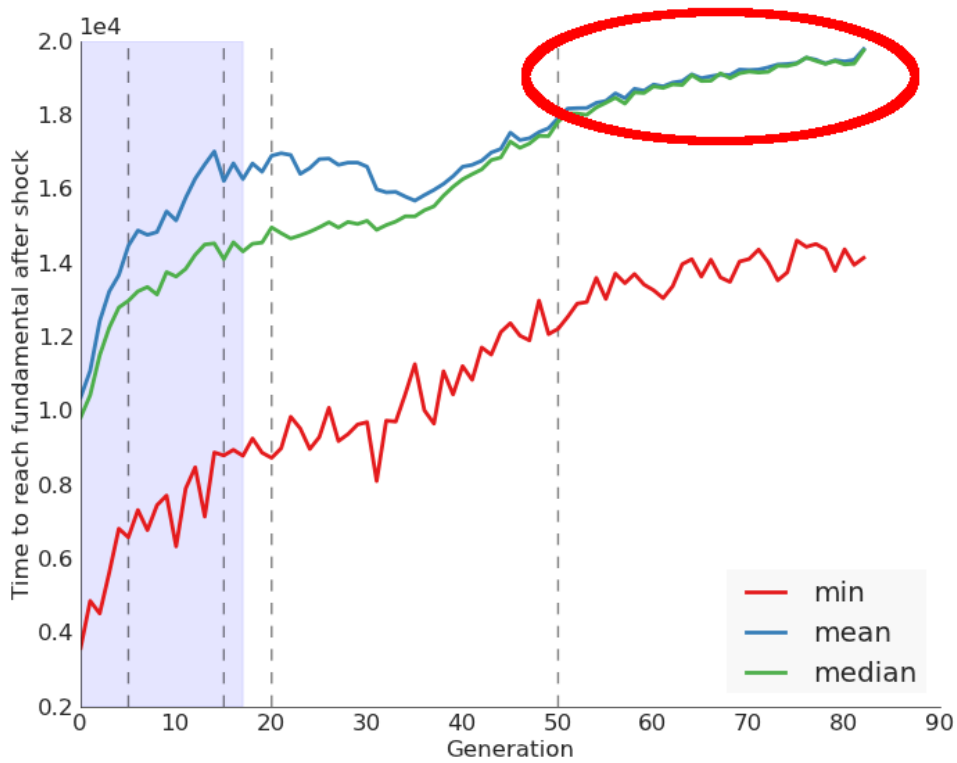
Speed/stability trade-off

The GA found stable markets (i.e.,*small overshoot*)



Speed/stability trade-off

... but the markets were unresponsive (i.e., *slow to reach the new fundamental price*)



Research goal recap 1

Central question

How does the fast trader speed affect the *market stability*?

E.g., do faster traders make the markets unstable?

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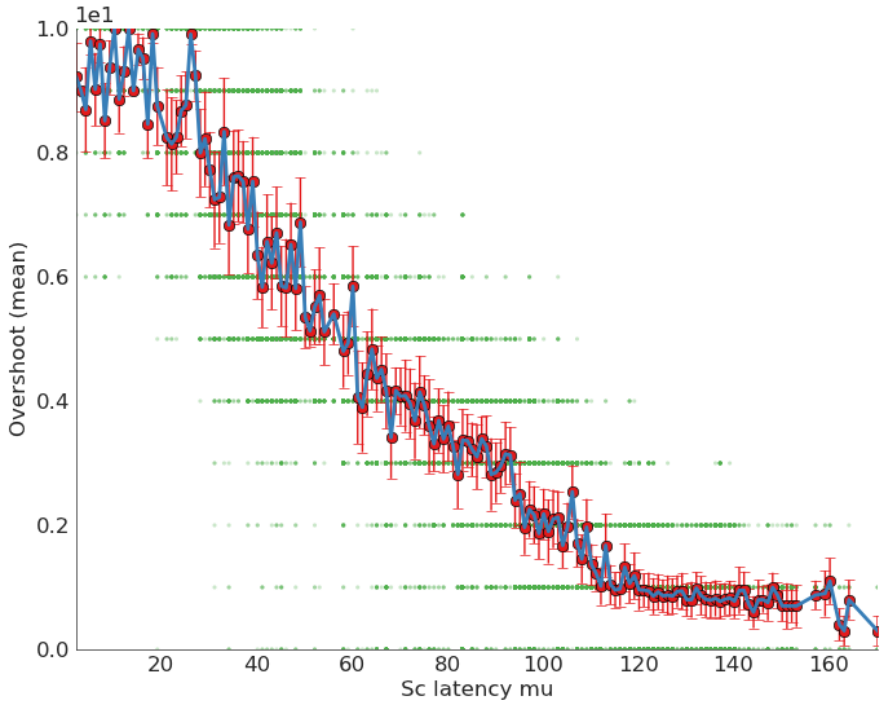
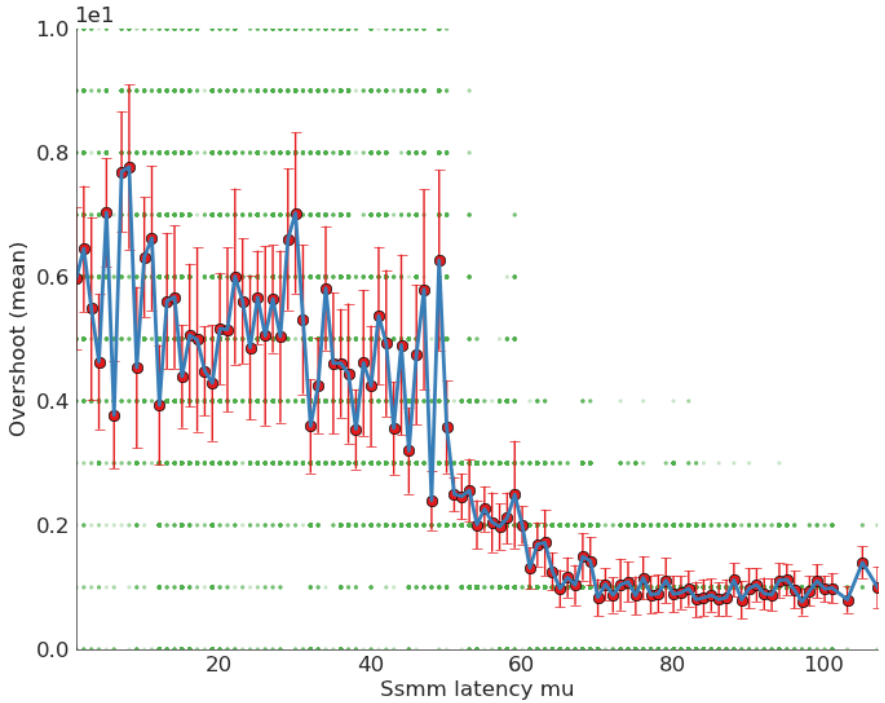
Chartist speed and market stability



Faster chartists cause the market to have a larger overshoot(i.e. the market becomes *unstable*).

Market maker speed and market stability



Faster market makers cause the market to have a somewhat larger overshoot *in some cases*.

Research goal recap 2

Central question

Does the relative speed of the fast traders matter to market stability, and if so *how*?

E.g., what happens when the chartists are faster than the market makers, or the other way around?

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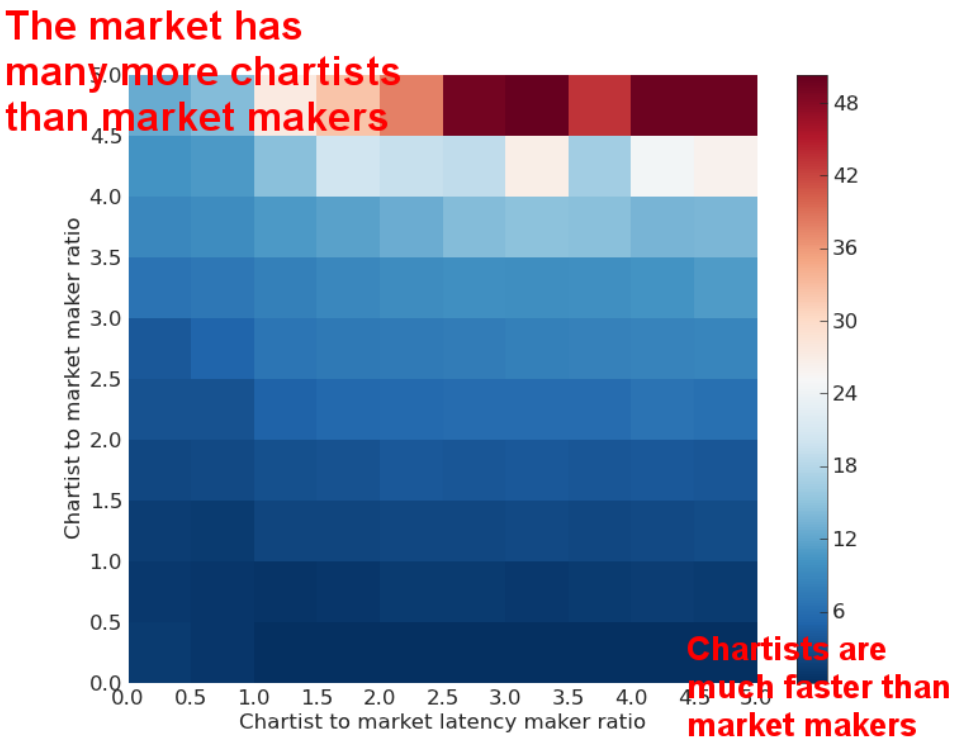
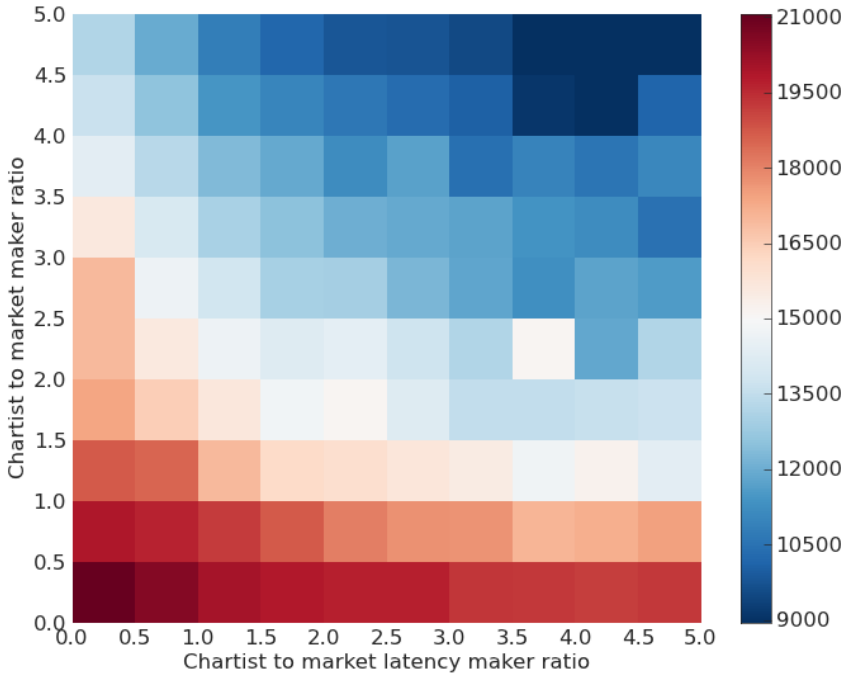
Relative trader speed and market crashes



- **Stable markets** had **few** and **slow** chartists
- **Market crashes** happened with many and **fast** chartists

Relative trader speed and response time



- **Unresponsive** market had few and **slow** chartists
- **Responsive** markets had **many** and **fast** chartists

Agent speed is important

1. Market makers **increase stability** the market, but **decrease responsiveness** .
2. Chartists **increase responsiveness** , but **decrease stability**

The influence was *larger* for *faster* agents

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Conditions for market crashes

1. The market *may* crash when there are **many fast** chartists, but **only** if there are also *some* active of market makers
2. The market was more likely to crash if the *chartists were faster than the market makers*

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Conclusion

Fast traders are both good and bad for the market:

- Fast traders can **reduce misvaluation** , but also cause **market crashes**.

Modeling relative speed of different agents can give new insights

- Market crashes did not just happen with many fast traders, but when some fast trader were **faster** than others.

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Thank you for your attention.


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