Spoofing the Limit Order Book: An Agent-Based Model
Spoofing refers to the practice of submitting large spurious orders to buy or sell some security to mislead other traders’ beliefs.
True buy order

True sell order

Spoofing buy order

Spoofing sell order

Source: Financial Conduct Authority, Animated Example of Mr Coscia’s Trading
Why an Agent-Based Model

- Simulate financial markets as complex multi-agent systems.
- Elucidate the strategic choices faced by market participants.
- Evaluate market performance and the impact of spoofing given agent interactions at Nash equilibrium.
Motivating Questions

• Can we model a market where spoofing effectively manipulates rational traders’ beliefs about prices?

• What is the impact of spoofing on market performance and trading behavior? Can we quantify the effect of spoofing?
Trading Agents

**Background Traders:** Investors with preference on longing or shorting.

*Zero intelligence* (ZI) [Gode & Sunder 1993, Wah & Wellman 2015]

Agents bid randomly based on its own valuation and a stochastic requested surplus.

*Heuristic belief learning* (HBL) [Gjerstad & Dickhaut 1998]

Agents learn from the limit order book in memory to approximate the probability of an order being accepted and choose a bid price to maximize expected surplus.

**Spoof:** A manipulator aims to push price up (or down) by submitting spurious orders. Spoofing can be effective only to the extent that traders use order book information to make trading decisions.
The fundamental value of the underlying security: a mean-reverting time series with a system-wide market shock.

\[ r_t = \max\{0, \kappa \bar{r} + (1 - \kappa) r_{t-1} + u_t\}, \quad u_t \sim N(0, \sigma_s^2) \]
An Agent-Based Market Model

- Observe fundamental value with noise.
- Estimate current fundamental.
- Estimate final fundamental.

The entries of a background trader follow a Poisson process with an arrival rate.
Submit a single unit order at price jointly decided by private value, fundamental estimation, and strategy.

- Adverse selection
- Incomplete information about fundamental
Experiments and Results

Market Environment:
• Markets with different levels of fundamental shock and observation noise.
• Markets with \( N = \{28, 65\} \) background traders.
• Markets with and without spoofing.

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Background Trading Strategies:
• Seven versions of ZI and four versions of HBL strategies.
• Conduct empirical game-theoretic analysis (EGTA) to find Nash Equilibrium.
Experiments and Results

Without Spoofing

- Strategic choices between HBL and ZI
- HBL’s impact on market performance

With Spoofing

- Market manipulated by spoofing trick
- Spoofing’s impact on agent performance
- Spoofing’s impact on strategic choices
- Spoofing’s impact on market performance

EGTA (HBL, ZI)
EGTA (ZI)

SP + EGTA (HBL, ZI)

EGTA (HBL, ZI | SP)
Experiments and Results

Without Spoofing

- Strategic choices between HBL and ZI
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Experiments and Results

Without Spoofing

EGTA (HBL, ZI)
EGTA (ZI)

With Spoofing

SP + EGTA (HBL, ZI)

EGTA (HBL, ZI | SP)

• Spoofing’s impact on strategic choices
• Spoofing’s impact on market performance
Agent Strategic Choices - EGTA (HBL, ZI)

When spoofing is absent, investors generally have incentives to make bidding decisions based on order book information.
HBL Improves Price Discovery - EGTA (HBL, ZI) vs EGTA (ZI)

(a) $N = 28$

(b) $N = 65$
HBL Improves Market Surplus - EGTA (HBL, ZI) vs EGTA (ZI)

(a) \(N = 28\)

(b) \(N = 65\)
Experiments and Results

Without Spoofing

- Strategic choices between HBL and ZI
- HBL’s impact on market performance

EGTA (ZI)
EGTA (HBL, ZI)

With Spoofing

- Market manipulated by spoofing trick
- Spoofing’s impact on agent performance

SP
+ EGTA (HBL, ZI)

EGTA (HBL, ZI | SP)

- Spoofing’s impact on strategic choices
- Spoofing’s impact on market performance
A Spoofable Market with HBL Traders

Amplified (diminished) spoofing effect in markets with more HBL (ZI).
In a market with spoofing, ZI can take advantages of HBL’s spoofed beliefs.
Experiments and Results

Without Spoofing

- Strategic choices between HBL and ZI
- HBL’s impact on market performance

With Spoofing

- SP
- SP + EGTA (HBL, ZI)

- Market manipulated by spoofing trick
- Spoofing’s impact on agent performance

- EGTA (HBL, ZI | SP)
- Spoofing’s impact on strategic choices
- Spoofing’s impact on market performance
Agent Strategic Choices with Spoofing

When re-equilibrating games with spoofing, HBL often remains in mixed equilibria but with smaller proportions.
The presence of spoofing generally decreases market surplus.
Ongoing Work & Future Directions

- What are some of the general characteristics of market environments subject to spoofing?
- Are there more robust ways for exchanges to disclose order book information?
- Are there strategies by which traders can exploit order book information but in less vulnerable ways?
- Based on a model of this kind, can we design effective spoofing detection methods?
Summary

Without Spoofing

EGTA (HBL, ZI)
EGTA (ZI)

- HBL is a strategic choice.
- HBL has positive impact on market performance.

With Spoofing

SP
+  
EGTA (HBL, ZI)

- Market with HBL traders are spoofable.
- Spoofing will cause a surplus redistribution.

EGTA (HBL, ZI | SP)

- Spoofing decreases the HBL proportion.
- Spoofing tends to decrease market surplus.

Thank you, questions?  

*Paper #619 Poster @ EE2*