Spoofing the Limit Order Book: An Agent-Based Model

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STRATEGIC REASONING GROUP

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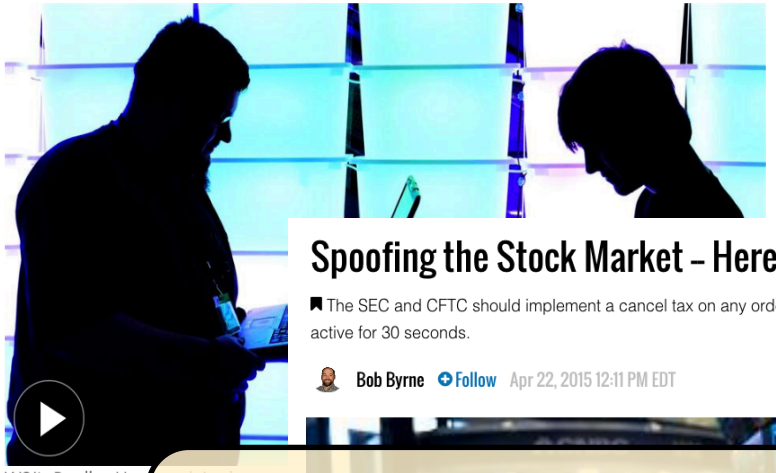
MARKETS

As 'Spoof' Trading Persists, Regulators Clamp Down

Bluffing Tactic That Dodd-Frank Banned in 2010 Can Distort Markets



WSJ's Bradley Hop explains how reg designed to trick other investors into
Getty

By BRADLEY HOPE

Updated Feb. 2015 12:3

CHICAGO – One June m traders ca "The Russian" l crude futures on a London

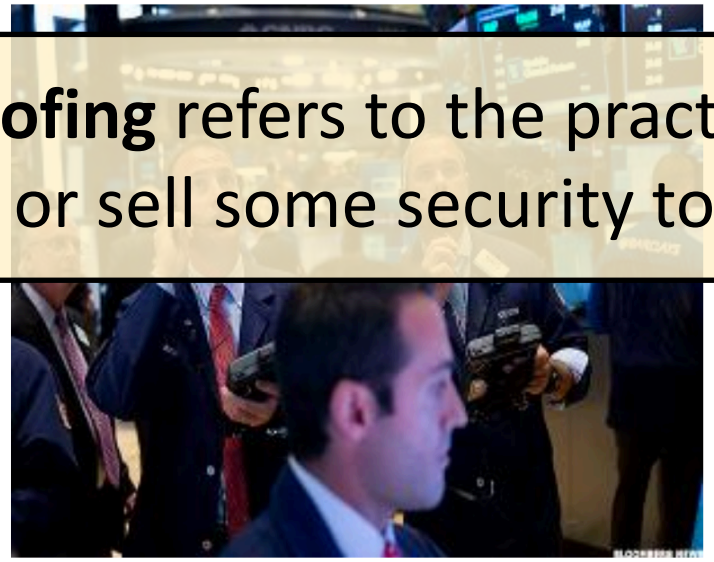
Over six hours, Igor Oystacl including thousands of buy the exchange to his clearing canceled many of those ord show, in what the exchange trick other investors into bu

Traders call the illegal bluff used to manipulate prices o

Spoofing the Stock Market – Here's One Way to Stop It

The SEC and CFTC should implement a cancel tax on any order entered within 1% of the national best bid o active for 30 seconds.

Bob Byrne Follow Apr 22, 2015 12:11 PM EDT



NEW YORK (Real Money) -- Tuesday's big story, away from the hustle and bustle of earnings season, was the arrest of Navinder Singh Sarao by British authorities (in cooperation with the U.S. Department of Justice).

Sarao is being accused by the U.S. Commodity Futures Trading Commission (CFTC) of "unlawfully manipulating, attempting to manipulate and spoofing" the E-Mini S&P 500 futures (Es) contract. The CFTC's complaint goes on to allege that Sarao was "engaged in a variety of other manual spoofing techniques whereby defendant(s) would place and quickly cancel large orders with no intention of the orders resulting in transactions."

Flash Crash Trader E-Mails Show Spoofing Strategy, U.S. Says

by Tom Schoenberg Tschoenberg22 Suzi Ring journosooz Janan Hanna

3, 2015 – 4:03 PM EDT *Updated on* September 4, 2015 – 9:32 AM EDT

Singh Sarao leaves Westminster Magistrates' Court in London, on Friday, Au apher: Chris Ratcliffe/Bloomberg Photographer: Chris Ratcliffe/Bloomberg

orders are `costing me,' Sarao said to tell programmer

hent's new details seen bolstering U.S. extradition case

The British day trader accused of contributing to the 2010 flash crash enlistec programmer to help him work out a system to manipulate stock prices, e-mai perfecting his "spoofing" efforts, U.S. prosecutors said in an indictment.

"I need to know whether you can do what I need, because at the moment I'm spoofs all the time and it's costing me a lot of money," Navinder Singh Sarao 2009 e-mail to a programmer he'd tapped to build trading software, accordin

US seals first prosecution against stock market trader for 'spoofing'

A jury convicts Michael Coscia on six charges of commodities fraud and six charges of spoofing, all of the charges he faced

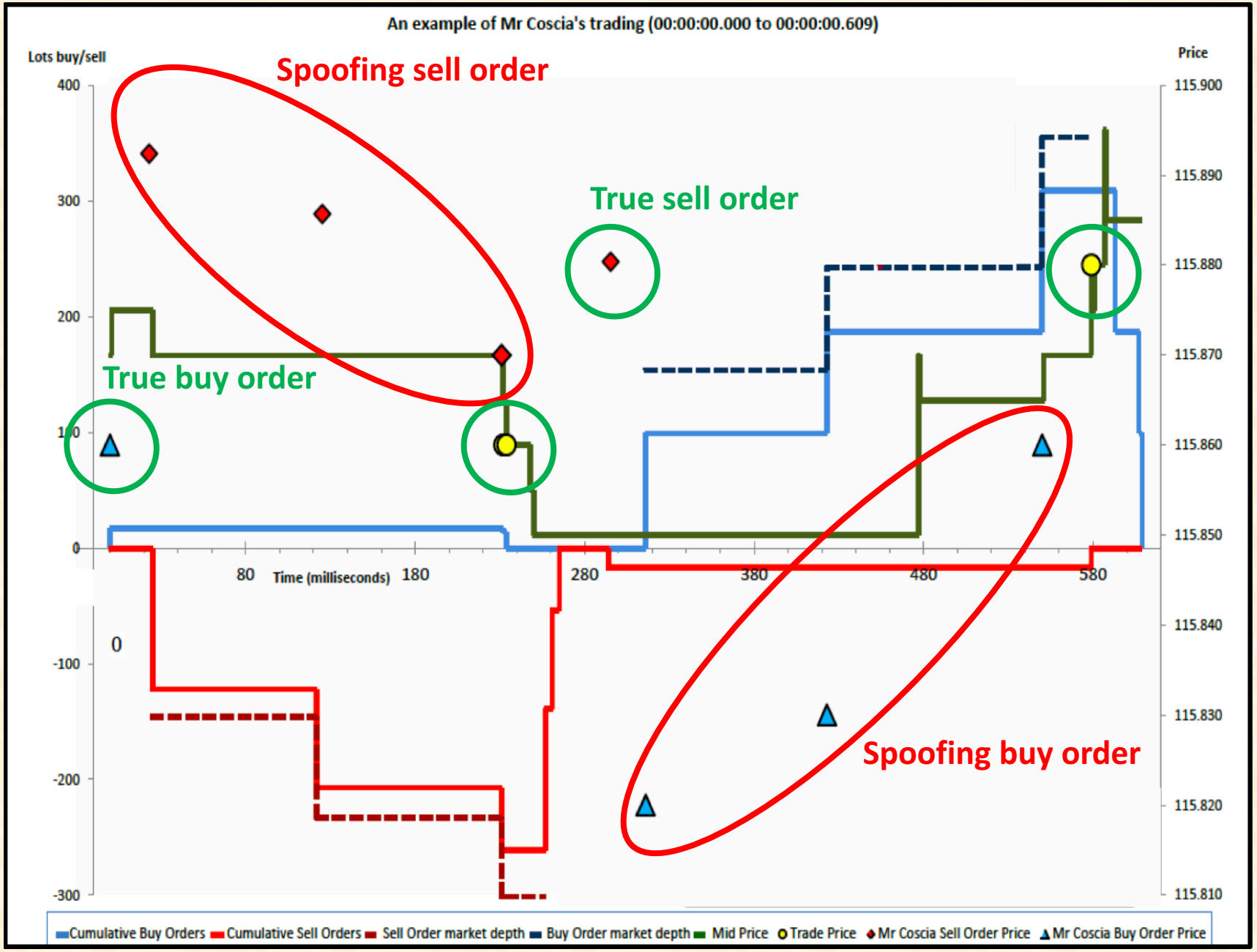
Prosecutors said Michael Coscia wanted to lure other traders to markets by creating an illusion of demand so that he could make money on smaller trades Photo: AP

By Reuters

11:48PM GMT 03 Nov 2015

A US jury has found high-frequency trader Michael Coscia guilty of

Spoofing refers to the practice of submitting large **spurious** orders to buy or sell some security to mislead other traders' beliefs.



Source: Financial Conduct Authority, Animated Example of Mr Coscia's Trading

Why an Agent-Based Model

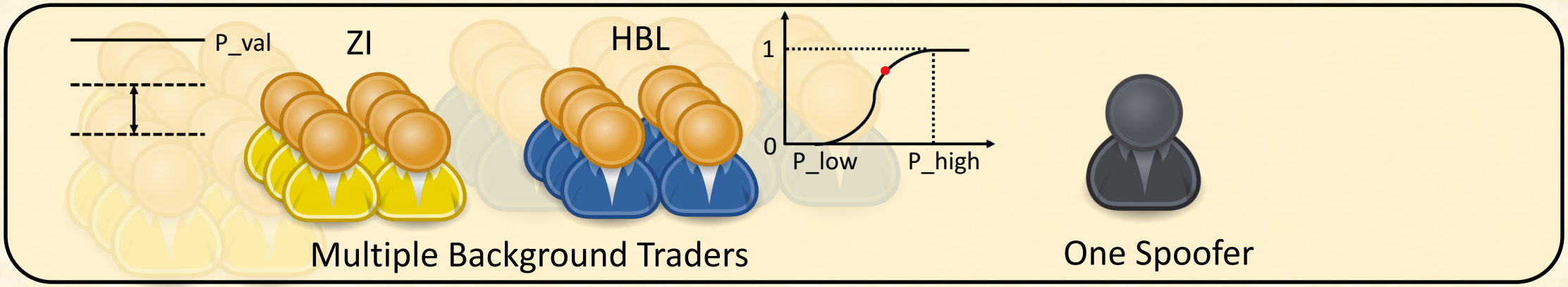
- Simulate financial markets as complex multi-agent systems.
- Elucidate the strategic choices faced by market participants.
- Evaluate market performance and the impact of spoofing given agent interactions at Nash equilibrium.

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.

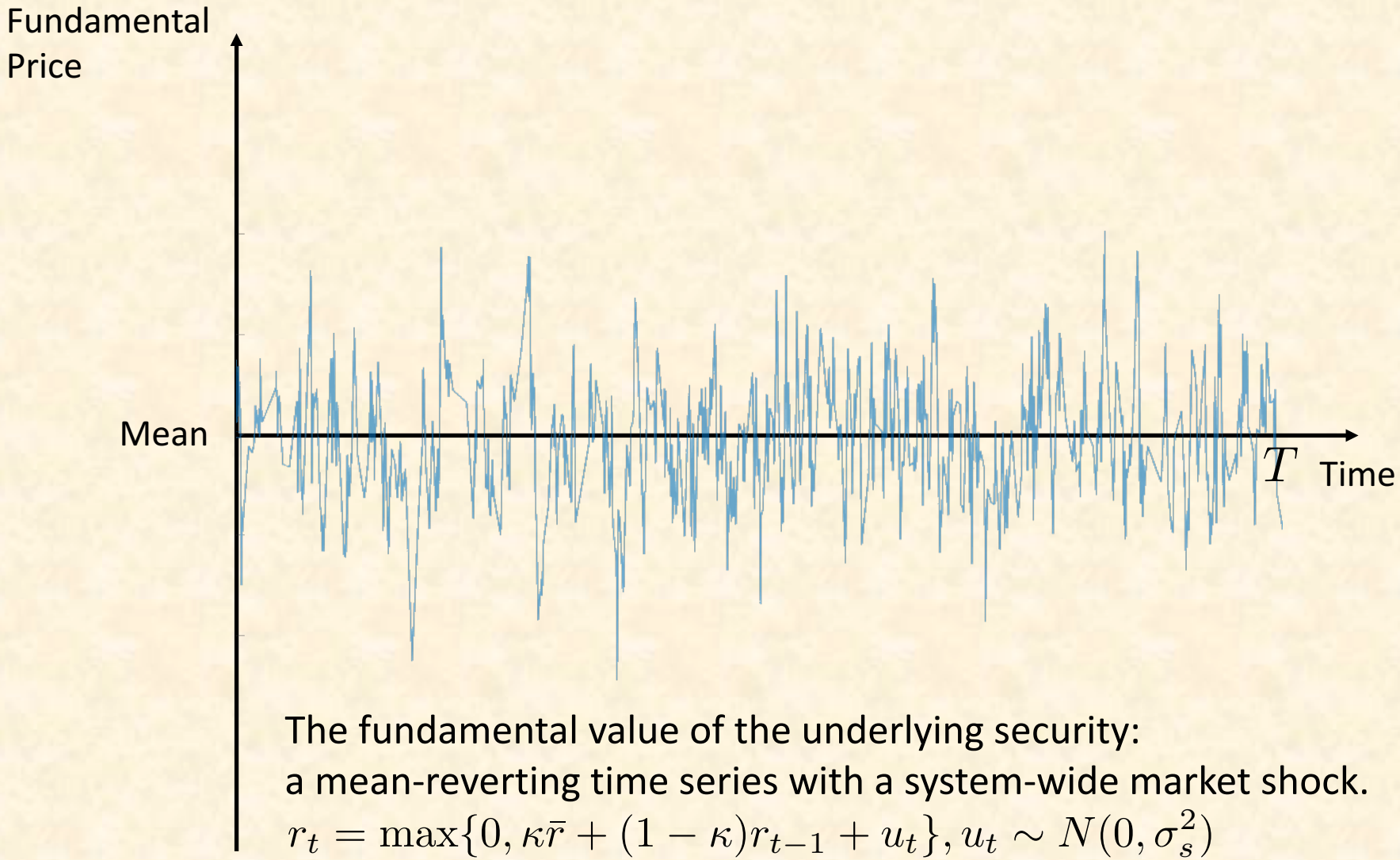
Heuristic belief learning (HBL) [Gjerstad & Dickhaut 1998]

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.

Spoofer: 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.

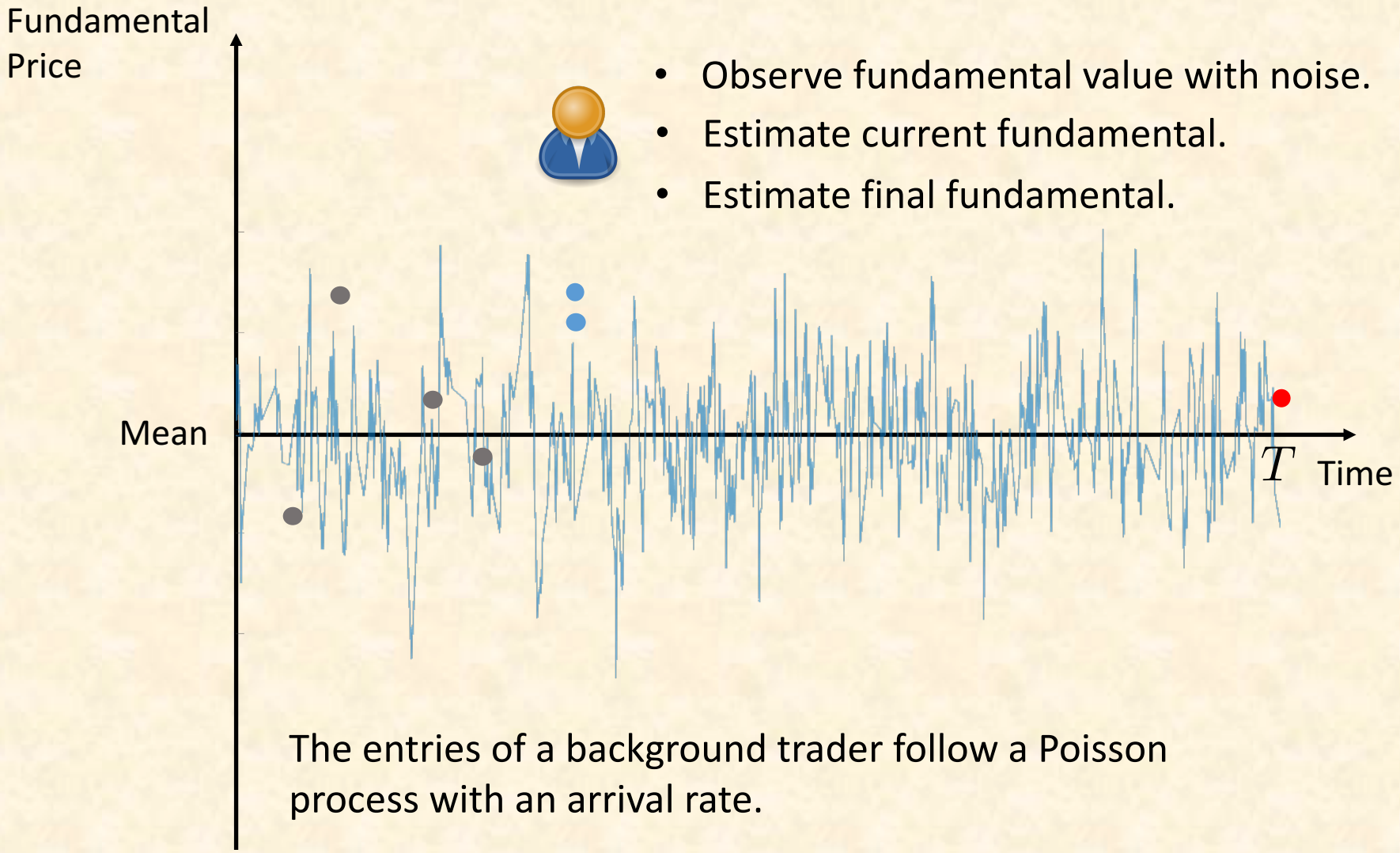
An Agent-Based Market Model



The fundamental value of the underlying security:
a mean-reverting time series with a system-wide market shock.

$$r_t = \max\{0, \kappa\bar{r} + (1-\kappa)r_{t-1} + u_t\}, u_t \sim N(0, \sigma_s^2)$$

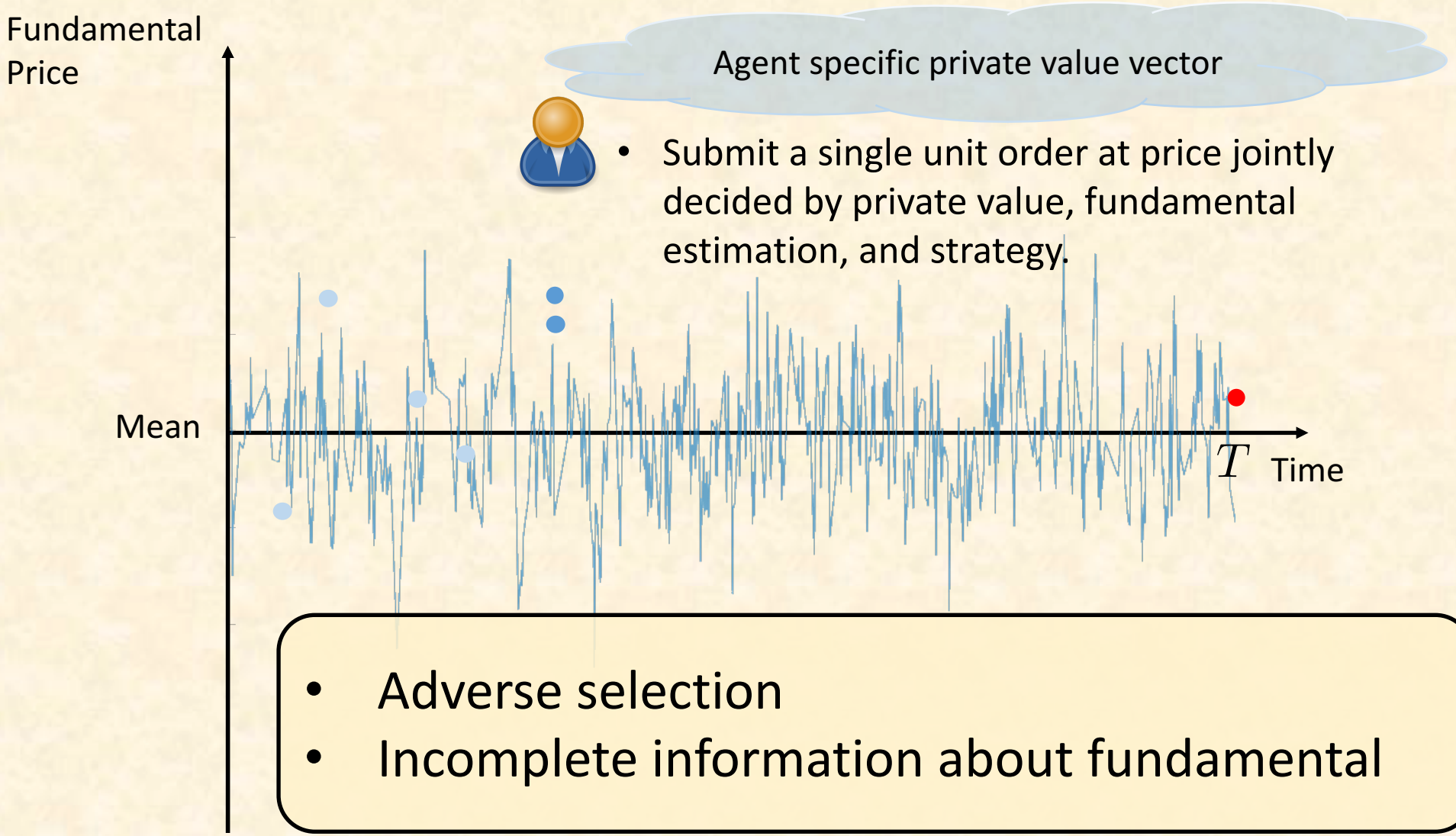
An Agent-Based Market Model



- 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.

An Agent-Based Market Model



- 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.

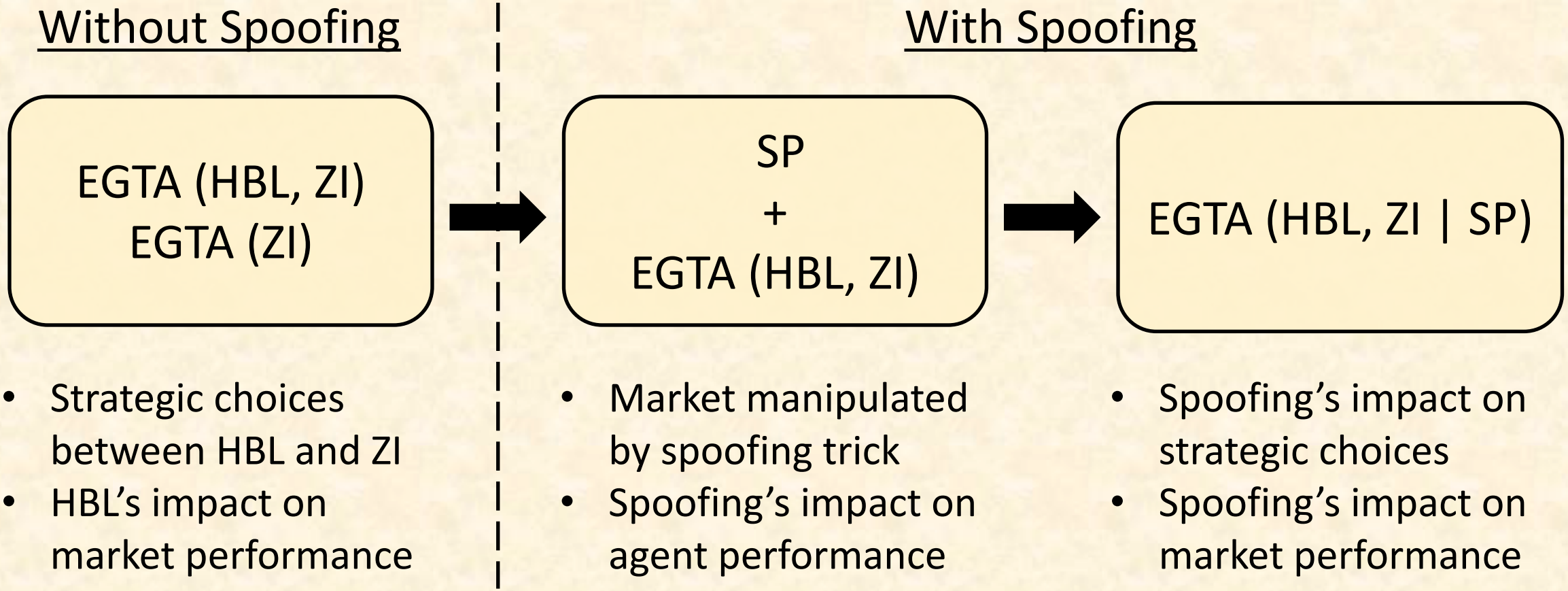
Env	A1	A2	A3	B1	B2	B3	C1	C2	C3
σ_s^2	low	low	low	medium	medium	medium	high	high	high
σ_n^2	low	medium	high	low	medium	high	low	medium	high

- Markets with *N* = {28, 65} background traders.
- Markets with and without spoofing.

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



Experiments and Results

Without Spoofing

EGTA (HBL, ZI)
EGTA (ZI)

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

With Spoofing

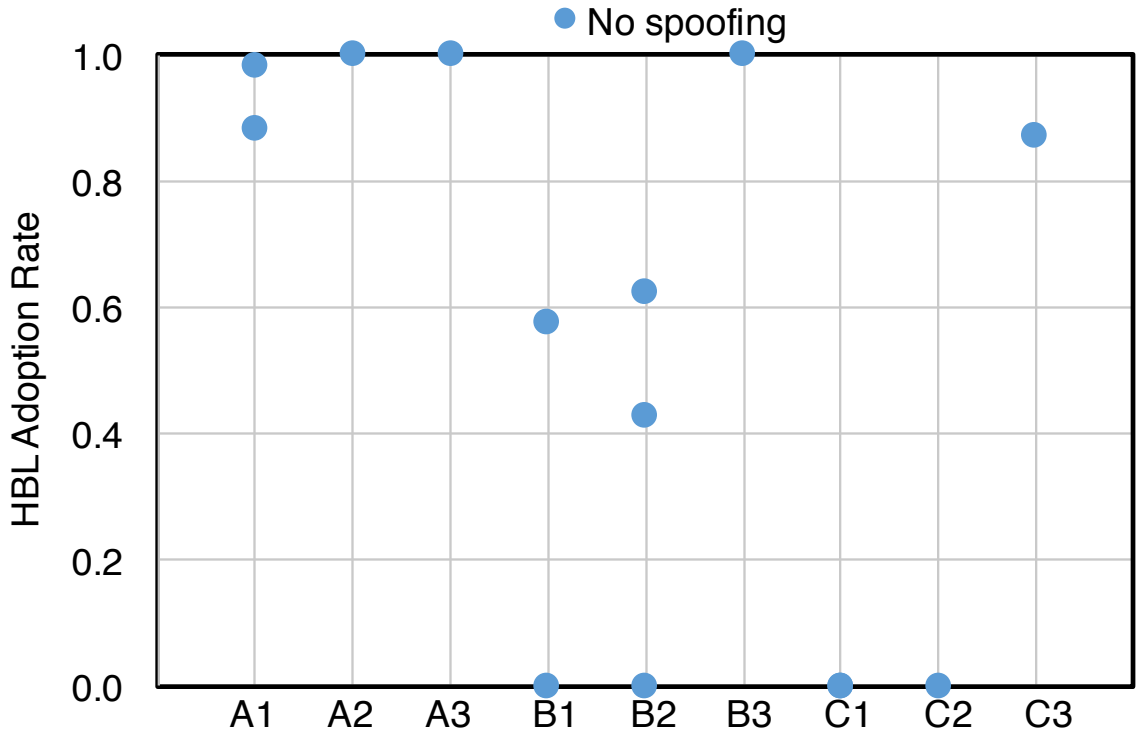
SP
+
EGTA (HBL, ZI)

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

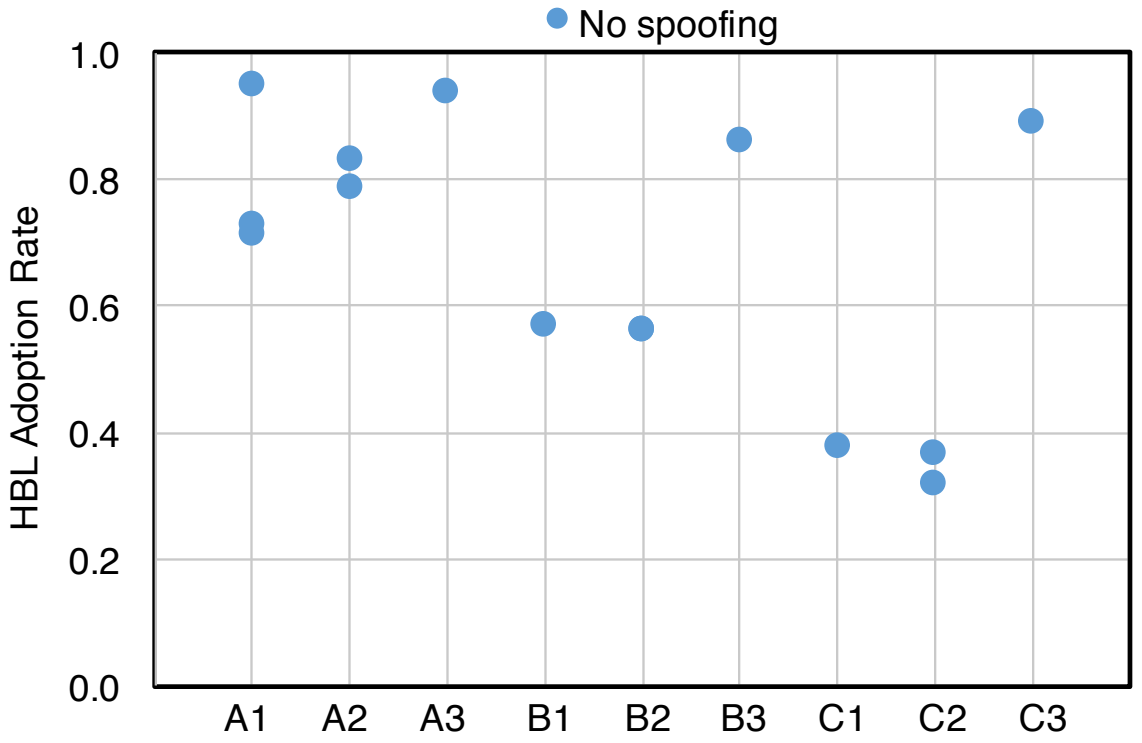
EGTA (HBL, ZI | SP)

- Spoofing's impact on strategic choices
- Spoofing's impact on market performance

Agent Strategic Choices - EGTA (HBL, ZI)



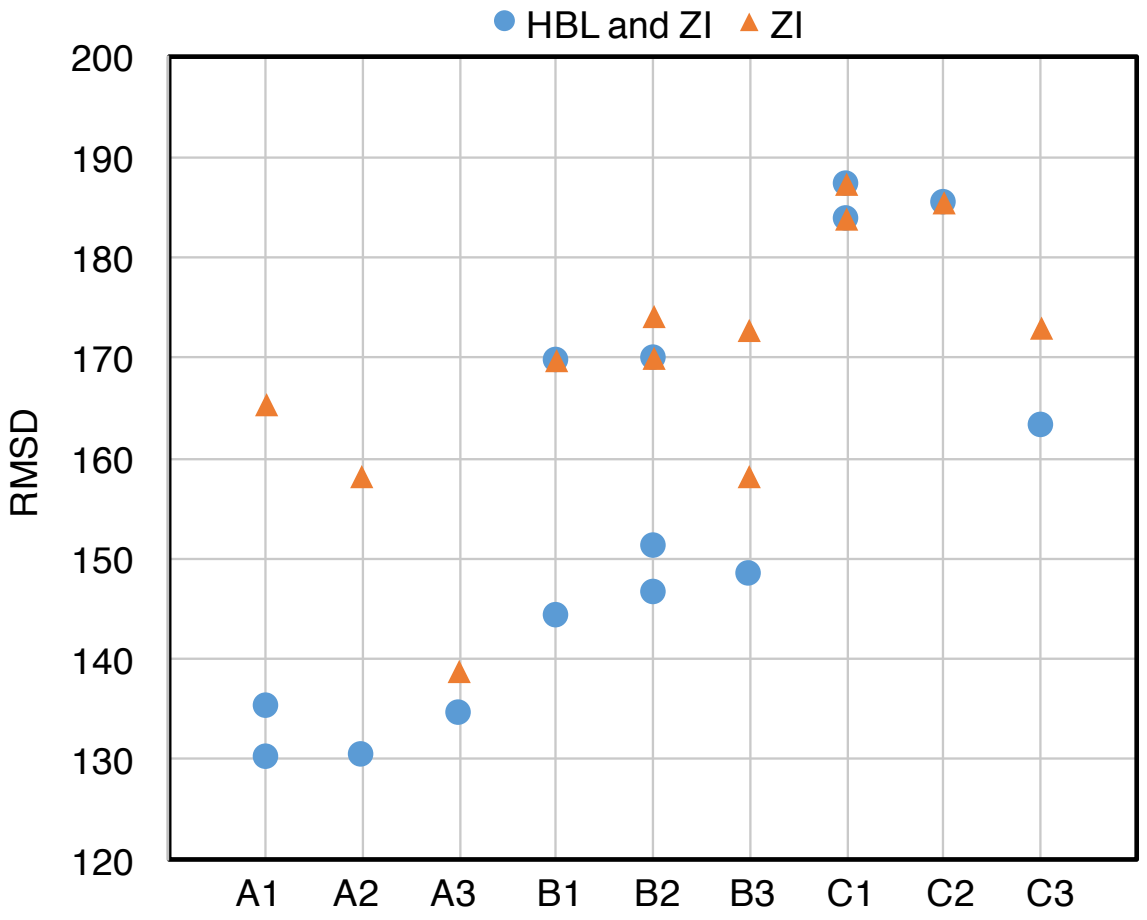
(a) N = 28



(b) N = 65

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)



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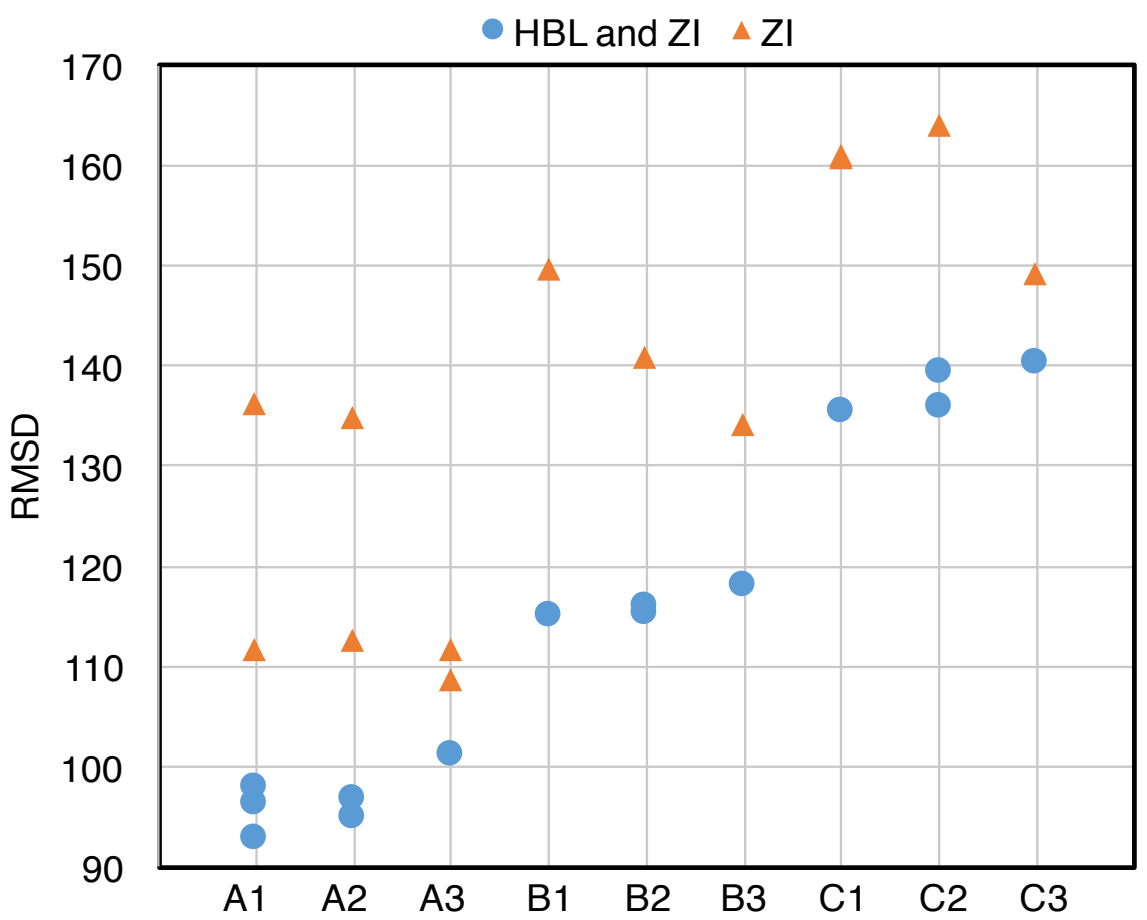
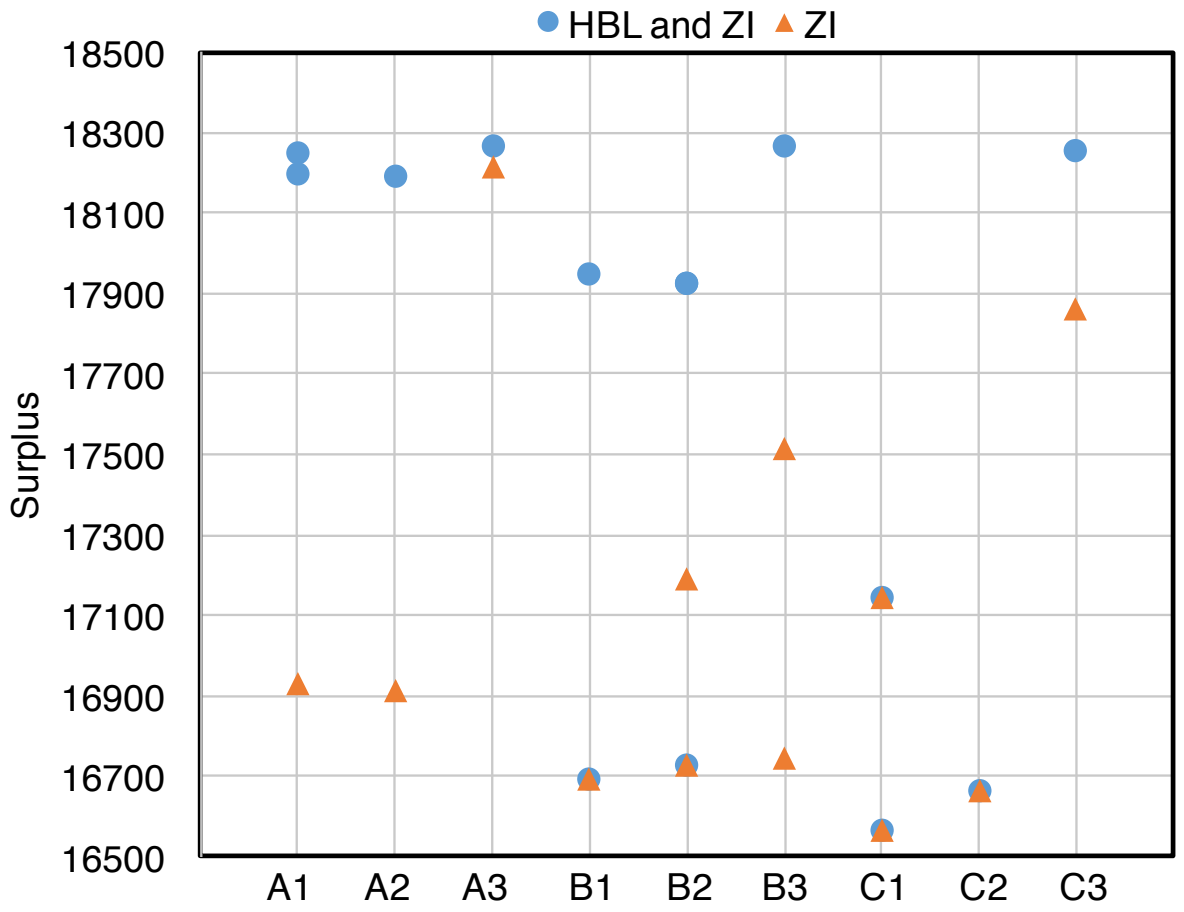


(b) N = 65

HBL Improves Market Surplus - EGTA (HBL, ZI) vs EGTA (ZI)



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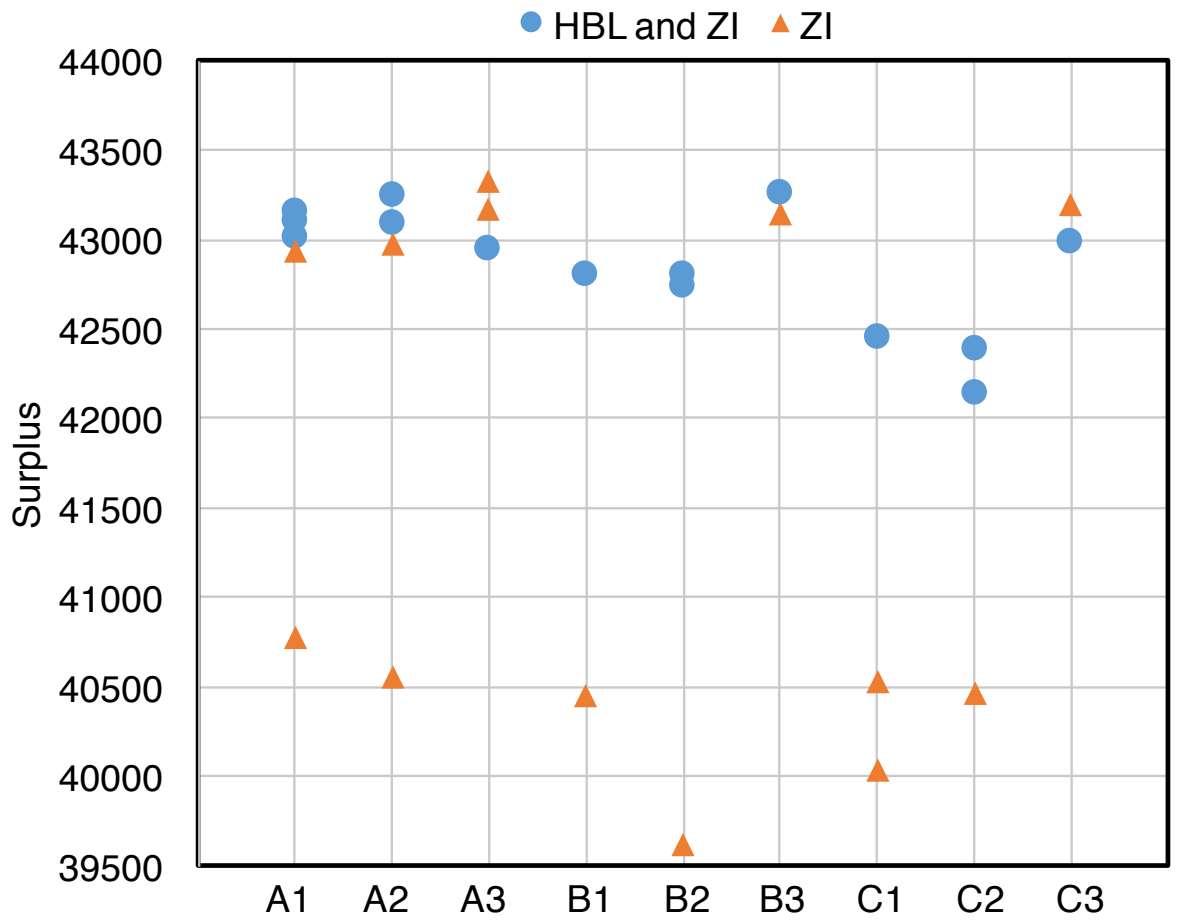

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Experiments and Results

Without Spoofing

With Spoofing

EGTA (ZI)
EGTA (HBL, ZI)

SP
+
EGTA (HBL, ZI)

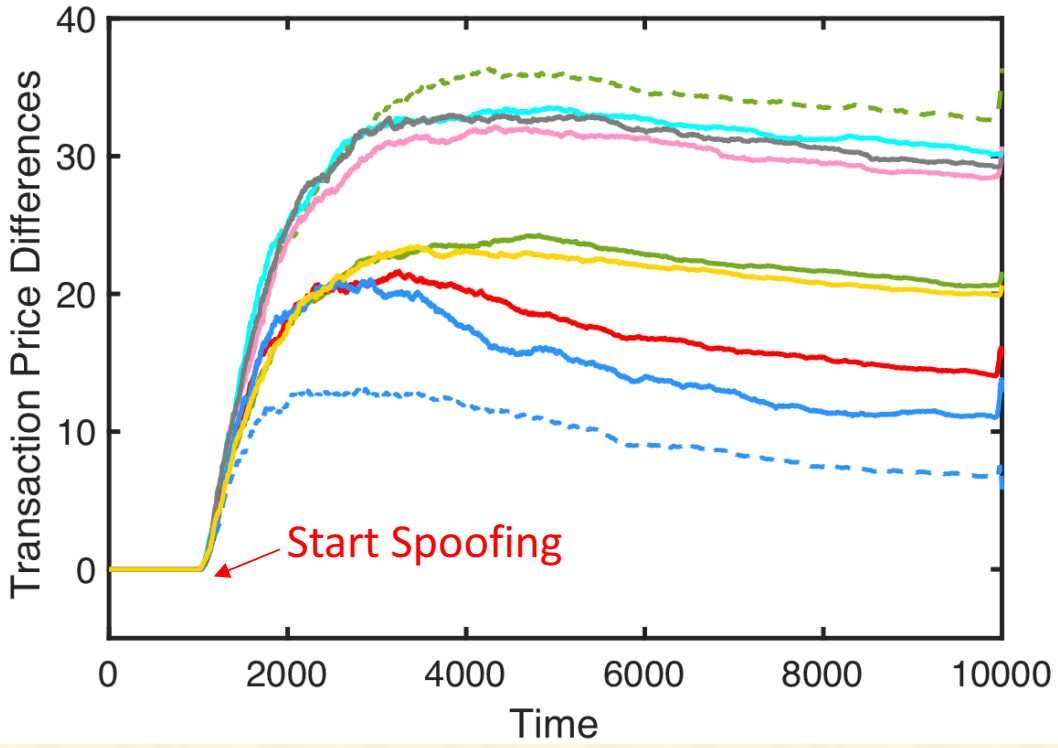
EGTA (HBL, ZI | SP)

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

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

- Spoofing's impact on strategic choices
- Spoofing's impact on market performance

A Spoofable Market with HBL Traders



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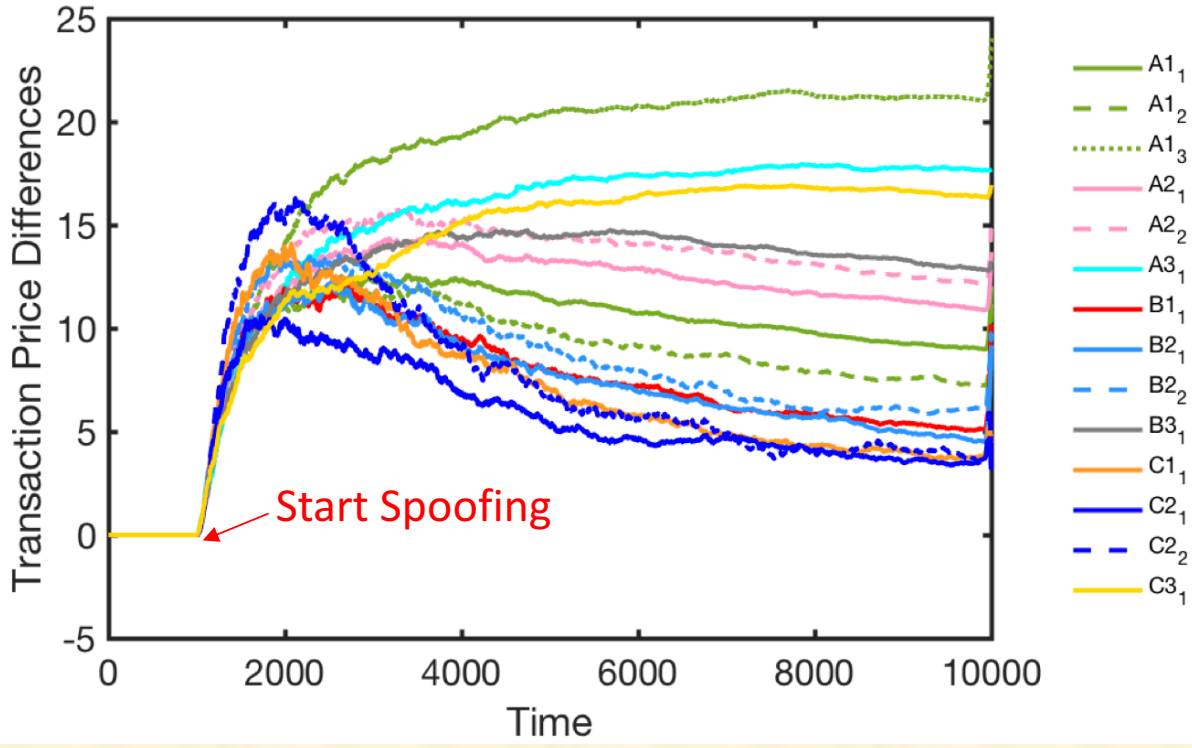
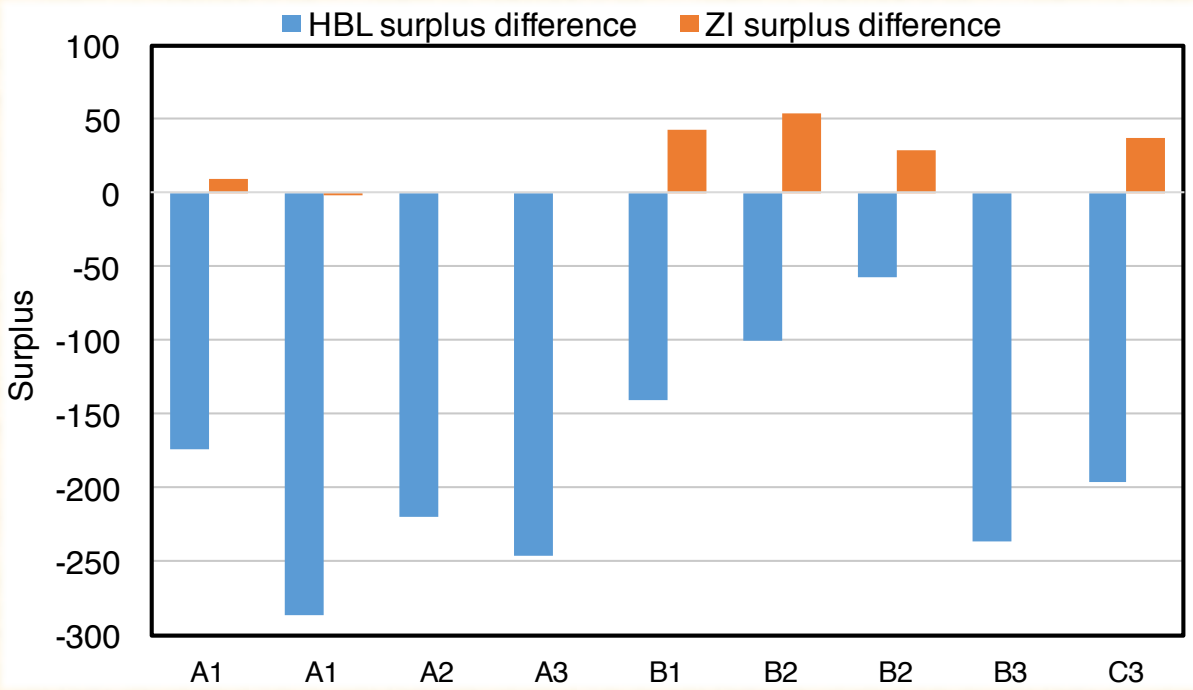


(b) N = 65

Amplified (diminished) spoofing effect in markets with more HBL (ZI).

Surplus Redistribution with Spoofing



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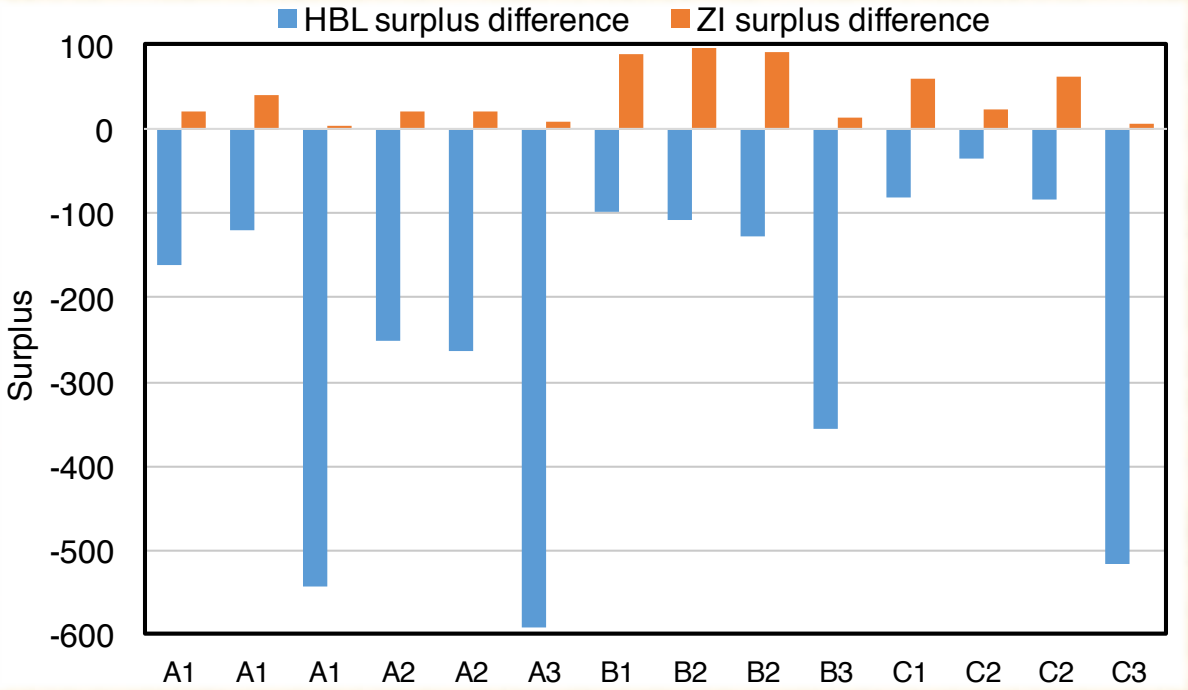


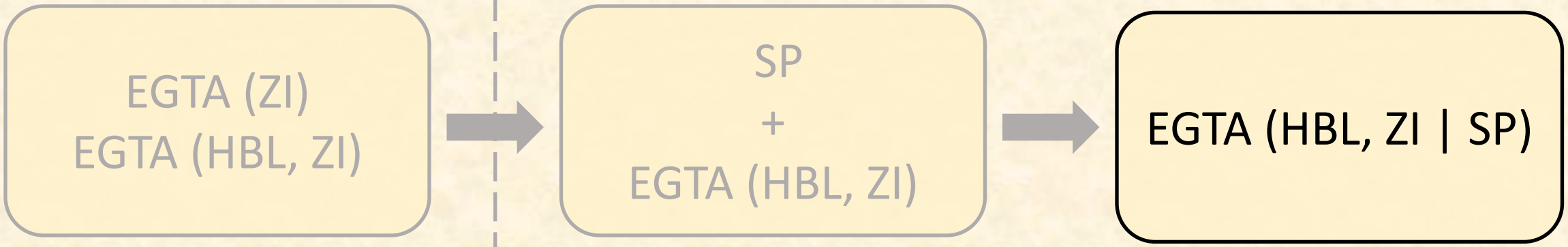
(b) N = 65

In a market with spoofing, ZI can take advantages of HBL's spoofed beliefs.

Experiments and Results

Without Spoofing

With Spoofing



- Strategic choices between HBL and ZI
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- Spoofing's impact on strategic choices
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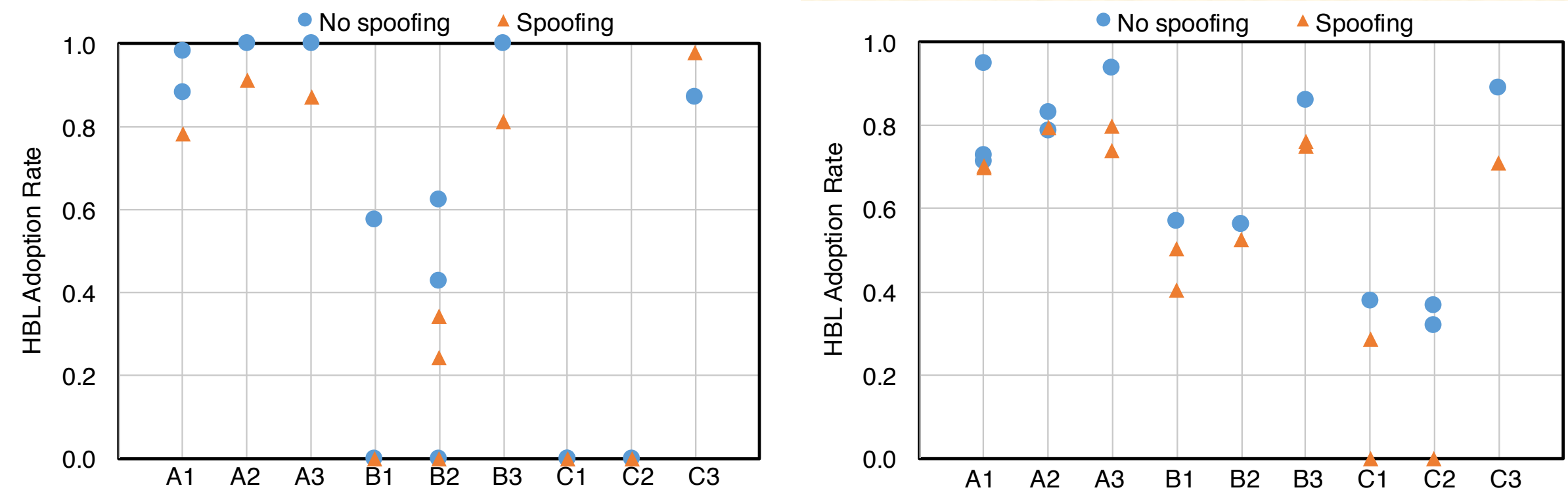
Agent Strategic Choices with Spoofing

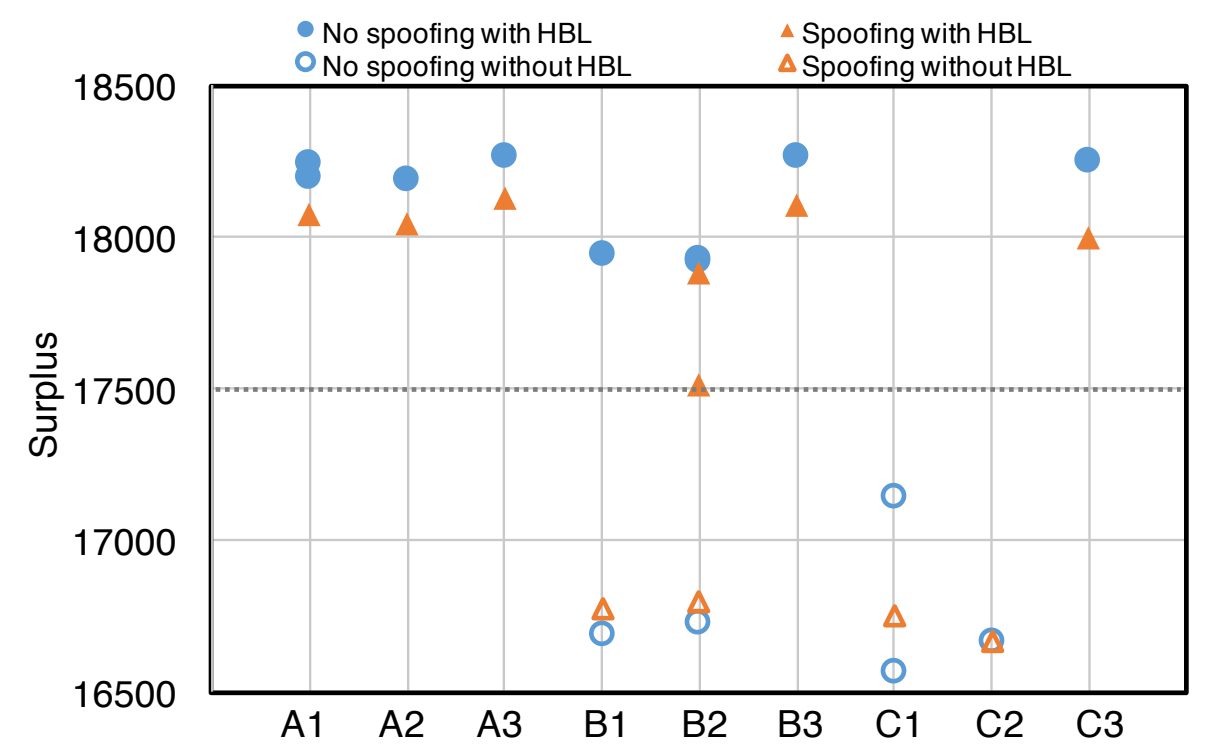


(a) N = 28

(b) N = 65

When re-equilibrating games with spoofing, HBL often remains in mixed equilibria but with smaller proportions.

Market Surplus with Spoofing



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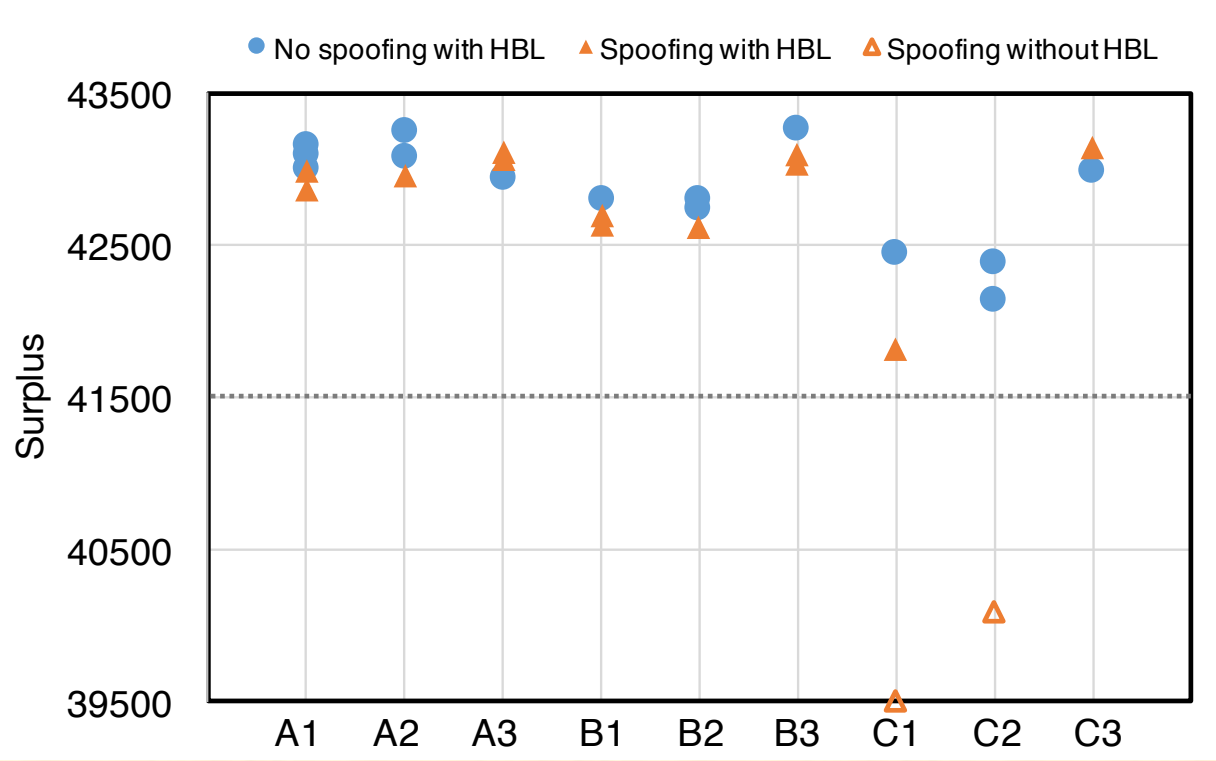


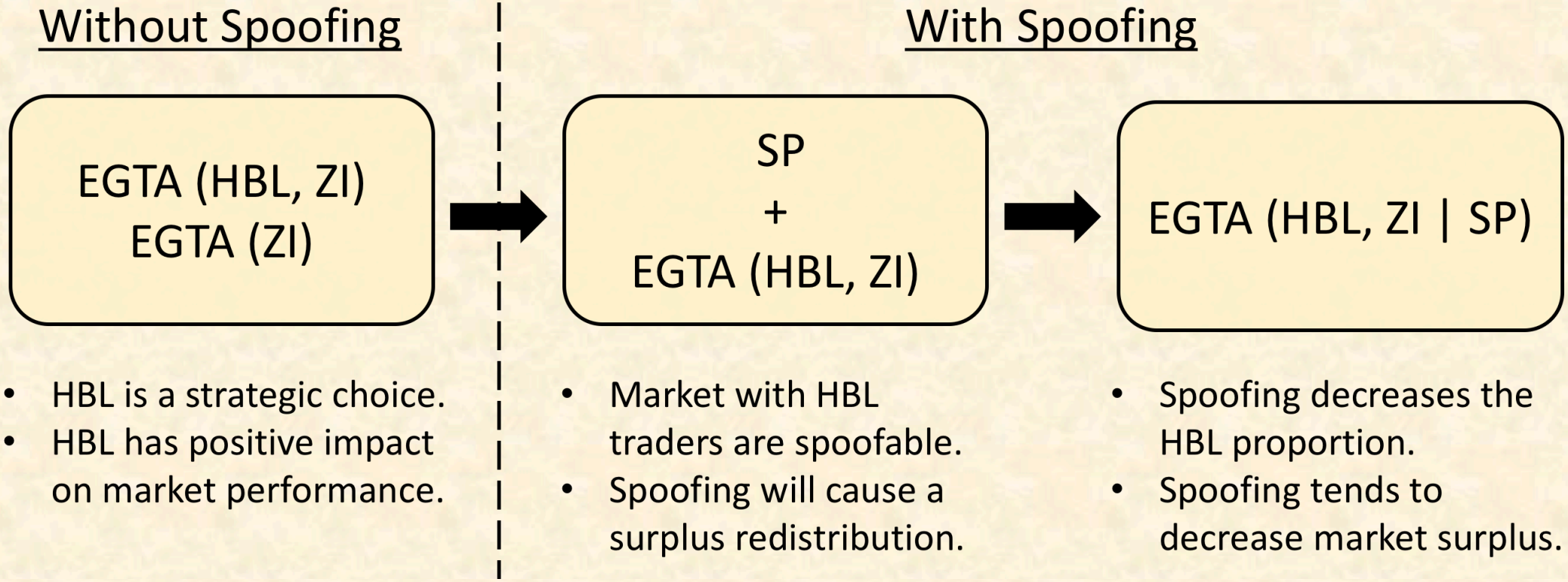
(b) N = 65

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



Thank you, questions?

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