Algorithmic Trading in Experimental Markets with Human Traders: A Literature Survey

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ZIMI2: The Second Conference on Zero/Minimal Intelligence Agents

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1.0. Motivation

- Most transactions are executed by automated trading systems (more than 70% of US stocks' trading volume in 2011, according to Treleaven et al., 2013)
- Flash crashes
- Overview of the experimental literature with the focus on human-robot interaction

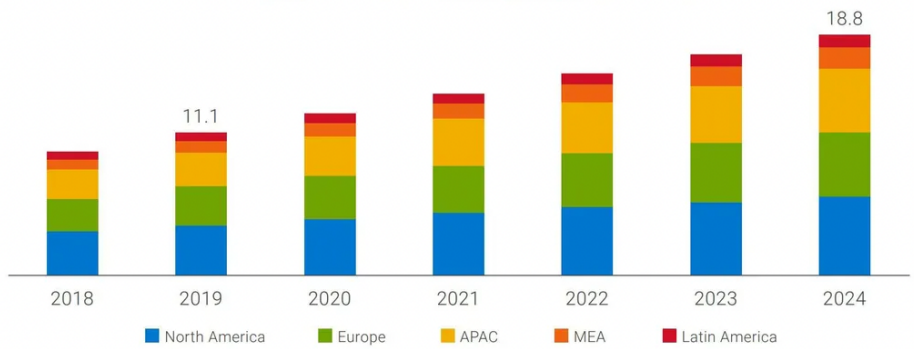

Figure: Algorithmic Trading Market, by Region in Billions of USD.
Source: MarketsandMarkets Analysis from https://analyzingalpha.com/algorithmic-trading-statistics

1.1. Comparison to other papers

Previous literature surveys:

- algorithmic trading reviews: Kirilenko and Lo (2013), Goldstein et al. (2014), Miller and Shorter (2016), Beckhardt et al. (2016)
- agent-based modeling reviews: Duffy (2006), Brewer (2008), De Luca et al. (2011)
- interaction of computer players with human subjects reviews: March (2019)

Current study is focused on human-robot interaction in algorithmic trading experiments

1.2. Broad Picture of the Literature

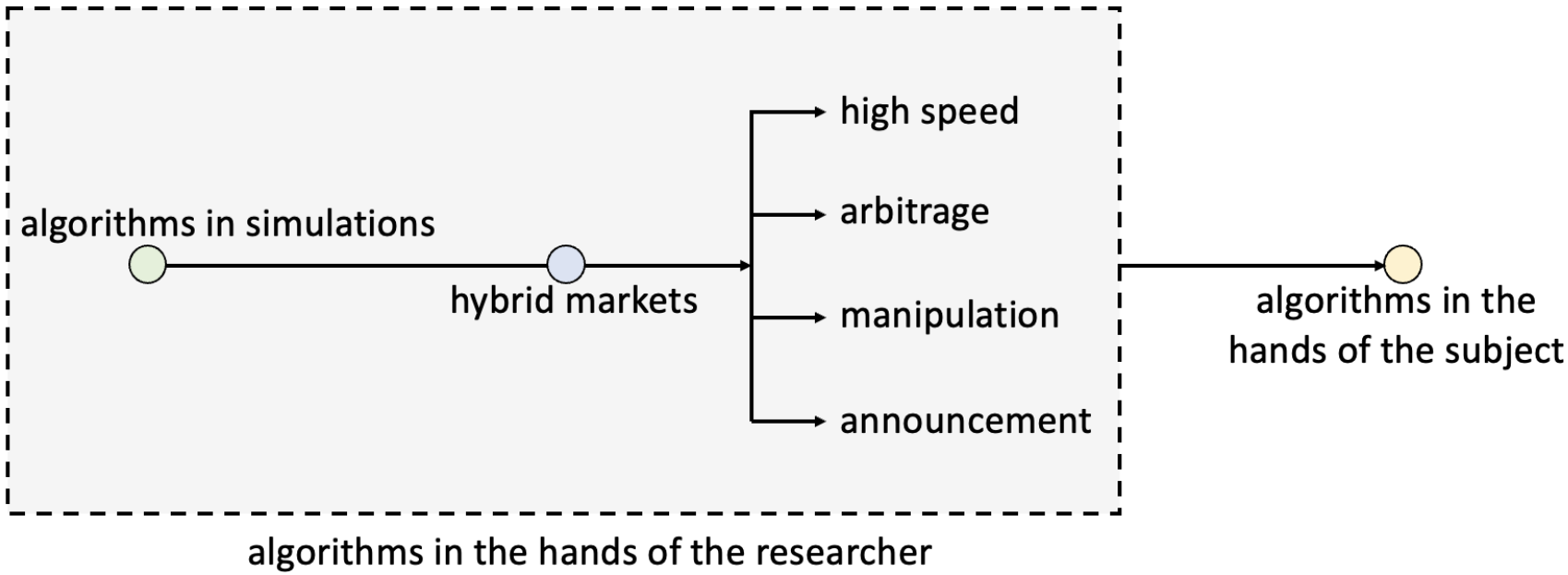

Figure: Structure of the Handbook

1.3. Overview of algorithmic traders

Algorithmic trader	Papers
Zero intelligence (ZI)	Gode and Sunder (1993)
Kaplan's Sniping Agent	Rust et al. (1994)
Zero intelligence plus (ZIP)	Cliff and Bruten (1997)
Gjerstad/Dickhaut - GD agent	Gjerstad and Dickhaut (1998)
Arbitrage trader	Angerer et al. (2019)
Spoofing	Leal and Hanaki (2018)
Manipulator	Veiga and Vorsatz (2009; 2010)
Market-maker	Aldrich and Lopez Vargas (2020)
Reactionary bot	Asparouhova et al. (2020)

2.0. Zero-intelligence (ZI) and zero-intelligence plus (ZIP) trader

ZI trader (Gode and Sunder 1993):

- random bids (for buyers) and asks (for sellers).
- with/without constraint
- with constraint: traders are not allowed to sell below their costs or buy above their values
- no intelligence, no profit-maximisation, no learning, etc.

ZIP trader (Cliff and Bruten 1997):

- adaptive profit margin = target price - submitted price
- profit margin is increased/decreased after successful/failed transactions

2.1. Comparison of algorithms in simulations with human traders in experimental markets

Papers: Gode and Sunder (1993), Cliff and Bruten (1997), Duffy and Ünver (2006), Rust et al. (1994)
Main idea: comparison of convergence paths in the markets **only** with human subjects or algorithms
Conclusion: similar to the human traders convergence pattern and introduction of popular algorithms (ZI, ZIP, GD)

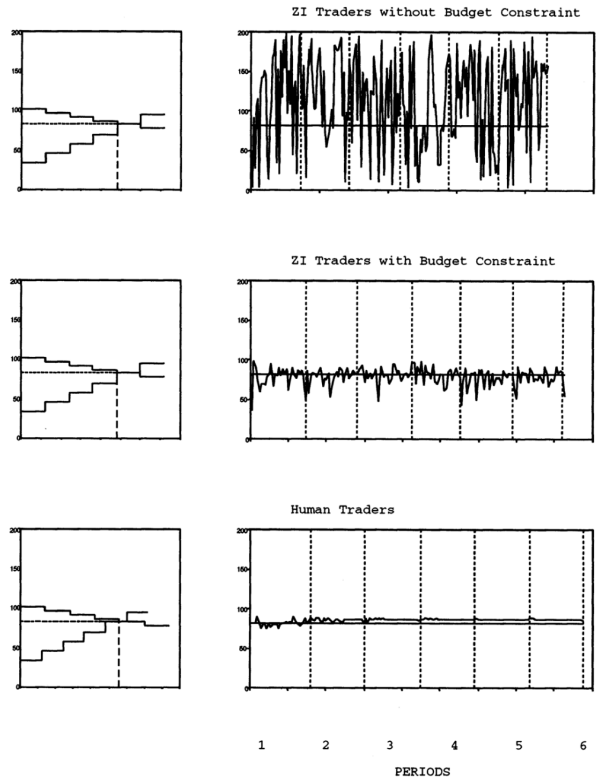

Figure: Demand and supply functions, transaction price paths in Gode and Sunder (1993)

2.2. Performance of algorithmic and human traders in hybrid experimental markets

Papers: Das et al. (2001), Gjerstad (2007), Peng et al. (2020), Feldman and Friedman (2010) and others
Main idea: comparison of human and algorithm performance, efficiency and convergence evaluation
Conclusion:

- convergence (but slower one (Das et al. (2001))
- high level of efficiency (Gjerstad, 2007)
- mixed evidence on the relative performance of humans and algorithms
- humans may learn and adapt more quickly to extreme volatility and more complex market environments

Further Research: Smith et al. (1988) environment

2.3. Algorithm Speed

Papers: Das et al. (2001), Gjerstad (2007), Cartlidge and Cliff (2013; 2018), Peng et al. (2020), Cartlidge et al. (2012)
Main idea: evaluation of algorithms' gain from low latency
Conclusion:

- mixed evidence, high level of dependence on market structure and algorithms' strategy
- robot-phase transition (Cartlidge and Cliff, 2013; 2018)

Further Research: high algorithm speed, adaptability of human and algorithmic traders to the market conditions

2.4. Arbitrage Algorithms

Papers: Harrison (1992), Angerer et al. (2019), Neugebauer et al. (2020), Rietz (2005), Grossklags and Schmidt (2006), Berger et al. (2020)

Main idea: effect of arbitrageurs on the law of one price

Conclusion: algorithmic arbitrage traders amend mispricing

Further Research: social cost of arbitrage activity, theory testing

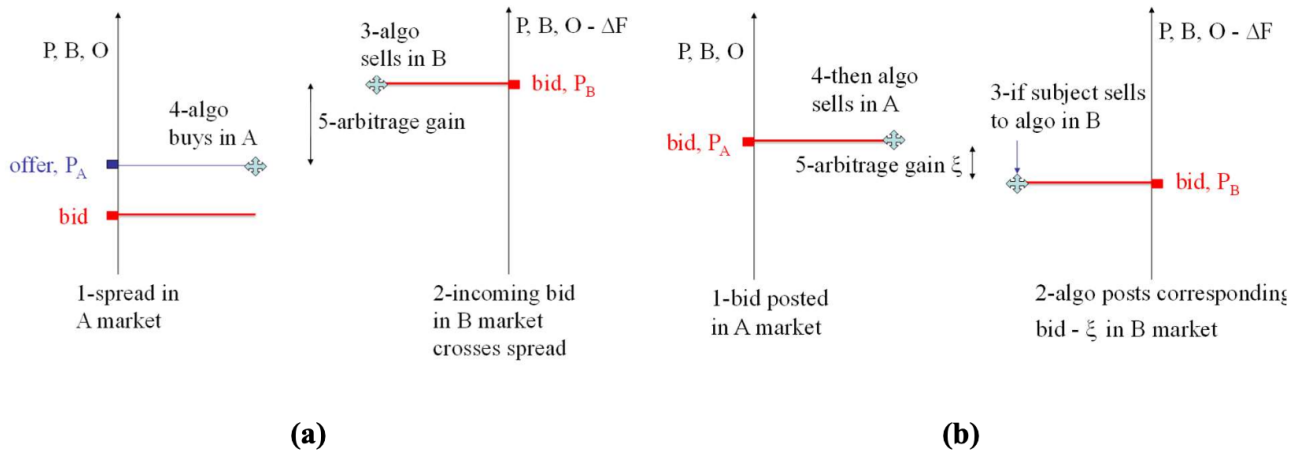

Figure: Liquidity (a) absorbing and (b) providing algorithmic arbitragers in Angerer et al. (2019)

2.5. Manipulation

Papers: Leal and Hanaki (2018), Veiga and Vorsatz (2009; 2010)
Main idea: susceptibility of experimental markets to manipulation
Conclusion: confusion with informed trader enables manipulator to push the prices
Further Research: other manipulative algorithms, conditions of manipulators' profitability

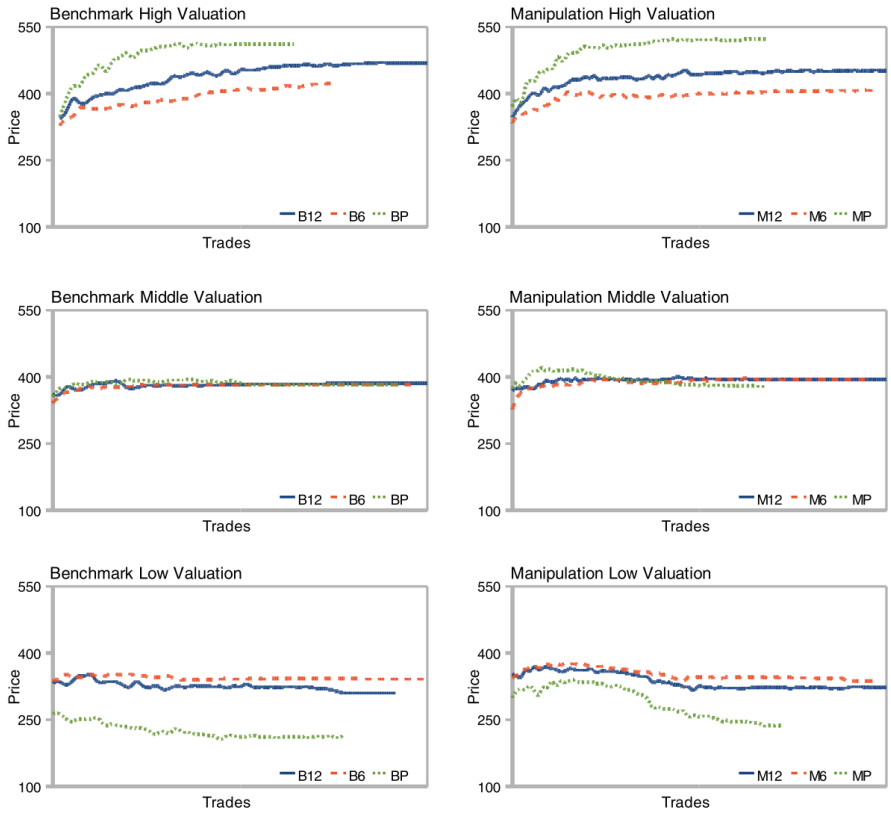

Figure: Average price paths in Veiga and Vorsatz (2010)

2.6. Announcement effect

Papers: Grossklags and Schmidt (2006), Farjam and Kirchkamp (2018), Leal and Hanaki (2018), Angerer et al. (2019)
Main idea: measurement of the impact of an algorithm's presence or the possibility of its presence on humans' actions and expectations
Conclusion: announcement effect seems to be dependent on the design of the experiment
Further Research: various formats of the announcement dissemination, development of the announcement effect over time

3. Algorithms in the hands of the subject

Papers:
Aldrich and López Vargas (2020): subjects' choice between manual trading and market-maker or sniper algorithm in CDA and FBA environment
Asparouhova et al. (2020): subjects' choice between manual trading and market-maker or reactionary robot

Main idea: conditions of algorithms utilisation, effect on mispricing
Conclusion: human traders utilize algorithms
Further Research: other types of algorithmic traders and market designs

4.0. Conclusion

- in simple markets algorithms frequently outperform humans
- in more complex markets algorithms may do worse
- enhanced market quality in human-algorithm markets relative to all-human markets
- announcement of algorithm participation enhances/does not affect market quality
- unaffected efficiency of the CDA market if subjects take algorithms in their hand or if they trade by submitting orders

4.1. Policy Implications

- introduction of batch auctions (Aldrich and Vargas 2020) or speed bumps (Khapko and Zoican 2020)
- assessment of the role of arbitrage algorithms: market quality VS wealth extraction
- ban on manipulative algorithms

4.2. Future Research

- From Smith (1962) to Smith (1988)
- From ZI to more complex algorithms
- Broader range of manipulative algorithms

Thank You for your attention!

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