Autonomous Agents in Financial Markets: Implications and Risks

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Why Finance?

• Critical sector of economy

• Potentially fragile, driven by information (beliefs, expectations), complex interdependencies

• Already highly infiltrated by AI
  • Trading in financial markets
  • Credit decision making
Trader
Algorithmic Trading

• By any measure, accounts for major fraction of activity on financial markets
• How does it work?
  • Specific methods and practices highly secretive
  • General ingredients readily apparent
    • Fast computing and communication
    • Real-time data analysis, risk management
    • Clever strategies, detailed understanding of microstructure
    • AI & machine learning

What is Special about Algorithms?

1. Speed and Precision
   • Response far faster than human reaction times
   • Can implement complex strategies involving coordinated actions across many markets
   • Enables latency arbitrage, “anticipatory” strategies, novel manipulations

2. Autonomy
   • Applies programmed and learned models to potentially unanticipated circumstances

3. Scalability
   • Replicate methods across securities, exchanges... worldwide
Latency Arms Race: Source of Instability?

- NYC trader splits order for multiple exchanges
- First order arrives at BATS exchange in Weehawken
- HFTs see order and race to Mahwah (NYSE) and Carteret (Nasdaq)
- ~200 µs
One-Second Call Markets

- Latency arms race an artifact of *continuous-time* market operation
  - no lower bound on a difference in speed that could matter
- Call market
  - Trade periodically rather than continuously
  - Orders received within interval hidden
  - Potential efficiency and stability advantages

Wellman blog entry July 2009

Flash Crash: 6 May 2010

Why did *this* happen?

Why did *this* happen?

DOW 9,869.62

\(^\text{▼} 998.50 / 9.2\%\)
Ultrafast Extreme Events

- Documented 18,520 UEEs in 5yr period
- Authors argue: Must be artifact of dynamic interacting agents
Alternate Explanation: ISOs

- Intermarket Sweep Order (ISO)
  - Special order type, allows override of NBBO-based routing

Golub, Keane, & Poone, 2012

Strategic Agent-Based Analysis

- Model-based studies of effects of algorithmic trading
- Challenge: sensitive to specification of agent behavior
- Empirical game-theoretic analysis
  - Combines agent-based simulation with game-theoretic reasoning
  - Explore a space of heuristic strategies, using strategic stability for selection

Studies
- Latency arbitrage (EC-13)
- Market making (AAMAS-15)
- Market choice by fast and slow traders (AMMA-15)
- Strategic shading (AGTw-16)
- Market manipulation (in progress)
Illustrative EGTA Results: Effects of MM Competition ($N = 25$)

**2MM vs 1MM**

**ARB-BOT**: A General Framework for AI Traders

- **Arbitrage**:
  - taking advantage of price differences across markets for the same asset

- **Simple arbitrage agent**:
  - monitor multiple markets for price discrepancies, then execute

- **Issues**
  - Transaction costs
  - Transport/storage costs
  - Execution risk
  - What is meant by “same” asset?
**ARB-BOT Early Warning System**

- Develop public (non-trading) Arb-Bots as an alert to what the AIs might be finding
- Search approaches
  - Reasoning from security descriptions
  - Automated discovery by machine learning

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**Levels of ARB-BOT Behavior**

1. Passive search for arbitrage opportunities
2. Attempts to amplify arb opps through purposeful instigation of market movements (e.g., spoofing)
3. Attempts to create new arb opps
   - new financial instruments
   - deliberate fragmenting
4. Malicious subversion of markets

most aggressive
Level 2: Market Manipulation

- SEC Definition: Intentional conduct designed to deceive investors by controlling or artificially affecting the market for a security
- Spoofing
  - Dodd-Frank defn: bidding or offering with the intent to cancel the bid or offer before execution
  - Widely known strategies, several recent prosecutions

Example: Dynamic Layering

Source: UK Financial Conduct Authority
Spoofable Agents

A spoofing agent can exploit the heuristic-based learning strategy and manipulate the market price.

Spoofing Equilibrium Strategies
Manipulation: Current Questions

• Can we automatically learn manipulation strategies?
• Can we reliably detect manipulation in market data?
• Can we build spoof-proof trading agents?

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Level 4

Finance and Design for Beneficial AI

• A consequential domain at the leading edge of AI automation
• Qualitatively new phenomena, interaction at superhuman time scales
• Rich technical (AI+Econ) and Social (Law+Policy) challenges