Experiments in High-Frequency Trading: Market Stability and Resiliency

(Work in Progress)

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Research Plan

1. Build and study a more realistic (complex) environment (e.g., fundamental not directly observed).
2. New formats and market rules (e.g., IEX, Kyle-Lee flow market).
3. Further questions (order shredding, competition and fragmentation).
4. Experiment: more lab and public tournament.

Exogenous Processes

- There is a $v(t)$ signal that is not publicly observed.
- v(t) follows a Poisson jump process (or...)
- Exogenous traders now arrive with limit orders around v(t) at random times at rates λ_a, λ_b for asks and bids.
- Limit prices for bids: $p_b = x_b + v(t)$
- Limit prices for asks: $p_a = x_a + v(t)$
- $x_b \sim G_b$ and $x_a \sim G_a$ (Gs independent of $v(t)$)
- Note $F_b(p) = G_b(p - v)$ and $F_a(p) = G_a(p - v)$
- *Time in force*: T_b, T_a, for bids and asks, respectively.

Exogenous Processes

Instantaneous, expected exogenous demand and supply at time $t > max\{T_a, T_b\}$ and price p are:

$$D(p) = T_b \lambda_b \left(1 - F_b(p)\right). \tag{1}$$

$$S(p) = T_a \lambda_a F_a(p). \tag{2}$$

Clearing price p^*, satisfies:

$$\frac{T_a \lambda_a}{T_b \lambda_b} = \frac{1 - F_b(p^*)}{F_a(p^*)} \tag{3}$$

Exogenous Processes

If we define h as:

$$h(p|v) = \frac{1 - G_b(p - v)}{G_a(p - v)} \tag{4}$$

The clearing price is:

$$p^* = h^{-1}\left(\frac{\lambda_a T_a}{\lambda_b T_b}\right) \tag{5}$$

Therefore under some symmetry conditions (e.g., $T_b\lambda_b = T_a\lambda_a$ and $G_a(0) = 1 - G_b(0)$):

$$p^*(t) = v(t) \tag{6}$$

v(t) also generates an exogenous NBBO representing the rest of the market (BBE, BOE).

Trading Algorithms

Notation/definitions:

- The trading period $[0, T]$. Events indexed by t or τ.
- $x(t, \rho)$: **signed volume** at time t. Number of net buy and sell executions in recent times, via exponential average.
- $z(t, d)$: **order imbalance** at time t. Stat for order book state
- $y_i(t)$: trader i's **inventory** position.
- $BB(t)$: Best bid at the main exchange.
- $BO(t)$: Best offer at the main exchange.
- $BB_E(t)$: Best bid at the external exchange(s).
- $BO_E(t)$: Best offer at the external exchange(s).
- S: price tick.

Trading Algorithms

Calculating signed volume:
Piece-wise constant over time. Remains constant until there is an update at an execution time.
For the CDA, it is defined recursively:

- At time $= 0$, $x(0, \rho) = 0$.
- Suppose last update occurred at t and there is an execution at time $t + \tau$.
- Then:

$$x(t + \tau, \rho) = e^{-\rho\tau} x(t, \rho) + I_S$$

where:

$$I_S = \begin{cases} 1 & \textit{if execution at BO} \\ -1 & \textit{if execution at BB} \end{cases}$$

Trading Algorithms

Algorithms follow a simple rule that reacts to stats in the external market (public signals) and to competitors behavior in the main market.
x(t) is the leading indicator of price increase.

$$\widetilde{Bid}_i(t) = w\left[BB_E(t) + b_x x_E(t)\right] + w'\left[BB_{-i}(t) + b_x x(t)\right] - b_y y(t)$$

$$\widetilde{Ask}_i(t) = w\left[BO_E(t) + b_x x_E(t)\right] + w'\left[BO_{-i}(t) + b_x x(t)\right] - b_y y(t)$$

where w'=1-w.

Traders' Strategy Space

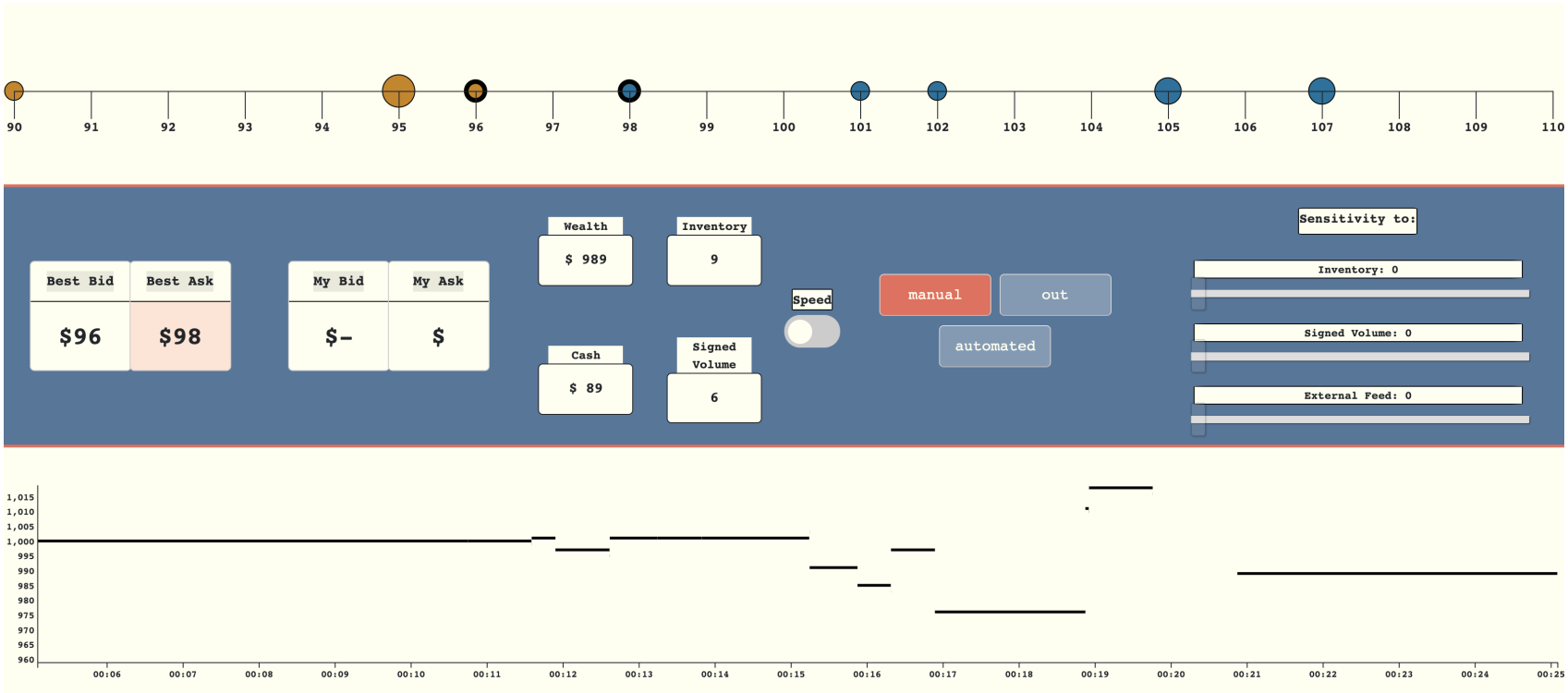
Trading strategies:

1. Out
2. Manual trader
3. Algorithmic: Traders adjust:
   - b_x sensitivity to leading indicators of price movement
   - b_y sensitivity to own inventory
   - w weight given to external exchange signals

Technology strategies (latencies):

- Slow (high latency)
- Fast (low latency)
- (or continuous)

Interface



Video

New Market Formats

1. Investors' Exchange
   - Order delay
   - Quote protection (pegging to NBBO)
2. Kyle-Lee flow
   - Submit flow orders
   - Can be sniped, but for negligible amounts.