Blockhouse Work Trial Submission

Title: Modeling Temporary Market Impact and Optimal Trade Execution Strategy

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1. Objective

This report addresses the problem of executing a total of S = 10,000 shares for stocks (FROG, SOUN, CRWV) during a single trading day, while minimizing the total temporary impact or "slippage".

The approach involves:

- Modeling the temporary impact function g_t(x)
- Fitting multiple impact models using historical order book data
- Formulating a constrained optimization problem
- Deriving and implementing optimal execution schedules under different assumptions

2. Data Overview

We use Level 2 market data (MBO) for 03-Apr-2025 for the stocks FROG, SOUN, and CRWV. Each dataset consists of:

- Timestamped bid and ask prices and sizes up to 10 levels
- Trade actions with associated price, size, and direction

Preprocessing:

- Data is resampled to 1-minute intervals (390 minutes in total)
- Only market hours (09:30 to 16:00 EST) are retained
- Only valid data rows with available top-of-book prices are used

3. Slippage Calculation

Definitions:

- Mid-price at time t: $m_t = (bid_t + ask_t) / 2$
- Average execution price: Simulated by walking the ask-side order book
- Slippage: $g_t(x) = avg\_price(x) - m_t$

Assumptions:

- Buy-side market orders
- Sizes: 100, 500, 1000 shares
- Liquidity = sum of ask sizes across top 10 levels

4. Temporary Impact Modeling

For each minute, we fit:

- Linear: $g_t(x) = \beta_t x$
- Square Root: $g_t(x) = k_t \sqrt{x} + c_t$
- Quadratic: $g_t(x) = a_t x^2 + b_t x$

Fitted using least squares. R^2 computed for validation. Plots generated for verification.

5. Optimization Formulation

We solve for x_t such that:

- $\sum(x_t) = S$
- $0 \leq x_t \leq volume_t$

Objective:

- Linear: $\sum(\beta_t^* x_t)$
- Sqrt: $\sum(k_t * \sqrt{x_t} + c_t)$
- Quadratic: $\sum(a_t^* x^2 + b_t^* x)$

Method: SLSQP optimizer with constraints

6. Results and Visualizations

Impact curves plotted. Quadratic fits best in most cases.
Optimal Allocations:

- Linear: most volume when β_t is lowest
- Sqrt: smoothed
- Quadratic: adjusts for nonlinear cost

7. Slippage Cofficient (β)

Stock	Avg Linear Beta	Sqrt Model K
FROG	0.000307	0.002953
SOUN	0.000020	0.000164
CRWV	0.000322	0.006780

8. Model Performance (Total temporary market impact costs)

For S = 10,000 shares:

Model	FROG_Cost	SOUN_Cost	CRWV_cost
Linear	$1.23	$0.19	$0.72
Squareroot	$3.57	$0.20	$7.60
Quadratic	$2.22	$0.10	$2.36

8. Conclusion

- Modeled temporary impact g_t(x)
- Fitted linear, sqrt, quadratic models
- Optimized execution for each stocks
- Visualized results

Future: add volatility, spread cost, risk models

9. Appendix

Code: Github LINK

Libraries: pandas, numpy, matplotlib, scipy

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Stocks: FROG, SOUN, CRWV