A study on temporary impact and the Almgren-Chriss Model, an optimal order execution strategy

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29 July 2025

1 Modeling temporary impact $g_t(x)$

We know, the temporary impact function $g_t(x)$ can be defined as the amount of slippage that occurs if x orders are placed at the current time t. To effectively model $g_t(x)$, I analyzed the given MBP-10 snapshots of three companies, namely CoreWeave Inc(CRWV), JFrog Ltd(FROG), and SoundHound AI Inc(SOUN). Each snapshot provides the top ten bid and ask price-size pairs, from which I compute the mid-price m_t and the spread. For each snapshot, I then "walk" the ask book, filling shares at successive price levels until x shares are filled. Slippage can then be calculated as:

$$g_t(x) \;=\; \frac{1}{x}\sum_{k=1}^{K}(p_k - m_t)\,\Delta x_k$$

For my initial simulations, I considered the following order sizes $\{5, 50, 100, 500, 1000\}$ to get a rough sense of the shape of the slippage curves. After plotting the median slippage curves on log-log axes[Figure 1], we observe that for CRWV and FROG, slippage grows with order size. However, slippage remains flat for SOUN until larger order sizes($x \geq 1000$). To capture a more representative curve for SOUN, I used a log-spaced grid of size 6 from 50 to 5000 shares(which increased the filesize from 3.38GB to 4.45GB).

The updated median slippage curves[Figure 2] now show SOUN rise sharply as the order size increases past 1000. The curves exhibit a concave trend where smaller order sizes incur a very small cost. If the order size

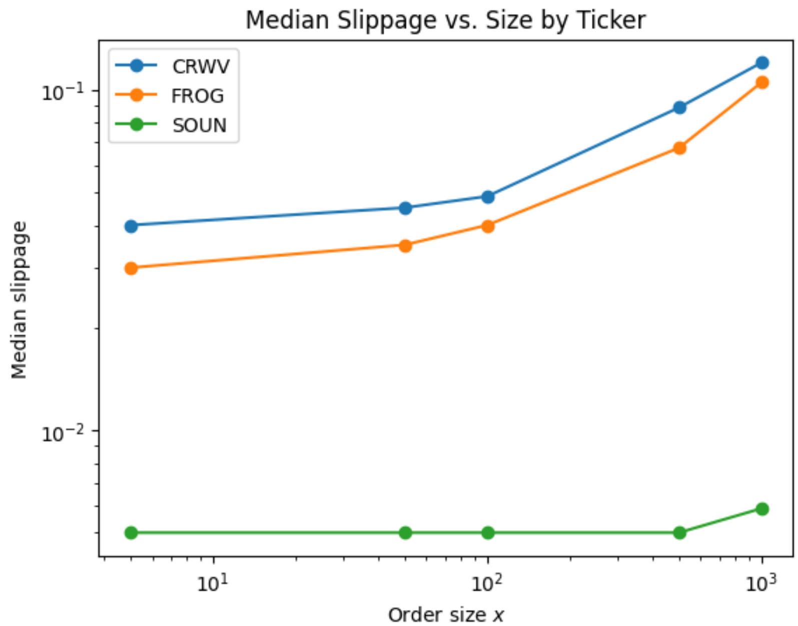

Figure 1: Median Slippage for fixed grid

was to be doubled, the increase in slippage would be far less than twofold. From my research, this behaviour points us towards two potential models:

- **Linear**: $g(x) = \beta x$, which will serve as my baseline.
- **Power-law**: $g(x) = \alpha x^{\gamma}$, which exhibits concavity similar to the slippage curves.

I fit the aforementioned models to the median slippage data and report the estimated parameters, RMSE, and R^2 for the models, proving that power-law fits significantly better than any linear model.

Ticker	β	RMSE	R^2
CRWV	4.30×10^{-5}	3.407×10^{-3}	-0.6382
FROG	3.10×10^{-5}	4.483×10^{-3}	-0.8701
SOUN	3.00×10^{-6}	1.400×10^{-5}	-0.5688

Table 1: Linear fit results.

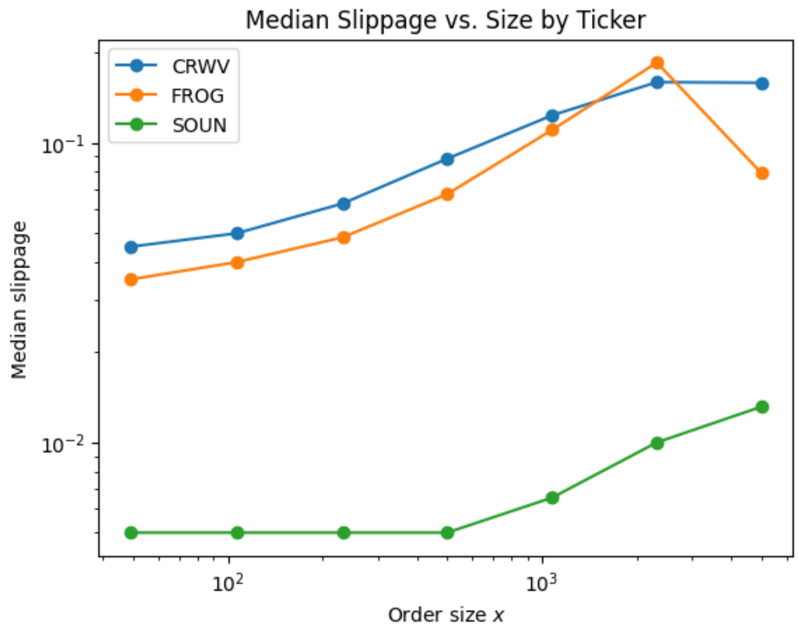

Figure 2: Median Slippage for log-spaced grid

Ticker	α	γ	RMSE	R^2
CRWV	1.2402×10^{-2}	0.3144	1.42×10^{-4}	0.9649
FROG	1.1103×10^{-2}	0.2940	1.393×10^{-3}	0.6835
SOUN	1.7750×10^{-3}	0.2112	2.00×10^{-6}	0.7733

Table 2: Power-law fit results.

2 Order Execution Strategy

2 pages at most.