Blockhouse

Hanwen Liu

December 2024

1 Results

Although this paper discusses various time decay models, the mathematical formulations presented in the main sections (e.g., Sections 3, 4, and 5) are only applicable for a single decay timescale ($N = 1$). This is because using multiple decay timescales would result in mismatched dimensions between C_t, C_f, and Q_t. Therefore, in the coding phase, only a single decay timescale will be implemented.

1.1 Question 1

Construct and code the linear OW model and nonlinear AFS model, and visualize the distribution of price impact based on the given data. (33 points)

The paper compares the performance of a mathematical strategy with a neural network strategy using simulated data. However, the challenge provides trading records ("merged data.csv") that include the signed volume (Q_t) and the non-impacted price (mid price, S_t). To generate the required price impact variables J_t and I_t, the following approach is adopted:

From the paper, the price impact is defined as:

$$J_t = e^{-\beta \Delta t} \left(J_{t-1} + Q_t - Q_{t-1} \right)$$

Since all trades occur within a single day, we set $T = 1$ and $\Delta t = \frac{T}{N}$. To align the scale of the data with that of the paper, Q_t is divided by 10^6. Additionally, to ensure performance consistency with the paper, the parameters are set as $\lambda = 0.1$ and $p = 0.8$.

1.1.1 OW Model

The OW model's price impact is visualized in Figure 1.

1.1.2 AFS Model

The AFS model's price impact is visualized in Figure 2.

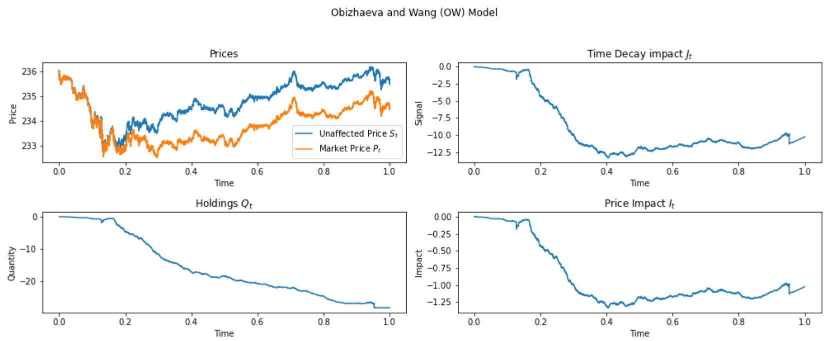

Figure 1: OW Price Impact

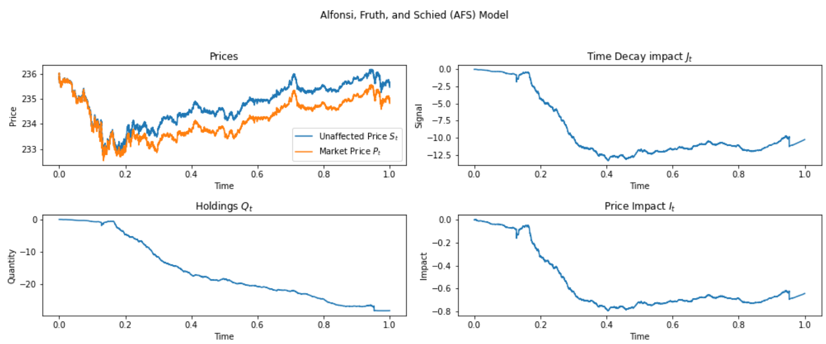

Figure 2: AFS Price Impact

1.2 Question 2

Implement and code the optimal strategy with Linear Impact and visualize the Sharpe Ratio plots as discussed in Section 6.2. (33 points)

Question 2 requires the implementation of the optimal strategy. However, the provided dataset ('merged data.csv') lacks the necessary parameters to calculate the optimal strategy. Therefore, it is assumed that the task involves disregarding the 'merged data.csv' and instead utilizing the models and parameters presented within the paper to generate the optimal policy.

As detailed in Appendix C.1, the paper does not specify the method to obtain J_t and the optimal strategy Q_t^* under a discrete setting. Therefore, the following derivations are performed to facilitate the analysis:

$$J_t = e^{-\beta \Delta t} \left(J_{t-1} + Q_t - Q_{t-1} \right), \tag{1}$$
$$Q_t^* = C_f f_t - C_J J_t, \tag{2}$$

By rearranging Equation (1), we obtain:

$$J_t = \frac{J_{t-1} + C_f f_t - Q_{t-1}}{e^{\beta \Delta t} + C_J}, \tag{3}$$

$$Q_t^* = C_f f_t - C_J J_t. \tag{4}$$

1.2.1 Experimental Setup

To streamline the computational process, the following adjustments were made to the experimental setup:

- **Number of Tracks:** Conducted 100 tracks instead of the 500 independent assets as described in the paper.
- **Parameter Tuning:** Performed experiments by fixing certain parameters to evaluate their impact on the Sharpe Ratio:
  - Fixed $\beta = 2$ and varied λ over the set $\{0.1, 0.2, 0.3\}$.
  - Fixed $\lambda = 0.01$ and varied β over the set $\{4, 5, 6, 7\}$.
- **Result:** The result is shown in Figure 3

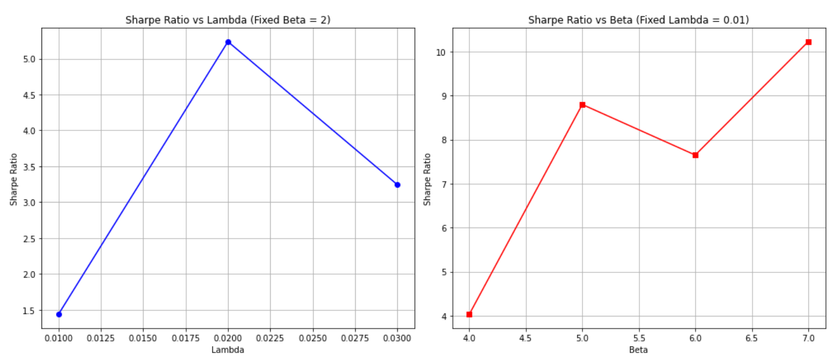

Figure 3: Sharpe Ratio plots

The paper incorporates Daily Risk (DR) as a constraint within the model. However, its influence on the discrete setting experiments remains unclear. Specifically, it is uncertain how DR affects the calculation of the optimal strategy and the resulting Sharpe Ratio. For the purposes of this experiment, the DR constraint was not implemented. Consequently, the observed Sharpe Ratios exceed those presented in Figure 1 of the paper.

1.3 Question 3

Implement and code the Deep Learning Algorithm in for discrete setting in Appendix C.2 and visualize the training loss for different network structures in Appendix C.2. (33 pt)

Due to time constraints, I was unable to execute and test the neural network within the available timeframe. Consequently, the complete code for the DL algorithm is provided in the final section of this report. The implementation adheres to the specifications detailed in Appendix C.2, ensuring consistency with the theoretical framework presented in the paper.