SIMP: A Simulator for Interactive Market Phenomena studies

Patrick Liston, Charles Gretton, Artem Lensky – *The Australian National University*

Introduction - Market Simulators & uses

Financial market simulators have been used for various applications, including testing trading algorithms, examining the impact of market design changes, and aiding regulatory efforts.

Earlier simulators often had limited capabilities in incorporating real market data. While more recent efforts like ABIDES and MAXE exist, they neglect the implementation of stop-loss orders.

Thus, we developed a hybrid framework that integrates real data with synthetic agents and features the novel inclusion of stop-loss orders.

Simulation Details - Our hybrid approach

Our market simulator leverages historical Limit Order Book data and historical trade/tick data, to guide realistic price development of a synthetic market. We used cryptocurrency BTC/USDT from exchange Binance.

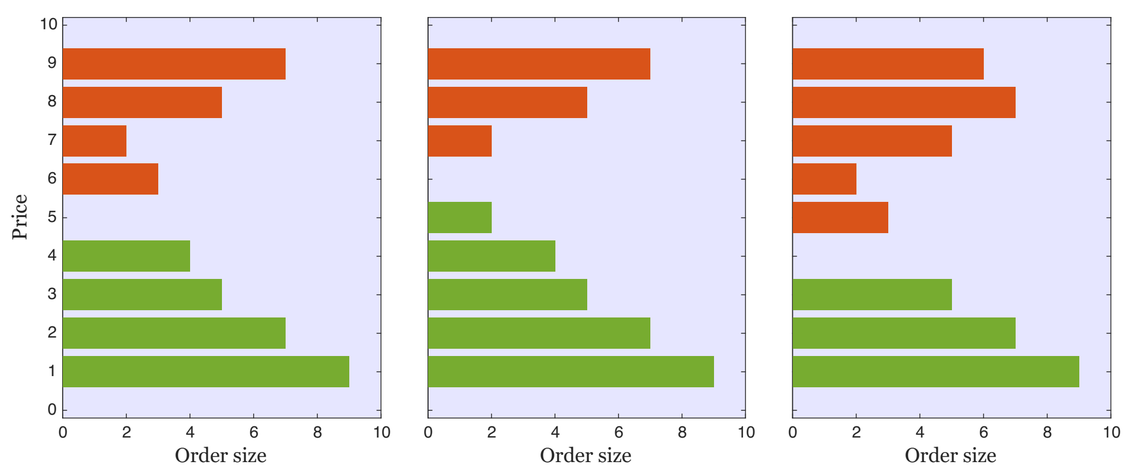

Figure 1. *Price development is shaped by the shifting of the LOB. We take the LOB as observed in real life, and shift it as shaped by agents' trades within the simulation. At time t_1 (Left), the original LOB is shown. In the real data (Middle), a buy order causes an upward price shift, however in the simulation (Right) a sell order is executed, resulting in a downward price shift – this LOB is then used in future steps.*

We use a variety of agent types (Zero-intelligence, Mean reverting, and trend-following) to populate the market. These agents determine the direction and size the market price moves by submitting market orders of a given size and direction as their strategy dictates. This moves the LOB up/down as shown in Figure 1. Where the historical LOB does not have sufficient depth to cover an order, order book extrapolation using neural network models is undertaken.

To aid in realism, agents' trades are timed and sized using historical trade distributions.

Importantly, we created a stop-loss order-book, into which agents lodge stop-loss orders, counter to their initial market order. This feature enhances realism, but more crucially, enables us to study a broader range of questions related to markets and their design.

Case Study 1: Impact of the Limit Order Book on Price Development

In this study we demonstrate the vital role of the LOB in shaping market price paths. We have Zero-Intelligence (ZI) agents randomly place trades; without a LOB, and with a LOB. Shown in Figure 2.

Comparing simulations (shown in Figure 2) with and without LOB integration highlights the order book's crucial role in generating realistic price movements. Simulations utilizing the LOB (both random and Markov agents, as shown in the full paper) exhibit a significantly better correlation with real price data, suggesting the LOB structure is a primary driver of short-term price dynamics.

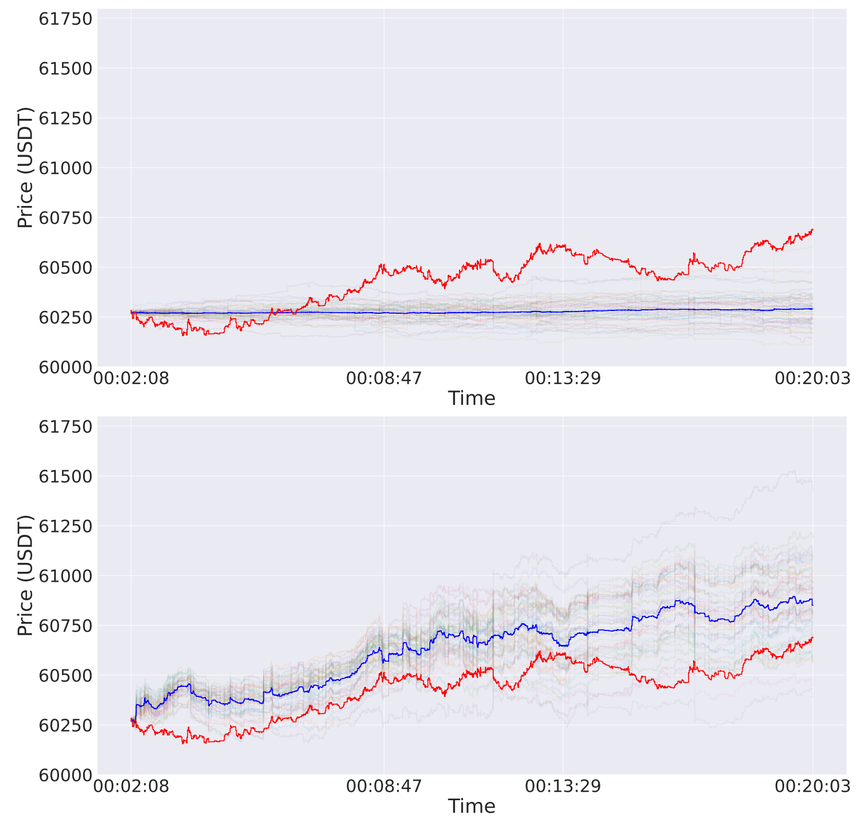

Figure 2. Simulated price dynamics of random trades, comparing simulated price (blue) against real price (read), without the LOB (top), and with the LOB (bottom).

Case Study 2: Stop-Loss Orders and Market Volatility

This study investigates the impact of stop-loss orders on market price volatility. We maintain consistent trade directions and sizes across simulations featuring: (1) No stop-loss orders (blue), and (2) Stop-loss orders (placed with probability p) in the opposing direction to the agent's trade (yellow).

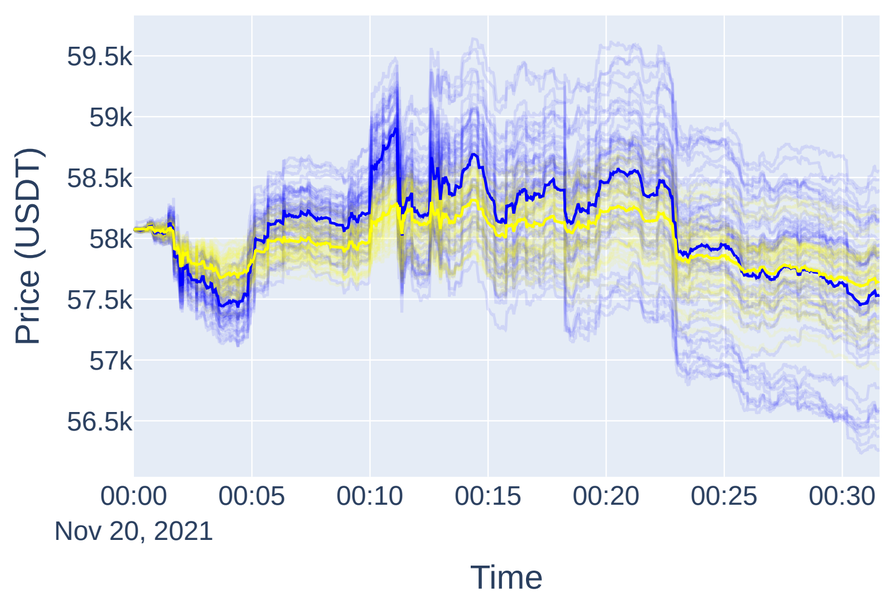

Figure 3. Market price dynamics without stop-loss orders (blue) and with stop-loss orders (yellow).

The presence of stop-loss orders increases volatility (2.14 vs. 1.68) and introduces the potential for rapid price movements and "shocks." This motivates the study of stop-loss hunting strategies and their systemic impact.

Conclusion

- We introduce a novel hybrid market simulation framework, with a unique stop-loss functionality.
- Through case study 1 we demonstrate the simulator's ability to replicate key market dynamics and reiterate the importance of the LOB in determining price dynamics.
- Through case study 2 we demonstrate the application of stop-loss orders in market simulation and show increased volatility when stop-loss orders are present.
- With suggest that use of this simulator opens up new areas of study that have previously been overlooked. Such as; the phenomena of stop-loss cascades, stop-loss hunting, and the application of stop-loss data within trading agents and strategies.

ICLR, Advances in Financial AI 2025, Singapore || Patrick.Liston@anu.edu.au || https://github.com/patrick-liston/SIMP