Analysis of Stochastic Processes with Neural Networks

Molnár András

Individual Project I.

08-01-2026

Table of Contents

Introduction and Motivation

- **Classical/Traditional asset price models**
  - Continuous time processes
  - Brownian motion
  - Mathematically convenient
  - Abstract away from discrete trading events
- **Market microstructure models**
  - Market activity is event-driven, not continuous
  - Prices evolve through jumps because of trading activity
  - Order flow and liquidity are modeled explicitly

Goal of the first project

- Study and implement a microstructure-based price model
- Understand how order flow and liquidity drive prices
- Build a simulation framework in python
- Explore statistical properties of simulated price paths

Model Overview

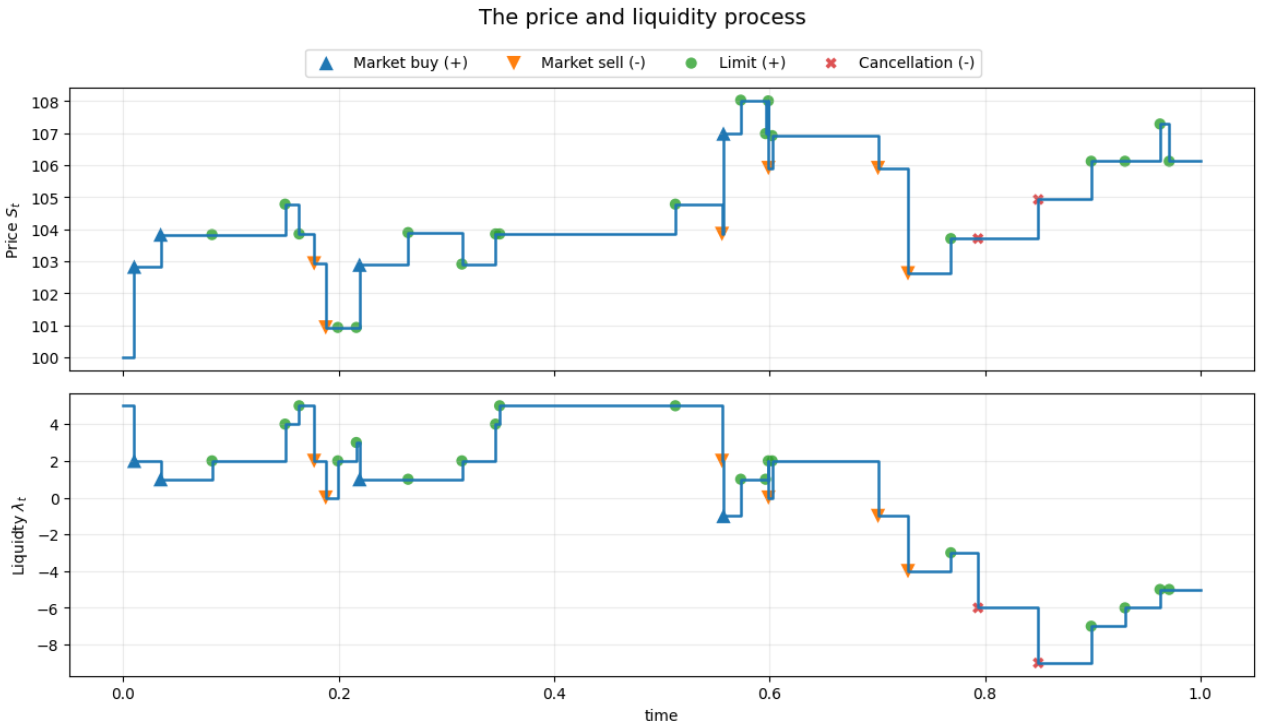
- Based on Bank, Cartea Körber (2024): Optimal execution and speculation with trade signals
- Market and limit orders
- Order arrivals are modeled by Poisson point processes
- Intensity depends on the level of liquidity

$$d\lambda_t = dL_t - |dM_t|$$

- The asset price reacts only to market orders
  - The impact depends on the level of liquidity

$$dP_t = I(\Delta_t M, \lambda_{t-})$$

The model implementation



- Single simulated price path
- Prices and liquidity evolve through discrete jumps

Analysis of simulated price paths

- Many independent simulations
- Statistical properties of price paths, liquidity and order arrivals
- Relation between them
- Autocorrelations, empirical distributions

Trader dynamics and trading signals

- Active trader submitting market orders
- Transaction costs and bid–ask spread included
- Signal-based trading allows anticipation of market events
- Trader faces an acquisition problem. Objective: maximize expected utility of terminal wealth
- Passive trader implemented as a first step

Future work and research directions

- Calibration of the model to real market data
- Learning model parameters using neural networks
- Agent-based and reinforcement learning for trading strategies

Thank you for your attention!

Use of Artificial Intelligence Tools

- During the project, I used ChatGPT and Gemini to help with the interpretation of the model and to help with the implementation of the simulation and code in Python.
- References: Bank, P., Cartea, Á., Körber, L. (2024). Optimal execution and speculation with trade signals. arXiv preprint.