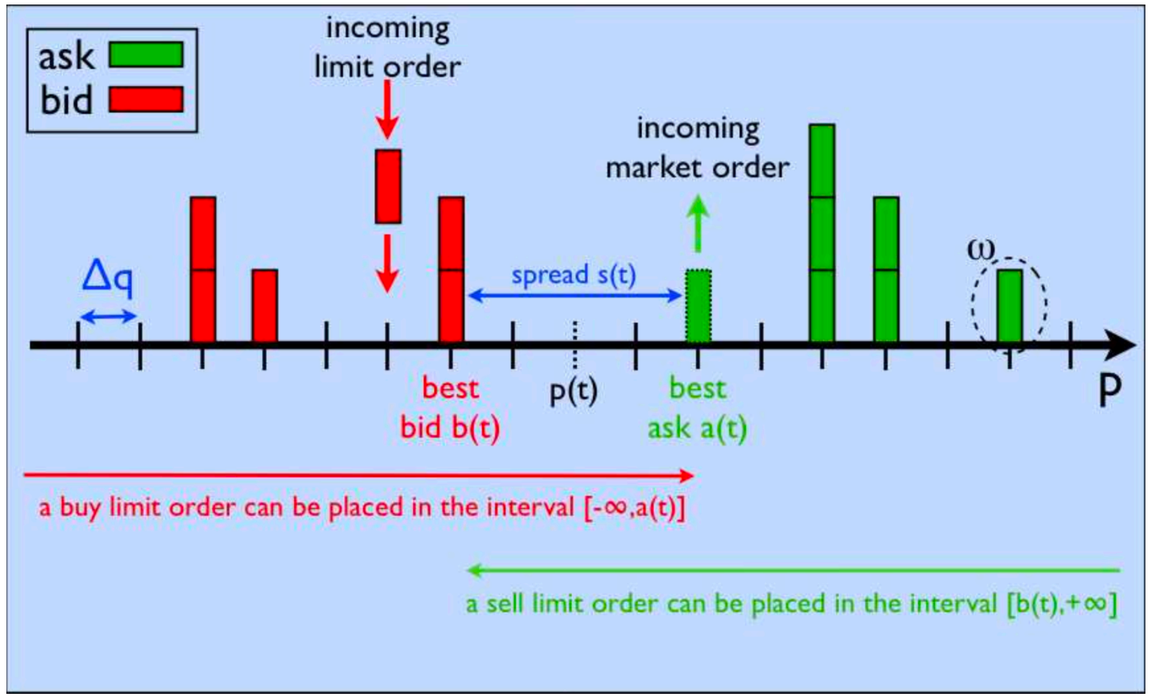
Market Dynamics: PCA and VAR Modelling of Order Flow of the LOB

Limit Order Books 101

02/06/2025

What is a Limit Order Book?

- A mechanism for matching buy and sell orders
- Types of orders:
  - Limit
  - Market
  - Cancellation



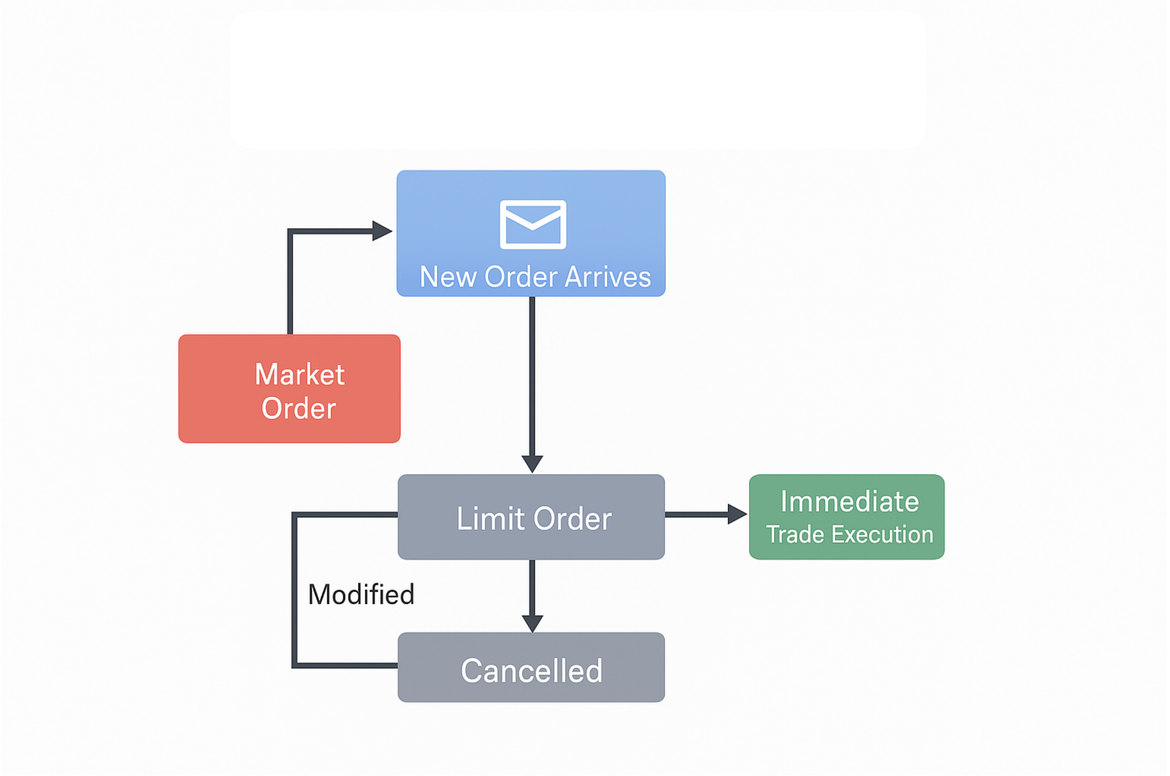
The Life of a Trade (Detailed & Nuanced)

- Orders enter the book through different intentions:
  - Passive: waiting to be executed later (limit orders)
  - Aggressive: immediate execution (market orders)
  - Strategic: to provide/withdraw liquidity, not necessarily to trade

- A trade happens when a market order matches an opposite-side limit order

- Unexecuted limit orders may:
  - Stay in the book (resting)
  - Get cancelled
  - Be modified or replaced

- Cancellations are not just "failed" trades — they are part of market strategy



Stylised Facts of the Limit Order Book

- Long memory in order flow
- Bid-ask bounce (mean reversion at high frequency)
- Concave market impact (square-root law)
- U-shaped intraday volume profile
- Heavy-tailed distribution of returns and volumes
- Volatility clustering

“What do we live for, if it is not to make life less difficult to each other?”

George Eliot

Why Do I Care?

- Stability of the market.
- Flash Crashes.
- Assets linked directly to tangible goods.

Because we cannot afford not to.

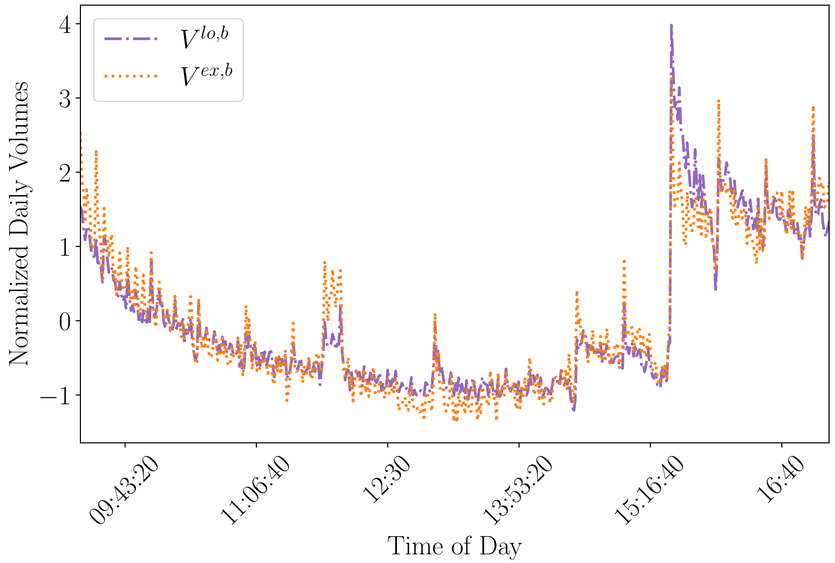
And it is fun!

Variables of Interest

For the n^{th} significant price change of the day, occurring at time t_n, we define the following variables:

- $\Delta t_n = t_n - t_{n-1}$: Time duration between the $(n-1)^{th}$ and n^{th} price changes.
- r_n: The return generated by the price change.

Flows	Bid	Ask
Limit Orders	$V_n^{\text{lo, b}}$	$V_n^{\text{lo, a}}$
Cancellations	$V_n^{\text{c, b}}$	$V_n^{\text{c, a}}$
Executions	$V_n^{\text{ex, b}}$	$V_n^{\text{ex, a}}$



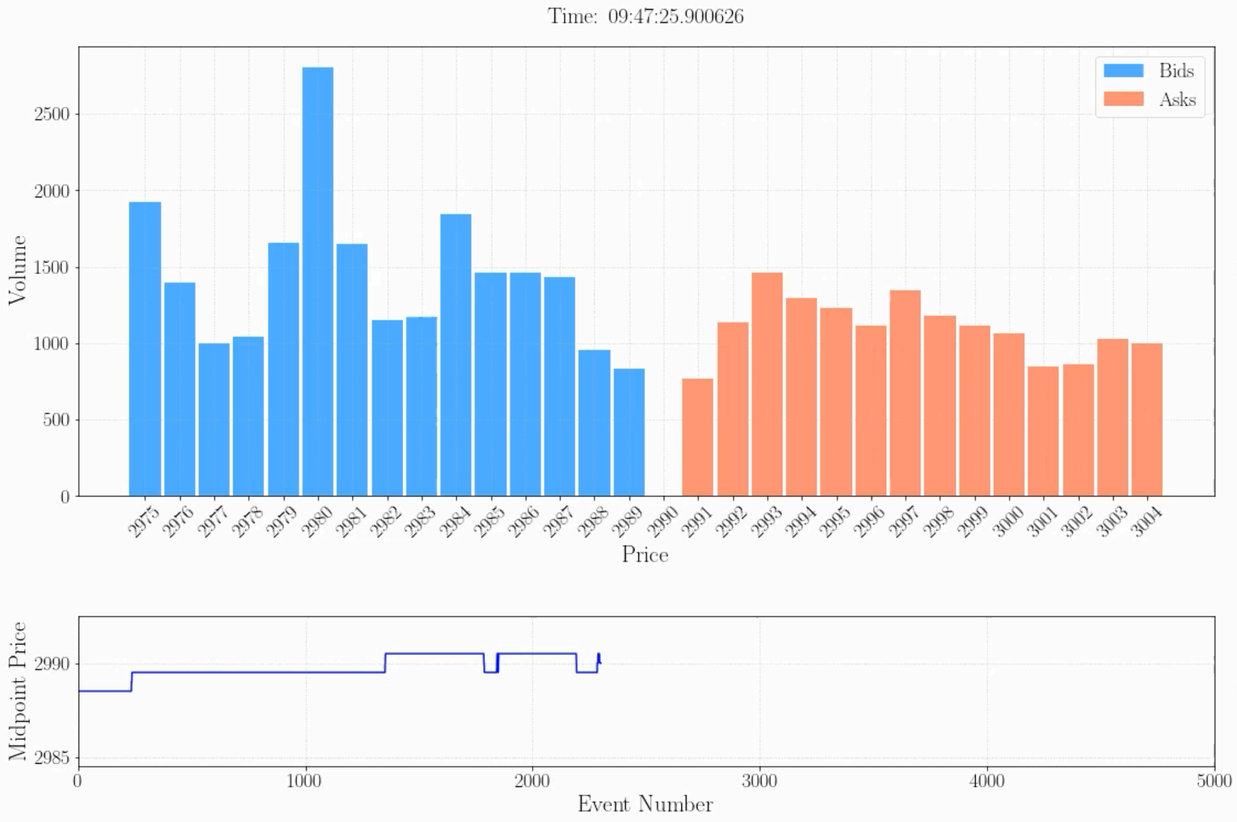
Intraday profile of the flows

The Flows are scaled by their intraday profile.

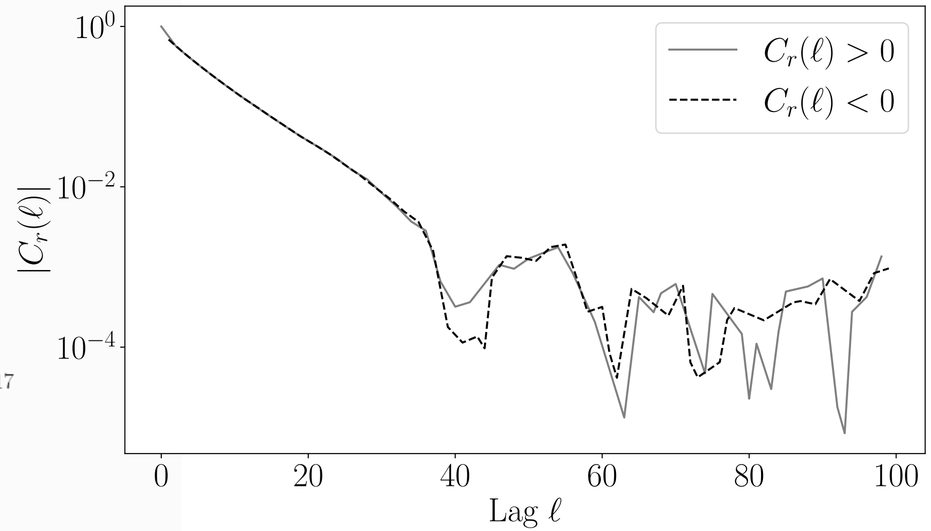
The variables are standardised, and a non linear transformation (Box Cox) is applied for better statistical properties.

$$y^{(\lambda)} = \begin{cases} \dfrac{y^{\lambda} - 1}{\lambda}, & \lambda \neq 0 \\ \ln(y), & \lambda = 0 \end{cases}$$

Are all price changes relevant?



A **<u>significant price change</u>** is a price change where the new bid corresponds to the old ask, or the new ask corresponds to the old bid.



Autocorrelation of the returns

We coarse grain over 20 price changes (~ 3 minutes) for less fluctuations.

First Step

- Understand the data
- Reproduce the stylised facts on this data.
- Create a visulization of the Limit Order Book