

# CUSUM Report

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October 2025

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## 1 Overview

This is a report on what CUSUM (cumulative sum), a statistical method used to detect small, persistent shifts in the mean level of a process over time. This report is tailored to the goals of the Intraday-Volatility-Monitor (IVM) team apart of QUANTT at Queen's.

## 2 The Scope of CUSUM in the IVM project

As stated in the overview, CUSUM (cumulative sum) is a statistical method that can be used to detect small shifts in expected mean values of a process over time. For the project IVM, the CUSUM method will be applied to detect subtle changes in the mean of high-frequency trading data on a minute-by-minute case. Specifically, we are interested in identifying persistent intraday shifts in trade volume, volatility, and price movement averages. We will be implementing positive and negative CUSUM charts to report on upward and downward deviations from the mean.

### 3 Required Inputs

To perform a CUSUM analysis effectively, the following inputs are required:

- **Time-stamped trade data:** including trade price, volume, and time of execution.
- $(\mu_0)$  **Target mean :** the expected mean of a monitored variable (trade volume or volatility level, etc.).
- $(h)$  **Threshold:** determines when a deviation is considered significant.
- $(\sigma)$  **Standard deviation:** used to normalize observed deviations.
- **Sampling frequency:** defines the interval of the analysis (e.g., 1 minute intervals).

With these parameters we will be able to keep our CUSUM charts very sensitive to the scale of expected intraday changes.

### 4 Expected Outputs

The expected outputs of the CUSUM analysis for IVM are as follows:

- The **CUSUM chart(s)** (positive and negative) showing the cumulative sum of deviations over time, allowing a visual of mean shifts.
- Identification of **breakpoints** where significant upward or downward deviations occur (values that go beyond  $(\pm h)$ ).
- Summary statistics indicating:
  - Magnitude of deviation,
  - Direction  $(\mu - \mu_0)$ .

The outputs will be used to inform the IVM team of intraday market changes and potential anomalies in some recent trading dynamics.

### 5 Issues and Limitations

Several issues and limitations may arise when applying CUSUM to high-frequency intraday trading data:

1. **Non-stationarity:** market data often exhibit time-varying mean and variance, which can lead to false detections.
2. **Noise:** e.g high-frequency traders rapidly updating quotes. Each input is a data point, but could be so small that it doesn't effect the mean  $\mu_0$ .

3. **Choice of thresholds:** selecting an appropriate decision interval  $h$  affects sensitivity; too low triggers false alarms, too high delays detection.
4. **Lag in detection:** CUSUM identifies shifts after some accumulation of evidence, so abrupt one-off events may go unnoticed (not enough evidence to support a detected event).
5. **Computational efficiency:** applying CUSUM on large-scale streaming data requires efficient rolling calculations.

## 6 Conclusion

CUSUM provides a simple yet powerful framework for detecting persistent changes in mean trade behaviour over short time windows. For the IVM project, it will serve as a **real-time alert mechanism** for market anomalies, complementing volatility estimation and order-flow monitoring modules. With careful parameter calibration and noise filtering, CUSUM can enhance the sensitivity of the IVM system to emerging intraday volatility patterns.