The dynamics of liquidity around price jumps

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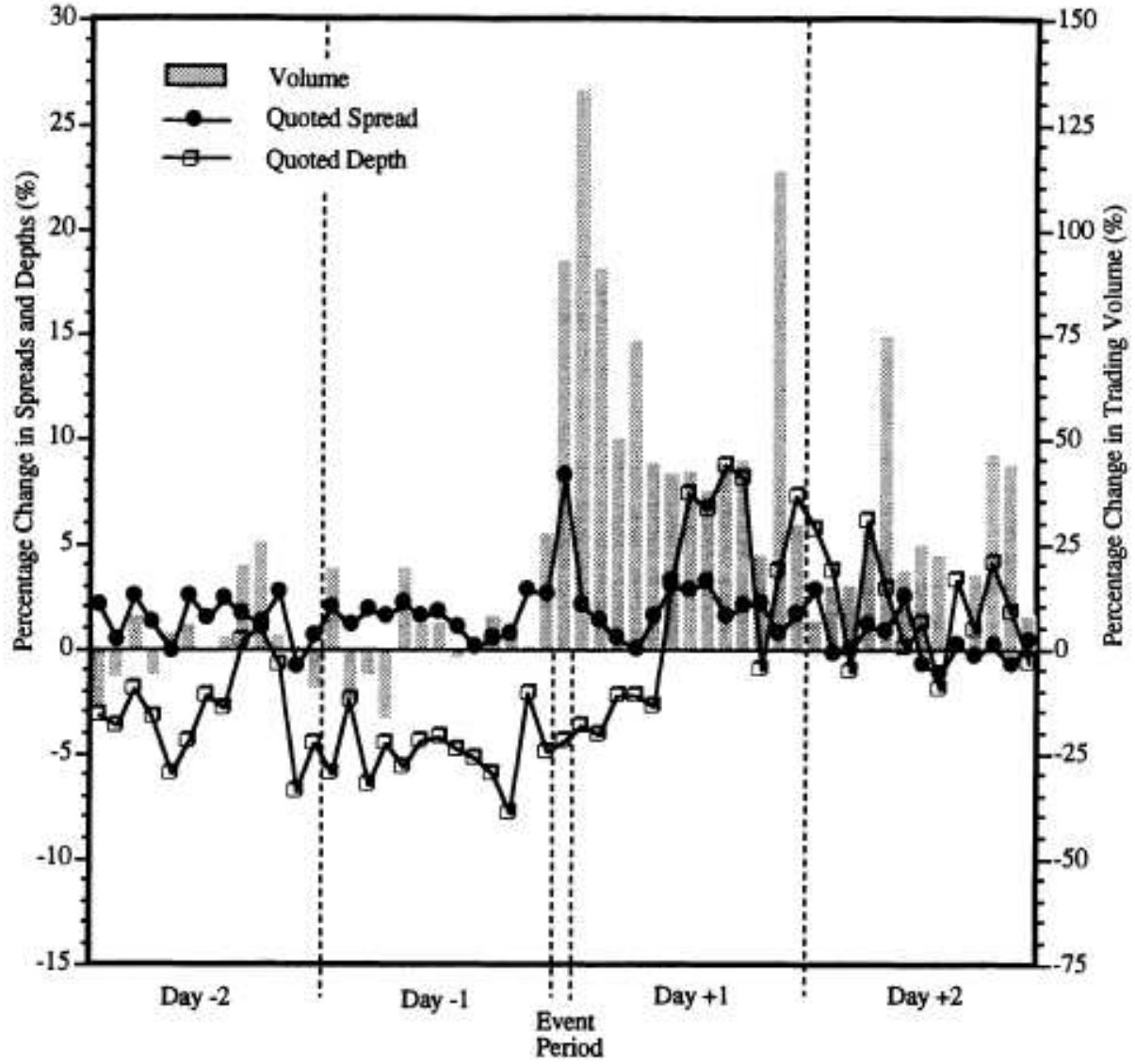
Research question

- Liquidity at NYSE: ability to trade large quantities quickly at low cost with little price impact
- Event: Price jumps
- Related research: Lee, Mucklow, Ready (1993)
  - ✓ Event: earnings announcement.
  - ✓ 1988 (230 randomly chosen firms, after liquidity filters), 30 min data

Lee, Mucklow, Ready (1993): NYSE

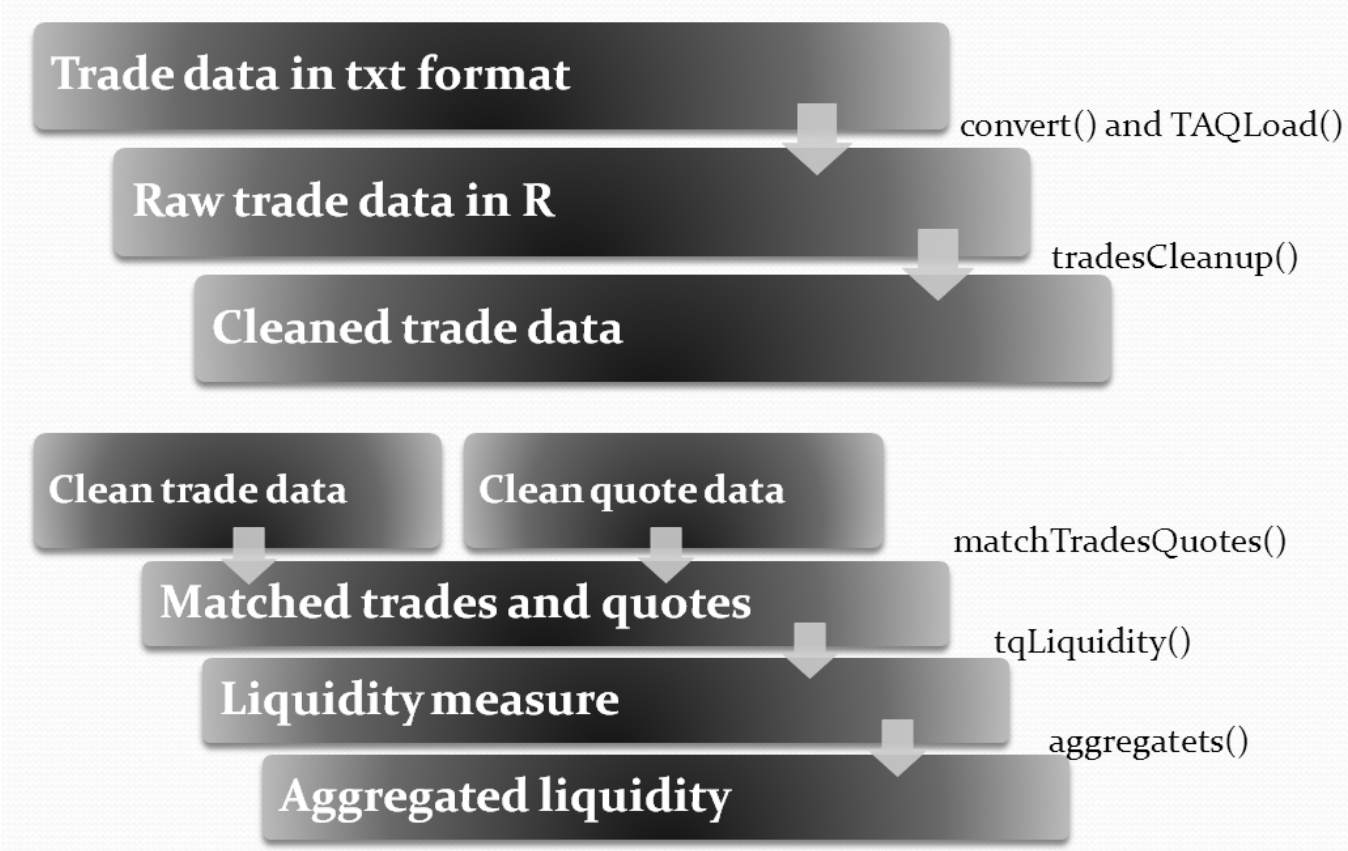


Outline

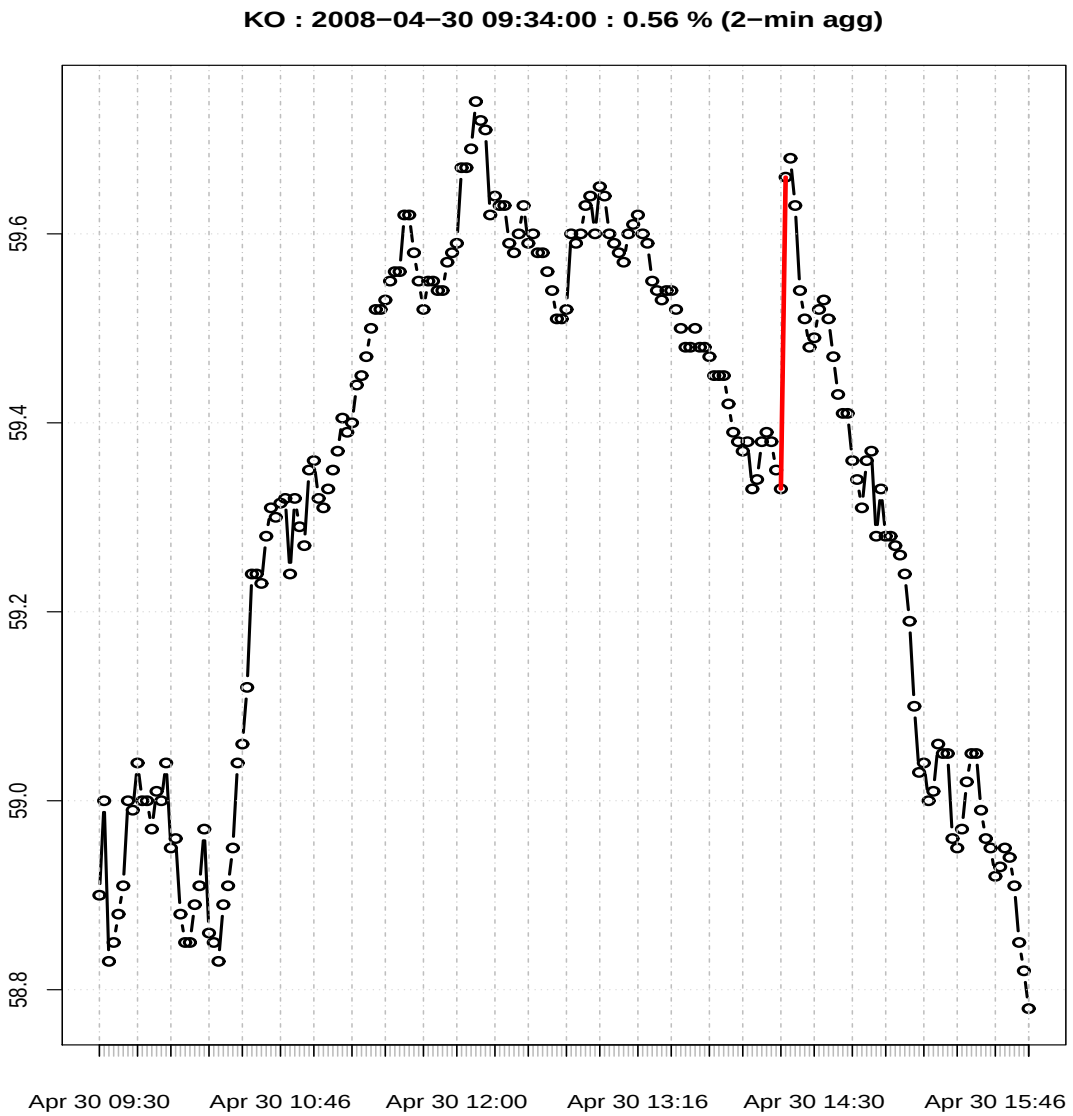
- This paper: market reaction to price jumps.
- Outline:
  1. Data;
  2. Measuring the event times;
  3. Results abnormal returns, volatility;
  4. Measuring the abnormal liquidity;
  5. Results abnormal liquidity.

Data, RTAQ

NYSE TAQ, 30 Dow Jones Industrial Average constituents (as of January 1, 2008), July 2007-December 2009 (628 days). 2 min agg.



Is this a price jump?



Model

- Observed log-prices p are generated by a continuous time Brownian semi-martingale process with jumps:

$$dp(s) = \underbrace{\mu(s)ds}_{\text{drift}} + \underbrace{\sigma(s)dW(s)}_{\text{spot vol}\times\text{Wiener diff}} + \underbrace{\kappa(s)dq(s)}_{\text{jumps}}.$$

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- Discrete time model for high frequency equispaced returns:

$$r_{t,i} = \sigma_{t,i}u_{t,i} + j_{t,i} \quad , \; u_{t,i} \sim N(0,1).$$

Intraday jump tests

- If $r_{t,i}$ is not affected by jumps, then

$$\frac{r_{t,i}}{\sigma_{t,i}} \sim N(0,1)$$

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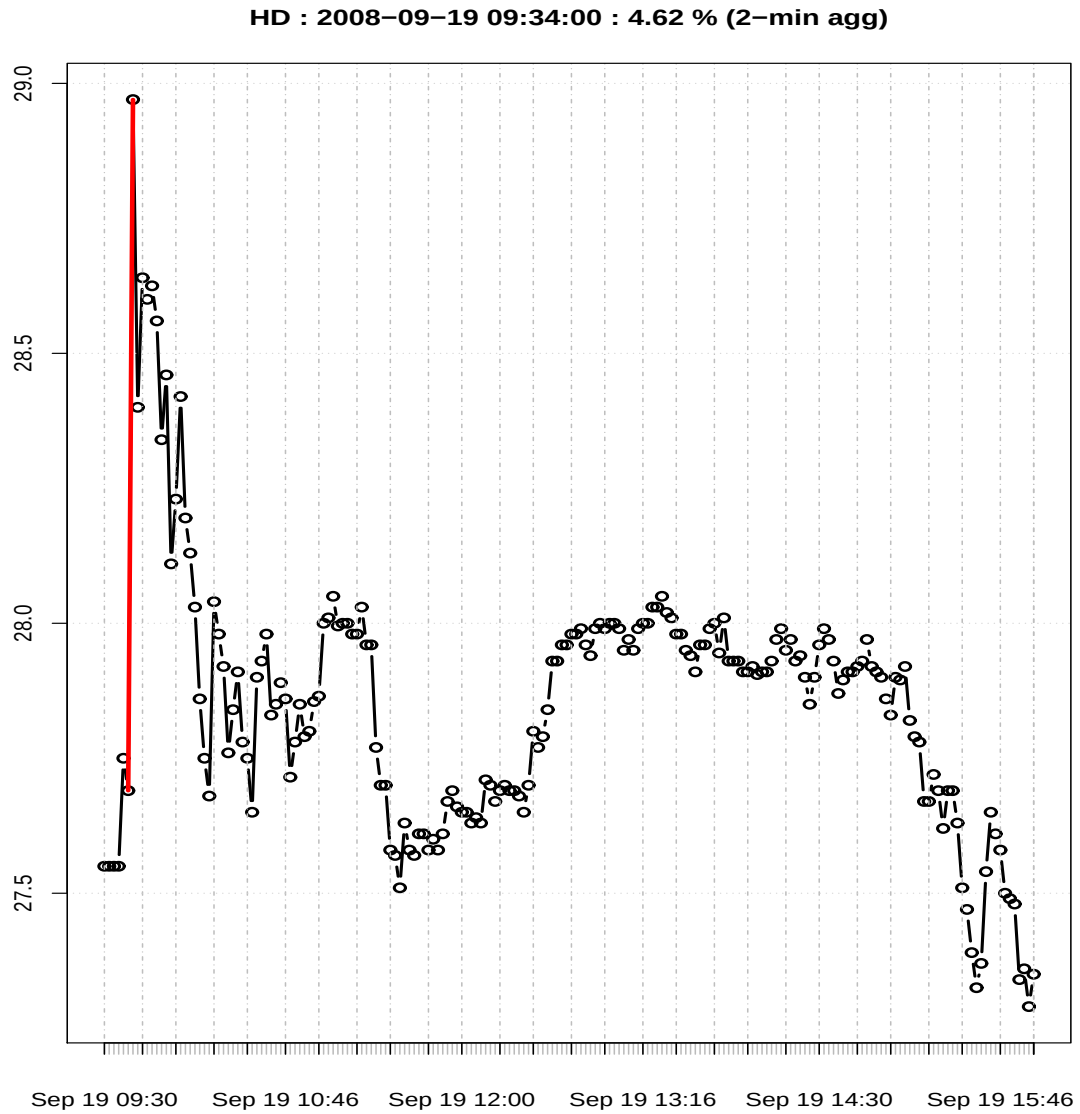
- Choice of threshold: Lee and Mykland (2008): extreme value theory: threshold such that α false positives over the entire sample. Typically: $\alpha = 10\%$, for a sample of 100000 observations:

$$\text{Jump if } \frac{|r_{t,i}|}{\sigma_{t,i}} > 4.89.$$

Examples of detected price jumps



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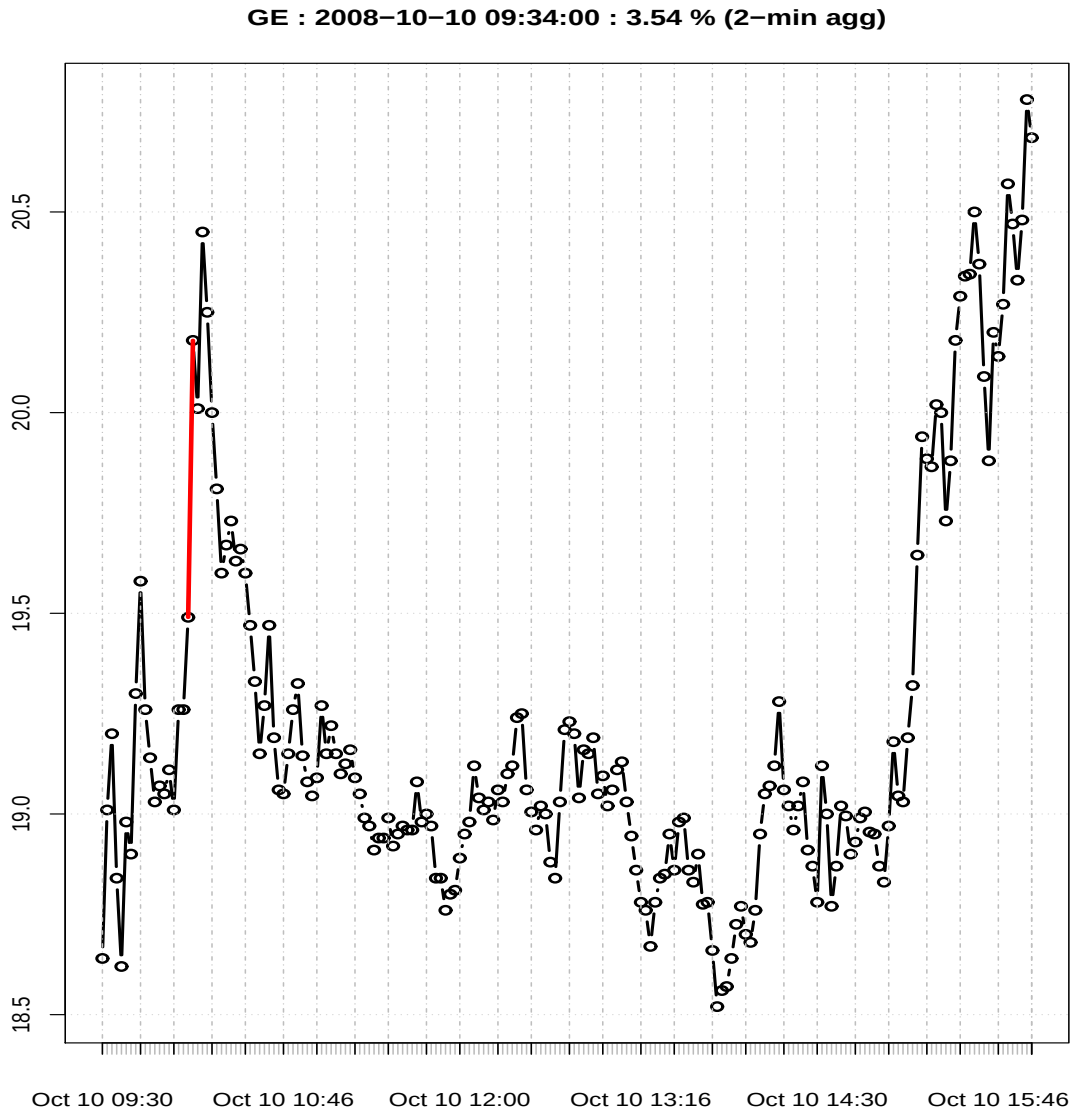

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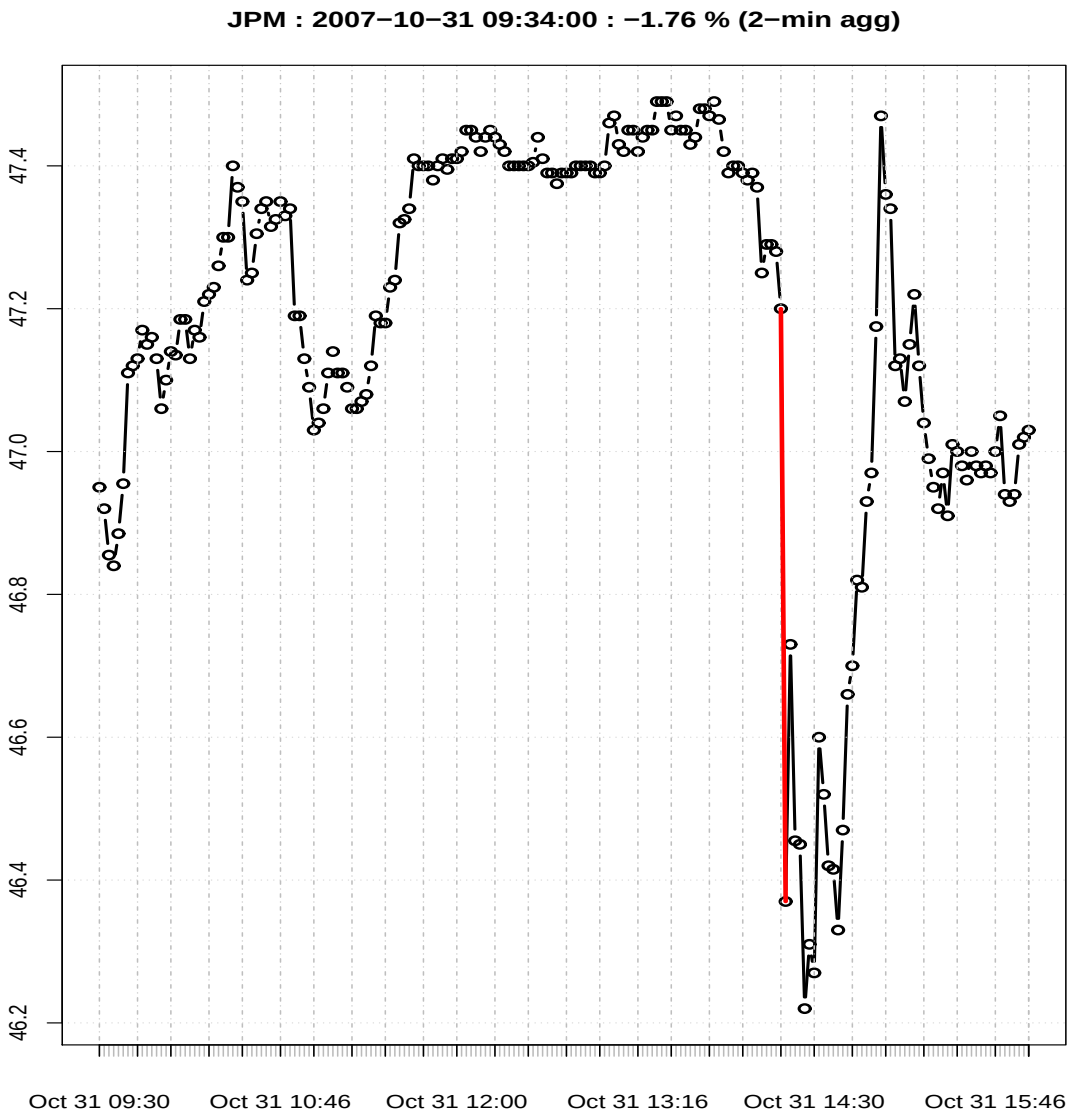

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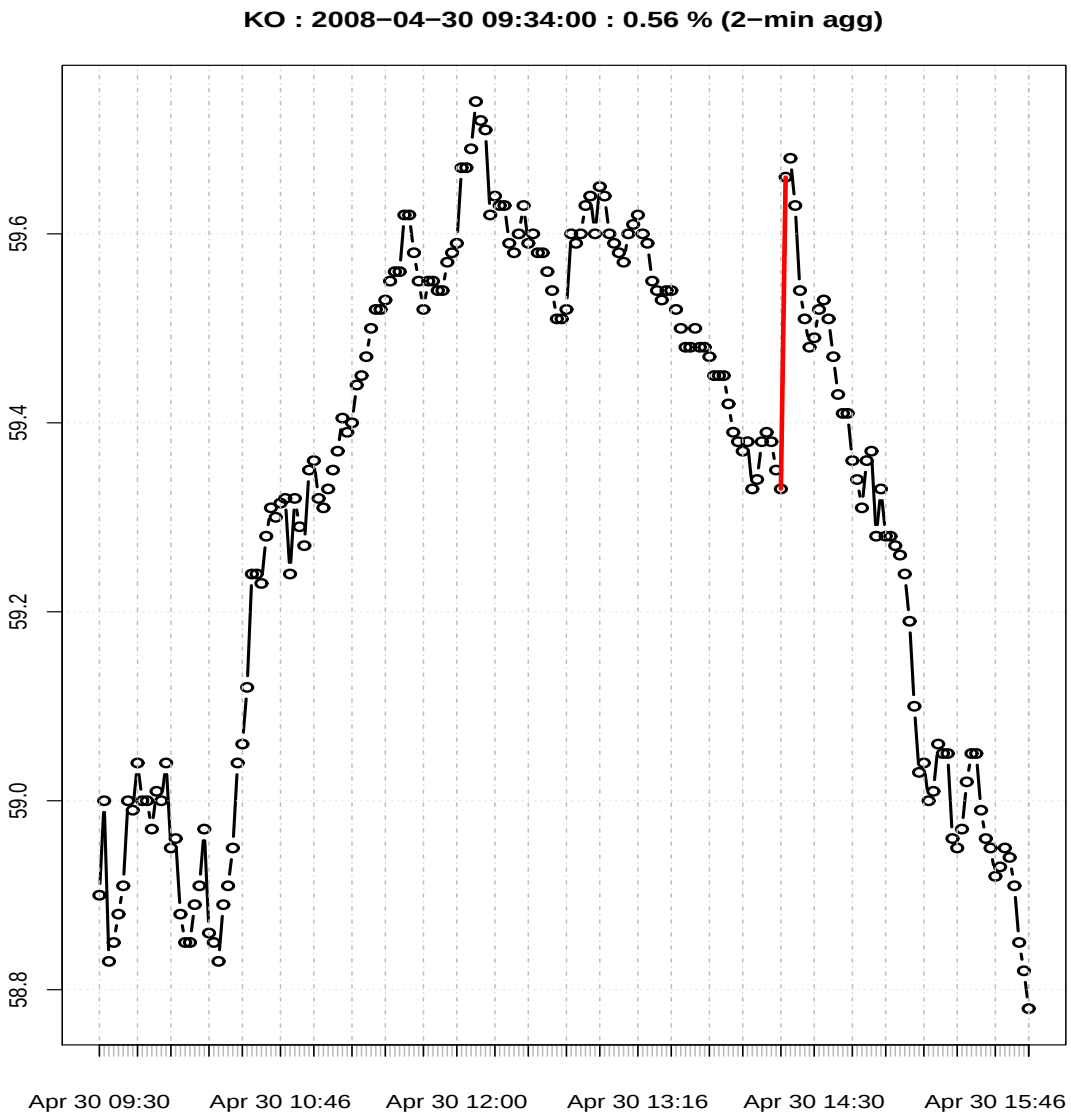
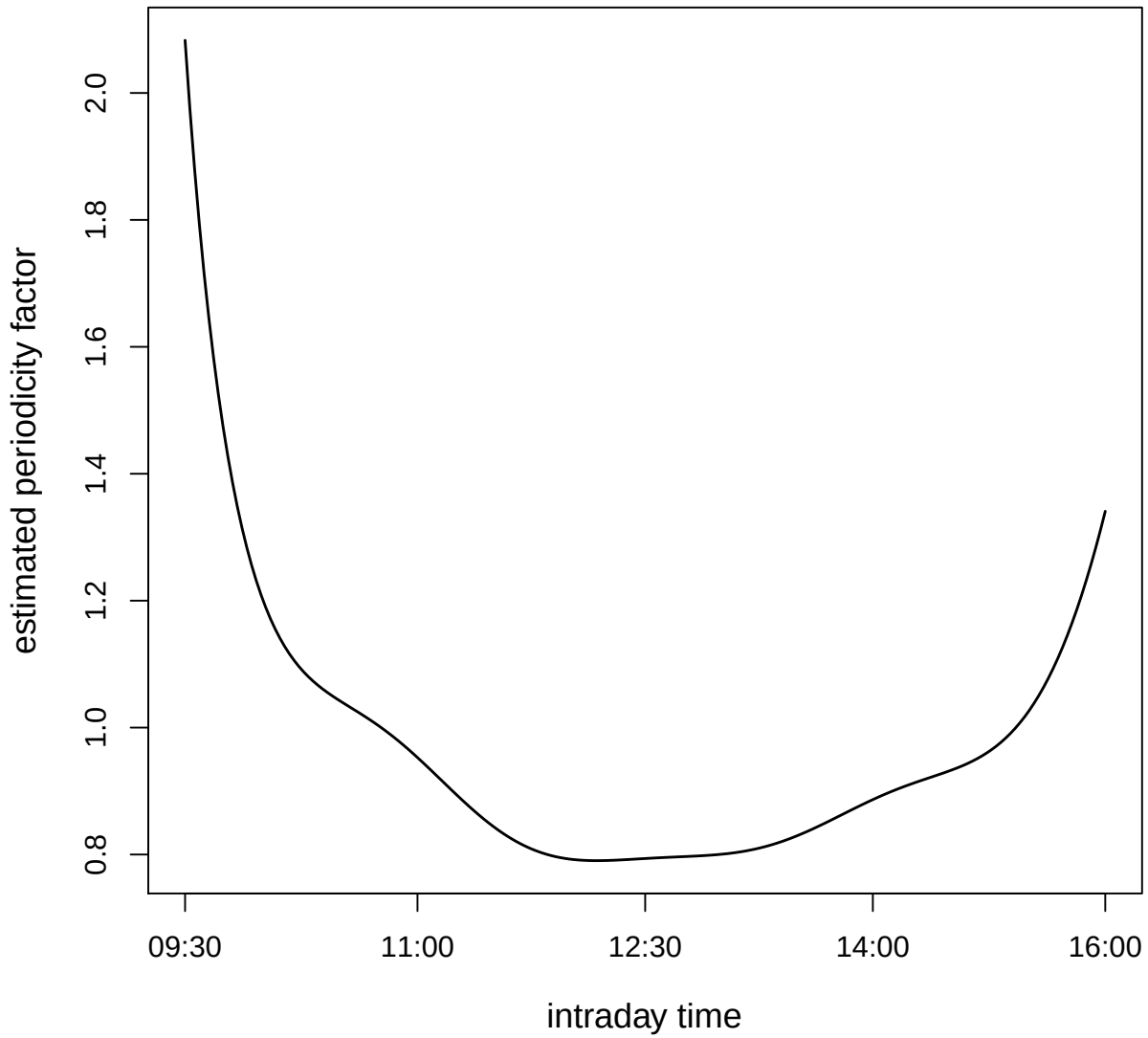


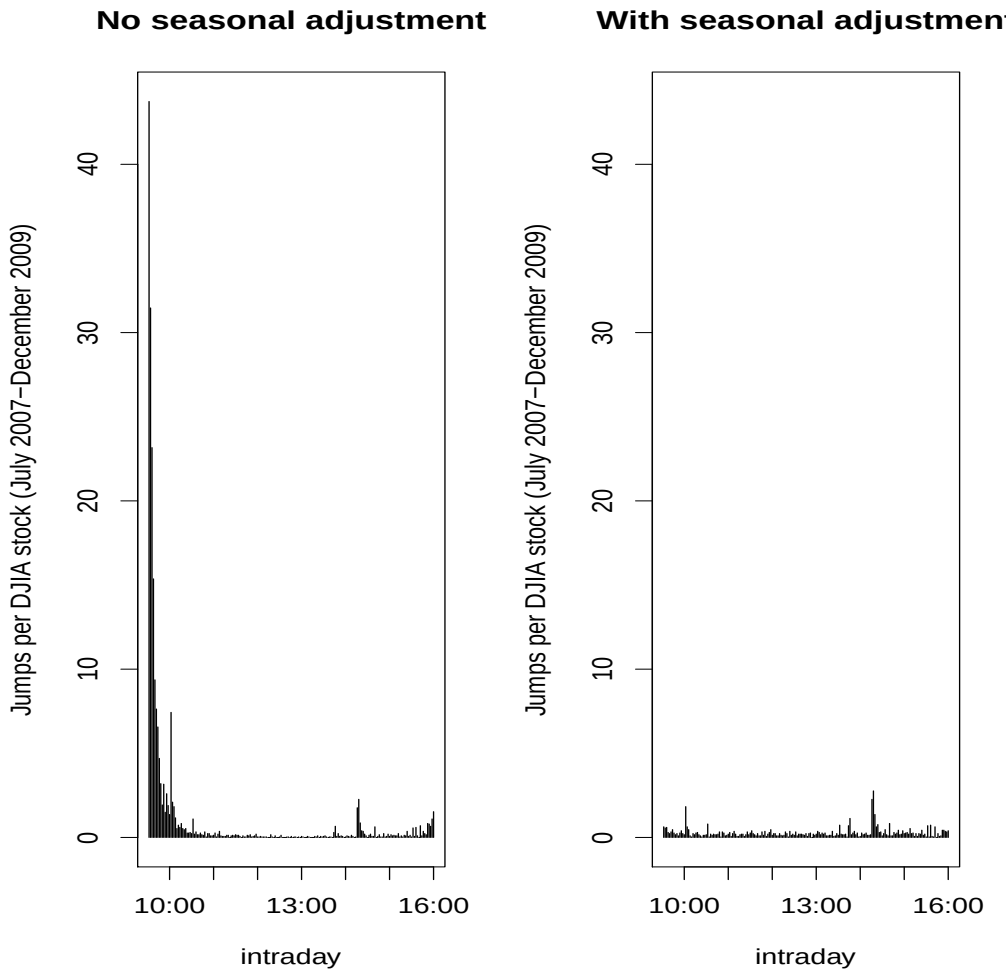
Estimation of $\sigma_{t,i} = \sigma_t f_i$

- Function “spotVol” in RTAQ.
- Spot volatility has two main components:
  1. s_t: (stochastic) day-to-day variation in volatility
  2. f_i: (deterministic) intraday variation in volatility (due to recurring calendar-based events such as opening, lunch and closing of financial markets).
- Jump robust estimators.

Estimated periodicity pattern in 2-min IBM data



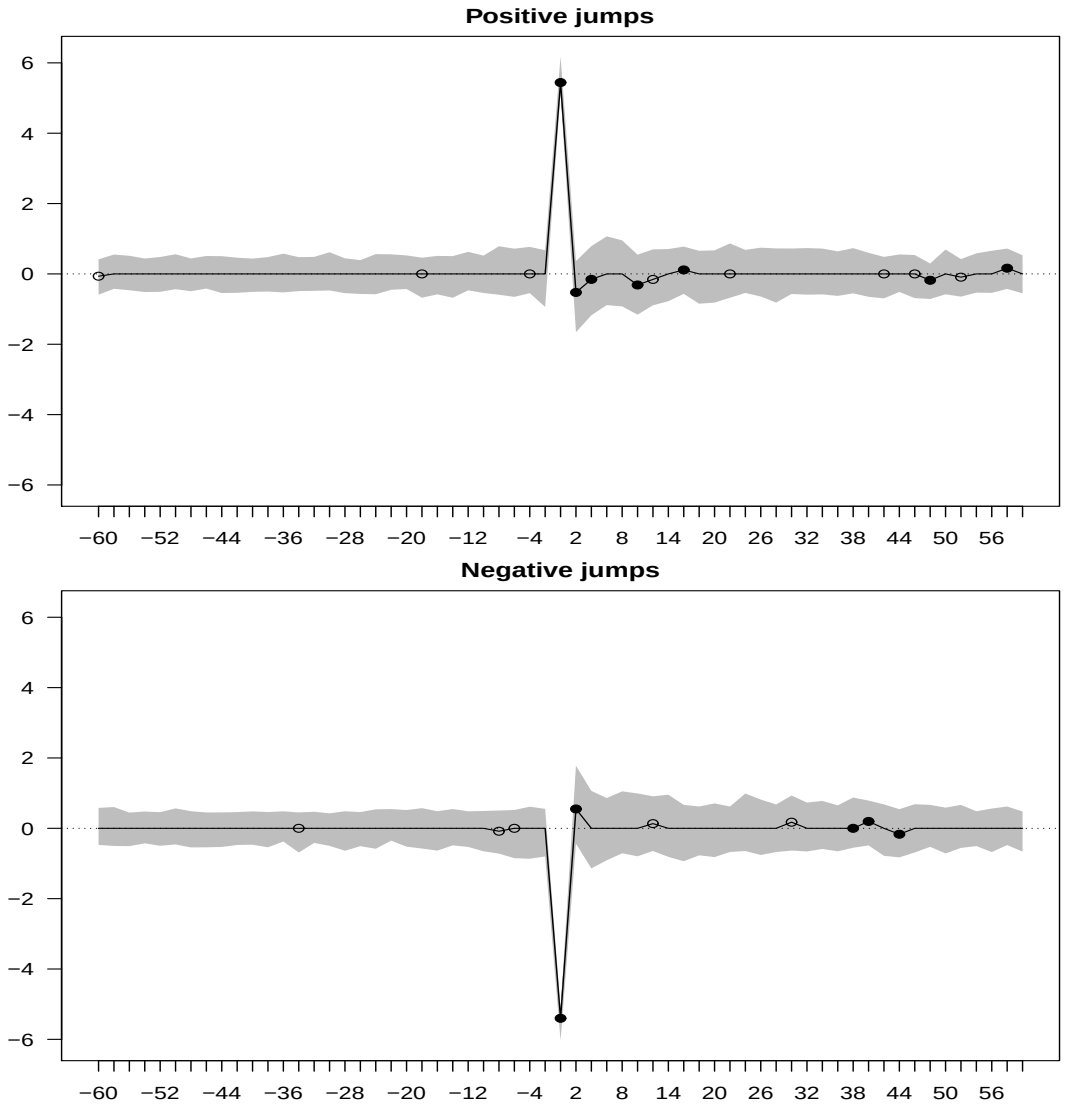
Jump detections per intraday period



Event study - event window

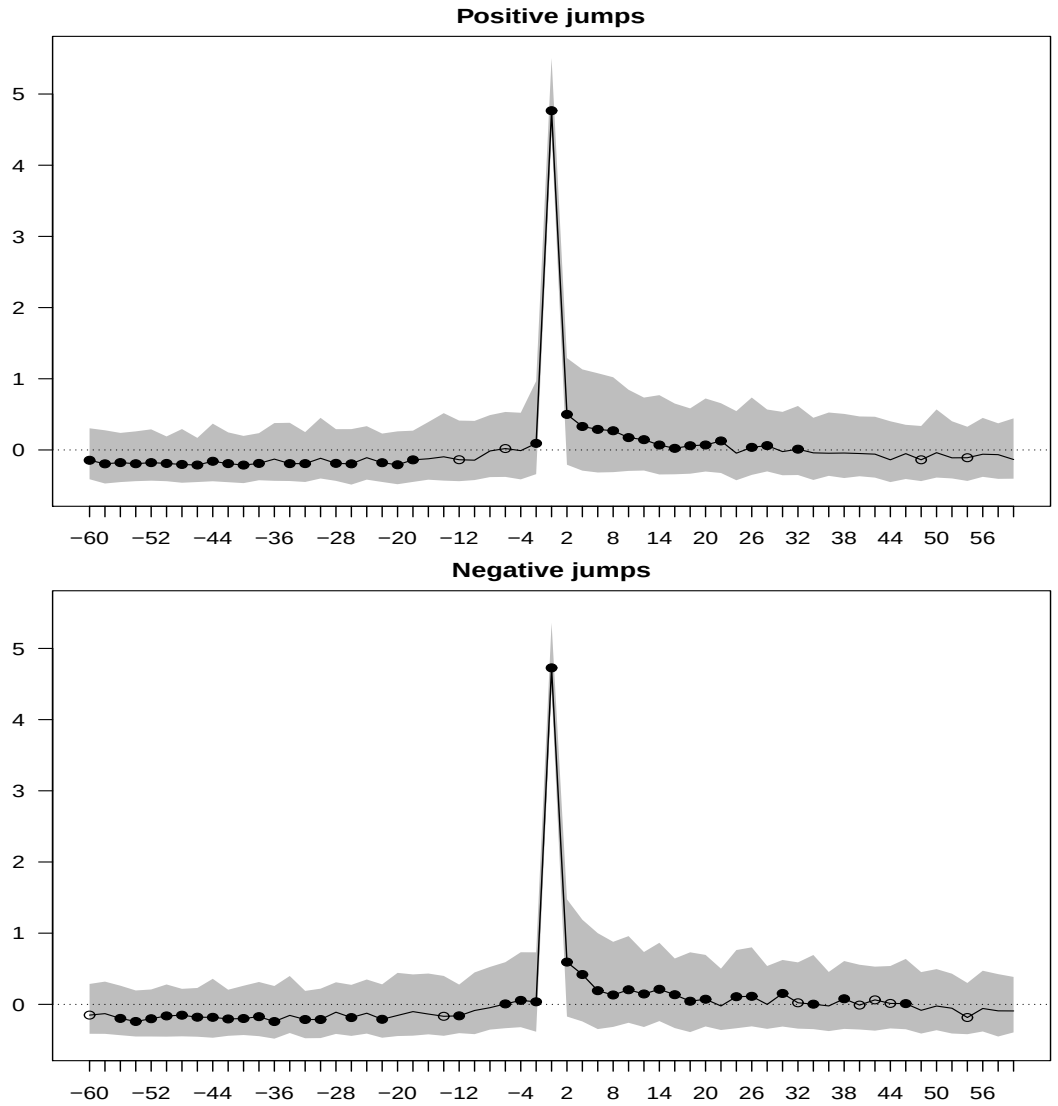
- Event: a detected jump [1829 jumps];
- Window length: $\pm$ 60 minutes around the jump;
- Filters:
  1. Filter 1: complete event window [i.e. removing obs in 1 and last hour of the day] = 828
  2. Filter 2: no multiple jumps in one window = 527

Abnormal std returns: $\frac{r_{t,i}}{\hat{f}_i \hat{s}_t}$



Median standardized returns, 2.5% and 97.5% quantiles. ● (○) indicate rejection at the 99% (95%) confidence using the Mann-Whitney test.

Abnormal volatility: $\frac{|r_{t,i}|}{\hat{f}_i \hat{s}_t} - 0.674$



Median centered absolute standardized returns, 2.5% and 97.5% quantiles. ● (○) indicate rejection at the 99% (95%) confidence using the Mann-Whitney test.

Measuring the abnormal liquidity

- Multiplicative model: spreads, volume, depth (no jump day)

$$L_{t,i} = L_t L_i \eta_{t,i}, \quad \text{with } \eta_{t,i}\ iid \text{ and median} \eta_{t,i} = 1.$$

For identification: median$L_i \eta_{t,i} = 1.$

- Then on days without jumps

$$\hat{L}_t \equiv \text{median}_i L_{t,i} \to L_t$$

$$\hat{L}_i \equiv \text{median}_{t \in ND} \frac{L_{t,i}}{\hat{L}_t} \to L_i.$$

Measuring the abnormal liquidity

- Abnormal liquidity:

$$\bar{L}_{t,i} = \frac{L_{t,i} - \hat{L}_i \hat{L}_t}{\hat{L}_i \hat{L}_t}.$$

Has median 0 if no impact of jumps on liquidity.

Order and depth imbalance

- Order imbalance:

$$OI_i = \frac{\sum_{k=1}^{NT_i} D_{i,k} Size_{i,k}}{SumSize_i},$$

where $D_{i,k}$ is 1 if the kth trade of interval i was a buy, -1 if it was a sell.

- Depth imbalance:

$$DI_i = \frac{(MeanAskDepth_i - MeanBidDepth_i)}{MeanDepth_i}$$

Order and depth imbalance

- Additive model: order imbalance and depth imbalance (no jump day)

$$L_{t,i} = L_t + L_i + \varepsilon_{t,i}, \quad \varepsilon_{t,i}\ iid \text{ and median}\varepsilon_{t,i} = 1.$$

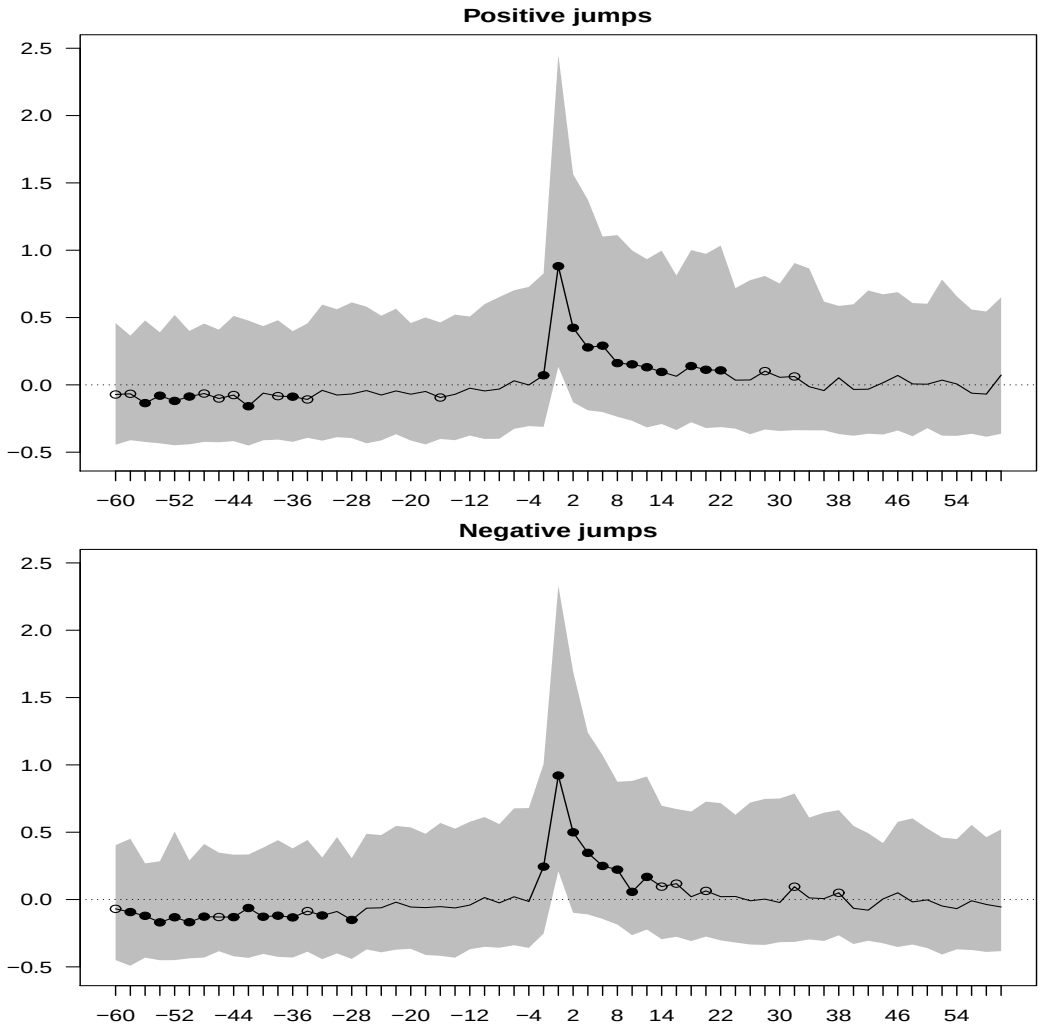
For identification: median$L_i = 0$.

$$\hat{L}_i = \text{median}_{t \in ND}(L_{t,i} - \text{median}_i L_{t,i})$$

- Abnormal liquidity:

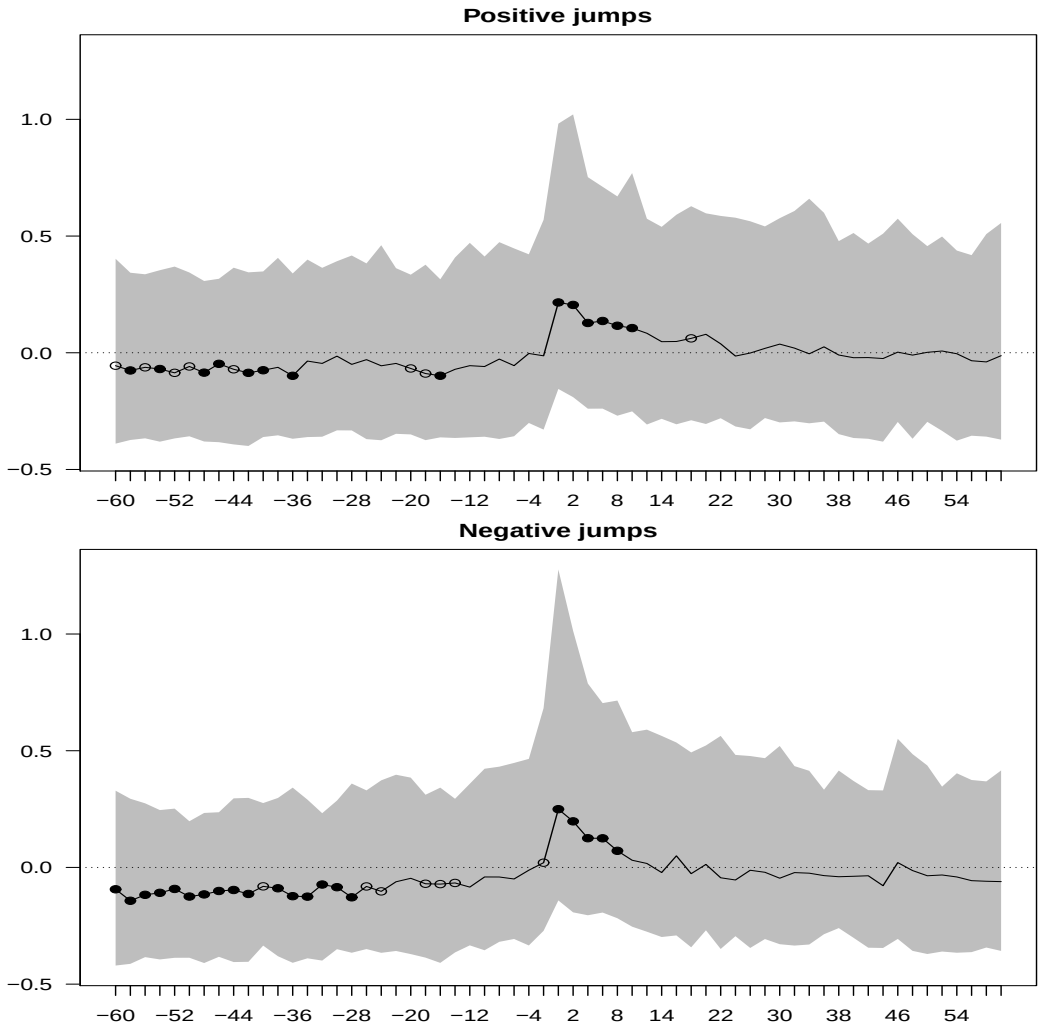
$$\bar{L}_{t,i} = L_{t,i} - \text{median}_i L_{t,i} - \hat{L}_i$$

Effective bid/ask spreads



Median standardized liquidity measure, 2.5% and 97.5% quantiles. ● (○) indicate rejection at the 99% (95%) confidence using the Mann-Whitney test.

Quoted bid/ask spreads



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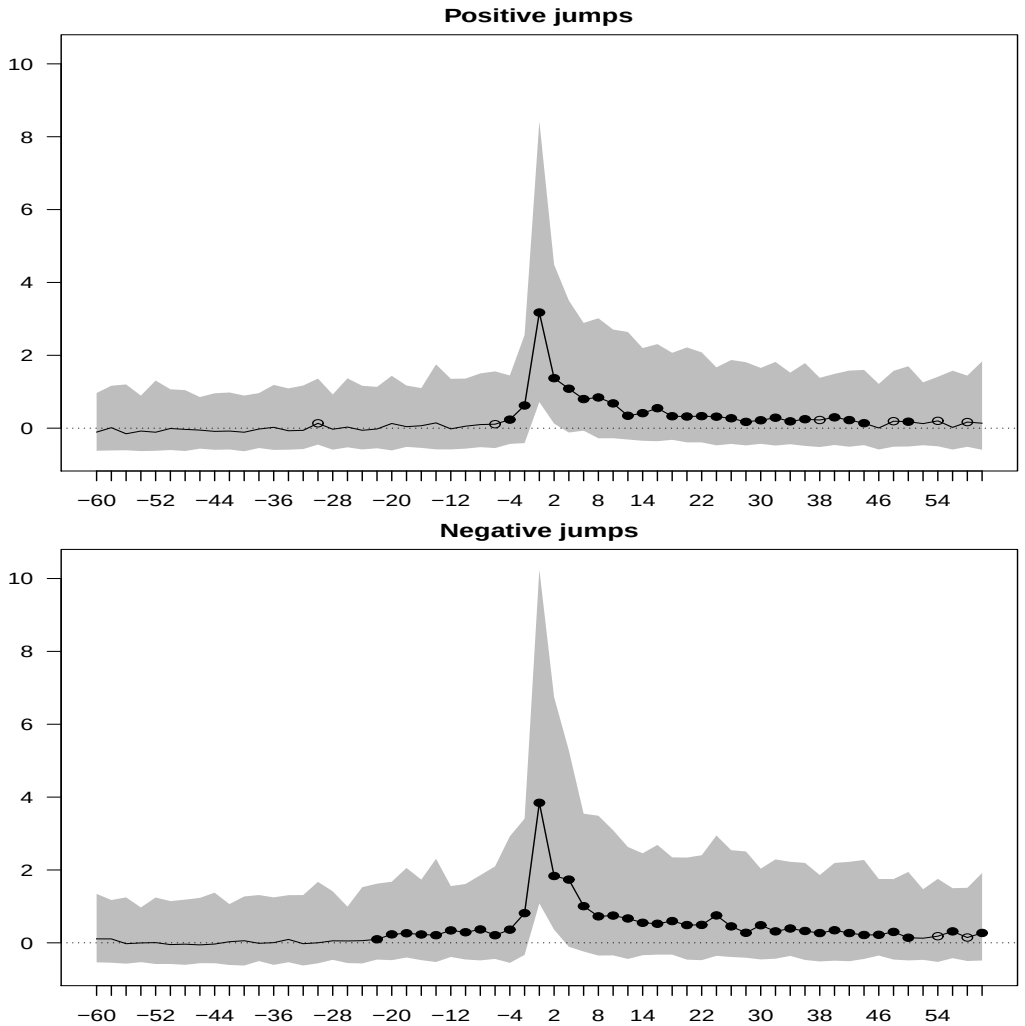
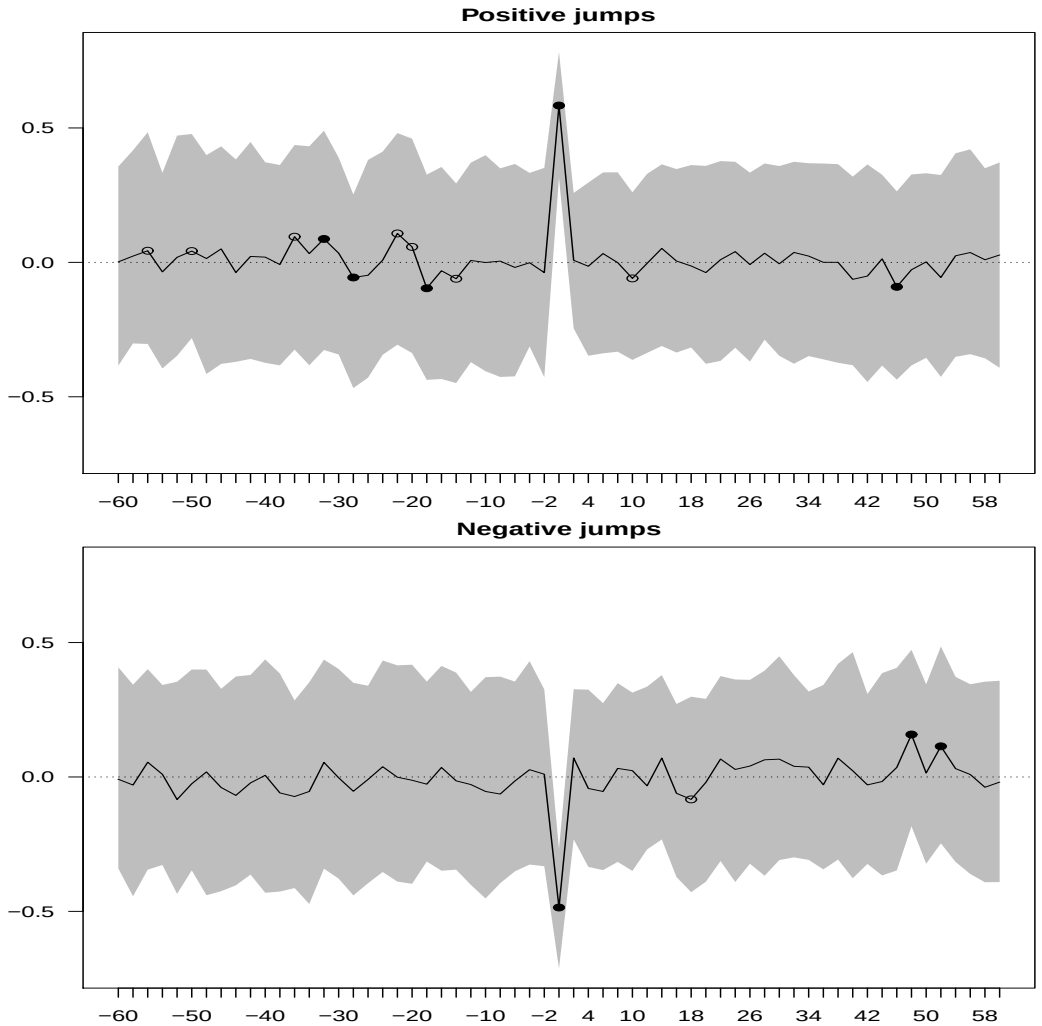
Trade volume



Full black line is the median standardized liquidity measure. The shaded region is the range between the 2.5% and 97.5% quantiles. ● (○) indicate rejection at the 99% (95%) confidence using the Mann-Whitney test.

Order imbalance



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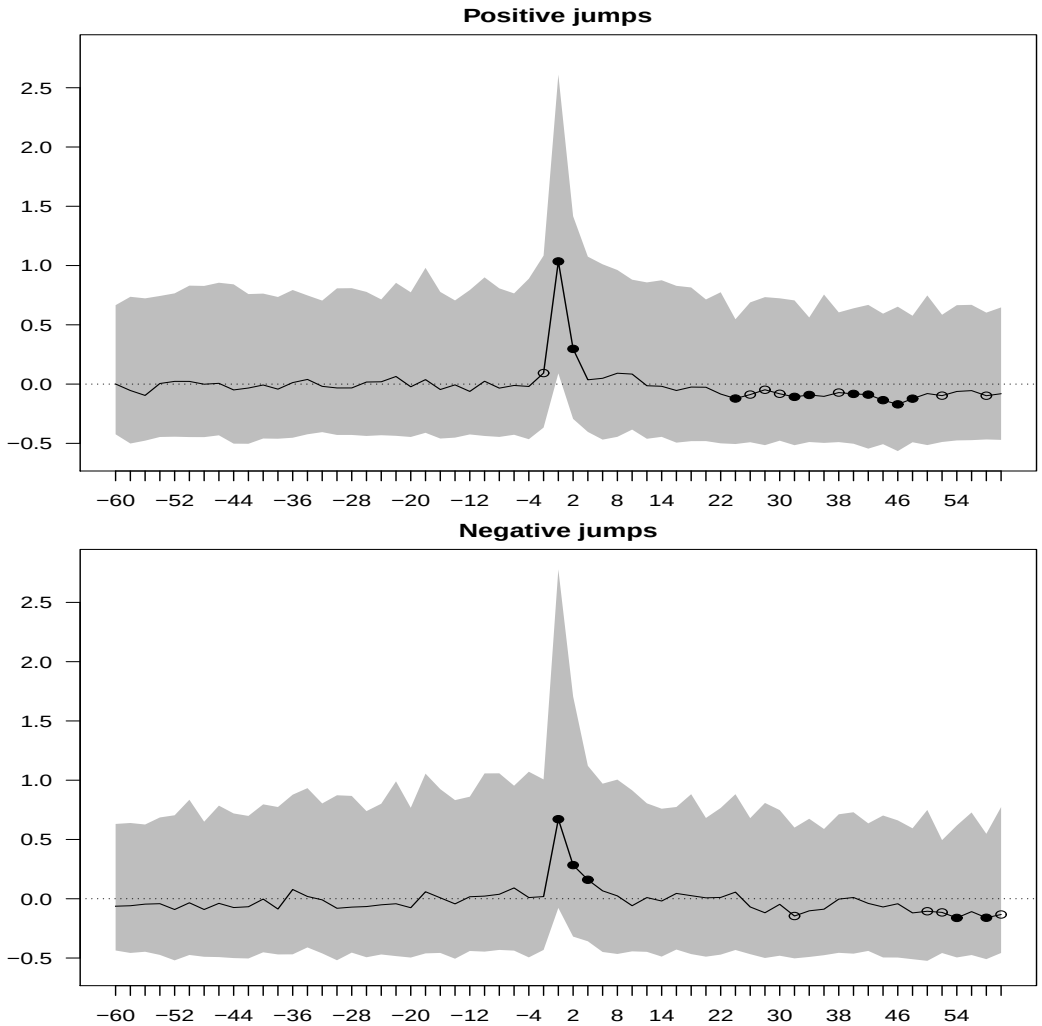
Mean depth (at the best ask,bid)



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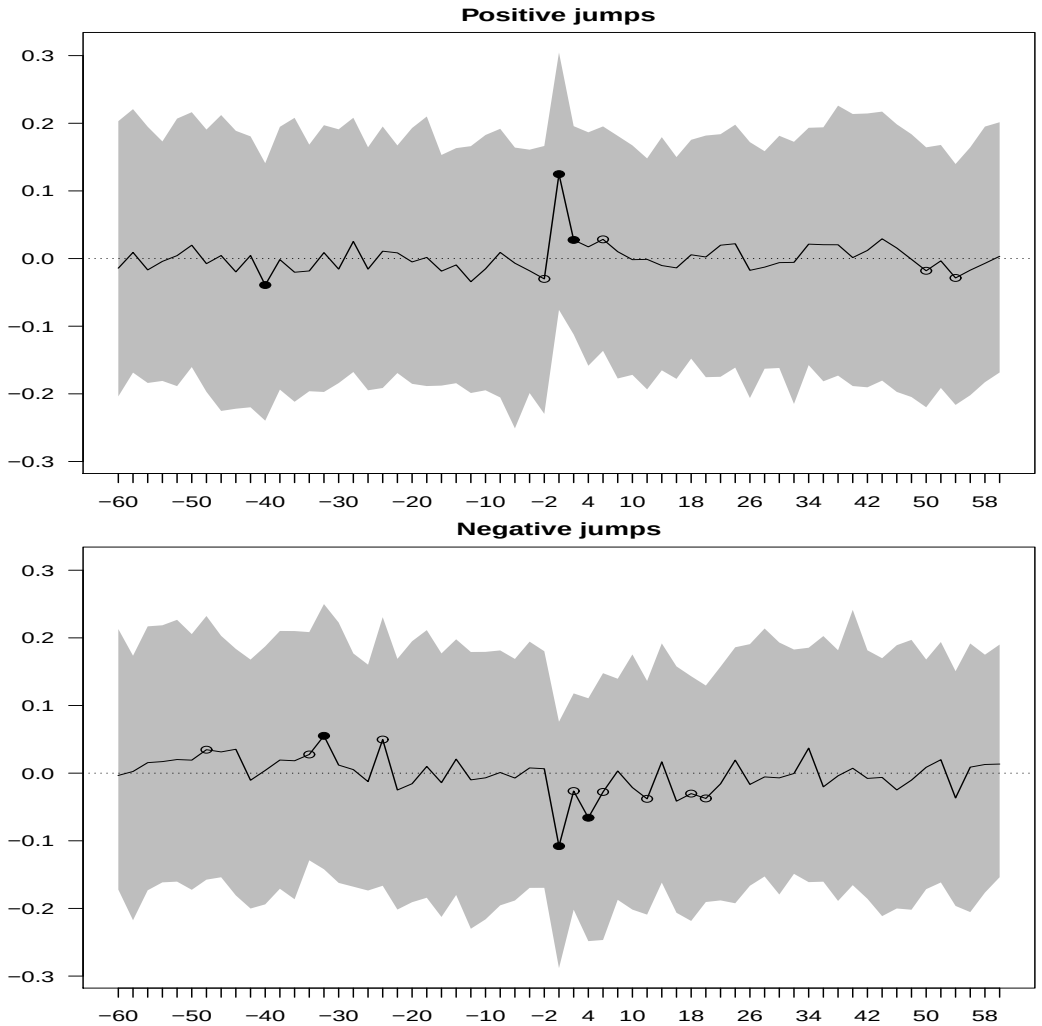
Depth imbalance



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Conclusions

After a jump:

- Some overreaction. Persistent increase in volatility
- Liquidity: ability to trade large quantities quickly at low cost with little price impact
  - ✓ Increase in spreads [30 min], some anticipation
  - ✓ Sharp and persistent increase in volume [$>$ 60 min], anticipation
  - ✓ Increase in depth: goes to the most aggressive side [6min], but dissipates quickly, anticipation

References

- Intraday jump detection [Boudt K., Croux C. and Laurent S. 2011. Robust estimation of intraweek periodicity in volatility and jump detection. Journal of Empirical Finance 18, 353-367.]
- Jumps and liquidity [Boudt K., Ghys H. and Petitjean M. The dynamics of liquidity around price jumps. Work in progress.]
- Software package RTAQ [Cornelissen J. and Boudt K. **RTAQ**: Tools for the analysis of trades and quotes in R. On CRAN.]

`www.econ.kuleuven.be/kris.boudt/public`