The dynamics of liquidity around price jumps

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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
Data
Event: price jump
Abnormal returns and vol around jumps
Abnormal liquidity around jumps
Conclusions
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.**

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- **Conclusions**
Is this a price jump?

Outline

Data

Event: price jump

- Test
- spotVol and intraday periodicity
- Event study

Abnormal returns and vol around jumps

Abnormal liquidity around jumps

Conclusions
Model

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

$$dp(s) = \mu(s)ds + \sigma(s)dW(s) + \kappa(s)dq(s).$$

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Model

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

  $$dp(s) = \mu(s)ds + \sigma(s)dW(s) + \kappa(s)d\mathcal{J}(s).$$

- 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

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

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

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

- Choice of threshold: Lee and Mykland (2008): extreme value theory: threshold such that $\alpha$ false positives over the entire sample. Typically:
  $\alpha = 10\%$, for a sample of 100000 observations:
  Jump if $\frac{|r_{t,i}|}{\sigma_{t,i}} > 4.89$. 
Examples of detected price jumps

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HD : 2008−09−19 09:34:00 : 4.62 % (2−min agg)
Examples of detected price jumps

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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

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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:** \( \frac{r_{t,i}}{\hat{f}_i \hat{S}_t} \)

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Median standardized returns, 2.5% and 97.5% quantiles. \( \bullet \) (○) indicate rejection at

the 99% (95%) confidence using the Mann-Whitney test.
Abnormal volatility: $\frac{|r_{t,i}|}{\hat{f}_i \hat{s}_t} = 0.674$

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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)

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

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

- Then on days without jumps

\[ \hat{L}_t \equiv \text{median}_i L_{t,i} \rightarrow L_t \]

\[ \hat{L}_i \equiv \text{median}_{t \in ND} \frac{L_{t,i}}{\hat{L}_t} \rightarrow L_i. \]
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 \( k \)th 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)

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

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

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- Abnormal liquidity
- Spreads
- Volume
- Depth

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

**Outline**

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❖ Depth

**Conclusions**

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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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


Software package RTAQ [Cornelissen J. and Boudt K. RTAQ: Tools for the analysis of trades and quotes in R. On CRAN.]