Time-varying Volatility Estimation with high Frequency Cryptocurrencies

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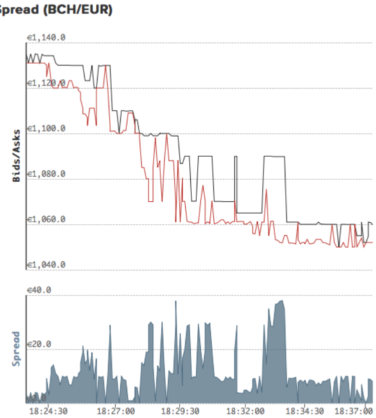
High Frequency (HF) Cryptocurrency Trading



Recent Trades (BCH/EUR)

1 - 15 of 250 trades

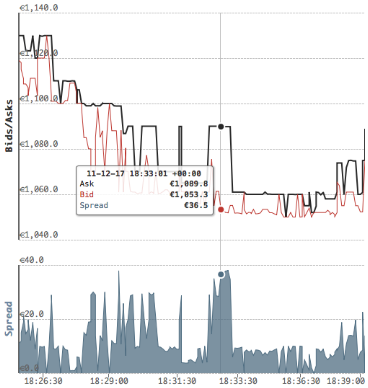
Time	Order	Price	Volume
18:37:05 +00:00	buy	€1,061.0	0.25820000
18:37:05 +00:00	buy	€1,060.8	0.21540000
18:37:05 +00:00	buy	€1,054.8	0.21540000
18:37:05 +00:00	buy	€1,052.0	0.14500000
18:36:53 +00:00	sell	€1,050.0	17.91719153
18:36:53 +00:00	sell	€1,050.0	0.32000000
18:36:53 +00:00	sell	€1,050.0	4.00000000
18:36:53 +00:00	sell	€1,050.0	0.00201000
18:36:53 +00:00	sell	€1,050.0	2.00000000
18:36:53 +00:00	sell	€1,050.0	1.00000000
18:36:53 +00:00	sell	€1,050.0	1.00000000
18:36:53 +00:00	sell	€1,050.0	0.02000000
18:36:53 +00:00	sell	€1,050.0	1.18571428
18:36:53 +00:00	sell	€1,050.0	0.25000000
18:36:53 +00:00	sell	€1,050.0	0.70000000

‹ 1 2 3 4 5 ... 17 ›

Source: kraken

HF Cryptocurrency Trading

Spread (BCH/EUR)



Recent Trades (BCH/EUR)

1 - 15 of 250 trades

Time	Order	Price	Volume
18:39:11 +00:00	sell	€1,075.0	0.06900000
18:39:11 +00:00	sell	€1,075.0	0.50000000
18:39:11 +00:00	buy	€1,088.9	1.73518517
18:39:11 +00:00	buy	€1,088.8	7.04000000
18:39:11 +00:00	buy	€1,080.0	0.20000000
18:39:11 +00:00	buy	€1,075.0	0.12587000
18:39:10 +00:00	buy	€1,074.9	0.89894483
18:39:05 +00:00	buy	€1,074.8	0.06940000
18:39:05 +00:00	buy	€1,074.7	0.09260000
18:39:05 +00:00	buy	€1,074.6	0.09260000
18:39:05 +00:00	buy	€1,060.8	1.09224540
18:39:05 +00:00	buy	€1,060.0	2.88410934
18:39:05 +00:00	buy	€1,060.0	0.10000000
18:39:04 +00:00	buy	€1,060.0	0.01269066
18:38:58 +00:00	sell	€1,052.3	0.02742651

‹ 1 2 3 4 5 ... 17 ›

Source: kraken

Event = surprise element?

Jump Detection

- In the case where a large jump occurs, a simple glance at the dataset might be sufficient to decide this issue.
- Such large jumps are usually infrequent, small frequent jumps should also be considered.
- Characterize jumps both theoretically and empirically.
- Need efficient tests available for jumps that are sufficiently robust to withstand misspecification and small sample bias.
- Literature: Xue, Genday and Fagan (2014), AÏt-Sahalia and Jacod (2009) etc.

CC Market

- Cryptocurrencies (CC) still represent an emerging market that suffers many changes because of updating regulatory requirements and contradictory attitudes from institutions and influential people

Data Source

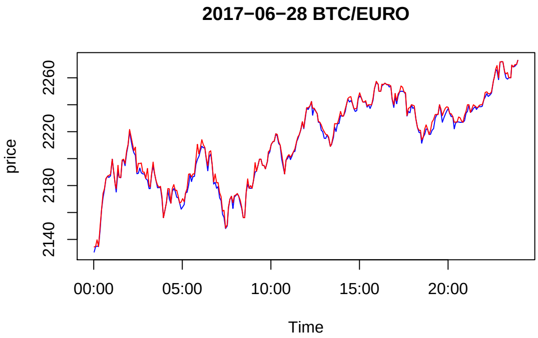
- Data collected by Prof. Dr. Hermann Elendner.
- Trading period: trading never stops, 24/7, every single day.
- Cryptocurrency/Fiat exchange rates
  - Source: kraken.com
  - Largest Bitcoin exchange in euro volume and liquidity.

Cryptocurrency Market

#	Name	Market Cap	Price	Volume (24h)	Circulating Supply	Change (24h)
1	Bitcoin	€95,721,192,940	€5739.54	€5,747,818,097	16,677,500 BTC	7.66%
2	Ethereum	€25,900,477,737	€270.64	€1,194,641,852	95,701,059 ETH	3.79%
3	Bitcoin Cash	€16,290,313,750	€969.65	€3,513,114,092	16,800,275 BCH	-28.91%
4	Ripple	€6,701,057,015	€0.173911	€145,051,449	38,531,538,922 XRP *	2.43%
5	Litecoin	€2,831,427,640	€52.62	€257,057,548	53,810,507 LTC	4.37%
6	Dash	€2,733,118,150	€355.60	€484,397,807	7,686,039 DASH	16.05%

Source: coinmarketcap.com

Data Structure



- 1st level bid and ask price of CC/EUR exchange rate.
- Timespan: 23.06.2017 - 30.07.2017, 24/7 every single day.

Basic Model

- Observe a microstruct-noise contaminated Y_t with latent X_t,

$$Y_t = X_t + \varepsilon_t, \quad t \geq 0$$

  with $\mathrm{E}(\varepsilon_t | X) = 0$.

- Efficient log price X_t is semi-martingale, Delbaen and Schachermayer (1994),

$$X_t = X_0 + \int_0^t a_s ds + \int_0^t \sigma_s dW_s$$

  - $(a_s)_{s \geq 0}$ càdlàg drift process, $(\sigma_s)_{s \geq 0}$ càdlàg volatility process.
  - $\int_0^t \sigma_s^2 ds$ integrated volatility.

Robust Integrated Volatility Estimator

- Realized kernel estimator: weighted autocovariances.
  - Barndorff-Nielsen, Hansen, Lunde, and Shephard (2008)
- Two-scale/Multi-scale estimator: weighted subsampled RVs.
  - Zhang, Mykland, Podolskij and Aït-Sahalia (2005)
  - Zhang (2006, 2011)
- Pre-averaging estimator: take weighted local averages before taking squares.
  - Jacod, Li, Mykland, Podolskij, and Vetter (2009)
  - Podolskij and Vetter (2009)

Price process with Jumps

- When

$$X_t = X_0 + \int_0^t a_s ds + \int_0^t \sigma_s dW_s + \sum_{j=1}^{N_t} J_i$$

- The limit of RV $\sum_{i=2}^{N}(X_{t_i} - X_{t_{i-1}})^2$ is $\int_0^t \sigma_s^2 ds + \sum_{j=1}^{N_t} J_i^2$
- In practice, it is necessary to distinguish the $\int_0^t \sigma_s^2 ds$ from $\sum_{j=1}^{N_t} J_i^2$
- The bipower variation, $\sum_{i=2}^{N_i} |X_{t_{i+1}} - X_{t_i}||X_{t_i} - X_{t_{i-1}}|$, converges to $\lambda_1 \int_0^t \sigma_s^2 ds$ as $max|t_i - t_{i-1}| \to 0$.
- Barndorff-Nelson and Shephard (2004, 2006) etc.

Non-synchronicity

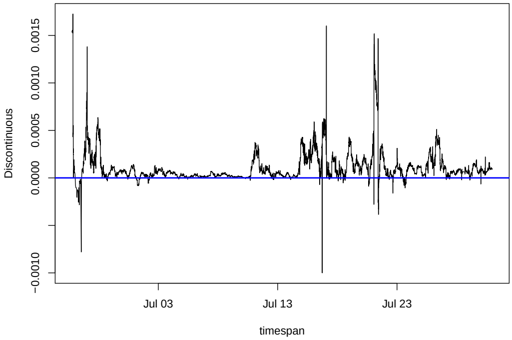
- Suppose covariation of two price process X_t^1, X_t^2 as $\langle X^1, X^2 \rangle$, its realized volatility estimator is,

$$V_{\Delta_n} = \sum_{i=1}^{[\frac{t}{\Delta_n}]} \left(\overline{X}^1_{i\Delta_n} - \overline{X}^1_{(i-1)\Delta_n} \right) \left(\overline{X}^2_{i\Delta_n} - \overline{X}^2_{(i-1)\Delta_n} \right)$$

  - Actual transaction are recorded at random times.
  - A portion of data missing at pre-specified grid.
- Based on Hayashi and Yoshida (2005),

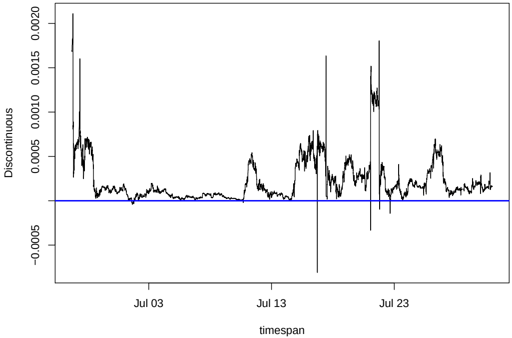
$$\begin{aligned} \mathsf{E}[V_{\Delta_n}] &= \mathsf{E}\Bigg[\sum_{i=1}^{[\frac{t}{\Delta_n}]} \Big\{ \langle X^1, X^2 \rangle_{\tau^1(i\Delta_n) \wedge \tau^2(i\Delta_n)} \\ &- \langle X^1, X^2 \rangle_{\tau^1((i-1)\Delta_n) \vee \tau^2((i-1)\Delta_n)} \Big\} \mathbf{I}_{G^1 \wedge G^2} \Bigg] \end{aligned}$$

Jump Detection - BTC/EURO



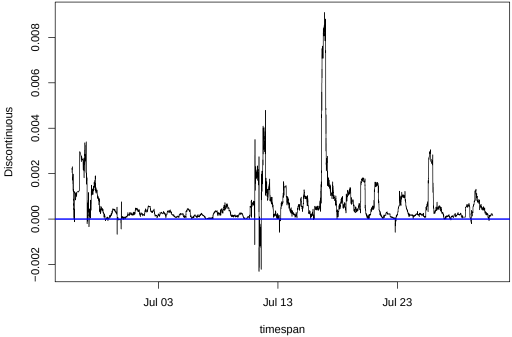
- h=100: unstable since 14th of July. Jumps detected on 16th, 21st, 22nd of July.

Jump Detection - BTC/EURO



- h=200: unstable since 12th of July. The impacts last longer.

Jump Detection - Ripple/EURO



- h=100: similar pattern as Bitcoin

Event?

- Jumps may be caused by the exogenous events. source: bitcoinmagazine.com

Outlook

- Co-movement across different CC/Fiat exchange.
- Efficient tests for jumps that are sufficiently robust to withstand misspecification and small sample bias.
- Combine with sentiment analysis.

References

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Journal of Business & Economic Statistics 31 (2), 165-183.