VCRIX

volatility index for crypto-currencies

Alisa Kolesnikova, Simon Trimborn, Wolfgang K. Härdle

Humboldt-Universität zu Berlin
Motivation

LEDGER X

THE FIRST U.S. BITCOIN FUTURES NOW AVAILABLE FOR TRADING

Deribit

Coinbase’s first investment, Compound, earns you interest on crypto

VCRIX
Motivation

- CRIX is Laspeyres type index - benchmark for the crypto-market
- Weights \( w \) are defined by market cap, \( k \) - number of constituents
- # of members chosen by AIC

\[
CRIX_t = \frac{\sum_{i=1}^{k} P_{it} Q_{it}}{Divisor_t}
\]
Motivation

- Option Pricing on CRIX and CCs, Chen CYH et al (2018)
- Stochastic Vola Corr Jump model
- VCRIX as a natural component for option pricing

\[ d\log Y_t = \mu dt + \sqrt{V_t} dW_{y,t} + Z_{y,t} dN_t \]

\[ dV_t = \kappa(\theta - V_t) dt + \sigma_V \sqrt{V_t} dW_{v,t} + Z_{v,t} dN_t \]
Outline

1. Motivation
2. Methodology
3. Implied volatility proxy
4. Backtesting
5. VCRIX
6. VIX simulation
7. Conclusion
Methodology

- VCRIX as analogue to VIX from CBOE - it will cover the market, not just BTC
- Index must provide the proxy to implied volatility in absence of derivative market
- Index must be forward-looking and offer predictive power
Implied volatility proxy

VIX-historic volatility correlation 0.76
VIX-forward volatility correlation 0.56
## Backtesting (2018)

### Metrics

<table>
<thead>
<tr>
<th></th>
<th>HAR</th>
<th>EWMA</th>
<th>LSTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>0.99</td>
<td>0.99</td>
<td>0.97</td>
</tr>
<tr>
<td>MSE</td>
<td>0.03</td>
<td>0.06</td>
<td>0.16</td>
</tr>
<tr>
<td>MAE</td>
<td>0.11</td>
<td>0.19</td>
<td>0.30</td>
</tr>
<tr>
<td>Mincer-Zarnowitz R-adj</td>
<td>0.98</td>
<td>0.98</td>
<td>0.94</td>
</tr>
</tbody>
</table>

![Graph showing the performance of HAR, EWMA, and LSTM over time.](image-url)
VCRIX

- log-returns of CRIX from 12.2015 to 03.2019 ($T = 1686$, $RV$=realised volatility, in case of VCRIX a 30-day rolling volatility)

$$VCRIX = \frac{RV_{t+1d}^d}{Divisor}$$

\[ RV_{t+1d}^d = \alpha + \beta^d RV_t^d + \beta^w RV_t^w + \beta^m RV_t^m + \omega_{t+1d} \]

\[ RV_t^w = 1/7(RV_t^d + RV_{t-1d}^d + \ldots + RV_{t-6d}^d) \]

\[ RV_t^m = 1/30(RV_t^d + RV_{t-1d}^d + \ldots + RV_{t-29d}^d) \]

where $d, w, m$ stand for daily, weekly and monthly

- $VCRIX_1 = 1000$

- Divisor adjusts to changes in constituents
VCRIX

BTC price jumps

SegWit

Government regulations

BTC price record

Market meltdown

governments and corporates getting onboard

Holidays rally and approach of the Constantinople hard fork (ETH)

LOESS mean (span 0.6)
VCRIX vs CRIX
VIX simulation

- Simulation of VIX for evaluation of methodology
- 21-day rolling volatility of returns on S&P 500 ETF (^SPY) for 20 years
- Scaled time series showed correlation of 89%
VIX simulation

Annualised daily volatility


0  2  4  6

red: est VIX  black: VIX
Conclusions

- successful estimation of implied volatility for crypto-currencies
- VCRIX provides a daily forecast for the mean daily volatility (30d)
- next step - adjustment of the model to capture the behavioural component (LSTM as a candidate)
Borke L, Härdle WK (2018) Q3-D3-LSA, Handbook of Big data Analytics, (Härdle, Lu, Shen eds), Springer Verlag, ISBN 978-3-319-18284-1, DOI: 10.1007/978-3-319-18284-1


