

Response to the referee report 1

This is a very interesting paper, well and clearly written. I think the authors should extend the discussions of the existing literature and also work on but be very careful the Bitcoin – gold relationship/ comparison. The two assets are very different in many respects (tangibility, counterparty risk etc.) and these issues should be carefully acknowledged and discussed. The following paper may also be useful:

Baur, Dirk G. and Lee, Adrian D. and Hong, Kihoon, Bitcoin: Currency or Investment? (February 6, 2015). Available at SSRN: <https://ssrn.com/abstract=2561183> or <http://dx.doi.org/10.2139/ssrn.2561183>

REPLY: We sincerely thank the referee for the comments.

We agree with the referee on the importance for extending the discussion of the existing literature; this can be easily addressed. Especially the discussions can be improved in regard to the comparison between Bitcoin and gold. These two assets differ in several aspects, as suggested by the reviewer. In this sense, we can consider some of the contents from Baur et al. (2015) and Popper (2015).

Major issues:

Bitcoin returns may exhibit strong serial correlation. The authors should account for this and include a lagged return in equation (1).

REPLY: Given our reliance on the SIC (Schwarz information criterion) in selecting the best specification of the asymmetric-GARCH model, we overlooked the serial correlation in Bitcoin returns. However, with the inclusion of the appropriate number of lagged return (see Appendix 1), this issue can be solved without affecting our empirical results. In fact, we add these lagged returns in equation (1) and find no evidence of serial correlation. Interestingly, we find quite similar results for the asymmetric effect, suggesting that our previous results were not affected by the presence of serial correlation (see Appendix 1).

NB: -In the post-crash period (Appendix 1), we find that Bitcoin return doesn't exhibit serial correlation and thus there is no need to add lagged return in the mean equation.

-Notably, in the entire and 2 sub-periods, we find no evidence of ARCH effect with the re-estimated models.

The Table 2 coefficient estimates look as if the coefficients summed up to more than one which would lead to explosive volatility. The authors should check and discuss this issue.

REPLY: While we understand the referee's concern regarding the issue of stationarity in the GARCH-based model, it is worth noting that this issue was only relevant for the entire period (August 18, 2011 – April 29, 2016) where no evidence of an asymmetric effect was reported. As for the two sub-samples (pre-crash and post-crash periods), the sum of $\alpha + \beta + 0.5\gamma$ was always below 1 in all cases, suggesting that stationarity constraint (see sub-section 3.1) has been ensured. Anyway, now we want to include an appropriate number of lagged return (i.e. 10 and 5), that issue – constraint - of stationarity becomes respected in the entire and the two sub-periods.

Figures 3 and 4 look strange (especially negative shock part) and wrong. The authors should check and discuss this issue.

REPLY: Now we consider including an appropriate number of lagged return in the Bitcoin mean equation, the shape of the News Impact Curve would be affected and thus become more common (less strange). However, the volatility of the USD-denominated Bitcoin returns is still indicating that the impact of positive shocks on the conditional volatility is far larger than that of negative shocks (see Appendix 2).

The “lack of liquidity” as mentioned in the Conclusions (for the first time) should be further investigated earlier in the paper and related to serial correlation.

REPLY: We totally agree with this suggestion which can be easily addressed. We can refer to the lack of liquidity in the introduction section, and again while discussing the evidence for the existence of serial correlation in the Bitcoin return series that can be removed by including lagged return in equation (1).

I find the robustness section contains interesting additional analyses that would deserve a more prominent place (e.g. the EGARCH or the S&P500 estimations). In contrast, Table 2 and the different currency denominations do not seem to add similar value.

REPLY: In order to put more emphasis on the analyses in regard to EGARCH and S&P 500, we can move these from sub-section 4.4 to the main empirical results sub-section 4.1. As for the different currency denominations, we can add a footnote indicating that several currency denominations had been considered but the results were quite similar to those reported for the USD-denominated Bitcoin series.

Other issues:

- Provide reference to CFTC swap statement (e.g. footnote)

REPLY: Bitcoin has been accepted as a commodity by a US regulator (the CFTC).

<https://www.bloomberg.com/news/articles/2015-09-17/bitcoin-is-officially-a-commodity-according-to-u-s-regulator>

<http://www.coindesk.com/us-swap-platform-registration-cftc/>

- Explain “digital gold”, i.e. elaborate on Popper (2015)

REPLY: We can address this while extending the discussions of the existing literature

- Change “American dollar” to “US dollar”

REPLY: This can be easily fixed.

- Figure 1 appears to show the same series six times. The authors should try to highlight differences due to currency denominations. Figure 1 doesn't do the job.

REPLY: It seems that there are no significant differences due to currency denominations. Therefore, we can just present a chart of the USD-denominated Bitcoin level and return series.

- Figure 2 same issue as Figure 1.

REPLY: Please refer to my above reply.

- Table 1 suggests that Bitcoin prices are very similar in different currencies (are the authors sure about that?) so perhaps change Figures 1 and 2 and report only one time-series and variations across currencies in another graph.

REPLY: We totally agree with this comment. Please refer to my above reply.

Summarizing, we thank the reviewer from the valuable comments and suggestions and hope our detailed reply paves the way for a revision that will make the paper stronger both in terms of its model specification and its contribution to our understanding of the return-volatility relationship in the Bitcoin market.

Appendix 1

Appendix 1A: Entire period: 9/02/2011 4/29/2016

GED parameter fixed at 1.2

| Variable | Coefficient | Prob. |
|------------------|-------------|--------|
| RBITCOINUSD(-10) | 0.066080 | 0.0066 |
| RBITCOINUSD(-9) | 0.044769 | 0.0763 |
| RBITCOINUSD(-5) | 0.055446 | 0.0373 |
| RBITCOINUSD(-4) | 0.051209 | 0.0616 |
| C | 0.218559 | 0.0127 |

Variance Equation

| | | |
|---------------------------|-----------|--------|
| C | 0.403227 | 0.0000 |
| RESID(-1)^2 | 0.158504 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.027461 | 0.2431 |
| GARCH(-1) | 0.840226 | 0.0000 |

Q-statistic

| Autocorrelation | Partial Correlation | AC | PAC | Q-Stat | Prob* | |
|-----------------|---------------------|----|-------|--------|--------|-------|
| | | 1 | 0.034 | 0.034 | 1.4187 | 0.234 |
| | | 2 | 0.046 | 0.045 | 4.0119 | 0.135 |
| | | 3 | 0.028 | 0.025 | 4.9409 | 0.176 |
| | | 4 | 0.016 | 0.012 | 5.2422 | 0.263 |
| | | 5 | 0.020 | 0.016 | 5.7146 | 0.335 |
| | | 6 | 0.006 | 0.003 | 5.7630 | 0.450 |

| | | | | | | | | |
|--|--|--|--|----|--------|--------|--------|-------|
| | | | | 7 | 0.072 | 0.070 | 12.092 | 0.098 |
| | | | | 8 | 0.005 | -0.001 | 12.118 | 0.146 |
| | | | | 9 | 0.033 | 0.026 | 13.438 | 0.144 |
| | | | | 10 | 0.037 | 0.031 | 15.107 | 0.128 |
| | | | | 11 | 0.009 | 0.003 | 15.209 | 0.173 |
| | | | | 12 | 0.029 | 0.023 | 16.270 | 0.179 |
| | | | | 13 | 0.001 | -0.004 | 16.271 | 0.235 |
| | | | | 14 | 0.056 | 0.048 | 20.129 | 0.126 |
| | | | | 15 | 0.010 | 0.005 | 20.259 | 0.162 |
| | | | | 16 | 0.001 | -0.008 | 20.260 | 0.209 |
| | | | | 17 | -0.009 | -0.017 | 20.350 | 0.257 |
| | | | | 18 | 0.048 | 0.047 | 23.198 | 0.183 |
| | | | | 19 | 0.053 | 0.045 | 26.672 | 0.113 |
| | | | | 20 | 0.029 | 0.022 | 27.686 | 0.117 |
| | | | | 21 | 0.017 | 0.002 | 28.058 | 0.139 |
| | | | | 22 | -0.032 | -0.041 | 29.351 | 0.135 |
| | | | | 23 | 0.006 | 0.002 | 29.390 | 0.168 |
| | | | | 24 | 0.056 | 0.055 | 33.284 | 0.098 |
| | | | | 25 | 0.024 | 0.015 | 33.989 | 0.108 |
| | | | | 26 | -0.005 | -0.019 | 34.024 | 0.134 |
| | | | | 27 | 0.029 | 0.022 | 35.108 | 0.136 |
| | | | | 28 | -0.003 | -0.015 | 35.122 | 0.166 |
| | | | | 29 | -0.027 | -0.030 | 36.020 | 0.173 |
| | | | | 30 | 0.011 | 0.008 | 36.165 | 0.203 |

Appendix 1B: Pre-crash period: 9/02/2011 11/29/2013

t-distribution degree of freedom parameter fixed at 10

| Variable | Coefficient | Prob. |
|------------------|-------------|--------|
| C | 0.528485 | 0.0004 |
| RBITCOINUSD(-9) | 0.100566 | 0.0101 |
| RBITCOINUSD(-10) | 0.082731 | 0.0223 |

| Variance Equation | | |
|---------------------------|-----------|--------|
| C | 0.374798 | 0.0005 |
| RESID(-1)^2 | 0.236479 | 0.0000 |
| RESID(-1)^2*(RESID(-1)<0) | -0.119471 | 0.0018 |
| GARCH(-1) | 0.804893 | 0.0000 |

Q-statistic

| Autocorrelation | Partial Correlation | AC | PAC | Q-Stat | Prob* | |
|-----------------|---------------------|----|--------|--------|--------|-------|
| . . | . . | 1 | 0.024 | 0.024 | 0.3473 | 0.556 |
| . . | . . | 2 | 0.037 | 0.037 | 1.1636 | 0.559 |
| . . | . . | 3 | 0.050 | 0.048 | 2.6350 | 0.451 |
| . . | . . | 4 | 0.032 | 0.028 | 3.2388 | 0.519 |
| . . | . . | 5 | 0.053 | 0.049 | 4.9219 | 0.425 |
| . . | . . | 6 | -0.011 | -0.018 | 4.9998 | 0.544 |
| . * | . * | 7 | 0.086 | 0.081 | 9.4004 | 0.225 |
| . . | . . | 8 | 0.010 | 0.002 | 9.4606 | 0.305 |

| | | | | | | | | |
|-----|--|-----|--|----|--------|--------|--------|-------|
| . . | | . . | | 9 | 0.027 | 0.020 | 9.8852 | 0.360 |
| . . | | . . | | 10 | 0.059 | 0.049 | 11.997 | 0.285 |
| . . | | . . | | 11 | -0.005 | -0.012 | 12.011 | 0.363 |
| . . | | . . | | 12 | 0.010 | -0.004 | 12.068 | 0.440 |
| . . | | . . | | 13 | 0.030 | 0.027 | 12.627 | 0.477 |
| . . | | . . | | 14 | 0.061 | 0.050 | 14.904 | 0.385 |
| . . | | . . | | 15 | 0.035 | 0.026 | 15.622 | 0.408 |
| . . | | . . | | 16 | 0.025 | 0.018 | 16.011 | 0.452 |
| . . | | . . | | 17 | 0.023 | 0.005 | 16.332 | 0.500 |
| . . | | . . | | 18 | 0.064 | 0.056 | 18.813 | 0.403 |
| . . | | . . | | 19 | 0.015 | 0.003 | 18.952 | 0.460 |
| . . | | . . | | 20 | 0.058 | 0.046 | 21.004 | 0.397 |
| . . | | . . | | 21 | 0.031 | 0.015 | 21.598 | 0.423 |
| . . | | . . | | 22 | -0.013 | -0.027 | 21.704 | 0.478 |
| . . | | . . | | 23 | -0.021 | -0.040 | 21.963 | 0.522 |
| . * | | . * | | 24 | 0.091 | 0.084 | 26.993 | 0.305 |
| . . | | . . | | 25 | -0.026 | -0.044 | 27.408 | 0.336 |
| . . | | . . | | 26 | -0.011 | -0.015 | 27.484 | 0.384 |
| . . | | . . | | 27 | 0.023 | 0.009 | 27.805 | 0.421 |
| . . | | . . | | 28 | 0.007 | -0.006 | 27.835 | 0.473 |
| . . | | . . | | 29 | -0.048 | -0.060 | 29.277 | 0.451 |
| . . | | . . | | 30 | -0.019 | -0.015 | 29.508 | 0.491 |
| . . | | . . | | 31 | -0.029 | -0.047 | 30.022 | 0.516 |

Appendix 1C: Pre-crash period: 12/01/2013 4/29/2016

GED parameter at 0.85

| Variable | Coefficient | Prob. |
|----------|-------------|--------|
| C | 5.82E-12 | 1.0000 |

Variance Equation

| | | |
|---------------------------|----------|--------|
| C | 0.905667 | 0.0211 |
| RESID(-1)^2 | 0.113344 | 0.0403 |
| RESID(-1)^2*(RESID(-1)<0) | 0.077481 | 0.2872 |
| GARCH(-1) | 0.803064 | 0.0000 |

Q-statistic

| Autocorrelation | Partial Correlation | AC | PAC | Q-Stat | Prob* | | | |
|-----------------|---------------------|-----|-----|--------|--------|--------|--------|-------|
| . . | | . . | | 1 | 0.035 | 0.035 | 0.7766 | 0.378 |
| . . | | . . | | 2 | 0.047 | 0.046 | 2.1594 | 0.340 |
| . . | | . . | | 3 | -0.020 | -0.023 | 2.4122 | 0.491 |
| . . | | . . | | 4 | 0.065 | 0.065 | 5.1231 | 0.275 |
| . . | | . . | | 5 | 0.059 | 0.057 | 7.3618 | 0.195 |
| . . | | . . | | 6 | 0.005 | -0.005 | 7.3778 | 0.287 |
| . . | | . . | | 7 | 0.040 | 0.038 | 8.3840 | 0.300 |
| . . | | . . | | 8 | -0.011 | -0.015 | 8.4630 | 0.390 |
| . . | | . . | | 9 | 0.030 | 0.020 | 9.0369 | 0.434 |
| . . | | . . | | 10 | 0.044 | 0.043 | 10.278 | 0.416 |
| . . | | . . | | 11 | 0.013 | 0.003 | 10.390 | 0.496 |
| . . | | . . | | 12 | 0.007 | 0.001 | 10.420 | 0.579 |

| | | | | | | |
|-----|-----|----|--------|--------|--------|-------|
| . . | . . | 13 | -0.059 | -0.060 | 12.640 | 0.476 |
| . . | . . | 14 | 0.070 | 0.065 | 15.764 | 0.328 |
| . . | . . | 15 | -0.034 | -0.039 | 16.508 | 0.349 |
| . . | . . | 16 | -0.031 | -0.041 | 17.113 | 0.378 |
| . . | . . | 17 | -0.039 | -0.026 | 18.102 | 0.382 |
| . . | . . | 18 | 0.005 | 0.006 | 18.116 | 0.448 |
| . * | . * | 19 | 0.089 | 0.087 | 23.246 | 0.227 |
| . . | . . | 20 | 0.012 | 0.015 | 23.341 | 0.272 |
| . . | . . | 21 | -0.023 | -0.032 | 23.688 | 0.308 |
| . . | . . | 22 | -0.043 | -0.029 | 24.888 | 0.302 |
| . . | . . | 23 | 0.013 | 0.011 | 25.005 | 0.350 |
| . . | . . | 24 | 0.004 | -0.006 | 25.015 | 0.405 |
| . . | . . | 25 | 0.051 | 0.054 | 26.721 | 0.370 |
| . . | . . | 26 | -0.012 | -0.014 | 26.818 | 0.419 |
| . . | . . | 27 | 0.040 | 0.053 | 27.868 | 0.418 |
| . . | . . | 28 | -0.025 | -0.037 | 28.288 | 0.449 |
| . . | . . | 29 | 0.003 | -0.011 | 28.293 | 0.502 |
| . . | . . | 30 | 0.039 | 0.037 | 29.289 | 0.502 |

Appendix 2: News Impact Curve

