To understand the meaning of the two principal components and characterize the outliers, we decided to look at correlation between exchanges. We used volume for the ETH/BTC pair to identify a general trend in the market and determine whether exchanges follow or are against the trend (see Figure 5). Although most exchanges show a similar trend (that is, they follow a similar daily volume trend), **OKEx**, **Bitflyer**, **BigOne** and **HitBTC** show a daily volume trend that goes against the market. Interestingly, ZB and Zaif follow the mean market trend this time. Also note that compared to the PCA biplot using daily volume data from January 16 to February 16, OKEx and ZB have swapped positions (see Figure 3 from the previous Exchange Report)

*Figure 4a. Top 5 negative volume correlations*

| Exchange 1 | Exchange 2 | Correlation(%) |
|------------|------------|----------------|
| fcoin | kraken | -28.76 |
| zaif | bigOne | -23.89 |
| gemini | hitbtc | -18.86 |
| bitstamp | hitbtc | -18.66 |
| huobiPro | zb | -27.21 |

*Figure 4b. Top 5 positive volume correlations*

| Exchange 1 | Exchange 2 | Correlation(%) |
|------------|------------|----------------|
| upbit | bitfinex | +88.30 |
| bittrex | bitfinex | +88.84 |
| upbit | gateio | +89.76 |
| bitfinex | gateio | +90.54 |
| upbit | bittrex | +99.92 |

*Figure 5. Daily volume correlations between exchanges from February 16, 2019 to March 16, 2019 for ETH/BTC. Correlation ranges between -1 and 1. Correlation close to 1 indicates a more positive relationship between the pair of cryptocurrency returns and correlation close to -1 indicates a more negative linear relationship. Correlation close to 0 indicates no linear relationship.*
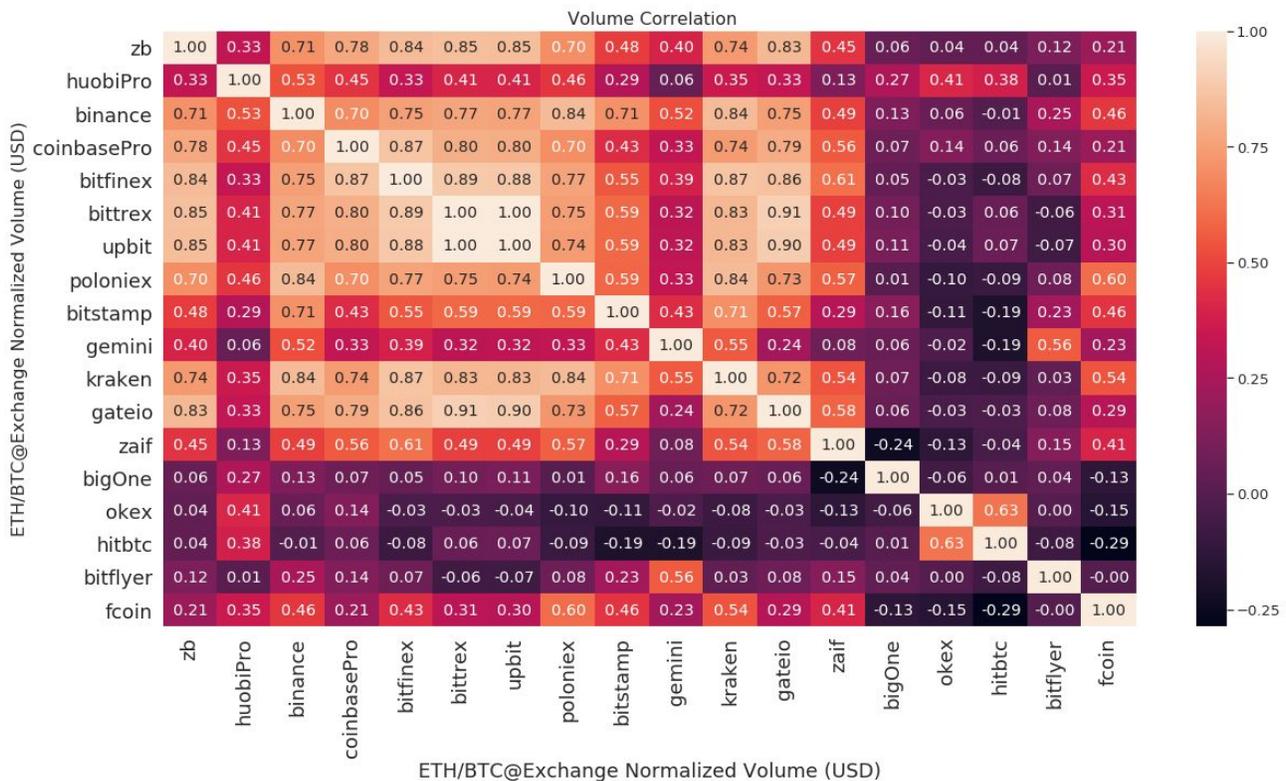
OKEx, in particular, shows negative correlations with all exchanges except for HitBTC and HuobiPro. This suggests that OKEx, Bitflyer, HitBTC and BigONE are acting against the market.

Again, Upbit and Bittrex show the highest correlation for all exchange pairs, suggesting that they share the same order book [2]. This was also noted in our previous Exchange Report.

To explore what other factors could contribute to the clustering in different groups after Volume PCA, we calculated the correlation between ETH/BTC price and volume for every exchange pair (see Figure 6).

*Figure 6. Daily price-volume correlations between exchanges from February 16, 2019 to March 16, 2019 for ETH/BTC. Correlation ranges between -1 and 1. Correlation close to 1 indicates a more positive relationship between the pair of cryptocurrency returns and correlation close to -1 indicates a more negative linear relationship. Correlation close to 0 indicates no linear relationship.*
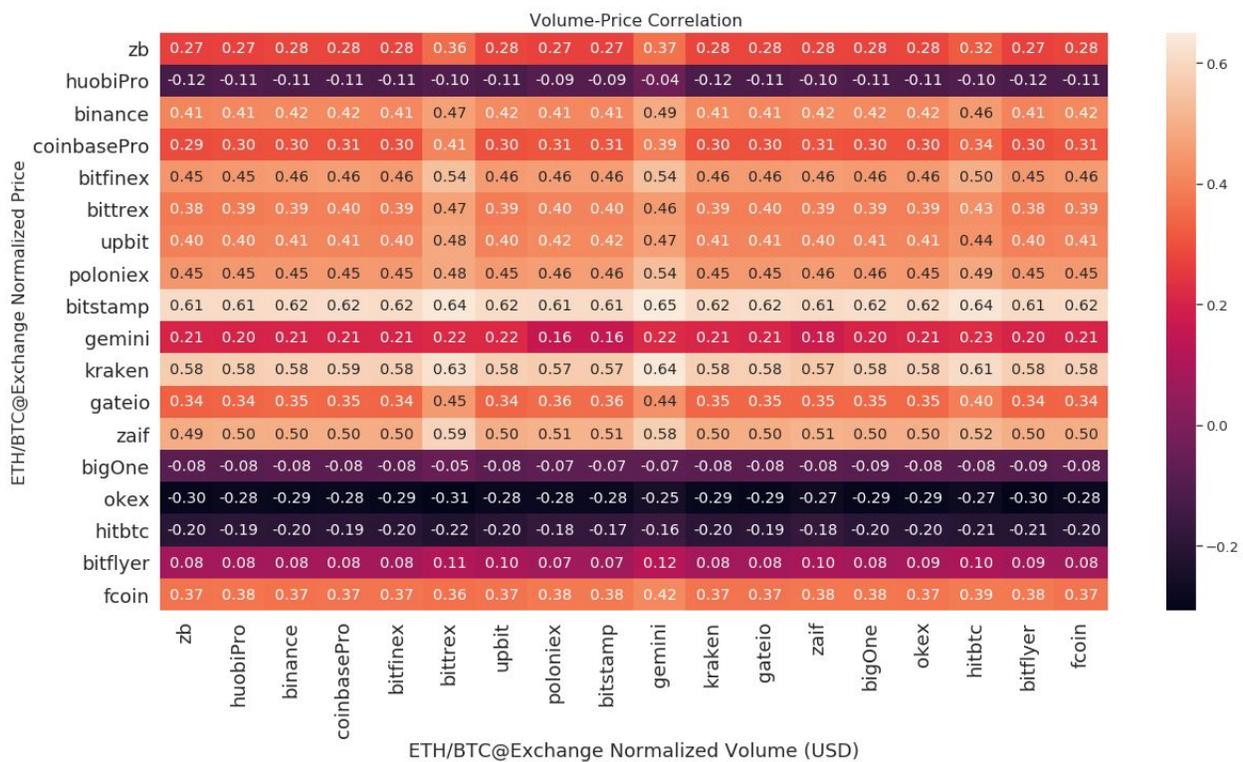


OKEx and HitBTC stand out as exchanges with the highest negative correlation between ETC/BTC price and volume for all exchanges. This shows that not only their volume, but also their ETH prices go against the market. While most exchanges show a positive trend (higher volumes associated with higher prices), OKEx, HitBTC, HuobiPro and BigONE show a negative trend (higher volumes associated with lower prices, and vice versa).

## SUMMARY

Using daily volume data from 18 of some of the most widely used cryptocurrency exchanges and principal component analysis, we identified three clusters of exchanges sharing similar volume trends. We mainly looked at volume correlations and price-volume correlations. Our findings include:

- Okex and HitBTC go against the market both in terms of volume correlation and price-volume correlation.
- Although Okex has reported the biggest traded volume in the past month, PCA analysis separates it from the other top exchanges (i.e. Binance and HuobiPro) and shows a low correlation with the market in terms of traded volume.

Here, these findings are simple observations of possibly correlated variables. We share this from the point-of-view of *something to look out for*. Overall, our exchange analysis has proven useful to study patterns of volume and price activity in the market and identify potential manipulation, that could be confirmed using blockchain data.

## APPENDIX A: Methodology

The daily volume of cryptocurrencies in USD at 4:00 PM EST from February 16, 2019 to March 16, 2019 was used for our volume ranking. Daily volume and price for the pair ethereum_bitcoin was used for the same time period for the PCA analysis and correlation analysis. Price and volume were normalized such that its distribution had mean value 0 and standard deviation of 1 in order to perform principal component analysis and calculate price-volume correlations. In subsequent reports, we may update our universe, sectors, methodology, and analysis to reflect new developments.

## APPENDIX B: Terminology

**Correlation:**       A measure of the linear relationship between two series of random variables, which in the context of finance, can be two series of returns. Correlation ranges between -1 and 1. Correlation close to 1 indicates a more positive relationship between the pair of cryptocurrency returns and correlation close to -1 indicates a more negative linear relationship. Correlation close to 0 indicates no linear relationship.

**PCA:**       A statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components, in order to maximize the explained variance.

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