

A Portfolio Approach to Investing in Crypto Currencies

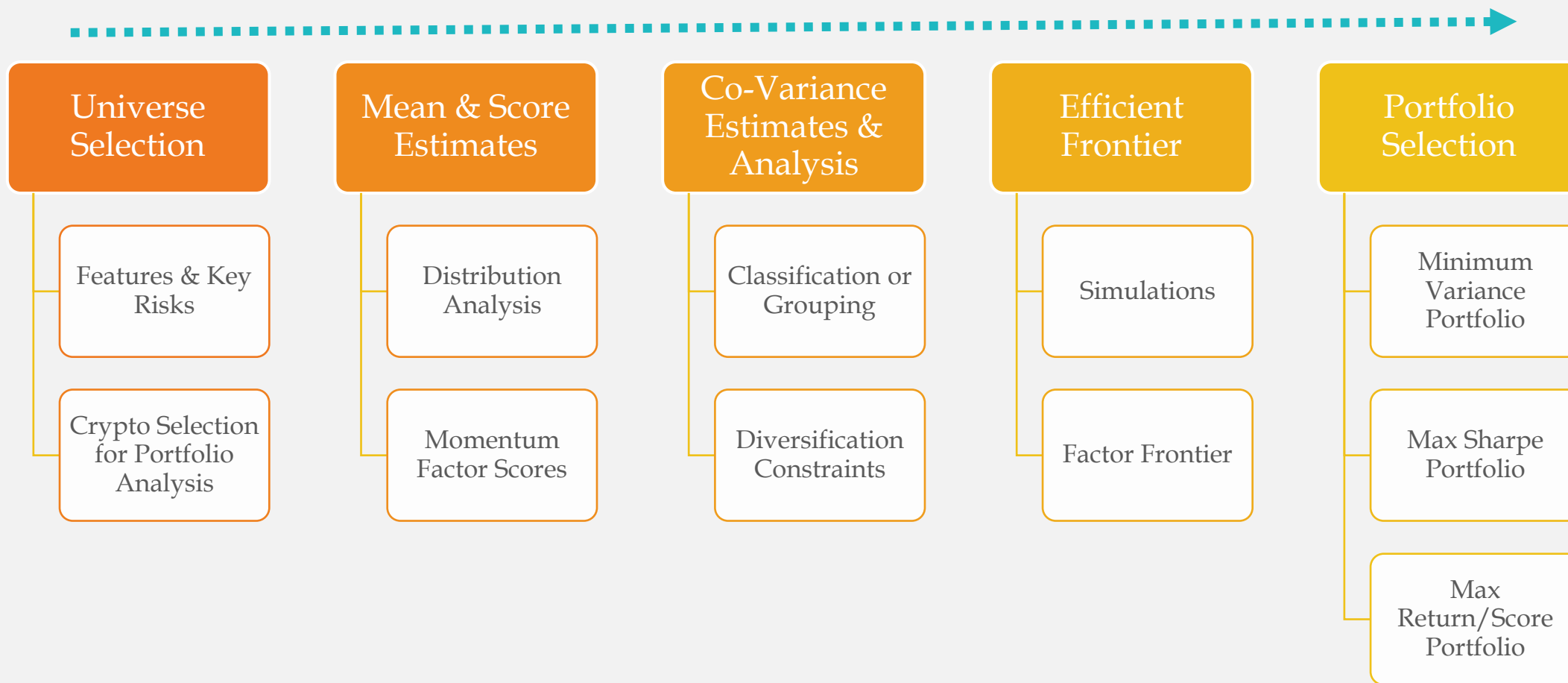
Anurag Bhatia and Uday Vikram

IE Business School

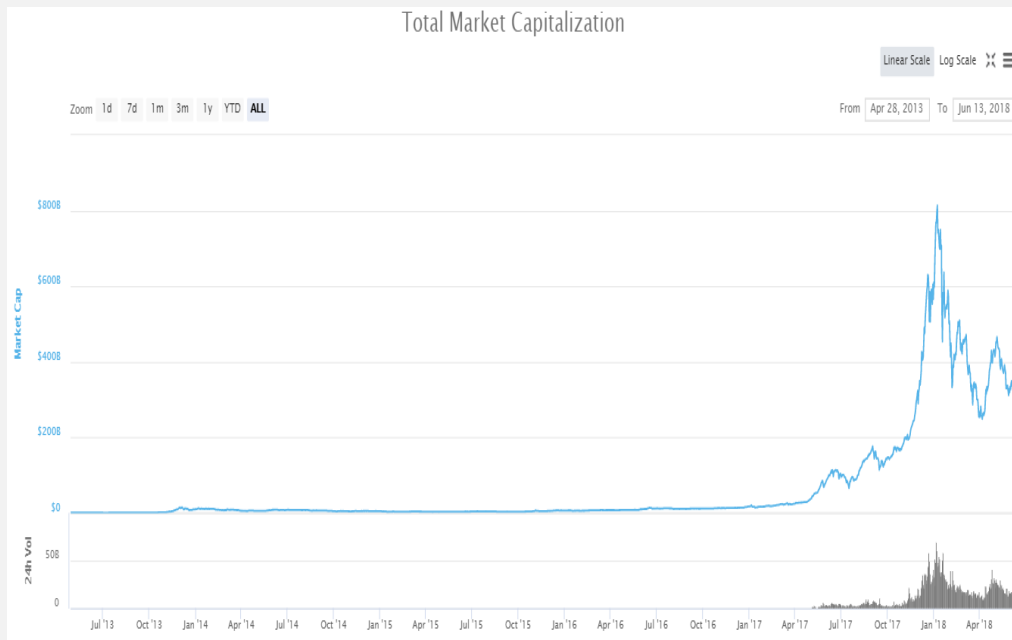
18th June 2018



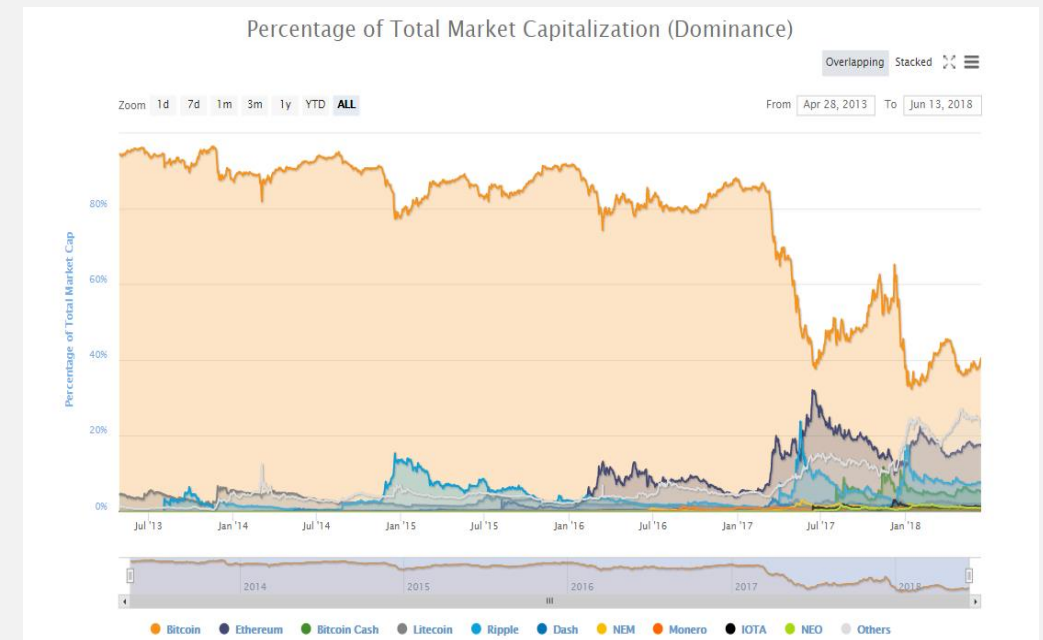
Framework of Analysis



Intro



Total market cap of ALL cryptocurrencies
(increase from \$ 1.7 BN to \$ 300 BN)



Bitcoin's relative share, over the years
(down from 94% to 40%)

Intro: polarized opinions

WARREN BUFFETT: Bitcoin is 'probably rat poison squared'

Graham Rapier, Business Insider · 5 May 2018 17:39h.

Jamie Dimon Slams Bitcoin as a 'Fraud'

(Bloomberg)

Hugh Son, Hannah Levitt and Brian Louis

September 12, 2017, 8:09 PM GMT+2 Updated on September 13, 2017, 12:59 AM GMT+2



VS.

JUN 11, 2018 @ 03:37 AM 5,730

2 Free Issues

Almost 500,000 People In Switzerland Voted For A Bitcoin-Like Financial System

(Forbes)

- J.P. Morgan Chase CEO said he regrets calling bitcoin a fraud.
- "The blockchain is real," Dimon tells Fox Business.
- Dimon remains concerned about how "governments are going to feel about bitcoin when it gets really big."

Tae Kim | @firstadopter

Published 7:42 AM ET Tue, 9 Jan 2018 | Updated 7:50 PM ET Tue, 9 Jan 2018

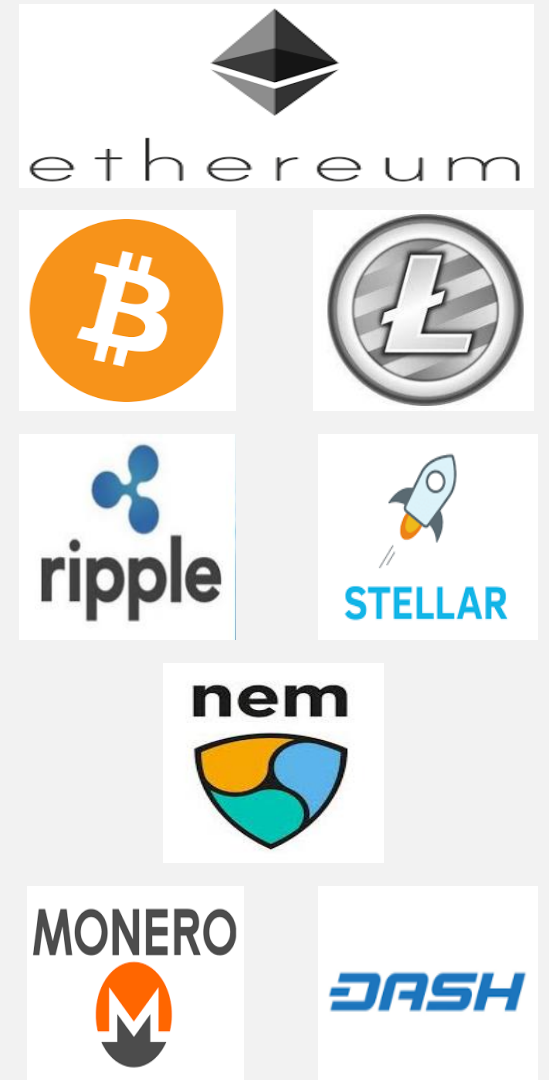


Cryptocurrency > Top Cryptocurrency Theft Hacks - List Of Biggest Security Breaches?

Top Cryptocurrency Theft Hacks - List Of Biggest Security Breaches?

Universe selection

- The **conventional wisdom** is to select about 15 different assets/securities, to get optimal benefits of portfolio diversification.
- However, there are inherent **challenges** in case of a crypto-portfolio:
 - There is a **trade-off** between portfolio width (no. of securities in the basket) and timeline (no. of data points)
 - Trading in cryptos happens **24 * 7 * 365**.
 - No single exchange hosts all cryptocurrencies.
 - **Different exchanges** may quote different prices.
- We considered the following **factors** in our universe selection:
 - Are there any fundamental differences in the underlying **blockchain** network?
 - Technology: consensus mechanism
 - Usage: the main purpose for which it has been built
 - **Market-capitalization** should be high, as it usually increases liquidity.
- We chose **coinmarket.com** since it is a widely-respected and reliable source of historical data on cryptos.

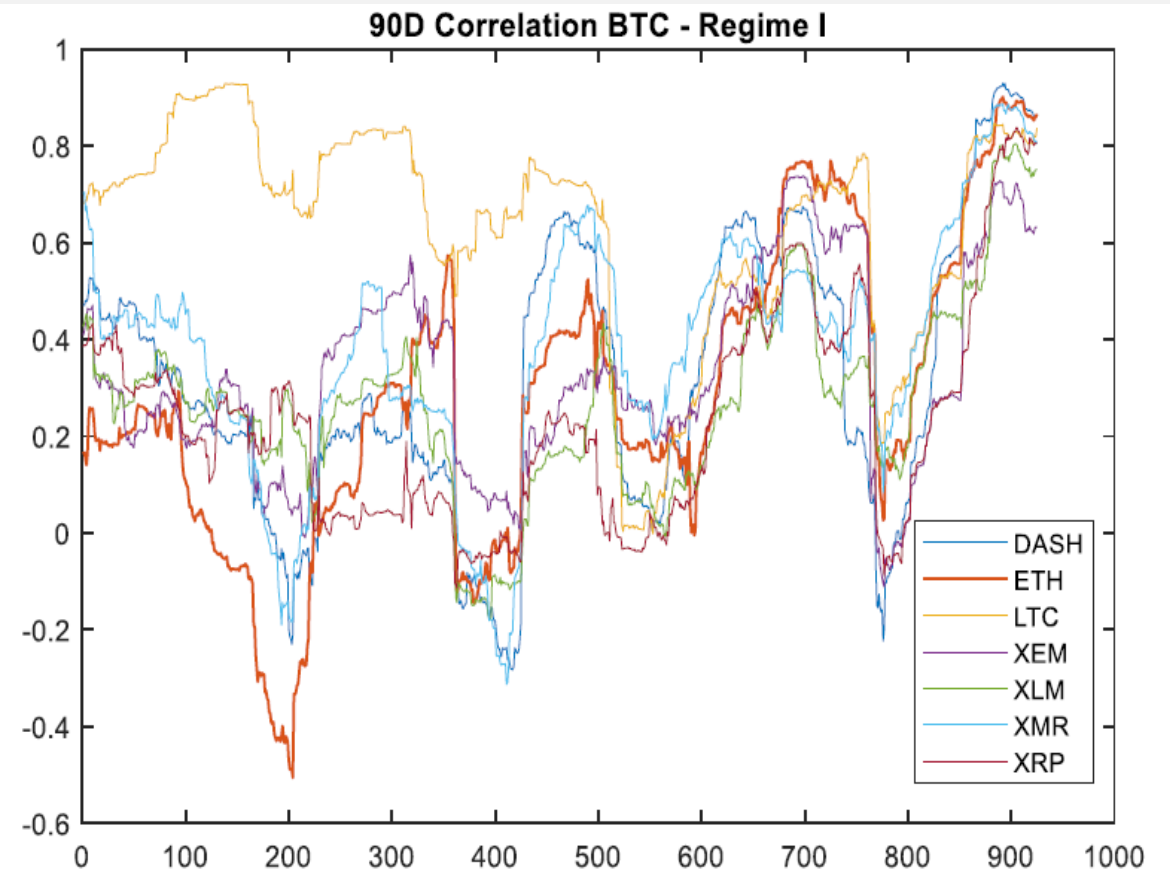


Asset Moments & Classification

S. No.	Crypto	M-cap (Rank)	M-cap (\$ BN) approx.	Consensus mechanism	Main application	Annualized Volatility	Sharpe Ratio	Sortino Ratio	Omega Ratio	Tooth to Tail Ratio
1	Bitcoin	1	110.9	PoW	P2P payments / Store of Value	78%	1.73	2.53	1.32	1.0
2	Litecoin	6	5.5	PoW	P2P payments / Store of Value	114%	1.22	2.05	1.25	1.2
3	Ethereum	2	50.1	PoW (moving to PoS)	Smart Contracts	131%	1.75	2.80	1.31	1.4
4	Ripple	3	20.8	Ripple	B2B payments	152%	1.11	2.07	1.26	1.4
5	Stellar	7	4.3	Stellar	B2B payments	170%	1.13	2.00	1.22	1.2
6	XEM (NEM)	15	1.7	PoI	Mixed	182%	1.64	2.92	1.31	1.2
7	Monero	14	2.0	PoW	Privacy	141%	1.55	2.59	1.27	1.2
8	Dash	13	2.1	PoW	Privacy	117%	1.59	2.63	1.28	1.3

Correlation

- In general, cryptocurrencies have so far had weak relationships **with traditional asset classes**.
- Bitcoin, in particular, has had consistently low correlations with other asset classes.
- Such correlations, (on both, rolling bases as well as average over a period), have been found to fluctuate from -0.5 to +0.3.
- However, correlations **between cryptocurrencies** can be fairly high.
- In fact, average of the rolling, pair-wise correlation ranges from 0.3 to 0.8, and **steadily increasing with time**.
- Another key consideration is that these correlations tend to **spike during a market downturn**, essentially diminishing benefits of a portfolio exactly when an investor needs it.



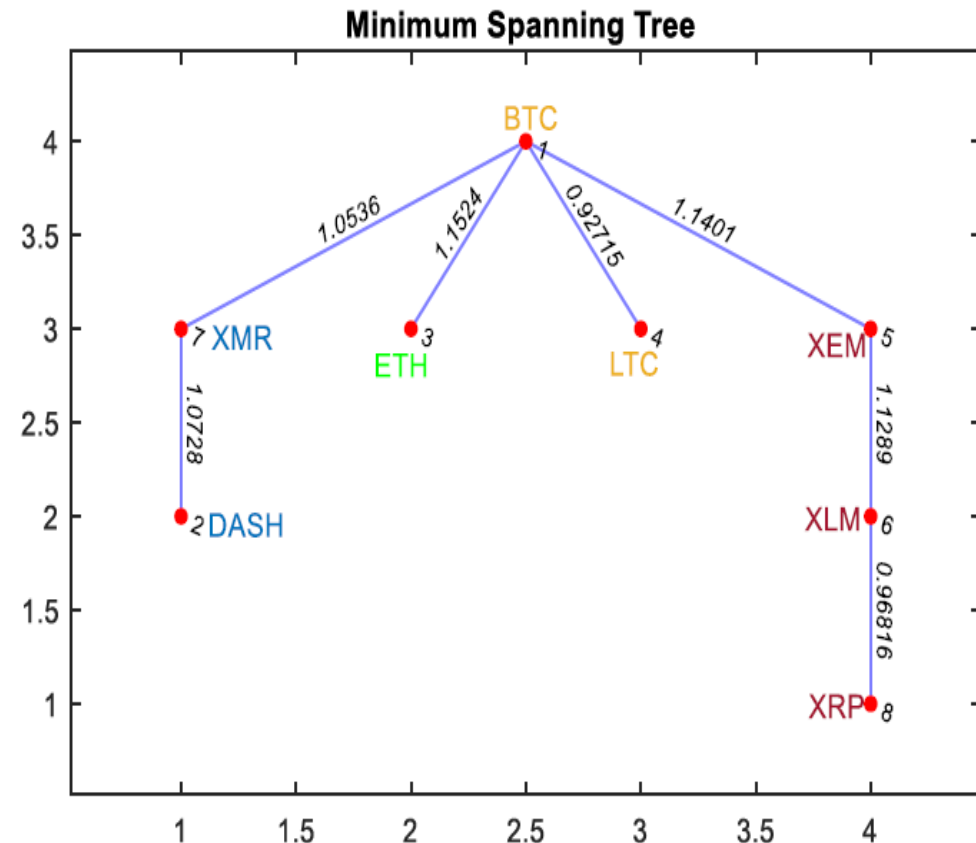
- 90 day rolling correlations of crypto currencies with BTC.

Visual Representation of Correlation Matrix: Minimum Spanning Tree (MST)

- It is an attempt to visualize the correlation matrix of the selected 8 cryptocurrencies.
- Correlation matrix (8 * 8) is converted into a distance matrix, based on the following equation:

$$D_{ij} = \sqrt{2(1 - C_{ij})}$$

- Each correlation coefficient is converted into a distance metric, having values b/w 0 and 2.
- MST is a **reduced and visual representation** of the correlation matrix.
- For every n vertices, the MST has (n-1) edges.
- MST is a **subset of a network** of connected nodes, such that the sum of displayed edges (distances) is the lowest possible, **without any cyclicity**.
- The subset includes every single node.
- **Distance** between 2 nodes is **inversely proportional to correlation** b/w the 2 respective securities.
- **BTC** turns out to be **central node** here, being connected to maximum number of other nodes.



Initial Correlation Matrix calculated via returns from 23/8/15 – 9/5/2018

Blue – Privacy Coins; Green – Smart contracts; Yellow – Store of Value; Red - Payments

[Date Range: 23/8/2015 – 09/05/2018]

Key Macro-Risks

- **Technology** is in a **nascent** stage, and unlike typical early stage investments like VC or PE, these assets are marked to market.
- There aren't any widely used **valuation frameworks** or **standardized data sets** to perform fundamental analysis either.
- **Regulatory paranoia** remains rampant as nations evolve their frameworks, with negatively perceived announcements creating market contagion.
- Communication and information flow is particularly viral & **sentiment** driven, given the integration with social media.
- Participation is largely retail, sometimes with minimal understanding of the underlying technology, leading to mass herd like or **trend** following behaviour.
- Also, the **infrastructure** around cryptos can be challenging:
 - Exchanges remain **centralized** and hence, prone to hacking.
 - For many potential blockchain applications in future, the **tech ecosystem** is not ready yet. **e.g.** need to tokenize (digitize) various assets.
 - **Transaction costs** vary and can be as high as \$ 30 per transaction.

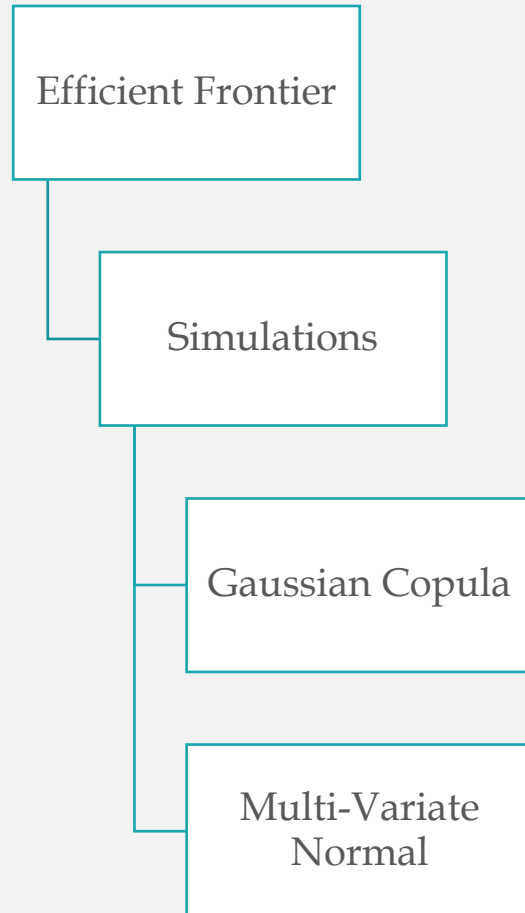
Constraints

- Markets for cryptocurrencies are not very deep and liquid. e.g. Time taken for **settlement of transactions** can take anywhere from a few seconds to a few weeks.
- Hence, we did not consider **short-selling** in our portfolio optimization, as the infrastructure is not ready for that yet.
- We classify BTC as a “safe haven” within the universe selection, due to its size and centrality. Accordingly we allow a maximum 100% weight in BTC vs 30% for other cryptos.
- As the correlation structure changes, re-estimation is required frequently for portfolio optimizations.

Portfolio Setup & Framework

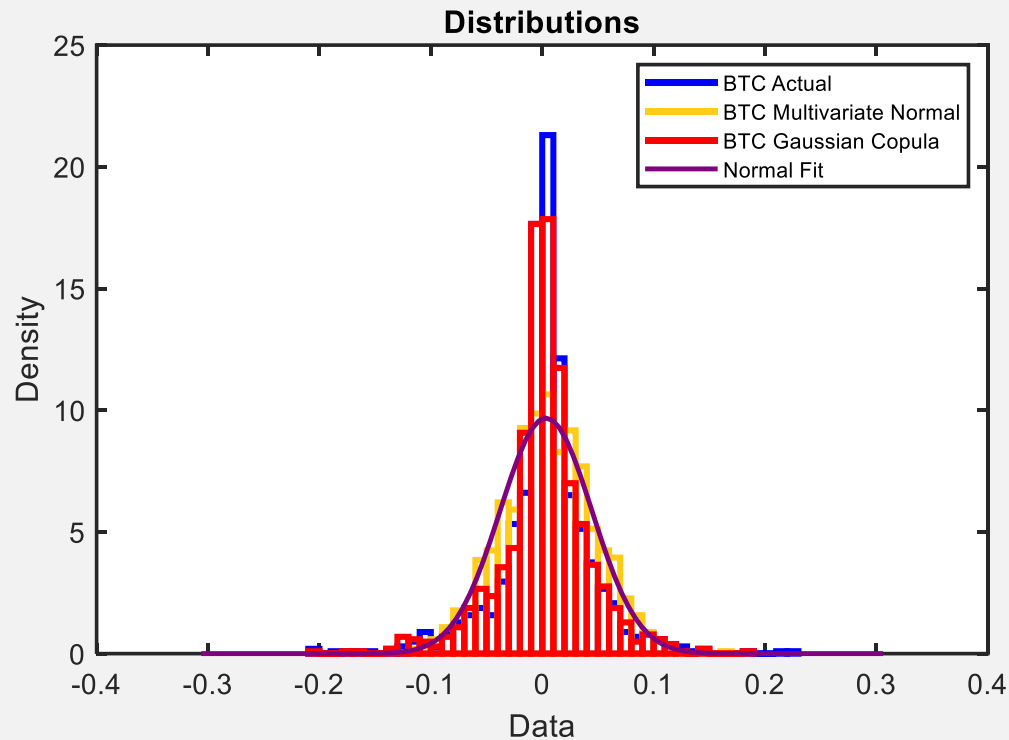
Portfolio Moments	Calculations	Remarks
Portfolio Return	$\sum_{i=1}^n x_i E(r_i)$	<ul style="list-style-type: none"> Expected returns per asset. Factor Scores.
Portfolio Variance	$\sigma(p)^2 = x^T S x$	<ul style="list-style-type: none"> Co-Variance matrix S, impacts the overall portfolio volatility. Weakly correlated assets produce greater diversification benefits. The key driver pertaining to the risk of an asset is not the risk of each asset in isolation, but the contribution of each asset to the risk of the overall portfolio.
Capital Market Line: (Max Sharpe Portfolio)	$E(R_p) = R_f + \frac{E(R_m) - R_f}{\sigma(R_m)} \sigma(R_p)$	<ul style="list-style-type: none"> Portfolio which has the highest Sharpe Ratio (also referred to as "Market Portfolio"). When combined with a risk free asset, the capital market line can be constructed.
Minimum Variance Portfolio	$MVP \text{ weights} = \frac{\{1, \dots, 1\} S^{-1}}{\{1, \dots, 1\} S^{-1} \begin{pmatrix} 1 \\ m \\ 1 \end{pmatrix}}$	<ul style="list-style-type: none"> Portfolio with the least amount of volatility. A risk averse investor's choice would be the MVP.
Max Return Portfolio	N/A	<ul style="list-style-type: none"> Portfolio with the highest return possible.

Portfolio Framework I

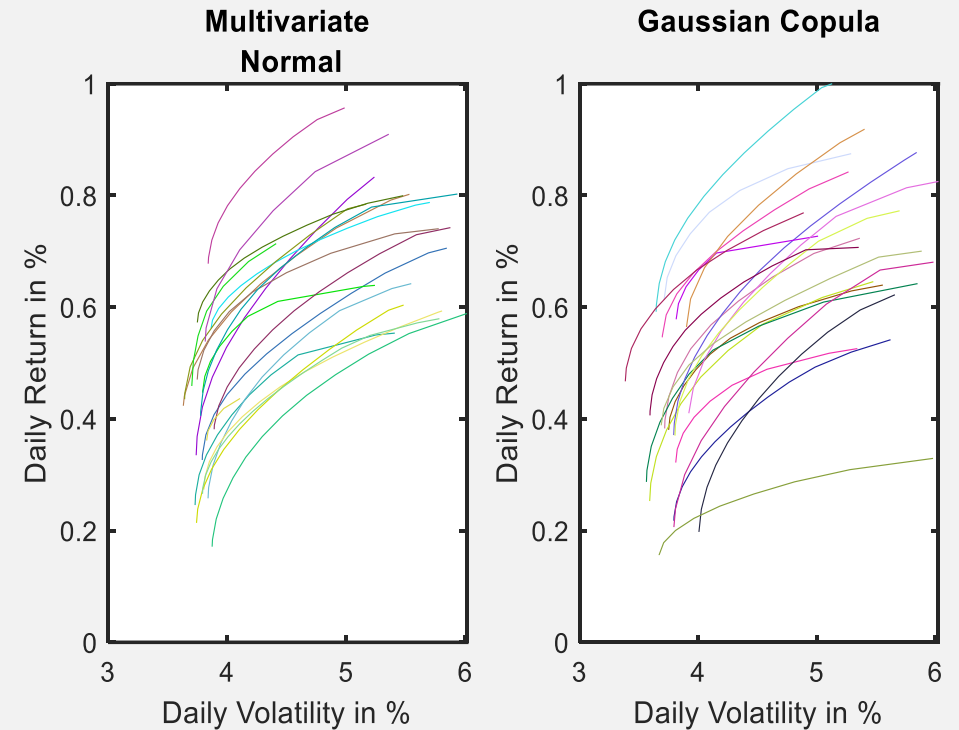


- Generate correlated random numbers using;
 - Gaussian Copula are functions that describe dependencies among variables and provide a way to create distributions.
 - Multi variate normal is a distribution for random vectors of correlated variables, each element of which has a univariate normal distribution.
- Both distributions are parametrized by mean and co-variance matrix only.
- For each correlated set of random numbers, we calculate mean and co-variance matrix and then construct an efficient frontier with 20 portfolios (low to high returns). We repeat this process 20 times (i.e. 20 simulations).
- Average the weights of each portfolio on the various simulated frontiers.
 - For example, the minimum variance portfolio would be the average of the portfolio weights of all the simulated minimum variance portfolios (i.e. 20 simulations).
- These averaged weights per portfolio are then used to redraw the efficient frontier by using the original means and co-variance matrix.

Frontier Simulations I

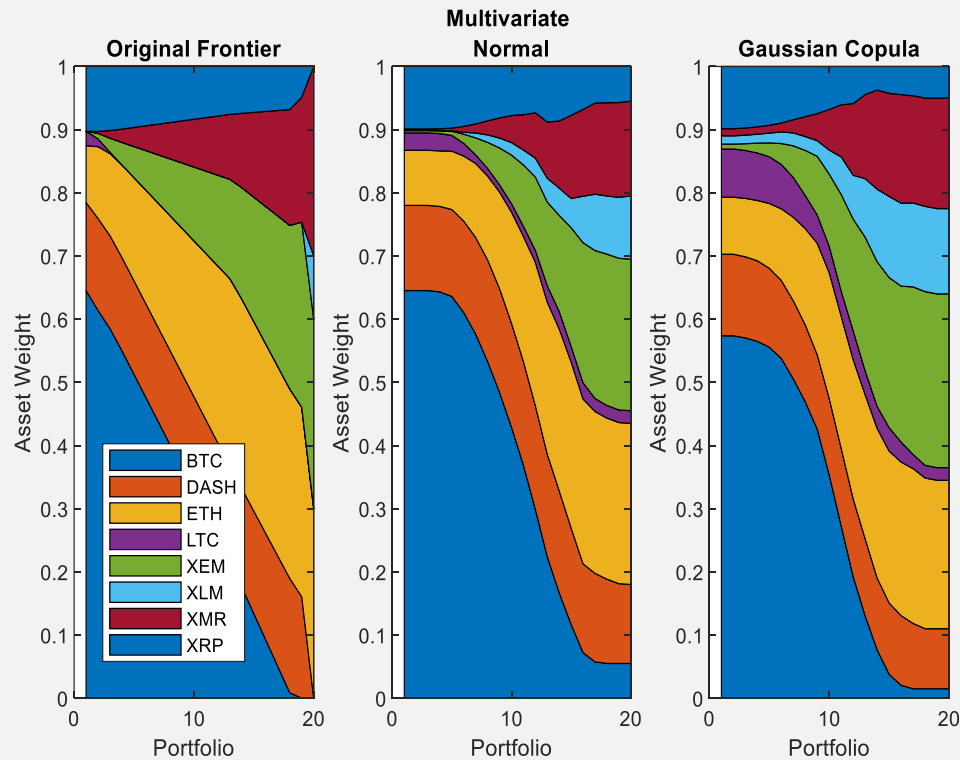


- Gaussian Copula is a better fit to the original distribution with fatter tails & tall peaks.
- Stronger tail dependence (extreme returns) between crypto currencies.

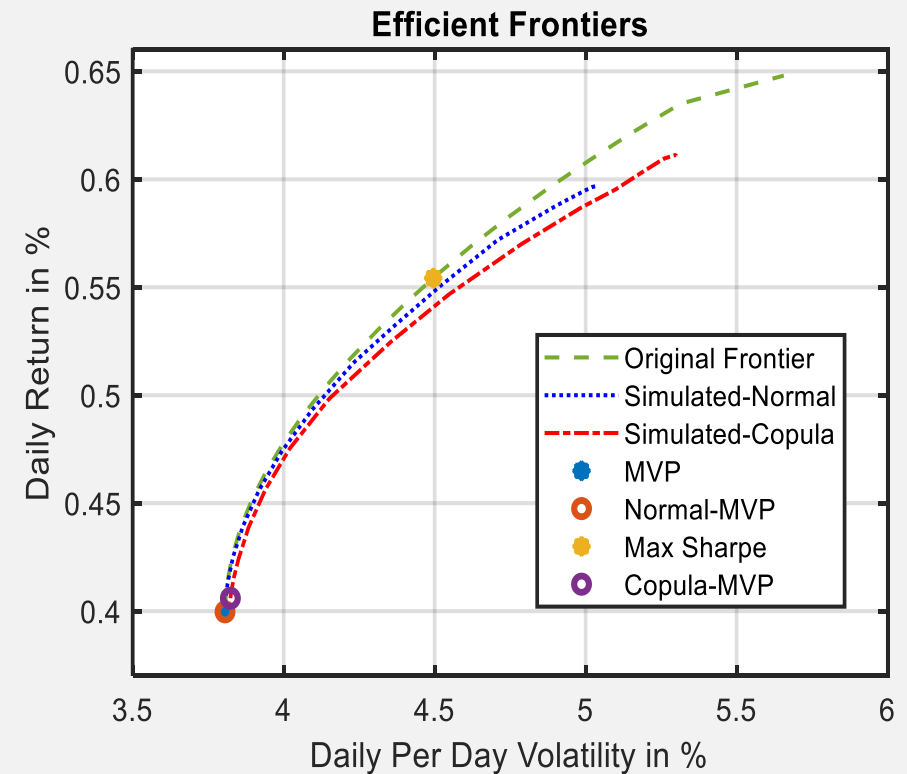


- Inherent uncertainty with parameters mean and co-variance matrix.

Frontier Simulations II



- Simulated frontier weights are more diversified.



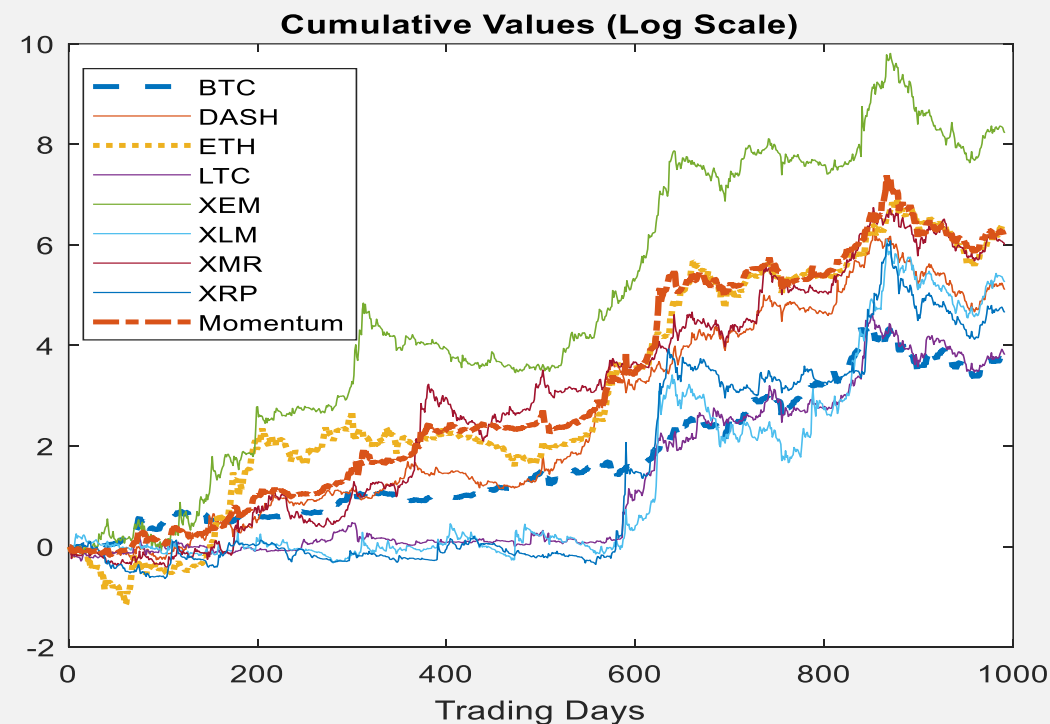
- Simulated frontiers are below the original frontier as we are averaging the weights of the various portfolios and then redrawing the simulated frontier using original estimates.

Portfolio Framework II - Momentum Strategy

- Objective: To build a long only momentum strategy, by allocating systematically to relative winners subject to constraints. The portfolio is optimized to have the maximum score (return) on the frontier.
- Momentum Score for each crypto is calculated by the following equation every 15 days:

$$\text{Momentum Score } (x_i) = \frac{(r_i) - \text{Avg}(r_{i..n}^n)}{\sigma_{i..n}}$$

- At every rebalance date, cryptos which have **performed better than average** will get a **higher score** and **accordingly a higher allocation**.
- Momentum Portfolio: Weights optimized using rolling 15-day momentum scores and covariance matrix. Portfolio is rebalanced every 15 days.
 - BTC: Max Weight: 100% [Minimum: 0%]
 - Others: Max Weight: 30% [Minimum: 0%]



Risk Ratio	BTC	ETH	Momentum
Sharpe Ratio	1.73	1.59	2.04
Sortino Ratio	2.53	2.63	3.07
Omega Ratio	1.32	1.28	1.42
VaR @ 99%	-12%	-18%	-17%

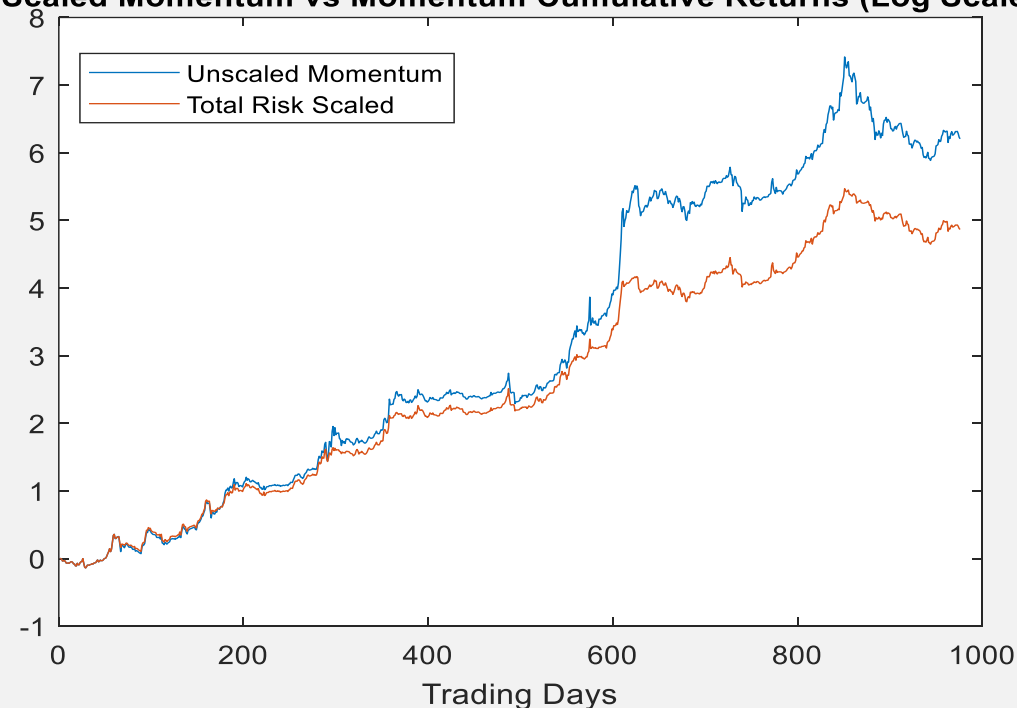
Volatility Targeting

- Considering the fact, momentum factor is prone to crash risk and large drawdowns; we aim to employ a risk management technique.
- We scale the exposure to the momentum portfolio **daily** by the following equation;

$$\text{Scaled Weights} = \frac{\text{Target } \sigma}{\text{Trailing } \sigma}$$

- Targeting a volatility of 3.5% per day; the exposure is below one if the 15-day trailing volatility of the momentum portfolio is higher than 3.5%.
- However the weights are capped at 100% to purely study the impact of volatility targeting on the downside.

Scaled Momentum vs Momentum Cumulative Returns (Log Scale)



Risk Ratio	BTC	Momentum	Scaled Portfolio
Sharpe Ratio	1.73	2.08	2.56
Sortino Ratio	2.53	3.12	4.03
Omega Ratio	1.32	1.43	1.51
VaR @ 99%	-12%	-17%	-11%

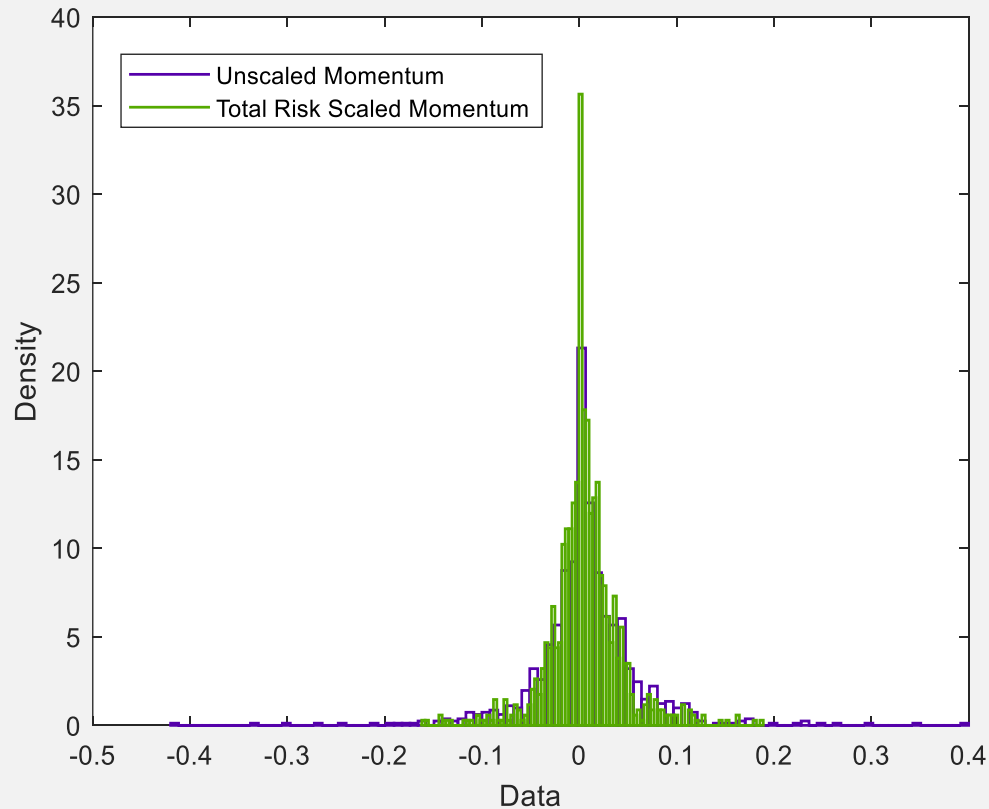
Conclusion

- We provide a **framework to select and classify** a basket of crypto currencies, based on their qualitative assessment.
 - **Classification framework** provided here can help an investor to frame constraints differently, based on his/her assessment of where the different categories are headed.
- **Simulating** frontiers, we believe, accounts for the inherent uncertainty in estimating parameters for portfolio construction.
 - We find Gaussian **copula distribution** to be a better fit to the original data, due to fatter tails and stronger tail dependence between currencies during extreme events.
 - While the simulated frontiers may seem sub-optimal, it accounts for the possibility of the original parameters (mean and co-variance) being wrong and tries to manage this by averaging many simulated future outcomes.
- We build a **short-term momentum factor portfolio** and test a method to scale the exposure by its trailing volatility. This leads to **better risk adjusted returns** of the momentum portfolio.
 - These momentum portfolios are based entirely on price action. However, an investor could incorporate **other inputs like sentiment data** (google trends, tweet analysis) to boost the information value during the optimization process to better reflect the behavioral heuristics within crypto markets.
- The return distributions are positively skewed with omega ratios (over 130%) and tooth to tail ratios (over 1.0) which indicate the magnitude and probability of positive returns is greater than negative returns.

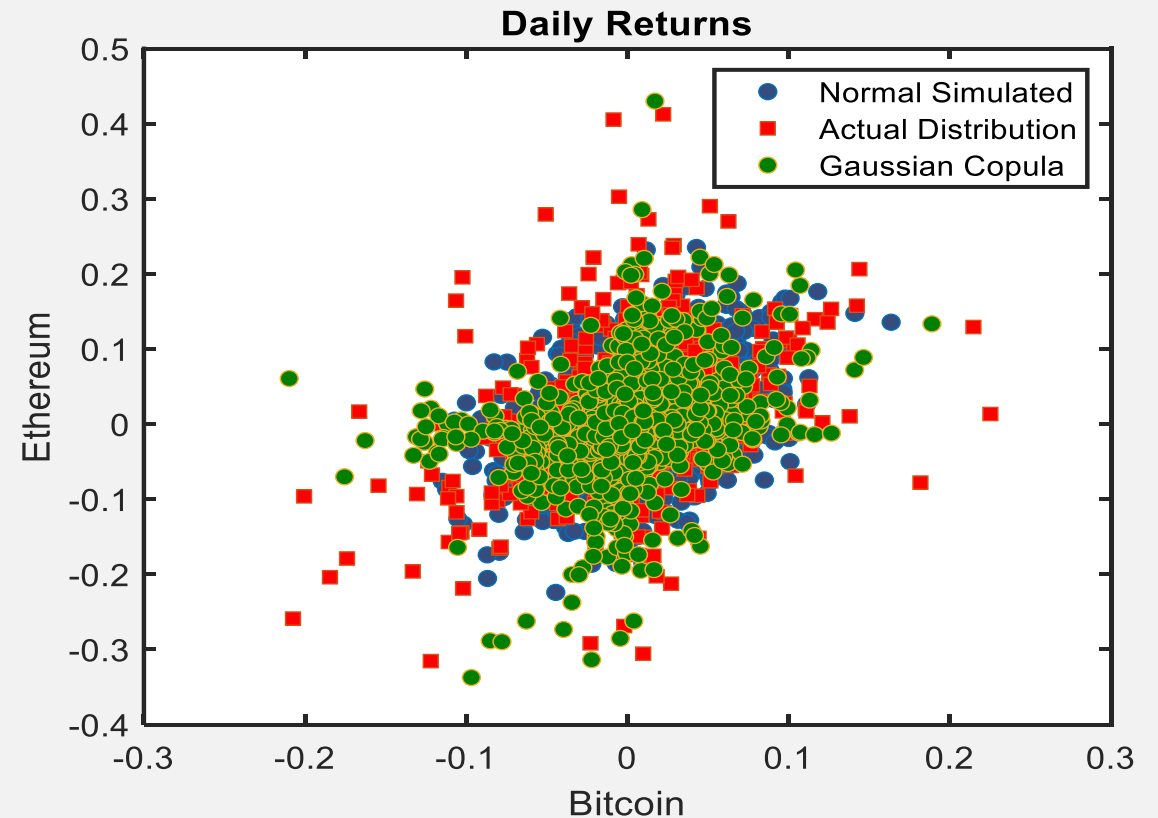
Q&A



Appendix



- Return distributions of the scaled momentum vs unscaled momentum. Not surprisingly, the scaled portfolio has thinner tails as the exposure varies between 20% and 100%.



- A sample draw of simulated returns of Bitcoin and Ethereum. Extreme Returns appear to be more strongly correlated in the actual and Gaussian copula distributions.

Appendix

Date Range: 23/8/2015 – 09/05/2018]

