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Inclusion of Bitcoin into an investor's portfolio

Abstract

This paper seeks to estimate the Beta of Bitcoin with respect to three different portfolios and answer the question whether we should include bitcoin as part of our investment portfolio using Markowitz Portfolio Optimization. The paper begins with a brief introduction to Bitcoin and challenges of investing in Bitcoin followed by a concise description of Beta calculation using the CAPM theory, results from calculation of Betas with respect to four portfolios and lastly, the efficient frontier obtained from including Bitcoin to an existing portfolio of twenty-one randomly selected stocks.

Bitcoin and Volatility

Although the initial excitement about cryptocurrencies and Bitcoin among investors has dwindled over the past year, optimists still believe that Bitcoin would fundamentally alter payments, economics and politics in the near future. Bitcoin is a decentralized digital currency without a central bank or single administrator that can be sent from user to user on the peer-to-peer bitcoin network without the need of intermediaries. Since the value of Bitcoin can be denominated in dollar value and it fluctuates with market conditions, we can consider bitcoin not only as a form of currency but also as an investment vehicle. One of the objectives of this paper is to discuss whether it is optimal to include Bitcoin to a well-diversified portfolio in spite of the several challenges posed by the volatility of cryptocurrencies. One major reason why the price of Bitcoin fluctuates severely over the course of a time period is because of the relatively small market of cryptocurrency. The total market capitalization of digital crypto-currencies exceeded US $800 billion in early 2018, with Bitcoin comprising of 40% of the total market capitalization. For comparison's sake, the global equity market crossed a total value of US $76.3 trillion. The reason why market capitalization plays a significant factor in increased volatility is because small markets are susceptible to manipulation compared to large markets. According to Kerim Derhalli, CEO and founder of Invstr Ltd., small changes to the key variables of supply and demand can have a significant influence on Bitcoin prices. A major investor or a small group of investors working collaboratively can create a sharp gain or loss in the value of Bitcoin. The phenomenon when the value of a cryptocurrency falls sharply in a short period of time is known as "flat-crash" and can be attributed to the small market-cap effect. Another significant factor that contributes to the volatility of Bitcoin is the low liquidity of Bitcoin. Low liquidity exacerbates the price fluctuations resulting in high volatility. Regulation is another contributing factor to the volatility of Bitcoin. Since the inception of Bitcoin in 2009, several governments have tried to regulate Bitcoin along with other digital crypto-currencies. The U.S. Commodity Futures Trading Commission (CFTC) announced in 2015 that bitcoin and other digital currencies were commodities, and as a result the government agency could regulate them. In India, the Reserve Bank implemented a ban on dealings with crypto-businesses in 2018. The Chinese Government has banned initial coin offerings (ICO) and has cracked down on domestic exchanges of cryptocurrencies. As a result of regulations and anti-cryptocurrency laws imposed by the governments around the world, the price of Bitcoin has become increasingly volatile over the years. The price of a Bitcoin as an asset is not immune to news events and speculation. Coinbase added 100,000 users in a single day after exchange operator CME Group Inc. announced in November 2017 that it planned to add bitcoin futures that year. Positive news can increase investor interest and increase demand resulting in higher prices, while negative news might cause the prices to plummet. In August 2016, nearly 120,000 units of bitcoin went

missing from Bitfinex. Soon after the news broke, the price of Bitcoin fell by more than 20%. Lastly, another major factor behind Bitcoin's volatility is the uneven distribution of Bitcoin among investors. Aaron Brown from AQR Capital Management, estimated that 1,000 individuals owned approximately 40% of all bitcoin. If a single individual possesses a significant amount of Bitcoin, the individual can cause substantial price fluctuations by selling a fraction.
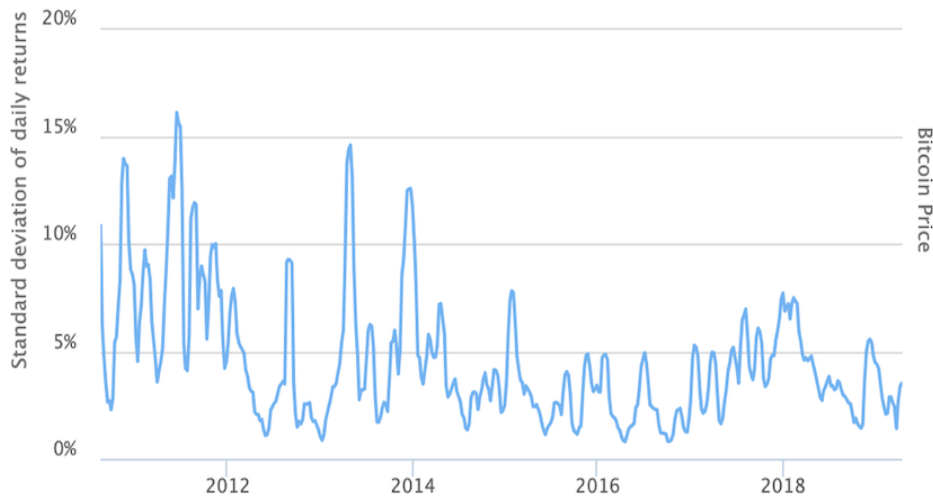

Fig I. Picture depicting standard deviation of daily returns for Bitcoin

As we can observe from Figure I, the Bitcoin volatility hit a 17-month low in the early October of 2018. While some pundits believed that this might be a sign of the cryptocurrency maturing and becoming more stable, some believed otherwise. This period of low volatility came to an abrupt end in mid-November as Bitcoin prices crashed. The volatility of gold averages around 1.2%, while other major currencies average between 0.5% and 1.0%. In contrast, the volatility of Bitcoin averages around 3.36%.

Beta (ß)

A beta coefficient is a measure of the volatility, or systematic risk, of an individual asset in comparison to the unsystematic risk of the entire market. Beta is used in the capital asset pricing model (CAPM), which

calculates the expected return of an asset using beta and expected market returns. In statistical terms, beta represents the slope of the line through a regression of data points from an individual asset's returns against those of the market. Beta measures the tendency of an asset to respond to changes in the price of a benchmark, like the S&P 500. The S&P 500 is a commonly used benchmark because it usually reflects the performance of the overall U.S. stock market. A positive beta indicates that an asset is correlated with a benchmark. If the benchmark increases in value, then the asset also tends to increase in value. A negative beta indicates the reverse.

The formula for Beta is:

$$\text{Beta} = \frac{\text{Covariance}(R_e, R_m)}{Variance(R_m)}$$

Where R_e is the return of an individual asset, R_m is return on overall market and Variance (R_m) is the variance of the entire market.

When viewed in the light of the CAPM, beta is a regression of asset returns against portfolio returns. We collect historical returns on the asset i, the market proxy m, and the risk free rate; that is, $r_{i,t}$, $r_{m,t}$, $r_{f,t}$ for t = 1 to T. The most common way to estimate the betas is to use the single index model, or characteristic line regression:

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_i(r_{m,t} - r_{f,t}) + \varepsilon_{i,t}$$

Where ε_i is the idiosyncratic risk of asset i

α_i is the alpha or excess return of asset i,

β_i is the beta of the asset i

In estimating betas, we typically rely on a relatively short rolling window of 5 year of historical data because Betas vary significantly over time which might be attributed to changes in a firm's leverage and operations, acquisitions or expansion of the firm into other industries or changes in the composition of the aggregate market. GARCH and related statistical procedures explicitly allow for time-variation of the Betas. In the process of estimating betas, we typically use monthly data. We can potentially get better estimates using higher frequency data. However, some significant drawbacks of higher frequency data are non-synchronous prices and bid-ask bounce effects. For CAPM, the benchmark portfolio is the market portfolio. However, we can calculate beta against other portfolios. The beta value calculated with respect to a particular portfolio would describe the activity of the asset's return with changes in the benchmark portfolio.

In this paper, I have tried to estimate the Beta of Bitcoin. I have attempted to calculate the beta of Bitcoin against S&P 500, the Dow Jones and the FTSE Global All Cap Index using CAPM theory. All analyses were performed using monthly data for five years from January 2013 to January 2018. All data for analysis was retrieved from Yahoo Finance using DataReader. A beta of greater than one would signify that bitcoin prices contain systematic risk related to benchmark portfolio. A beta close to zero would imply that bitcoin prices are uncorrelated with the benchmark portfolio. A beta of less than zero would imply that bitcoin prices are negatively correlated and could act as a hedge against systematic risk from the benchmark portfolio.

S&P 500

The S&P 500 measures the value of the stocks of the 500 largest corporations by market capitalization listed on the New York Stock Exchange. The intention of Standard & Poor's is to have a price that provides a quick look at the stock market and economy. It's calculated by taking the sum of the adjusted market capitalization of all S&P 500 stocks and then dividing it with an index divisor, which is a proprietary figure developed by Standard & Poor's. The S&P 500 is considered an effective representation for the economy due to its inclusion of around 500 companies, which covers all areas of the United States and across all industries. The beta of bitcoin calculated on five years of monthly data against the S&P 500 was performed by calculating the covariance of bitcoin and S&P 500 returns and dividing by the variance of S&P 500 returns.
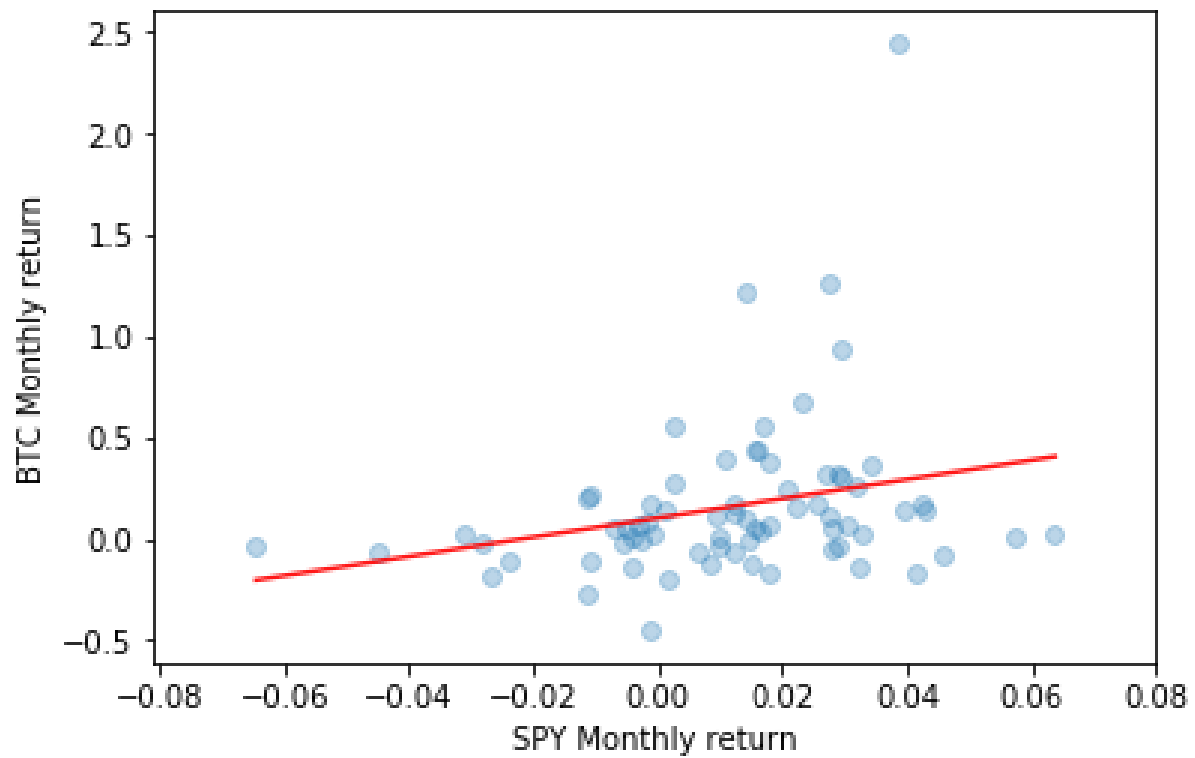
Fig II. BTC monthly return vs SPY monthly return for five years
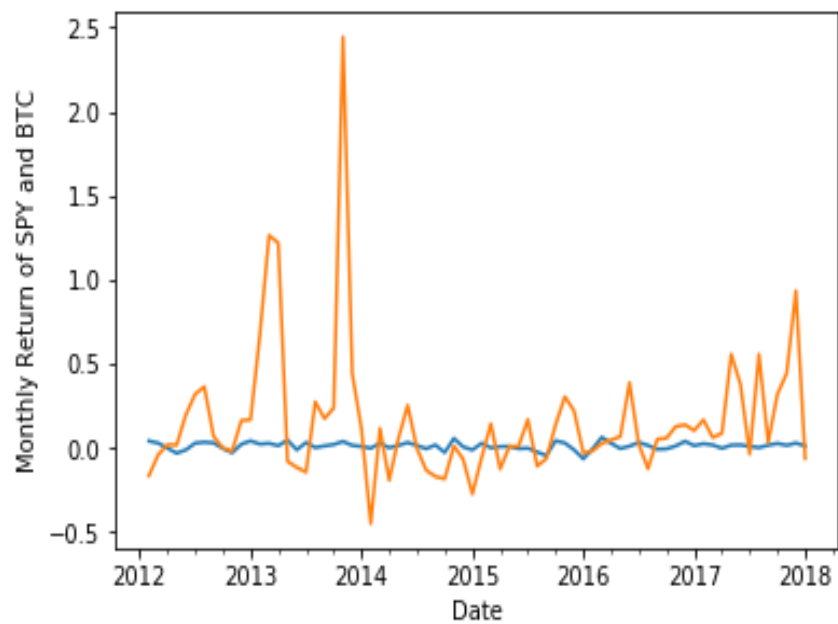

Figure III: Monthly return of SPY and BTC for five years

The resulting beta from running the regression was found to be 4.74 with the standard error being 2.05. This suggests that the price of bitcoin is significantly more volatile compared to the market. However, the R^2 value for the regression was found to be 0.0676, thus indicating that the regression is a poor descriptor of the data. We can also observe from figure III, that the returns of BTC is much more volatile compared to SPY500.

FTSE Global All Cap Index (VT)

The FTSE Global All Cap Index is a free-float, market-capitalization weighted index representing the performance of around 7400 large, mid and small cap companies in 47 developed and emerging markets worldwide, including the USA. It is is tracked by the VTWSX, which was used for this analysis.
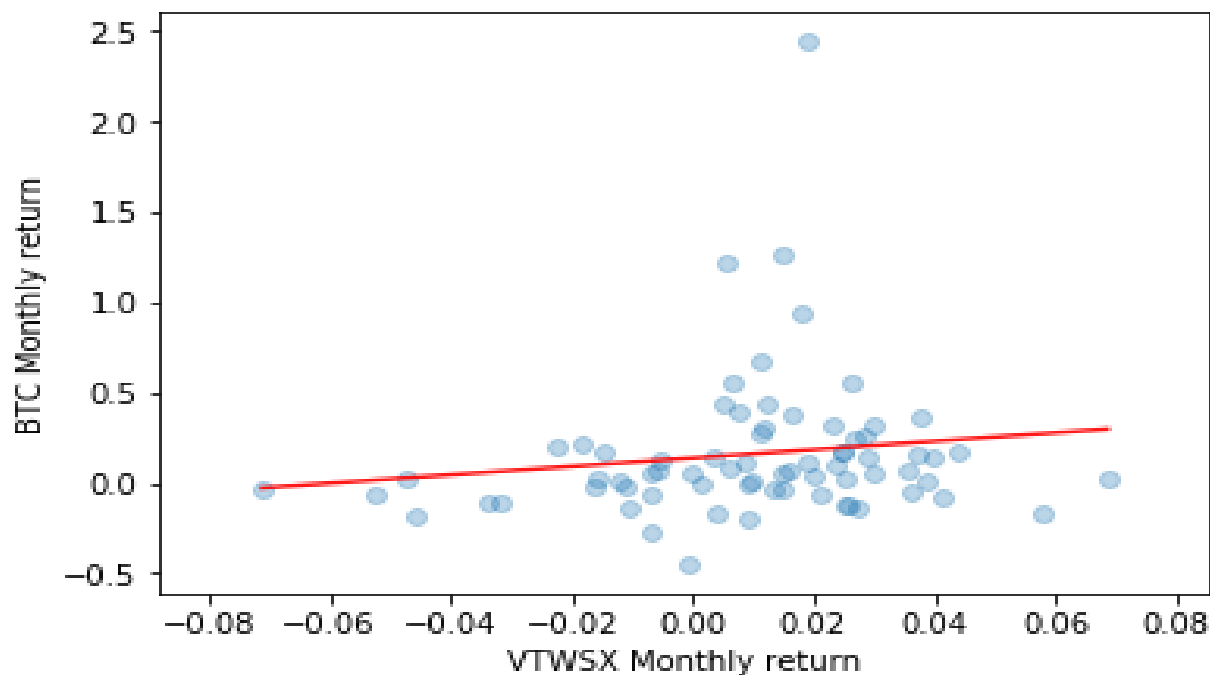

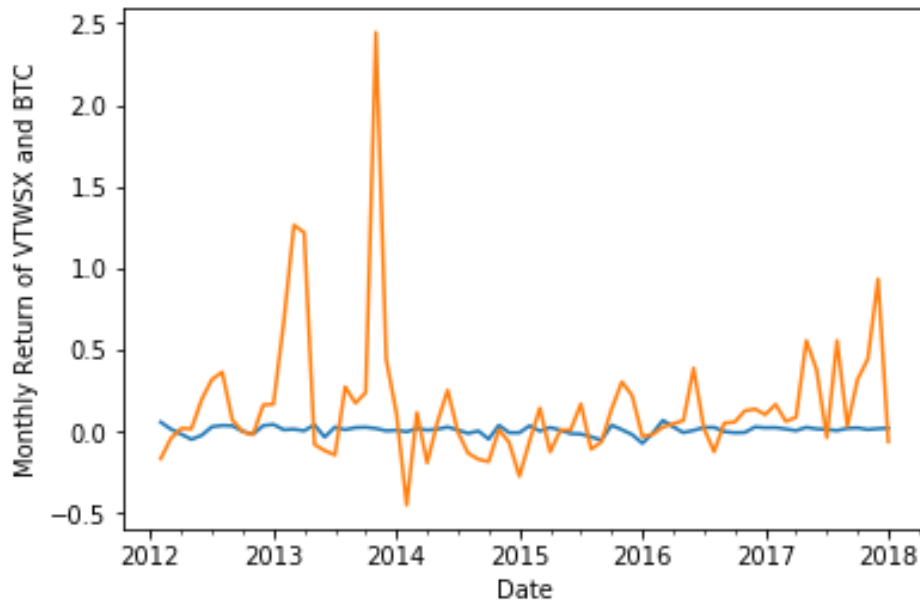Figure IV. VTWSX monthly return vs SPY monthly return for five years

Figure V. Monthly return of VTWSX and BTC for five years.

The resulting beta from running the regression was found to be 2.33 with the standard error being 1.89. This suggests that the price of bitcoin is significantly more volatile compared to VTWSX, however the volatility is comparatively lesser than what was observed we ran the regression against SPY500. However, the R^2 value for this regression was found to be 0.0196, thus indicating that the regression is a poor descriptor of the data. We can also observe from figure III, that the returns of BTC is much more volatile compared to VTWSX.

Dow-Jones Industrial Average (DJIA)

The Dow Jones Industrial Average (DJIA) is an index that tracks 30 large, publicly-owned companies trading on the New York Stock Exchange (NYSE). The Dow Jones Industrial Average was designed to serve as a proxy for the broader U.S. economy. When the index launched, it included just 12 companies that were almost purely industrial in nature. The first components operated in railroads, cotton, gas, sugar, tobacco and oil. The S&P 500 is often the institutional investor's preferred index given its depth and breadth, while the Dow Jones Industrial Average has historically been associated with the retail investor's gauge of the U.S. stock market.
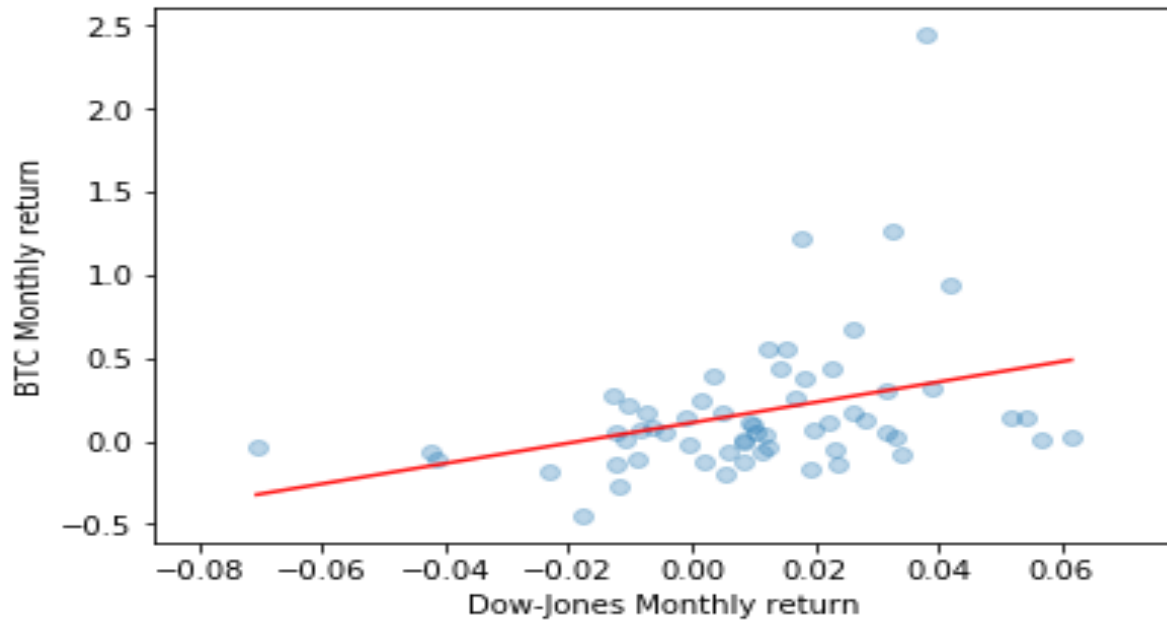
Figure VI. DJIA monthly return vs SPY monthly return for five years

Figure VII. Monthly return of DJIA and BTC for five years

The resulting beta from running the regression was found to be 6.13 with the standard error being 2.22. This suggests that the price of bitcoin is significantly more volatile compared to DJIA, the volatility is comparatively higher than what was observed we ran the regression against SPY500. However, the R^2 value for this regression was found to be 0.1156, thus indicating that the regression is a poor descriptor of the data, however more reliable than our previous regressions. We can also observe from figure VII, that the returns of BTC is much more volatile compared to VTWSX.

Markowitz Portfolio Theory and Bitcoin

Markowitz Portfolio Theory is a theory on how risk-averse investors can construct portfolios to optimize or maximize expected return based on a given level of market risk, emphasizing that risk is an inherent part of higher reward. According to the theory, it's possible to construct an "efficient frontier" of optimal portfolios offering the maximum possible expected return for a given level of risk. In this experiment, I tried to generate an efficient frontier with two risky assets – the market portfolio (SPY500) and Bitcoin. I imported the daily returns for SPY500 and Bitcoin for the period 2016-01-01 to 2017-01-01 and calculated the annual returns from the imported data for this experiment. I generated 50000 random portfolios with the two risky assets being the constituents in different proportions. In the optimal portfolio, the standard deviation was found to be 13.8%, whereas the return was calculated to be 16.7%. The proportion of Bitcoin in the optimal portfolio was calculated to be 6.12%, whereas, the proportion of the market portfolio was calculated to be around 93.88%. However, when I imported the daily returns for SPY500 and Bitcoin for the period 2018-01-01 to 2019-01-01, calculated the annual returns and ran the same experiment the standard deviation of the optimal portfolio was found to be 16%, whereas the return was calculated to be – 7.8%. The proportion of Bitcoin in the optimal portfolio was calculated to be 3.69%, whereas, the proportion of the market portfolio was calculated to be around 96.3%.

Next, I repeated the experiment with 22 different risky assets which comprised of 21 randomly selected stocks and Bitcoin. The stocks randomly selected were AAPL, INTC, CAT, JNJ, FB, TWLO, QCOM, GE, F, PEP, GS, EW, BK, FOXA, AMD, PFE , BAC, OMC, KL, W and GOOG. I imported the daily returns for the 21 stocks and Bitcoin for the period 2016-01-01 to 2017-01-01 and calculated the annual returns from the imported data for this experiment. The standard deviation of the optimal portfolio was calculated to be 13.44 % whereas the return was found to be 23.49 %. The proportion of Bitcoin by weight in the optimal portfolio was calculated to be 12.5%. However, when I imported the daily returns for the 21 stocks and Bitcoin for the period 2018-01-01 to 2019-01-01, calculated the annual returns and ran the same experiment the standard deviation of the optimal portfolio was calculated to be 15.3%, whereas the return was found to be -2.5%. The proportion of Bitcoin by weight in the optimal portfolio was calculated to be .15%. Thus, in both experiments, we observe a huge change in the composition of the optimal portfolio from one year to another which can be attributed to the high volatility of Bitcoin.
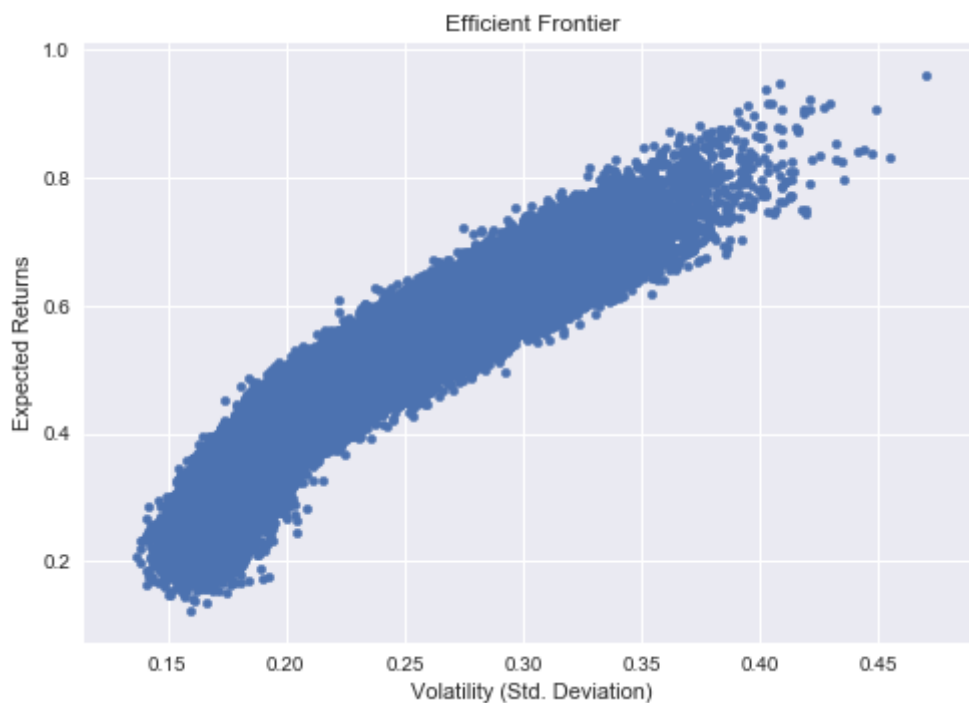

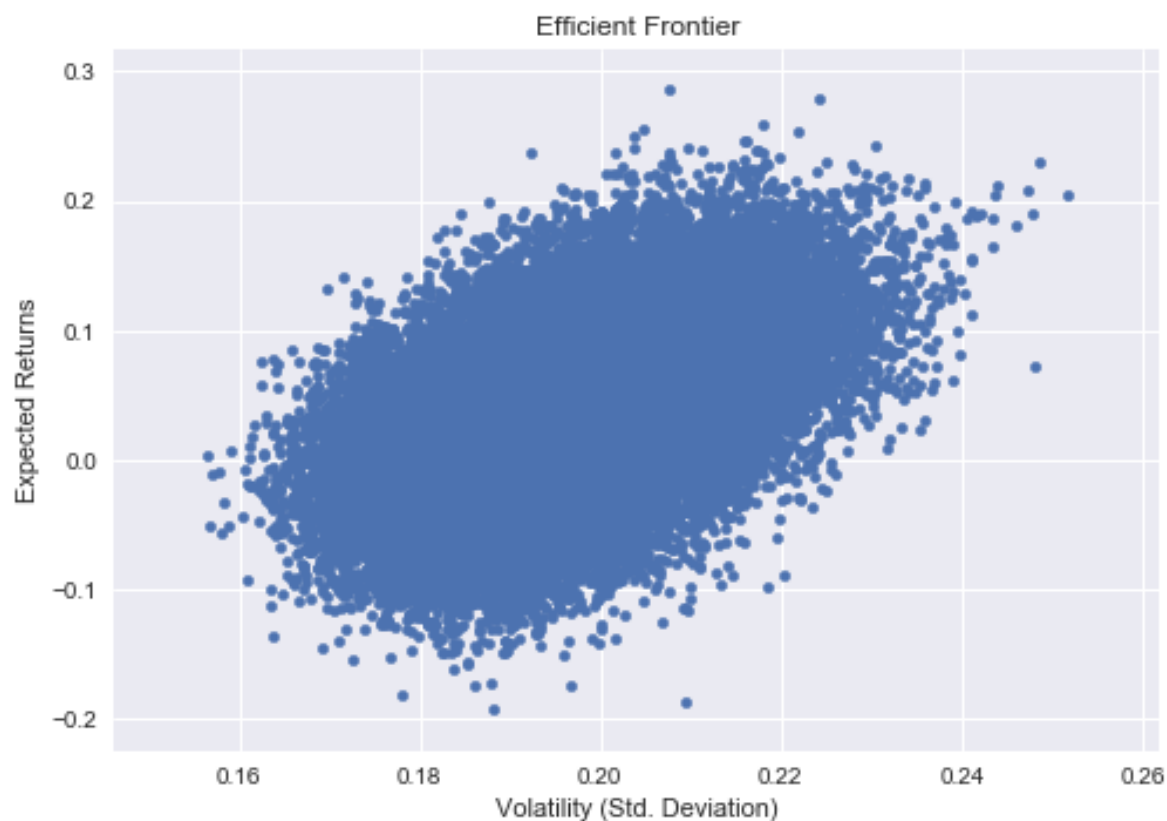Figure IX. Twenty-two risky assets including BTC for the period of 2016-01-01 to 2017-01-01

Figure X. Twenty-two risky assets including BTC for the period of 2018-01-01 to 2019-01-01

According to a study by Yale economist Aleh Tsyvinski , BTC-USD should occupy about 6% of every portfolio in order to achieve optimal construction. Even those who are strong bitcoin skeptics should maintain at least 4% BTC allocation, according the study. The study indicates that even the staunchest opponents of the cryptocurrency world are best off investing 1% of their assets in this space, if only for diversification purposes. From our experiments, we observed that high volatility of Bitcoin might be a deterrent to risk-averse investors from investing in Bitcoin. However, we saw that we could get high returns from an optimal portfolio containing Bitcoin which excelled the average market returns. Hence, we can conclude that Bitcoin does add value to a portfolio, but only when held in small amounts.

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