

# Investment Optimization

Bitcoin, Gold, and S&P 500 for Optimal Portfolio Growth



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# Our Data

## 1. Bitcoin and S&P500 Daily Data

- "date" : date from September 17, 2014 to November 17, 2021
- "open" : the price at the beginning of the day
- "high" : the highest price at the day
- "low" : the lowest price at the day
- "close" : the price at the closing of the day
- "volume" : how many lots were traded that day

|      | date       | open         | high         | low          | close        | volume       |
|------|------------|--------------|--------------|--------------|--------------|--------------|
| 0    | 2014-09-17 | 465.864014   | 468.174011   | 452.421997   | 457.334015   | 2.105680e+07 |
| 1    | 2014-09-18 | 456.859985   | 456.859985   | 413.104004   | 424.440002   | 3.448320e+07 |
| 2    | 2014-09-19 | 424.102997   | 427.834991   | 384.532013   | 394.795990   | 3.791970e+07 |
| 3    | 2014-09-20 | 394.673004   | 423.295990   | 389.882996   | 408.903992   | 3.686360e+07 |
| 4    | 2014-09-21 | 408.084991   | 412.425995   | 393.181000   | 398.821014   | 2.658010e+07 |
| ...  | ...        | ...          | ...          | ...          | ...          | ...          |
| 2614 | 2021-11-13 | 64158.121094 | 64915.675781 | 63303.734375 | 64469.527344 | 3.047423e+10 |
| 2615 | 2021-11-14 | 64455.371094 | 65495.179688 | 63647.808594 | 65466.839844 | 2.512209e+10 |
| 2616 | 2021-11-15 | 65521.289063 | 66281.570313 | 63548.144531 | 63557.871094 | 3.055876e+10 |
| 2617 | 2021-11-16 | 63721.195313 | 63721.195313 | 59016.335938 | 60161.246094 | 4.684434e+10 |
| 2618 | 2021-11-17 | 59967.230469 | 66304.296875 | 58838.714844 | 60276.031250 | 4.089261e+10 |

2619 rows × 6 columns

**S&P500 Data**

## 2. Gold Data

- "date" : date from September, 2014 to November, 2021
- "gold\_usd" : price in usd of gold for that month

|     | date       | gold_usd |
|-----|------------|----------|
| 0   | 2014-09-01 | 1241.330 |
| 1   | 2014-10-01 | 1223.565 |
| 2   | 2014-11-01 | 1176.413 |
| 3   | 2014-12-01 | 1200.440 |
| 4   | 2015-01-01 | 1249.333 |
| ... | ...        | ...      |
| 82  | 2021-07-01 | 1774.800 |
| 83  | 2021-08-01 | 1817.000 |
| 84  | 2021-09-01 | 1816.700 |
| 85  | 2021-10-01 | 1757.200 |
| 86  | 2021-11-01 | 1785.300 |

87 rows × 3 columns

**Gold Data**

The dataset includes daily observations for the S&P 500, with 1805 rows and no missing data. It also includes daily observations for Bitcoin, with 2619 rows and 4 missing data points. Additionally, there are monthly observations for gold, with 87 rows and no missing data. All data in the dataset are denominated in USD. The time period covered by the data spans approximately 7 years, from September 2014 to November 2021.

# Our Data

We will begin by importing the necessary libraries that will be utilized in our analysis. Additionally, we will merge the data for Bitcoin, S&P 500, and gold into a monthly frequency.

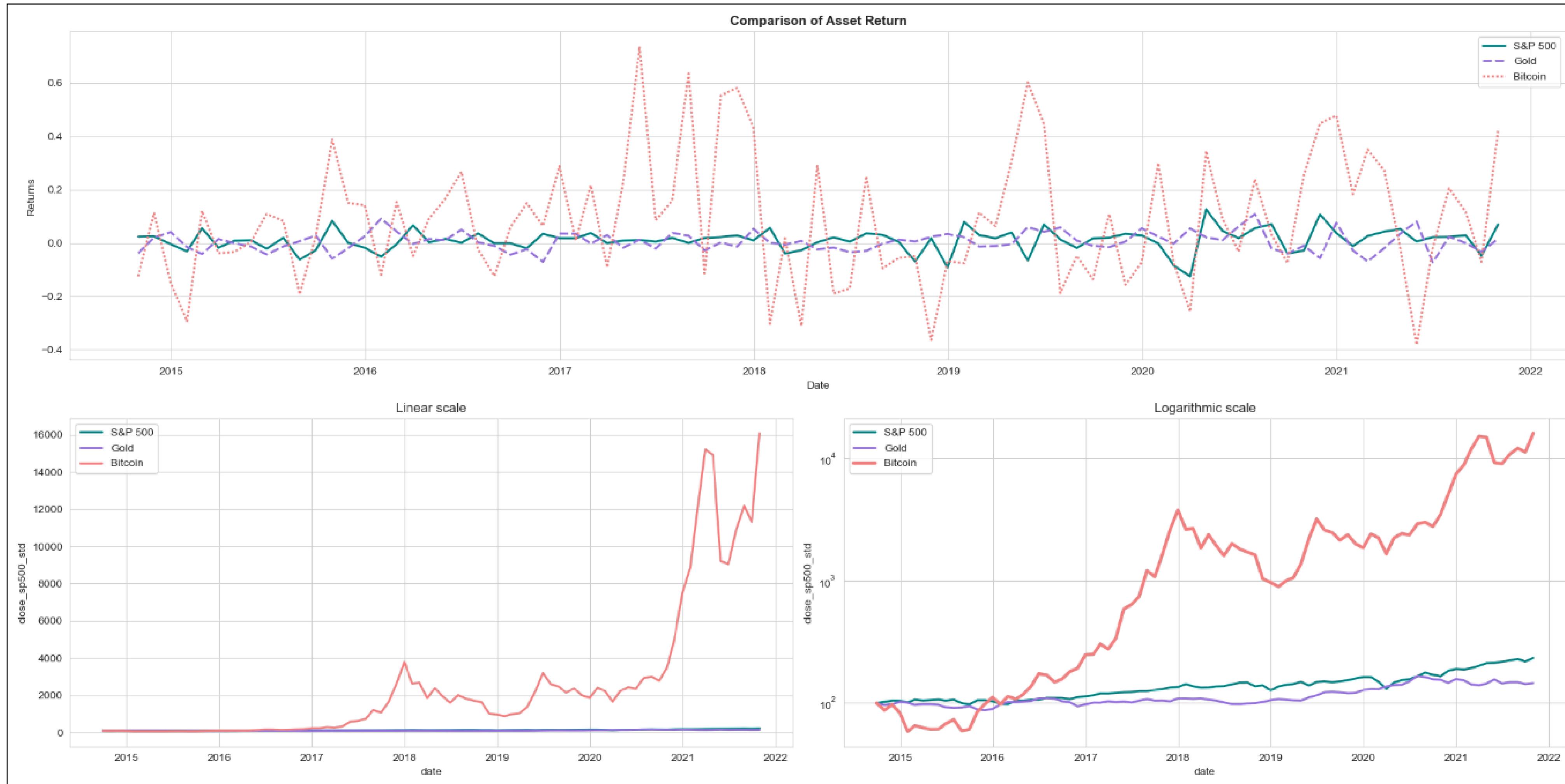
It is important to note that we will predominantly perform the analysis using monthly data, as this frequency is considered appropriate for making asset allocation decisions. By utilizing monthly data, we can gain a comprehensive understanding of the performance and characteristics of the *Asset Price Movement* assets over longer time periods, enabling us to make informed investment choices.

| date       | close_sp500 | close_btc    | gold_usd |
|------------|-------------|--------------|----------|
| 2014-09-30 | 1972.290039 | 386.944000   | 1223.565 |
| 2014-10-31 | 2018.050049 | 338.321014   | 1176.413 |
| 2014-11-30 | 2067.560059 | 376.446991   | 1200.440 |
| 2014-12-31 | 2058.899902 | 320.192993   | 1249.333 |
| 2015-01-31 | 1994.989990 | 226.425003   | 1231.100 |
| ...        | ...         | ...          | ...      |
| 2021-06-30 | 4297.500000 | 35040.835938 | 1774.800 |
| 2021-07-31 | 4395.259766 | 42235.546875 | 1817.000 |
| 2021-08-31 | 4522.680176 | 47166.687500 | 1816.700 |
| 2021-09-30 | 4307.540039 | 43790.894531 | 1757.200 |
| 2021-10-31 | 4605.379883 | 62227.964844 | 1785.300 |

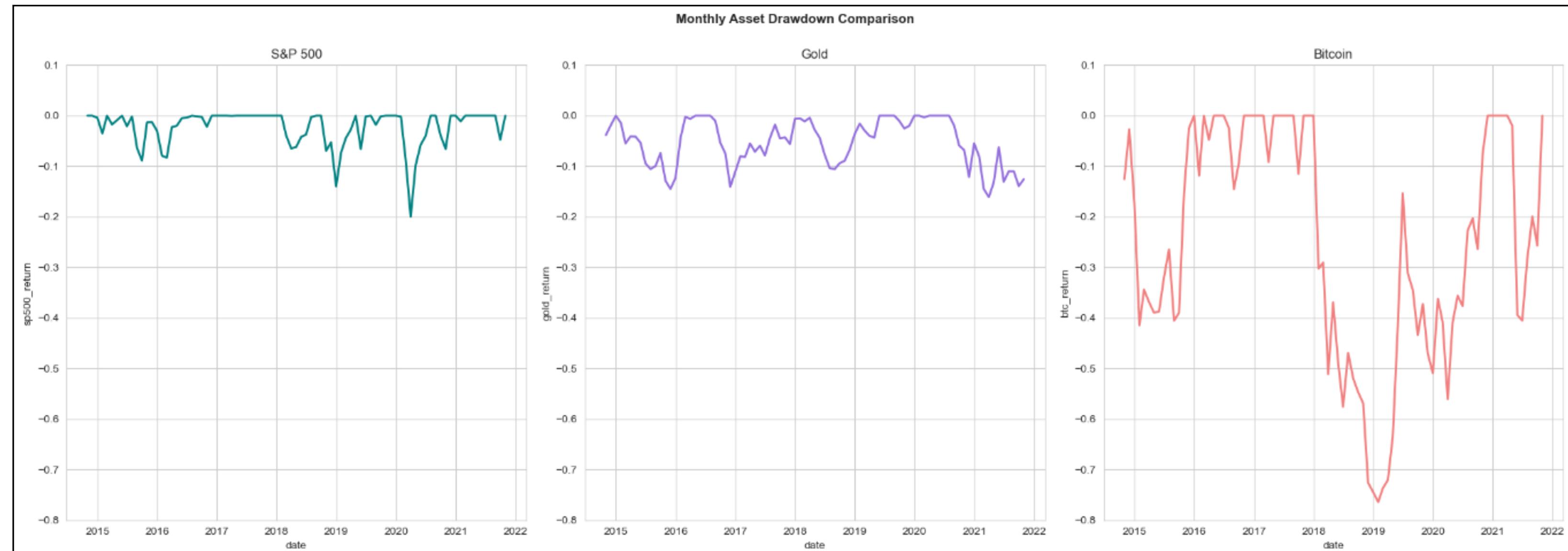
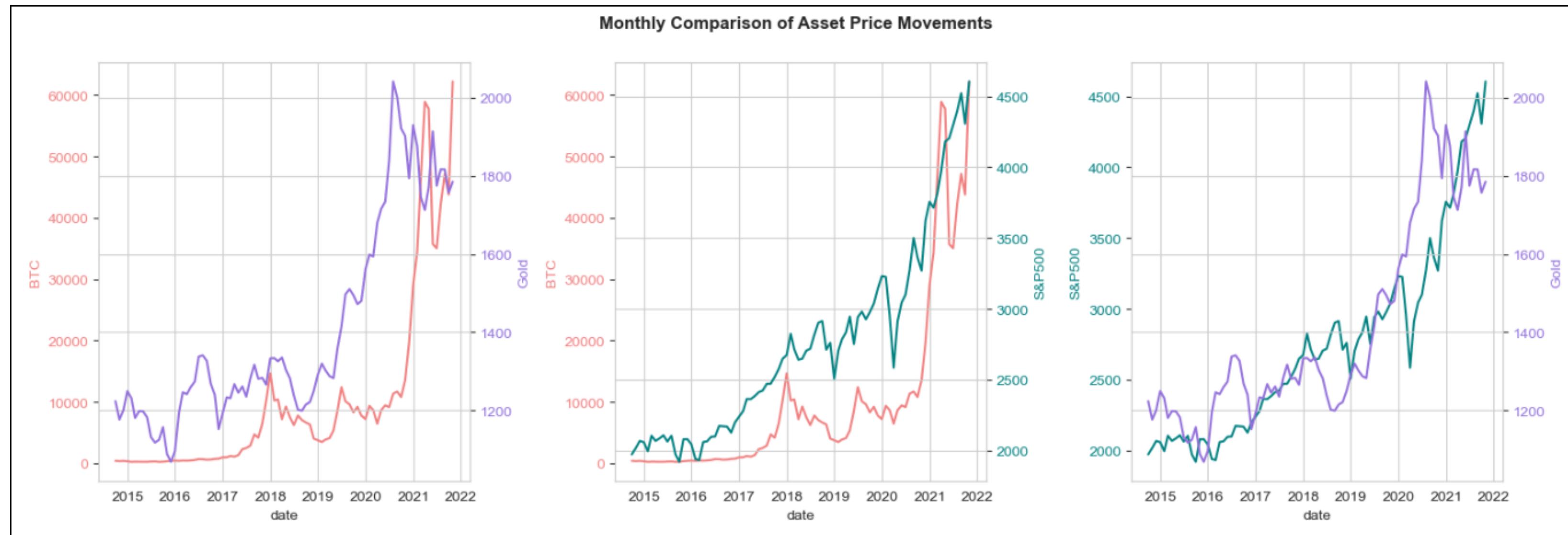
86 rows × 4 columns

*Merged Data in Monthly Frequency*

# Asset Performance



# Asset Performance



# Asset Performance

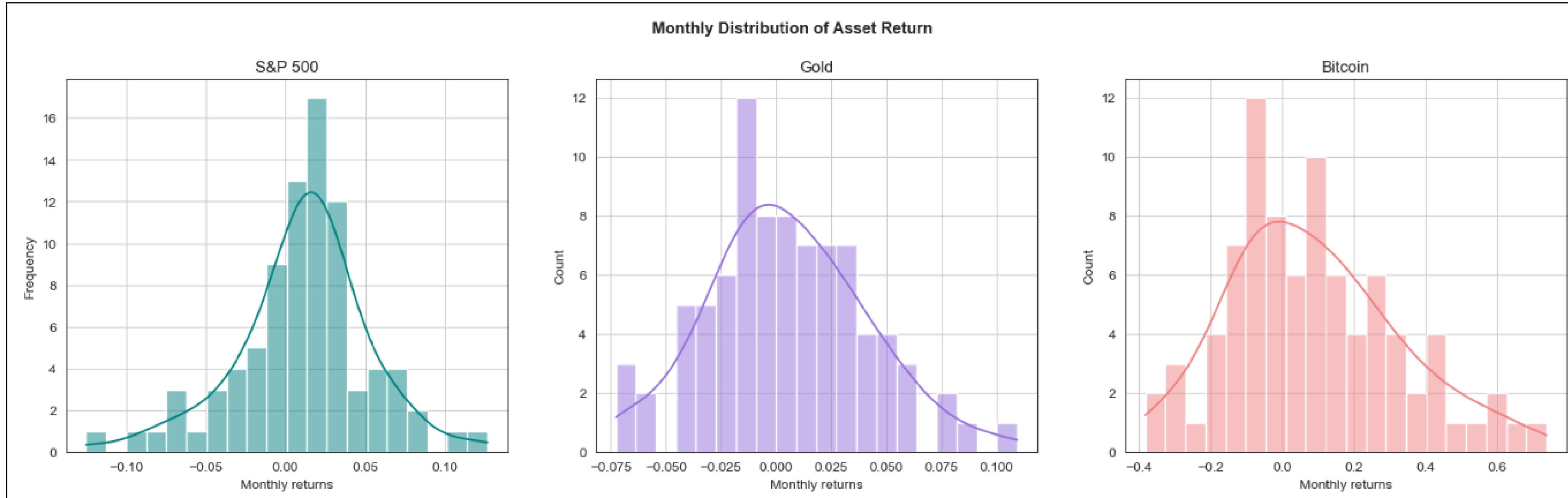
The monthly returns plot tells us a lot about how these assets behave. **Bitcoin's returns are all over the place and much more unpredictable than the S&P 500 and gold.** As for the S&P 500, its returns showed more variability than gold but less than Bitcoin. It's like the S&P 500 is the middle ground between the two. So, when we look at the overall picture, Bitcoin is the most volatile of the three. It can go up and down like crazy, while the S&P 500 and gold are more stable in comparison.

It's clear that **Bitcoin has been the real superstar!** Over the seven-year period, Bitcoin started with a lower price but shot up to incredible heights, leaving the S&P 500 and gold far behind.

To emphasize Bitcoin's remarkable growth, the chart above is presented on a logarithmic scale. If we had used a linear scale, the progress of the other assets would have looked like a flat line in comparison.

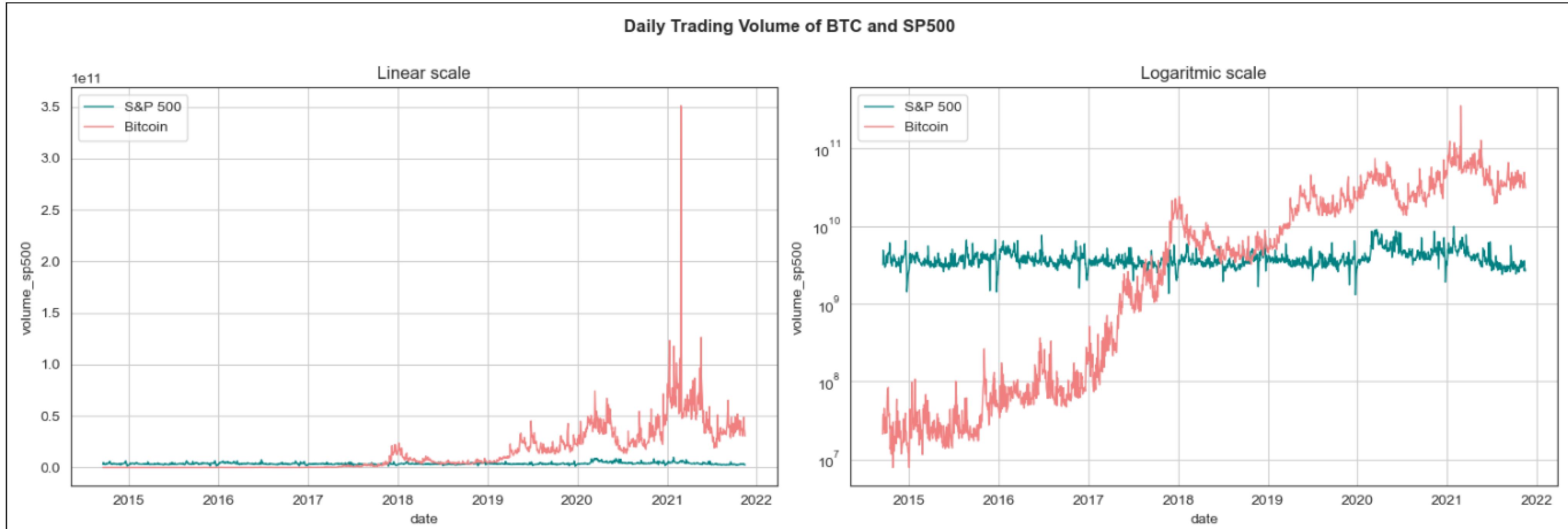
Bitcoin has consistently outperformed both gold and the S&P 500 throughout September 2014 to October 2021, Bitcoin experienced a jaw-dropping **annual growth rate of 103.2%**, leaving **gold's 5.4% and the S&P 500's 12.5%**. Over the entire period, Bitcoin's value increased by roughly 160 times, while the S&P 500 and gold saw growth of 2.3 times and 1.5 times. It's like Bitcoin embarked on an incredible adventure, while the other assets were content with a leisurely stroll.

# Monthly Asset Return



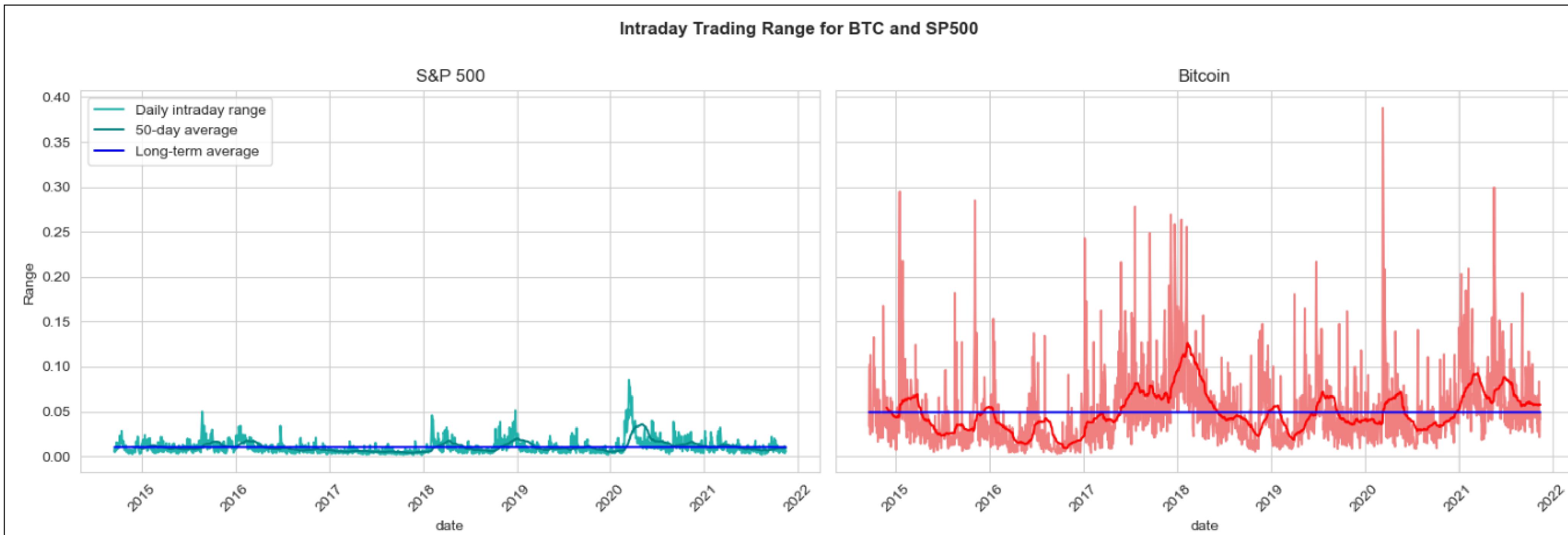
Monthly Returns Distribution shows that Bitcoin has a higher probability of extreme gains or losses compared to the S&P 500 and gold, indicating **high volatility but also potential opportunity**. Gold, on the other hand, has a more balanced set of returns outcomes and significantly lower volatility, while the S&P 500 falls somewhere in between with medium volatility and positively cumulative returns in the long run.

# Bitcoin vs S&P500 Volatility : Daily Trading Volume



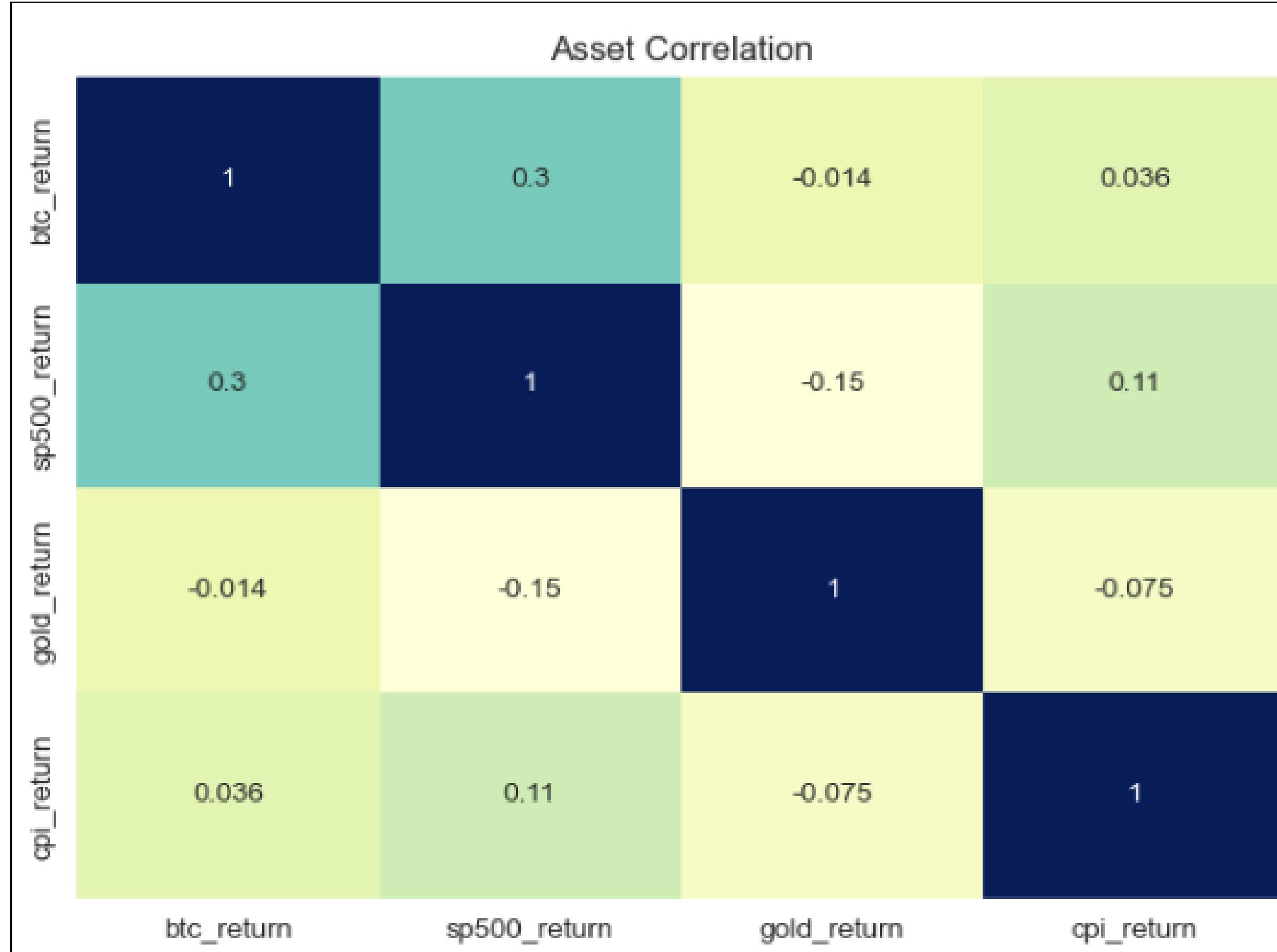
It appears that Bitcoin has gained popularity in terms of trading volume compared to the relatively stable trading volume of S&P 500 stocks over the years. In late 2017, the daily trading volume of Bitcoin surpassed that of the S&P 500, and the margin between the two has widened significantly in recent times, with Bitcoin trading volumes averaging 12.5 times that of the S&P 500 so far in 2021.

# Bitcoin vs S&P500 Volatility : Daily Trading Range



If we want to talk about how risky Bitcoin can be, we can compare its daily trading range to S&P500. On average, Bitcoin's range is around 4.9%, while the S&P 500's range is only 1%. But what really catches your attention are the spikes! On those wild days, **Bitcoin can swing as much as 30-40% in a single day**, which is way more than what we see with stocks. These crazy ups and downs can be a real challenge when it comes to managing a portfolio and dealing with risk

# Asset Correlation



Inflation eats away the value of money, reducing what we can buy with it. Investing is a way to protect against inflation. To combat inflation, the assets in our portfolio should generate positive returns that align with inflation.

The heatmap reveals that the returns of Bitcoin, gold, and the S&P 500 are not strongly related. This makes them suitable for inclusion in a portfolio. we can see that the S&P 500 has a weak positive correlation with inflation. In terms of volatility, gold is the least volatile. Bitcoin has a slight advantage because it has a small positive correlation with inflation.

# Portfolio Optimization

## Maximum Sharpe Ratio

This portfolio **focusing on maximizing the potential return** for a given level of risk. By considering the risk-free rate and measuring the excess return of assets, the MSR portfolio selects the allocation that offers the highest risk-adjusted return

## Minimum Volatility

This portfolio **aims to minimize the overall risk or volatility** of a portfolio. This strategy provides a smoother and more stable investment experience, with potentially lower ups and downs.

## Equal Weights

This portfolio **treats all assets equally**, without considering individual characteristics or market conditions. This strategy offers a simple diversification approach, ensuring that each asset contributes equally to the overall performance of the portfolio

# Portfolio Optimization

## Maximum Sharpe Ratio

| ----- Portfolio Weights ----- |                    |
|-------------------------------|--------------------|
| Bitcoin                       | 0.840909           |
| S&P500                        | 0.056818           |
| Gold                          | 0.102273           |
| AnnualisedReturns             | 1.459705           |
| AnnualisedVolatility          | 0.714727           |
| Sharpe                        | 2.042323           |
| Name:                         | 91, dtype: float64 |

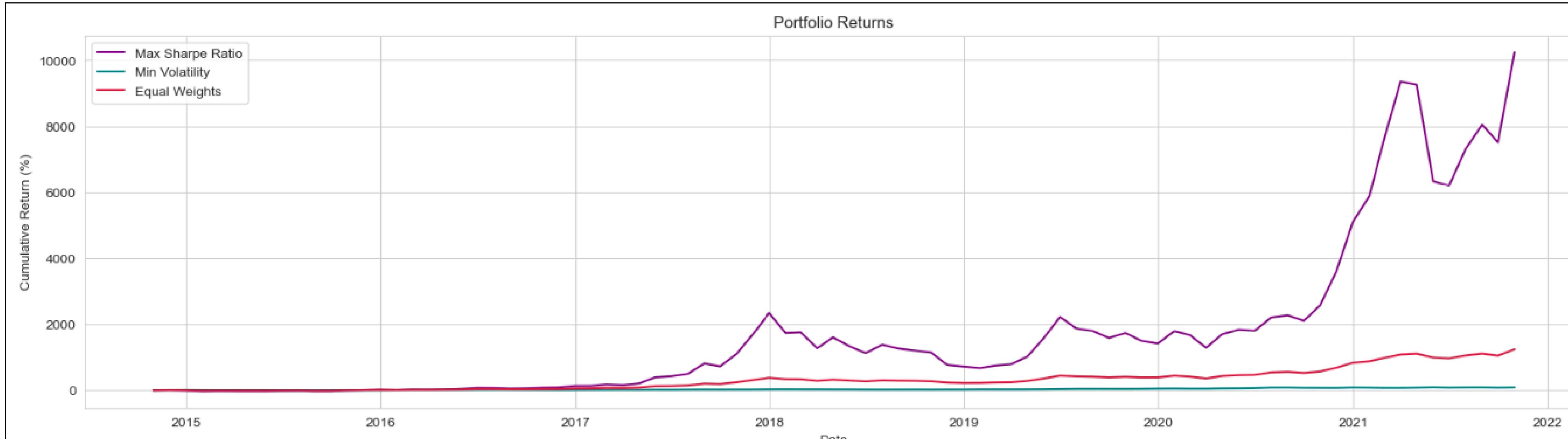
## Equal Weights

| ----- Portfolio Weights ----- |                     |
|-------------------------------|---------------------|
| Bitcoin                       | 0.333333            |
| S&P500                        | 0.333333            |
| Gold                          | 0.333333            |
| AnnualisedReturns             | 0.640143            |
| AnnualisedVolatility          | 0.364768            |
| Sharpe                        | 1.754930            |
| Name:                         | 100, dtype: float64 |

## Minimum Volatility

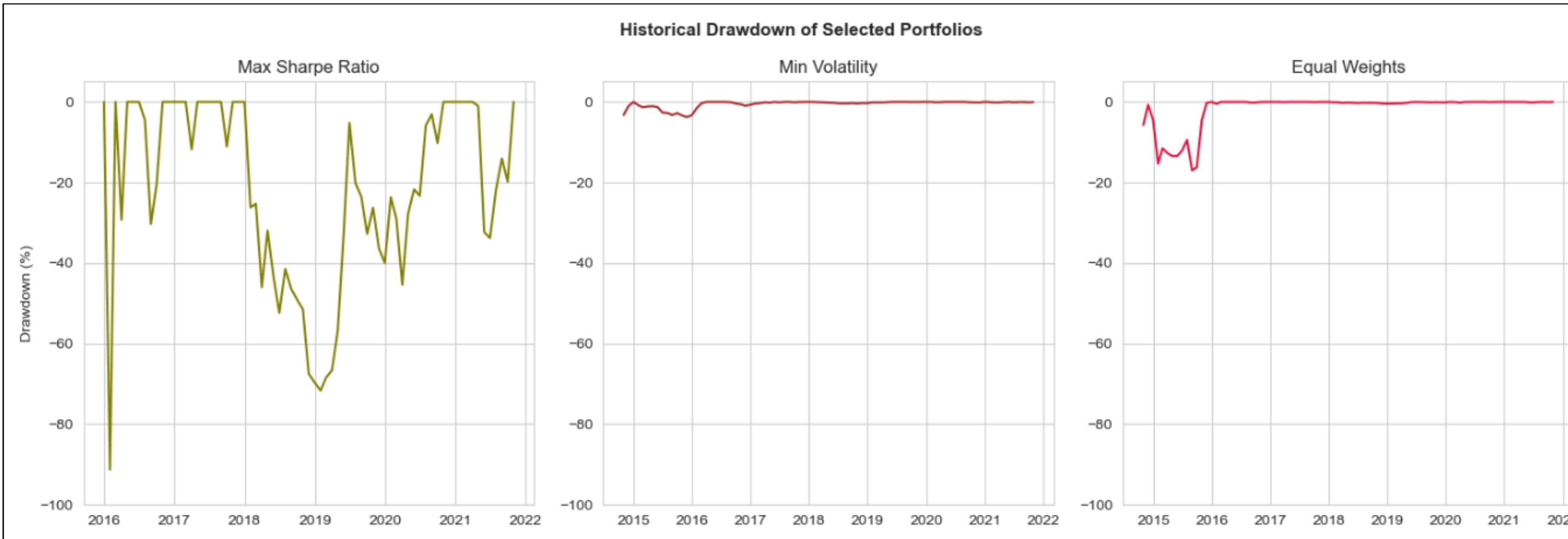
| ----- Portfolio Weights ----- |                    |
|-------------------------------|--------------------|
| Bitcoin                       | 0.008403           |
| S&P500                        | 0.277311           |
| Gold                          | 0.714286           |
| AnnualisedReturns             | 0.097855           |
| AnnualisedVolatility          | 0.136619           |
| Sharpe                        | 0.716263           |
| Name:                         | 24, dtype: float64 |

# Portfolio Optimization



1. **Max Sharpe Ratio Portfolio** suggests allocating a higher weight to Bitcoin (84%), a moderate weight to gold (10%), and a smaller weight to the S&P 500 (6%). It aims to achieve the maximum risk-adjusted return. The estimated annualized returns are 145.97% with a volatility of 71.47%. This portfolio has a Sharpe ratio of 2.04, indicating favorable risk-adjusted performance.
2. **Minimum Volatility Portfolio** focus is on minimizing volatility. It suggests a very small weight in Bitcoin (0.84%), a higher weight in the S&P 500 (27.73%), and a significant weight in gold (71.43%). The estimated annualized returns are 9.79% with a lower volatility of 13.66%. The Sharpe ratio is 0.72, suggesting a relatively lower risk-adjusted performance compared to the Max Sharpe Ratio Portfolio.
3. **Equal Weights Portfolio** aims for an equal allocation across all three assets: Bitcoin, the S&P 500, and gold. Each asset receives a weight of 33.33%. The estimated annualized returns are 64.01% with a volatility of 36.48%. The Sharpe ratio is 1.75, indicating a good risk-to-return tradeoff.

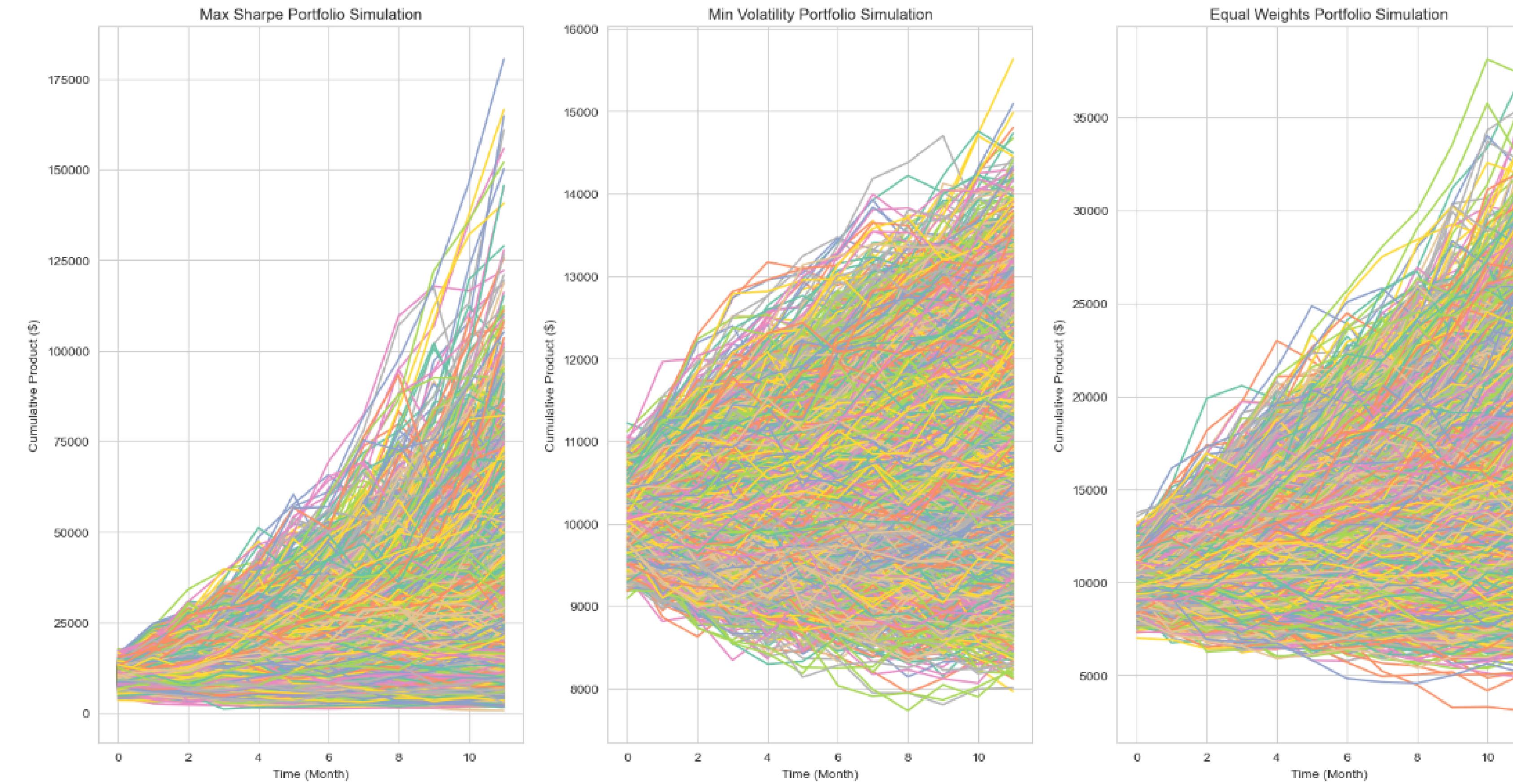
# Portfolio Optimization



The Max Sharpe Ratio portfolio had a tough time during the beginning of 2016 and during the 'crypto winter' of 2019. It faced its biggest drop in value, sinking more than 80% at 2016 and more than 70% at 2019 from its previous high. Talk about a rollercoaster ride!. The Minimum Volatility Portfolio experienced a maximum drawdown of 9% from its previous highs in the end of 2015. It may not have been as dramatic as the MSR portfolio, but it held its ground quite well. On the other hand, Equal weights portfolio gives equal weight to Bitcoin, S&P 500, and gold. It's a balanced approach that aims to keep things steady and maintain moderate risk.

# Monte Carlo Simulation

Forecasted Returns using Monte Carlo Simulation



If we consider the Max Sharpe Portfolio, it's projected to generate an average return of \$16,398 over the course of 12 months. The range of potential returns spans from \$722 up to \$180,478. On the other hand, if we opt for the Min Volatility Portfolio, the estimated average return for the same period is around \$15,634, with a range between \$10,501 and \$7,735. Alternatively, the equal-weighted portfolio is expected to yield an average return of approximately \$12,537 in 12 months, with potential returns ranging from \$3,105 to \$38,127. It's important to note that these estimates are based on simulations, and the actual results may deviate.

# Introduction

Imagine a carefully crafted portfolio that **combines the traditional with the cutting-edge, the stable with the exhilarating**. That's what portfolio optimization with the S&P 500, Bitcoin, and gold offers – an intriguing balance of risk and reward.

By intelligently allocating your funds across these assets, you can embrace the growth potential of the S&P 500, ride the waves of Bitcoin's volatility, and seek refuge in the timeless allure of gold. **It's like having a multi-dimensional adventure, where each asset plays its part in diversifying your risk and potentially maximizing your returns.**

So, whether you're a thrill-seeker, a traditionalist, or a risk-conscious investor, this trio of investment options opens up a world of possibilities. Strap in, hold on tight, and let portfolio optimization take you on an exhilarating journey to financial success.

**Note of caution :** This analysis is all about looking at how things went in the past, so it's not a crystal ball for the future. The data only covers a short period from 2014 to 2021, and things might change a lot going forward. So, before you make any big investment decisions, it's a good idea to do some more research and look ahead to see what might happen. It's better to be safe than sorry!

# Summary

- Bitcoin exhibits the highest volatility and significant price swings compared to the S&P 500 and gold.
- Over a seven-year period, Bitcoin outperformed the S&P 500 and gold with remarkable growth.
- The Monthly Returns Distribution highlights Bitcoin's potential for extreme gains or losses, while gold exhibits more balanced returns.
- Bitcoin's trading volume has surpassed that of the S&P 500, indicating its growing popularity.
- Bitcoin's daily trading range is much larger than that of the S&P 500, with significant spikes in price fluctuations.
- The Max Sharpe Ratio Portfolio suggests allocating a higher weight to Bitcoin, while the Minimum Volatility Portfolio focuses on reducing volatility with a larger weight in gold.
- The equal-weighted portfolio offers a balanced approach across Bitcoin, the S&P 500, and gold.
- Each portfolio has its own risk-return characteristics, providing different average returns and ranges.
- Investing in Bitcoin, gold, and the S&P 500 can offer protection against inflation.

In summary, Bitcoin is highly volatile and has shown impressive growth, while gold provides stability and the S&P 500 offers a middle ground. Investors can choose portfolios based on their risk preferences and objectives, considering the different risk-return profiles and estimated returns.

