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Stocks, Bonds, Gold, and Bitcoin: A Comparative Analysis of Risk-Adjusted Returns from 2022 to 2024

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ABSTRACT

This paper examines the relationship between U.S equities, gold, Bitcoin and short-term government debt over the three years from January 2022 to December 2024, a period defined by the fastest Federal Reserve rate hiking cycle in four decades, the beginnings of a cutting cycle, alongside the January 2024 approval of spot Bitcoin exchange-traded funds. Using a monthly return rate data and a risk-free rate derived from Treasury bill yields, this study calculated Sharpe and Sortino ratios, a six-month rolling beta for Bitcoin and gold against the S&P 500 as well as a pairwise correlation matrix across all three price based assets which is set against the Federal Funds Effective Rate as a contextual overlay. The findings show that gold recorded the highest risk-adjusted return among the three assets. This was the case for both the Sharpe and Sortino ratios. Bitcoin's beta against the S&P 500 also changed significantly during the period studied. It moved from below zero to above four within a few months. This increase occurred during the period following the approval of the Bitcoin ETFs. However, Bitcoin's beta later fell again as the Federal Reserve approached its first rate cut in late 2024. Bitcoin's correlation with the S&P 500 (0.571) was substantially stronger than gold's (0.243). In comparison, Bitcoin and gold themselves had only a weak correlation of 0.299. Overall, these results suggest that Bitcoin behaved more like a volatile and equity-adjacent asset rather than an independent store of value during this period. The study connects this pattern to prospect theory and loss-averse behaviour.

Keywords: *Portfolio Diversification, Risk-Adjusted Return, Bitcoin, Monetary Policy, Safe-Haven Assets, Behavioral Finance*

1. INTRODUCTION

In recent years, researchers have become increasingly interested in whether Bitcoin can act as a genuine alternative to traditional safe-haven assets such as gold. They have also examined whether it is better understood as a high-risk extension of the same equity markets that it is often positioned against. This question became more important following two major developments. The first was the fastest Federal Reserve interest rate hiking cycle in over four decades, which began in early 2022. The second development was the approval of spot Bitcoin exchange-traded funds in January 2024. This brought more institutional investors into a market that had previously been dominated by retail investors. However, Bitcoin's earlier price movements raised questions about whether it could really act like gold. In October 2021, Bitcoin traded above $67,000 and was being called "digital gold." By November 2022, its value had fallen by more than three-quarters. Bitcoin fell along with the stock market during this period. This was surprising because Bitcoin was expected to move differently from stocks. The stock market was also having its worst year since 2008. Gold barely changed during this time even though Bitcoin was meant to be its digital equivalent.

The relationship between traditional and alternative assets during periods of monetary stress has been widely studied. However, the findings are not consistent. Several recent studies identify gold as the more dependable safe asset. These studies suggest that Bitcoin is more useful as a diversifier than as a hedge against falling equity markets. Other studies have reached different conclusions. Using different methods or shorter time periods, they find that Bitcoin can have a lower correlation with equities than gold, especially over shorter periods. A smaller group of studies links these different findings to structural breaks and changes in the wider economy. This suggests that Bitcoin's behaviour may change depending on the conditions rather than being fixed. Another smaller group of studies looks at investor psychology to explain these risk-return patterns. They argue that investors who are affected by loss aversion and prospect theory may hold Bitcoin for reasons that cannot be fully explained by standard risk and return measures. However, these studies do not focus on the specific period covered by this research. During this period, the rate-hiking cycle, its later plateau, the start of the rate-cutting cycle, and the ETF approval all took place within a relatively short window. Existing research either focuses on an earlier period, is heavily influenced by the COVID-19 pandemic and the Russia-Ukraine war, or ends before the later stages of the 2022–2024 rate cycle and the ETF approval could be studied.

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This investigation examines the relationship between U.S. equities, gold, Bitcoin and short-term government debt over this three-year period. It uses monthly return data, a risk-free rate based on Treasury bill yields and the Federal Funds Effective Rate as the policy benchmark. The study focuses on four main areas. First, it compares the risk-adjusted returns of each asset. Second, it examines whether Bitcoin's volatility relative to equity markets remained stable or changed during the period. Third, it looks at how strongly the assets were correlated with each other. Finally, it considers how these patterns relate to the different phases of the monetary policy cycle. Section 2 reviews existing literature on stock-bond correlation, Bitcoin and gold as diversifiers, the macroeconomic factors that affect these relationships and their behavioural aspects. Section 3 explains the data and methodology. Section 4 presents the results and discusses their implications. Section 5 concludes the study.

2. LITERATURE REVIEW

2.1 Correlation and Diversification Dynamics Between Traditional Assets

The relationship between stock and bond returns has long been an important part of traditional portfolio construction. This is based on the assumption that fixed income can provide a stable hedge against equity risk. However, recent research increasingly suggests that this relationship can change over time rather than remaining constant. This idea is important to the argument developed in this study. Vanguard (2026) shows that the long-term correlation between equities and bonds has generally been negative for several decades. This has allowed bonds to reduce the impact of equity downturns during most historical sell-offs. However, 2022 was a clear exception, as both asset classes fell at the same time. The report links this change to the unusually aggressive rise in interest rates during the year. It therefore suggests that the relationship between equities and bonds depends on the wider economic conditions rather than following a fixed pattern. During periods of cashflow-driven growth, equities tend to benefit from economic expansion while bonds are affected by rising interest rates. This can lead to a negative correlation. In contrast, supply-side shocks can create both growth concerns and pressure for tighter monetary policy. In these situations, equities and bonds can both decline, resulting in a positive correlation. This is a useful observation from a practitioner perspective. However, it is still a report rather than a peer-reviewed study, and its explanation is based on an intuitive framework rather than just formal testing.

This changing relationship is one reason why the post-2022 period deserves closer study. If the diversification benefits of holding stocks and bonds together depend on the economic conditions, then they cannot be assumed to work in the same way in every period. This makes it important to examine whether gold or Bitcoin can provide the diversification that stocks and bonds may have lost under the current economic conditions. This can only be properly assessed using data from the current period rather than relying on general findings from previous research. Existing literature has mainly focused on the two-asset stock-bond relationship and does not directly address this issue. This forms the first main area that this review examines.

Academic theory provides a more detailed explanation of why this relationship can change over time. Campbell, Pflueger, and Viceira (2020) use a consumption-based habit-formation asset pricing model to show that the stock-bond correlation changed from positive during 1979Q3–2001Q1 to negative during 2001Q2–2011Q4. They link this change to a shift in the relationship between inflation and the output gap. When inflation rises during economic expansions, as has generally been the case since the early 2000s, bonds can act as a hedge against equity risk. Bond prices tend to fall during stronger economic periods and rise during downturns. However, when inflation rises during economic downturns, which was more common during the stagflation-prone decades before 2001, bonds tend to move in the same direction as equities. This reduces their diversification value. The study also finds that time-varying risk premia significantly increase this shift in covariance. They account for an estimated 70 to 81 percent of the total change in bond-stock covariance across the two regimes studied.

The model provides a useful and well-tested explanation, but there are two limitations to consider. First, the habit-formation framework is based on specific assumptions about investor preferences. These assumptions are not universally accepted in the asset-pricing literature. This means that the change in correlation may partly result from the model used rather than being a relationship that exists independently of the model. Second, and more importantly for this study, the sample ends in 2011. This was before the near-zero interest rate period, the large-scale quantitative easing programs of the 2010s and the emergence of cryptocurrency as a major investable asset class. As a result, applying the paper's inflation-output gap mechanism to the 2022–2024 period goes beyond the period the model was designed and tested to explain. It should therefore be treated as an extrapolation rather than a confirmed extension of the relationship.

Taken together, the two studies provide useful evidence that the relationship between stocks and bonds can vary over time. However, their findings do not cover the period examined in this study. The 2022–2024 period included the rapid rise in interest rates as well as the later shift towards rate cuts. Neither study examines how stocks and bonds behaved through these changes. The focus of both studies is also limited to stocks and bonds. Gold and Bitcoin are not included in either analysis. This leaves a gap in understanding whether these two assets could provide diversification during this period. It is also unclear whether the 2022–2024 period followed the same pattern seen in earlier research or whether the changes in monetary policy created a different relationship between the assets.

2.2 Bitcoin and Gold as Diversifiers and Safe Havens

A common finding in the literature is that Bitcoin does not necessarily provide the same safe-haven benefits as gold. This is despite the fact that Bitcoin is often described as "digital gold." Kumar, Mohan, and Niveditha (2025) use a rolling-window DCC-GARCH model to study the COVID-19 pandemic and the Ukraine war. Their findings show that gold was the more reliable safe haven across the major equity indices they studied. Bitcoin was more consistently useful as a diversifier than as a safe haven during periods of high market stress. The difference between a hedge and a safe haven is important here. A hedge helps reduce portfolio risk on average, while a safe haven is expected to protect value during periods of extreme market stress. The study suggests that Bitcoin meets the first condition more consistently than the second. Feder-Sempach, Szczepocki, and Bogołębska (2024) reach a similar conclusion using a multivariate stochastic volatility model over an eight-year period. They distinguish between strong and weak safe havens. A strong safe haven has a reliably negative correlation with equities during periods of market stress, while a weak safe

haven remains uncorrelated. Under this stricter definition, Bitcoin never qualifies as a strong safe haven. It recorded zero days of negative correlation with any of the five equity indices included in the study. Interestingly, the study also shows that gold does not always act as a strong safe haven. Its performance was strongest for European equity indices rather than across all the markets studied. This suggests that whether an asset acts as a safe haven may depend on the market being considered rather than being a fixed characteristic of the asset.

The findings are not completely consistent across the literature. Bhuiyan, Husain, and Zhang (2023) use wavelet coherence analysis and find that Bitcoin had a lower correlation with equities than gold, especially over shorter investment periods. This method is useful because it allows the relationship between assets to be studied across different time horizons instead of treating correlation as one fixed value. Hong et al. (2025) provide more recent evidence from the approval of spot Bitcoin ETFs in January 2024. Their study finds a statistically significant structural break in Bitcoin's relationship with traditional assets after the ETFs were introduced. Bitcoin's correlation with the S&P 500 increased sharply following the ETF launch, while its relationship with gold changed very little. These findings challenge the idea of Bitcoin as "digital gold" and suggest that its relationship with traditional assets may change as the market develops.

Despite their different findings, all four studies point to a similar conclusion. Bitcoin's relationship with traditional assets is not fixed. It changes depending on the time period, market conditions and investment horizon being studied. The studies disagree on how strong this relationship is and in which direction it moves, but none of them finds that Bitcoin behaves consistently across all periods. This suggests that Bitcoin's role as a diversifier or safe haven depends on the conditions being examined.

Each study also has limitations that need to be considered when interpreting its findings. Kumar, Mohan, and Niveditha focus mainly on the COVID-19 pandemic and the Ukraine war. Since these were periods of major global uncertainty, their results may reflect crisis-specific behaviour rather than how Bitcoin and gold behave under more normal market conditions. Feder-Sempach, Szczepocki, and Bogołębska use a longer sample, but their study ends in 2022. It therefore does not include some of the developments most relevant to this research, such as the later stages of the rate-hiking cycle and the approval of spot Bitcoin ETFs. Hong et al. provide evidence from the period after the ETF approval, but their observation period is much shorter and only covers a few months. Their findings therefore show the immediate effect of the ETF launch but do not establish whether the change lasted over a longer period. Overall, the studies show that Bitcoin's role can change depending on the economic conditions and time horizon. However, none of them covers the full 2022–2024 period examined in this study. This leaves a gap in understanding how Bitcoin behaved during the later stages of the monetary policy cycle, when market conditions became less extreme.

2.3 Structural and Regime Shifts, and Macroeconomic Drivers

Another group of studies focuses on the factors that cause these changes in asset behaviour. Nia et al. (2025) use an EGARCH model within an Arbitrage Pricing Theory framework to study gold, Bitcoin, equities and government bonds. Their research uses ten years of monthly data from Indonesia. The study finds that gold was relatively resilient to interest rate and inflation shocks. This supports its role as a safe haven from the perspective of how it responds to economic shocks, rather than only based on its correlation with other assets. Bitcoin showed a different pattern. It was sensitive to all three macroeconomic variables examined in the study. This goes against the idea that Bitcoin is largely unaffected by changes in monetary policy. The study also uses mean-variance optimization to examine different portfolio combinations. It finds that a portfolio with a large allocation to gold and a smaller allocation to Bitcoin had a higher Sharpe ratio than an equally weighted portfolio. This suggests that even a relatively small Bitcoin allocation can improve risk-adjusted returns, although Bitcoin remains more sensitive to changes in the wider economy.

However, the Indonesian context is an important limitation when applying these findings to this study. Indonesia has a managed currency system and capital controls, and it is an emerging market rather than a developed one. These conditions are different from those in the U.S. market examined in this research. As a result, gold's resilience to economic shocks in Indonesia may not be the same in a developed market. This needs to be tested separately using U.S. data.

Benigno and Rosa (2023) reach a different conclusion using a Federal Reserve event-study approach. Their findings suggest that Bitcoin shows little reaction to monetary policy surprises within narrow announcement windows. This differs from gold, silver and equities, which responded more clearly to these announcements. However, the difference between their findings and those of Nia et al. (2025) may be explained by the methods used rather than by a direct disagreement. Benigno and Rosa focus on immediate market reactions around policy announcements. This approach is useful for measuring short-term repricing but may miss effects that develop over longer periods. In contrast, Nia et al. examine how assets respond to realized macroeconomic shocks over a ten-year period. Their method is better suited to capturing gradual changes that occur over weeks, months or even years. Taken together, the two studies suggest that Bitcoin's relationship with monetary policy may not be immediate. It may respond more gradually to changes in economic conditions, even if it shows little reaction to individual policy announcements.

Interest rates are not the only macroeconomic factors that may affect these assets. Other studies also point to liquidity conditions, investor risk appetite and institutional capital flows as factors that can influence demand for gold and Bitcoin. These factors may affect asset prices independently of the interest rate cycle. Therefore, understanding the 2022–2024 period requires looking at these factors alongside monetary policy instead of focusing only on interest rates. This literature provides a basis for the empirical analysis that follows. The study examines whether the changes in correlation and beta identified in previous research can also be observed during the different monetary policy phases of the 2022–2024 period. These phases include the rate-hiking period, the pause and the later rate-cutting period.

2.4 Behavioural and Psychological Dimensions

The previous three themes explain how these relationships change over time and identify some of the main economic factors behind those changes. However, they do not explain why investors choose to hold one asset instead of another. This is important because investor decisions can affect how diversification works in real portfolios, not just in statistical models. The final theme focuses on

this behavioural side of investing. It connects the quantitative findings from the earlier studies with the factors that influence actual investor decisions.

Arvanitis, Topaloglou, and Tsomidis (2026) examine how different types of investors respond to risk and losses. They compare traditional investors who evaluate portfolios using standard mean-variance methods with loss-averse investors who place greater importance on losses than on equivalent gains. The study finds that adding cryptoassets provides little additional statistical benefit for traditional investors when compared with a portfolio of stocks, bonds and gold. However, crypto-inclusive portfolios perform better out-of-sample for loss-averse investors. This difference became much larger after the start of the COVID-19 pandemic. These findings show that the value of adding crypto to a portfolio may depend on how investors view risk. Standard portfolio models may not fully capture the decisions of investors who are more sensitive to losses. This makes investor behaviour relevant when considering how diversification works in practice.

Sahu, Uddin, and Hossain (2025) provide evidence at the individual investor level. Their study finds that personality traits, particularly openness and agreeableness, can predict an investor's tendency to show certain behavioural biases. These include giving too much importance to information that is easily available or noticeable and holding onto losing investments for too long in the hope that they will recover. Both of these biases are linked to sub-optimal investment behaviour in the study. This suggests that investors may not always make decisions based only on an asset's measured risk and return. Their behaviour and personal characteristics can also influence which assets they choose to hold and how they respond to losses. This is relevant to the earlier findings on correlation and Sharpe ratios. These measures show the statistical risk and return characteristics of an asset, but they do not fully explain how investors behave in practice. Investor behaviour can influence whether these theoretical diversification benefits are actually reflected in real investment decisions.

This behavioural perspective is an important part of the present study because it adds to the quantitative analysis from the first three themes. The earlier research shows how the relationships between stocks, bonds, gold and Bitcoin change and how economic conditions can affect them. However, these measures alone cannot fully explain how investors allocate their money in real markets. Including behavioural factors therefore gives a more complete view of portfolio allocation. Correlation, beta and risk-adjusted returns remain important measures, but investor behaviour can also affect whether these potential diversification benefits are actually used in practice. This makes the behavioural perspective a necessary part of understanding the four asset classes examined in this study.

3. METHODOLOGY

3.1 Research Design

The analysis focuses on four asset classes: U.S. equities, gold, cryptocurrency and short-term government debt. Monthly data is used to examine their performance and relationships from January 2022 through December 2024. This period was selected because it includes several important changes in monetary policy, including the Federal Reserve's rate hikes, the pause in rate increases and the start of rate cuts. To examine the assets from different perspectives, the study uses several quantitative methods. These include descriptive statistics, risk-adjusted performance measures, correlation analysis and a time-varying sensitivity measure. Each method provides a different way of understanding how the assets performed and how their relationships changed during the period. The approach is partly based on the methods used by Nia et al. (2025) and Ullah, Sohag, and Haddad (2024). Both studies use descriptive statistics, risk-adjusted performance measures and correlation analysis to study Bitcoin, gold, equities and fixed-income assets. This study applies similar methods but focuses specifically on the 2022–2024 period and the changes that occurred across different monetary policy phases.

The analysis is based on five main questions. First, it compares the four asset classes in terms of their average monthly returns and volatility. Second, it examines how much return each asset provides for the level of risk taken. This is measured using both total volatility and downside risk. Third, it looks at the sensitivity of Bitcoin and gold to movements in the U.S. equity market and examines whether this sensitivity remained stable or changed during the study period. Fourth, it measures the correlation between the three price-based assets: U.S. equities, Bitcoin and gold. Finally, it examines whether the behaviour of these assets changed across the different stages of the U.S. monetary policy cycle. These questions come directly from the gaps identified in the literature review. Previous studies have not provided a four-asset analysis focused specifically on the 2022–2024 period. They have also produced different findings about Bitcoin's correlation with traditional assets. In addition, there is limited research on how these relationships changed across the different stages of the recent U.S. interest rate cycle. The purpose of the analysis is therefore to describe what actually happened between these four assets during this period. It does not aim to create a general model that can be applied to every historical period. This focus on the 2022–2024 period also influences the methodological choices used in the analysis.

3.2 Data Collection

The study uses monthly data covering the period from January 2022 to December 2024. This gives 36 monthly observations for each of the four main assets. To keep the data consistent, each asset price series was taken from the same data provider instead of combining information from different platforms. This follows the approach used by Ullah, Sohag, and Haddad (2024), who also use a single data provider for each asset's return series.

The data used in the analysis are as follows:

- **S&P 500 (U.S. equities):** monthly returns from StatMuse Money.
- **Bitcoin (BTC/USD) (cryptocurrency):** monthly returns from StatMuse Money.
- **Gold (XAU/USD) (commodity and traditional safe-haven benchmark):** monthly returns from StatMuse Money.
- **3-Month Treasury Bill (risk-free proxy):** monthly annualized discount-basis yields from the Federal Reserve Bank of St. Louis (FRED), series TB3MS.

- **Federal Funds Effective Rate (monetary policy benchmark):** monthly values from FRED, series FEDFUNDS.

The sample covers January 2022 to December 2024. This period was chosen because it contains several major changes in U.S. monetary policy and in the cryptocurrency market. In 2022, the Federal Reserve went through its most aggressive rate-hiking cycle in four decades. Interest rates then stayed at their peak for much of 2023 before rate cuts began in the second half of 2024. January 2024 also marked the approval of spot Bitcoin exchange-traded funds. Hong et al. (2025) identify the ETF approval as a structural break in Bitcoin's relationship with equities, making it particularly relevant to this study. The choice of these dates also relates to the limitations of previous research. Campbell, Pflueger, and Viceira (2020) use data only up to 2011, so their study does not cover the recent period of high interest rates or the development of cryptocurrency markets. Kumar, Mohan, and Niveditha (2025) focus on a period heavily affected by the COVID-19 pandemic and the Ukraine war. Feder-Sempach, Szczepocki, and Bogołębska (2024) include data up to 2022, but their sample does not cover the later part of the rate cycle or the approval of the Bitcoin ETFs. Nia et al. (2025) and Ullah, Sohag, and Haddad (2024) also show the value of choosing a sample around a clearly defined economic period. For this reason, the 2022–2024 window allows the study to follow one complete period of monetary policy change, from rate increases to a pause and then to rate cuts. At the same time, the three-year period is long enough to compare these different stages without mixing them with several unrelated economic cycles. This makes it possible to examine whether the relationships between the four assets changed as monetary policy changed.

3.3 Variables

The collected data were used to create five variables for the analysis. Four of these represent the monthly returns of the assets, while the fifth is the risk-free benchmark used in the risk-adjusted return calculations in Section 3.5. The S&P 500, Bitcoin and Gold data did not need to be converted because the source already provided them as percentage monthly returns. The 3-Month Treasury Bill data were different. FRED reports the TB3MS series as an annualized discount-basis yield, so it could not be used directly as a monthly return alongside the other three assets. The Treasury Bill yield was therefore converted into a form that could be compared with the other monthly return data. This was done in two steps. First, the annualized discount rate was converted into an annualized investment, or bond-equivalent, yield using the standard Treasury conversion formula:

$$Investment\ Yield\ = \frac{365 \times d}{360 - (d \times t)}$$

Here, d represents the discount rate as a decimal and t represents the number of days until the bill matures, which is 91 days for a 3-month Treasury Bill. The adjustment is needed because the discount-basis rate does not represent the actual return earned by the investor. It is calculated using the bill's face value instead of the price the investor actually pays. The adjusted annual yield was then converted into a monthly return so that it could be compared directly with the monthly returns of the S&P 500, Bitcoin and Gold. This was done using:

$$R_f = (1 + Investment\ Yield)^{1/12} - 1$$

The annualized yield was then converted into a monthly return using compounding instead of simply dividing the annual figure by twelve. Dividing by twelve would assume that the return builds up at a constant rate each month, which is not the case when returns are compounded. The compounding approach therefore gives a more accurate monthly return. This produced a monthly risk-free rate series with a sample mean of 0.335 percent. This rate was used throughout the Sharpe ratio, Sortino ratio and other risk-adjusted calculations described in Section 3.5. The Federal Funds Effective Rate did not require any transformation because it was used only to provide context for changes in asset prices. It was not included as an input in any of the calculated ratios. The five variables were chosen to represent the four asset classes discussed in the literature review: equities, bonds, gold and cryptocurrency. The Federal Funds Effective Rate was included separately to show the monetary policy environment in which these assets were being studied.

3.4 Data Preparation

Before carrying out the analysis, the four monthly return series were checked and prepared in the same way. The full dataset contained 36 months of observations, and all four assets had complete data for this period. There were no missing values, so no interpolation or estimation was needed. The monthly returns were also used to create indexed price series. Each series was given a starting value of 100 in January 2022, with the value for each following month calculated by applying that month's return to the previous indexed value. This made it easier to compare the performance of the three price-based assets on the same scale. Their actual prices and monthly movements are very different, so using raw prices would make direct visual comparison difficult. An index starting at 100 instead shows how an equal initial investment in each asset would have grown or fallen over the study period. For the rolling beta analysis described in Section 3.5, the monthly returns of Bitcoin, Gold and the S&P 500 were placed into overlapping six-month periods. The window moved forward by one month each time. The calculation starts with January to June 2022 and then moves to February to July, March to August, and so on until the final July to December 2024 window. The first beta value can only be obtained once the first six months of data are available, so the series starts in June 2022. This gives 31 beta estimates from the original 36 monthly observations. The original return data were kept unchanged during preparation. In particular, no smoothing, interpolation or removal of unusual observations was carried out. This was important because large movements, including Bitcoin's biggest monthly gains and losses, are part of the actual behaviour being examined in this study.

3.5 Analytical Techniques

Descriptive Statistics: For each asset, the mean monthly return and standard deviation were calculated using the full 36-month sample. The arithmetic mean was used to find the average monthly return, while the population standard deviation was used to measure the overall variation in monthly returns. These figures provide the initial comparison of return and risk before applying the risk-adjusted measures.

Sharpe Ratio: The Sharpe ratio measures the excess return earned for each unit of total volatility. It is calculated as:

$$Sharpe = \frac{\underline{R} - R_f}{\sigma}$$

The Sharpe ratio was calculated for the S&P 500, Bitcoin and Gold. The 3-Month Treasury Bill was not included as an asset in this calculation because its return is used as the risk-free benchmark. Including it as a separate asset would not provide a meaningful Sharpe ratio comparison.

Sortino Ratio: A Sortino ratio was also calculated for the three assets. This was useful because Bitcoin had several unusually large positive monthly returns during the sample period, which contributed to its high overall volatility. Unlike the Sharpe ratio, the Sortino ratio focuses only on downside movements. It is calculated as:

$$Sortino = \frac{\underline{R} - R_f}{\sigma\, downside} \quad \text{where } \sigma downside = \sqrt{\frac{1}{n}\sum_{i=1}^{n} \quad min(0, R_i)^2}$$

The Sortino ratio was included alongside the Sharpe ratio because the two measures treat volatility differently. The Sharpe ratio counts both positive and negative deviations as risk, while the Sortino ratio only considers negative returns. This distinction is particularly relevant for Bitcoin, where some of the largest movements during the sample were positive. Comparing the two ratios therefore gives a clearer picture of how Bitcoin's return compares with its total volatility and its downside

Rolling beta. To examine whether Bitcoin's and Gold's sensitivity to the S&P 500 changed during the study period, a six-month rolling beta was calculated for both assets:

$$\beta_t = \frac{Cov(R_{asset}, R_{S\&P500})\ t-5 \to t}{Var(R_{S\&P500})\ t-5 \to t}$$

The calculation uses the six months ending in month *t*. The window then moves forward by one month and the beta is recalculated using the new six-month period. This produces a series of beta values instead of one value for the whole sample. The rolling approach was chosen based on the method used by Hong et al. (2025). Their study uses rolling and event-window analysis to examine whether Bitcoin's relationship with traditional assets changed around the January 2024 ETF approval. A single beta calculated over the full three years would hide these changes because it would combine periods with very different market conditions into one number. Using shorter windows makes it possible to see whether the sensitivity of Bitcoin and Gold to the equity market increased or decreased over time. Six months was chosen as a middle ground between having enough observations for a meaningful beta estimate and keeping the calculation responsive to changes in the market. A much shorter window would contain fewer observations and could make the beta more unstable. The reasons for using this window length and its limitations are discussed further in Section 3.7.

Pearson correlation. Pearson correlation coefficients were calculated for each pair of the three price-based assets: the S&P 500, Bitcoin and Gold. This gives three pairwise relationships and forms a correlation matrix for the full 36-month period:

$$r_{X,Y} = \frac{Cov(X,Y)}{\sigma_X \sigma_Y}$$

The correlation shows how closely the monthly returns of two assets moved together during the sample period. A positive value means that the assets generally moved in the same direction, while a negative value indicates that they tended to move in opposite directions. This method is also used by Ullah, Sohag, and Haddad (2024) and Feder-Sempach, Szczepocki, and Bogołębska (2024), who use correlation matrices to compare relationships between different assets. In this study, the correlation matrix provides an overall view of the relationships across the full sample. This can then be compared with the rolling beta results, which show how the relationship between the assets and the S&P 500 changed over time.

Macroeconomic overlay. The monthly Federal Funds Effective Rate was plotted alongside the indexed asset price series from Section 3.4. This was done to compare movements in the assets with changes in U.S. monetary policy throughout the study period. The NBER U.S. recession indicator (USREC) was also considered as a possible measure of the wider business cycle. However, there was no NBER-declared recession during the 2022–2024 period, so the series was not included in the final chart. This is useful for the study because the sample does not contain a formal recession alongside the rate cycle. The changes in asset prices can therefore be examined mainly in relation to the different stages of monetary policy, without a recession being present as an additional major factor. The Federal Funds Effective Rate was kept as the main macroeconomic reference because it directly represents the Federal Reserve's policy rate. It also provides context for the movements in the 3-Month Treasury Bill yields discussed in Section 3.3.

3.6 Reliability and Validity

Several choices were made during the preparation of the data to keep the analysis consistent. First, as explained in Section 3.2, each asset's return data came from a single provider. This avoided combining data from different sources that may calculate returns differently. For example, providers may use different closing prices, dividend adjustments or rounding methods. Using one source for each series reduced these differences. The 3-Month Treasury Bill was treated differently because its monthly return had to be calculated from the reported yield. As described in Section 3.3, the conversion used the Treasury's standard method for converting a discount rate into an investment yield. The result was then checked against the annual total return of an actual short-term Treasury investment. This provided a simple check that the calculated monthly values were within a reasonable range. Finally, all of the methods in Section 3.5 used the same 36 months of data. The descriptive statistics, Sharpe and Sortino ratios, rolling beta and correlation matrix were all based on the same underlying return series. Keeping the sample consistent means that the results from the different methods can be compared directly without differences in the sample affecting the comparison.

The study was designed so that the methods used match the questions identified in the literature review. The four-asset framework, the five research questions and the 2022–2024 study period all came from gaps found in Section 2. This helps ensure that the analysis is actually measuring the relationships that the study set out to investigate. The use of both the Sharpe and Sortino ratios also helps

when measuring risk. Using only the Sharpe ratio could give an incomplete picture because it treats positive and negative volatility in the same way. This is especially relevant for Bitcoin, which had several unusually large positive returns during the sample. Nia et al. (2025) also highlight the importance of considering different aspects of risk when studying these assets. Using both measures allows the results to reflect total volatility as well as downside risk. The rolling beta calculation was chosen for a similar reason. The literature review suggests that the relationship between these assets and equities can change over time. A single beta for the entire sample would reduce this relationship to one average value and could hide changes that occurred during the period. Calculating beta over six-month windows instead allows these changes to be observed and compared across different points in the 2022–2024 period.

3.7 Limitations

Several limitations should be considered when interpreting the results of this study. The main limitation is the sample size. There are only 36 monthly observations for each asset, which means that some of the methods, especially the correlation matrix and full-sample descriptive statistics, are based on a relatively short period of data. This is shorter than many studies in empirical finance, which often use data covering several years or even decades. As a result, the reported statistics may have less precision and may not fully represent longer-term relationships between the assets. However, this limitation does not mean that the patterns found in the study should be ignored. The short sample was a deliberate choice because the study focuses on a specific period with unusual monetary policy conditions. As discussed in Section 3.2, the 2022–2024 period was selected to capture the Federal Reserve's rate hikes, the pause and the later rate cuts within one defined window. The shorter sample therefore reflects the specific focus of the research rather than being simply a result of limited data availability.

A second limitation concerns the rolling beta series described in Sections 3.4 and 3.5. Since six months of data are needed before the first beta can be calculated, the series does not include the first five months of the sample, from January to May 2022. This means that any changes in market sensitivity during the earliest part of the 2022 rate-hiking cycle are not captured by the rolling beta analysis. However, these months are still included in the descriptive statistics and correlation analysis, which use the full 36-month sample. The six-month window also involves a trade-off between responsiveness and stability. A shorter window would respond more quickly to changes in asset sensitivity but could produce more unstable estimates because it uses fewer observations. A longer window would produce more stable and smoother estimates but would respond more slowly to changes in the market. The six-month window used in this study is therefore one reasonable choice between these two extremes, rather than the only possible choice.

A third limitation concerns the ability to apply the findings to other time periods. The study focuses only on the 2022–2024 period, which was chosen because it included an unusually rapid change in U.S. monetary policy. This makes the period useful for studying this particular monetary policy cycle, but it also means the findings may not apply to calmer or more typical periods. The relationships between the assets may also be different under other economic conditions or during earlier and later monetary policy cycles. This is a limitation that also appears in some of the studies discussed in the literature review. For example, Kumar, Mohan, and Niveditha (2025) focus on the COVID-19 pandemic and the Ukraine war, which were periods of unusually high global uncertainty. Their findings may therefore also reflect conditions that were specific to that period. Similarly, the findings of this study should be understood mainly in the context of the 2022–2024 period rather than as evidence of how these assets will behave in every market environment.

The analysis is based on the methods explained in Section 3.5, which were chosen to address the research questions in Section 3.1. These include descriptive statistics, the Sharpe and Sortino ratios, correlation and rolling beta. However, the study does not use all of the methods found in the literature reviewed in Section 2. Some of those studies use GARCH models, wavelet coherence analysis and event studies based on short periods around specific announcements. Not using these methods means that some features of the relationships between the assets may not be picked up by this study. For example, GARCH models could give more information about how periods of high or low volatility continue over time. Wavelet analysis could show whether the relationships between the assets are different over shorter and longer time periods. Event studies could also give a clearer picture of how the assets reacted immediately to individual Federal Reserve announcements. These are areas that the monthly approach used here cannot examine in the same detail. There was a practical reason for keeping the methodology narrower. The main aim was to answer the research questions without making the analysis unnecessarily complicated. The methods used also make the results easier to compare across the four assets and across the 2022–2024 period. Even so, this choice limits the amount of detail that can be obtained from the data. Using some of the more advanced methods in future research could therefore provide a deeper understanding of the volatility and short-term market reactions that are not covered here.

4. RESULTS AND ANALYSIS

4.1 Descriptive Statistics

Table 1 presents the mean monthly return and standard deviation for each asset over the 36-month sample period (January 2022–December 2024).

Table -1

Asset	Mean Monthly Return	Standard Deviation
S&P 500	0.653%	4.899%
Bitcoin	3.397%	17.176%
Gold	1.066%	3.881%

Bitcoin had the highest average monthly return at 3.397%. This was around 5.2 times the return of the S&P 500 and about 3.2 times the return of gold. However, this higher return came with much greater variation in monthly returns. Bitcoin's standard deviation was 17.176%, compared with 4.899% for the S&P 500 and 3.881% for gold. This means that Bitcoin was around 3.5 times as

volatile as the S&P 500 and 4.4 times as volatile as gold. The results therefore show a clear difference between the assets in terms of both return and risk. Bitcoin produced the highest average return, but it also experienced much larger movements from month to month. Gold had a lower average return than Bitcoin but the lowest standard deviation of the three assets. The S&P 500 fell between the two in terms of both measures. However, these figures only show the return and volatility in raw terms. They do not show whether the higher returns were enough to compensate for the additional risk. This is examined using the Sharpe and Sortino ratios in the following section.

4.2 Risk-Adjusted Performance: Sharpe and Sortino Ratios

Table -2

Asset	Monthly Sharpe Ratio	Monthly Sortino Ratio
S&P 500	0.065	0.096
Bitcoin	0.178	0.320
Gold	0.188	0.400

Note: Rf (monthly) = 0.335%, derived from FRED series TB3MS. All figures in this table are calculated on a monthly basis, consistent with the monthly return data used throughout this study, and are not directly comparable to annualized Sharpe ratios commonly cited elsewhere in the finance literature without the adjustment shown in Table 3 below.

The Sharpe ratio is calculated as: (Mean Return − Risk-Free Rate) / Standard Deviation.

Worked example for the S&P 500: Sharpe = (0.653% − 0.335%) / 4.899% = 0.318% / 4.899% = 0.065.

The Sharpe ratios in Table 2 are monthly figures, so they look smaller than the Sharpe ratios normally reported for U.S. stocks. This is because those figures are usually based on annual returns. The two cannot be compared directly without adjusting for the different time periods. In Table 3, the monthly ratios are therefore annualized by multiplying them by $\sqrt{12}$. The results also add some context to the returns shown in Section 4.1. Bitcoin had the highest average monthly return at 3.397%, but it also had much greater volatility. This is reflected in its Sharpe ratio of 0.178. Gold had a slightly higher Sharpe ratio of 0.188 despite having a much lower average return. Its Sortino ratio was also the highest at 0.400. For comparison, Bitcoin's Sortino ratio was 0.320 and the S&P 500's was only 0.096. The difference between the average returns and the risk-adjusted ratios is important. Bitcoin's higher return did not automatically give it the best risk-adjusted performance because the asset also experienced much larger fluctuations. Gold's lower volatility meant that its return was achieved with less overall and downside risk. The S&P 500 had the lowest values for both ratios, despite having much lower volatility than Bitcoin.

Table -3

Asset	Annualized Sharpe Ratio	Annualized Sortino Ratio
S&P 500	0.225	0.332
Bitcoin	0.618	1.109
Gold	0.653	1.385

After annualizing the ratios, the S&P 500 has a Sharpe ratio of 0.225. This is lower than the long-run values often reported for U.S. equities. One possible reason is the period used in this study. The 2022–2024 sample included a very rapid increase in interest rates and large changes in financial market conditions. Gold has the highest annualized Sharpe ratio at 0.653, although Bitcoin is quite close at 0.618. The S&P 500 is lower at 0.225. The Sortino ratios give a slightly different view because they only treat downside movements as risk. Bitcoin's ratio rises from 0.618 under the Sharpe measure to 1.109 under the Sortino measure. This is a much larger change than for the other two assets. One reason is that Bitcoin had some very large positive monthly returns during the sample. In particular, it gained 43.76% in February 2024 and 37.36% in November 2024. These large gains increase Bitcoin's overall standard deviation and therefore affect its Sharpe ratio, even though they are not considered downside risk in the Sortino calculation. Gold still has the highest Sortino ratio at 1.385. This is consistent with the lower volatility seen in Section 4.1 and suggests that Gold's returns were achieved with less downside risk during the period. The result also fits with the findings discussed in the literature review. Kumar, Mohan, and Niveditha (2025) and Feder-Sempach, Szczepocki, and Bogołębska (2024) both found evidence supporting Gold's role as a more reliable safe-haven asset than Bitcoin.

4.3 Time-Varying Market Sensitivity: Rolling Beta

The measures discussed so far give one value for each asset over the entire 2022–2024 period. This is useful for comparing the assets, but it can hide changes that happened within the sample. This is particularly important for Bitcoin because the studies discussed in Section 2 found that its relationship with traditional assets can change over relatively short periods. To look at this change more closely, Figure 1 shows the six-month rolling beta of Bitcoin and Gold relative to the S&P 500. The first beta is calculated for the six months from January to June 2022, so the rolling series begins in June 2022 and continues until December 2024. Each new beta uses the most recent six months of returns. This allows the sensitivity of Bitcoin and Gold to the equity market to be compared at different points in the study period instead of using one beta for the entire sample. The figure therefore provides a more detailed view of how the two assets moved in relation to U.S. equities as market conditions changed. This is especially relevant when considering the different stages of the Federal Reserve's monetary policy cycle during 2022–2024.

Figure 1. 6-Month Rolling Beta: Bitcoin and Gold vs. S&P 500 (Jun 2022–Dec 2024)

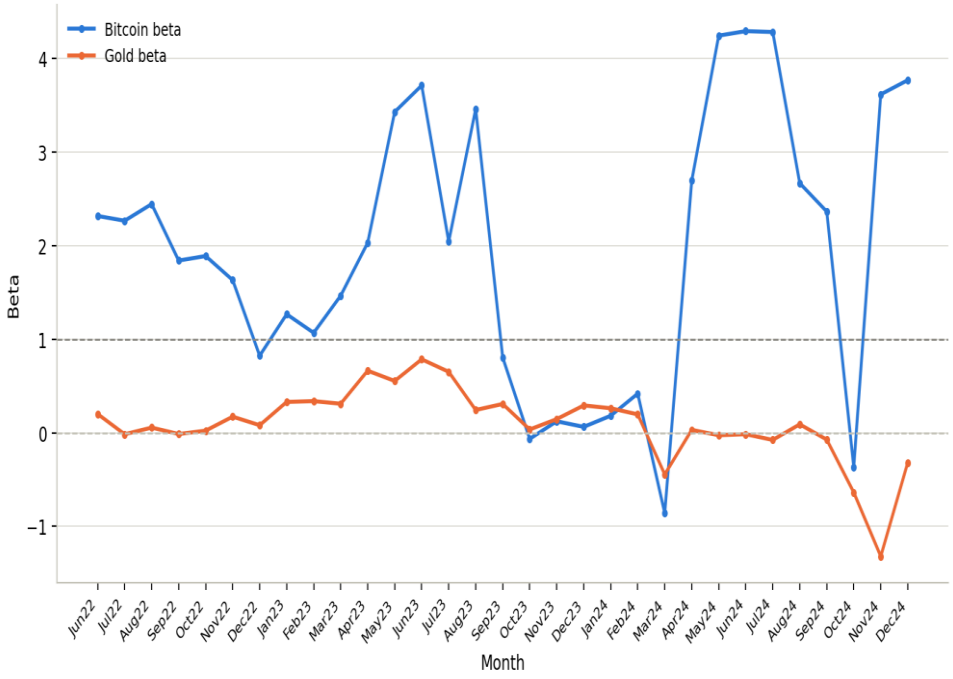

Figure -1

Two main patterns can be seen in Figure 1. Bitcoin's beta changes considerably over the sample period. It reaches a low of −0.86 in the six-month window ending in March 2024 and then rises to 4.29 by June 2024. This is a change of more than five beta points in only three months. A single beta calculated using the full sample would not show this movement and would make Bitcoin's relationship with the S&P 500 appear more stable than it actually was. Gold shows a very different pattern. Its beta stays close to zero for most of the period, meaning that its movements were generally not very sensitive to changes in the S&P 500. The beta becomes more negative toward the end of 2024, which is discussed in more detail later in this section.

Bitcoin's high and changing beta is also relevant to the debate discussed in the literature review about whether Bitcoin behaves more like an equity-related asset or like "digital gold." During several parts of the sample, a 1% movement in the S&P 500 was associated with a 2–4% movement in Bitcoin in the same direction. This level of sensitivity is much higher than would normally be expected from an asset being used mainly for diversification. The increase in Bitcoin's beta is particularly noticeable after the January 2024 approval of spot Bitcoin ETFs. The beta was −0.86 in the window ending March 2024, before increasing to 4.25 by May 2024. Hong et al. (2025) also identify a structural break in Bitcoin's relationship with traditional assets following the ETF approval. The results here show a similar change, although the increase in beta did not appear immediately. Instead, it developed over the following months. This gradual change is consistent with the delayed response discussed in Section 2 and helps explain why Nia et al. (2025) and Benigno and Rosa (2023) reached different conclusions about Bitcoin's response to monetary conditions.

Another noticeable change occurs between July and October 2024. Bitcoin's beta was still very high in July at 4.28, but it fell to 2.67 in August and 2.36 in September. By October, it had moved into negative territory at −0.37. This is a fall of more than 4.6 beta units over three months. At around the same time, the Federal Funds Effective Rate also started to fall. It had stayed at 5.33% from mid-2023 and then fell to 4.72% in September 2024 and 4.51% in October. Bitcoin's monthly returns during these months were also quite mixed. It gained 3.10% in July, fell by 8.75% in August, and then rose by 7.39% in September and 10.86% in October. As the rate environment changed, Bitcoin's beta fell sharply and briefly became negative, even though its monthly returns were still relatively large. Gold showed a smaller change over the same period. Its beta fell from −0.08 in July to −0.64 in October. This was the most negative value recorded for Gold up to that point in the sample. Since Gold's beta had already stayed close to zero for most of the period, this late-2024 movement was much less dramatic than Bitcoin's.

Overall, the two assets moved in a similar direction during this part of 2024, with both becoming less positively related to the S&P 500. However, Bitcoin's change was much larger, moving from a beta of 4.28 in July to −0.37 in October. Gold moved from −0.08 to −0.64 over the same period. This suggests that the change in Bitcoin's relationship with equities after the ETF approval was not seen in Gold to the same extent. This is consistent with Hong et al. (2025), who found that Bitcoin's relationship with Gold changed much less after the ETF approval than its relationship with equities.

4.4 Macroeconomic Context: Asset Performance and the Federal Funds Rate

Beta shows how strongly an asset moves when the equity market moves, but it does not tell us what may have caused that relationship to change. Interest rates are one factor that can affect equities, gold and cryptocurrency at the same time. The literature in Section 2 discusses how changes in monetary policy can influence all three assets, although not necessarily in the same way. Looking at the beta values alongside the interest rate data can therefore give more context to the changes seen above. Figure 2 shows this by plotting the indexed prices of the S&P 500, Bitcoin and Gold from January 2022 to December 2024, with January 2022 set to 100. The Federal Funds Effective Rate is plotted over the same period. This makes it possible to compare the changes in asset prices with the different stages of the U.S. interest rate cycle and see whether any clear patterns appear during the rate hikes, the pause and the later rate cuts.

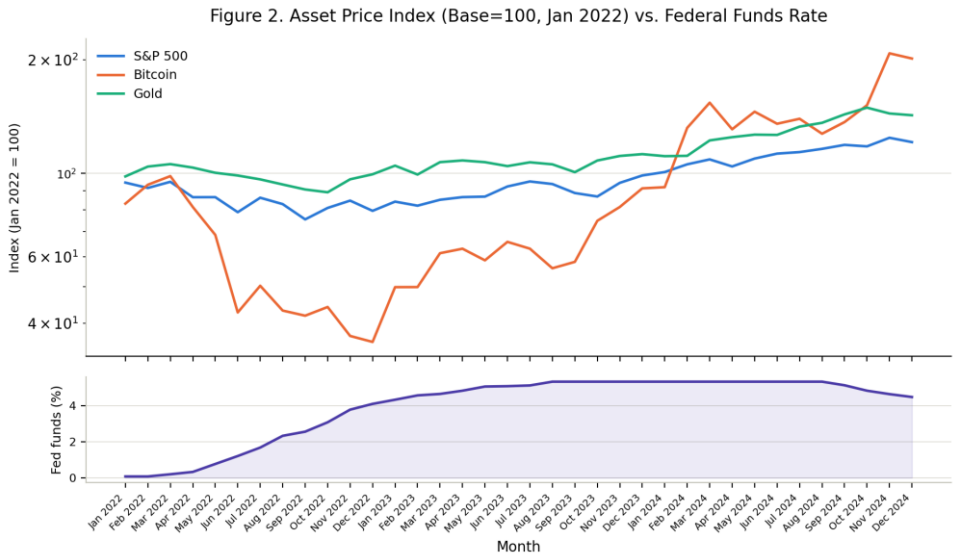

Figure -2

The chart shows three main phases which follow the changes in the Federal Reserve's policy. The first phase was the rate hikes from January 2022 to mid-2023. During this period, the funds rate increased from 0.08% to above 5%. Both the S&P 500 and Bitcoin fell sharply. Bitcoin fell much more, reaching an index value of around 34 in December 2022 from the starting value of 100. This was the lowest value for Bitcoin in the sample. Gold stayed relatively stable during the same period. The second phase was the plateau from mid-2023 to mid-2024. The funds rate remained close to its peak during this period, while Bitcoin recovered strongly. This recovery also took place around the approval of spot Bitcoin ETFs in January 2024. The S&P 500 and Gold increased as well, although their increases were more gradual.

The third phase can be seen from July to October 2024, as the funds rate began to fall. It decreased from 5.20% in July to 4.51% in October. This was only a 0.69 percentage point decrease compared with the much larger increases during the earlier rate hikes. Gold continued to perform strongly during these months, increasing by 5.20% in July, 2.34% in August, 5.30% in September and 4.21% in October. Bitcoin moved in both directions during the same period. It increased by 3.10% in July, fell by 8.75% in August and then increased by 7.39% in September and 10.86% in October. The S&P 500 also fell by 0.91% in October, while Gold increased again. The three assets therefore showed different movements even though they were exposed to the same interest rate environment. This is also seen in the earlier beta and correlation results, particularly in the weaker relationship between Gold and the S&P 500 and the larger changes in Bitcoin's beta.

Overall, there appears to be a clear relationship between the monetary policy cycle and the performance of the three assets during the sample. The largest rate increases occurred during the same period as the major falls in the S&P 500 and Bitcoin. Bitcoin then recovered strongly while the funds rate remained at its peak, before all three assets increased during the early stage of the rate cuts in late 2024. This does not mean that the interest rate changes were the only reason for these movements, but the timing shows that the two were closely related during this period. Bitcoin's large fall during the rate-hiking period can also be linked to the higher returns available from lower-risk assets. As risk-free returns increased, investors had less reason to take on additional risk, which could reduce demand for assets such as Bitcoin. Vanguard (2026) describes a similar effect from supply-side rate shocks, where higher rates put pressure on risk assets more generally. Gold behaved differently during the rate hikes and the plateau, with its price remaining relatively stable. It also performed strongly at the beginning of the rate-cutting period. This is similar to the findings of Kumar, Mohan, and Niveditha (2025), who identify Gold as a relatively stronger safe-haven asset. The higher Sharpe and Sortino ratios for Gold in Section 4.2 also support this pattern. It is also important to consider that the NBER did not announce a recession during the 2022–2024 period, despite the large falls in equity and cryptocurrency prices shown in Figure 2. This supports Vanguard's (2026) view of the 2022 market decline as mainly a supply-side and rate-driven shock rather than a normal cyclical downturn. The analysis so far has focused on how the assets changed over time and how their sensitivity to equities changed during the monetary policy cycle. The next section looks at the direct relationship between the three assets using the correlation results.

4.5 Correlation Analysis

The beta and monetary policy analysis looked at the assets in relation to the wider market and changes in interest rates. Correlation looks at the assets directly and shows how closely their returns moved together. This is useful for the portfolio side of the analysis because two assets can have similar betas against the S&P 500 but still have very different correlations with each other. The correlation between two assets is important when considering whether holding them together could reduce overall portfolio risk. A lower correlation means that their returns tend to move less closely together, which can provide greater diversification.

Table -4

	S&P 500	Bitcoin	Gold
S&P 500	1.000	0.571	0.243
Bitcoin	0.571	1.000	0.299
Gold	0.243	0.299	1.000

Bitcoin has the strongest correlation with the S&P 500 at 0.571. This represents a moderate positive relationship between the two assets. Gold has a much lower correlation with the S&P 500 at 0.243. The correlation between Bitcoin and Gold is also relatively weak at 0.299. This means that Bitcoin and Gold did not generally move together in a strong way during the 2022–2024 period, even though both are sometimes considered alternatives to traditional assets.

The correlation results also support the rolling beta results from Section 4.3. Bitcoin had a higher average beta against the S&P 500 and also had the highest correlation with it. The two measures show that Bitcoin was fairly closely linked to equity movements during the period. Beta shows how much Bitcoin moved when the S&P 500 moved, while correlation shows how closely the two returns moved together. The 0.299 correlation between Bitcoin and Gold gives a different result. Their returns were not strongly related, which does not support the idea that they always behave in the same way as alternative assets. Bhuiyan, Husain, and Zhang (2023) also found that the diversification relationship between Bitcoin and Gold can change during periods of financial stress. For this study, the low correlation means that Bitcoin and Gold could provide different diversification effects within a portfolio rather than simply behaving as two versions of the same asset.

4.6 Interpreting the Findings Through a Behavioural Lens

The results above show how the risk and return of each asset changed during the study period and how these changes occurred alongside the Federal Reserve's policy decisions. However, these results do not explain why investors may have continued to hold or buy Bitcoin despite its high volatility. This is particularly relevant given that Bitcoin's beta changed from above 4 to below zero within a few months. Behavioural finance can help explain this part of the results. It also connects to the monetary policy findings in Section 4.4.

Prospect theory was introduced by Kahneman and Tversky (1979) and later developed further in their 1992 cumulative formulation. The theory states that investors judge gains and losses relative to a reference point rather than only looking at their final outcome. It also suggests that losses have a greater effect on investors than gains of the same size. This is known as loss aversion. A related idea is myopic loss aversion, discussed by Benartzi and Thaler (1995). Their research suggests that investors who check their portfolios more frequently are more affected by short-term losses. This can make them less willing to hold assets with high volatility, even when those assets may have higher expected returns over the long term.

This framework helps explain some of the patterns seen in Section 4.4. Bitcoin's beta increased sharply after the approval of spot Bitcoin ETFs in January 2024 and then changed considerably again between July and October 2024 as the Federal Reserve moved towards rate cuts. One possible explanation is that investors responded to these changes in the interest rate environment by changing their exposure to Bitcoin rather than making gradual portfolio adjustments. This may be particularly relevant for retail investors, who make up a large part of the Bitcoin market. Research applying prospect theory to cryptocurrency markets suggests that retail investors can show stronger loss aversion and greater probability-weighting effects than more experienced institutional investors. Dobrynskaya (2022) applies prospect theory to Bitcoin returns and finds that investors may place too much weight on the small probability of very large gains. This is relevant to the results in this study because Bitcoin had some unusually large positive monthly returns. For example, Bitcoin increased by 43.76% in February 2024 and 37.36% in November 2024. These returns increased the average return and also affected the Sortino ratio reported in Section 4.2. A preference for the possibility of these large gains could help explain why investors may continue to hold Bitcoin despite its much higher volatility.

This also provides a possible explanation for the different behaviour of Bitcoin and Gold during the rate-cut transition. When the funds rate began to fall in September and October 2024, Bitcoin experienced relatively large movements, while Gold continued to rise more steadily. The beta results in Section 4.3 show a similar change in Bitcoin's relationship with the S&P 500 during this period. Gold's more stable movement was different from this pattern. The results therefore show that the two assets responded differently to the same monetary policy environment. Behavioural factors such as loss aversion and probability weighting may help explain why Bitcoin continued to experience larger price movements than Gold, although the data used in this study cannot directly measure investor behaviour.

The findings of Arvanitis, Topaloglou, and Tsomidis (2026), discussed in Section 2, provide another link between investor behaviour and portfolio performance. Their study found that portfolios including cryptocurrency performed better out of sample for loss-averse investors. For more rational investors, a traditional portfolio of stocks, bonds and Gold provided similar benefits. This is relevant to the results of this study because Bitcoin had a much higher Sortino ratio than its Sharpe ratio. Its large changes in beta during the different stages of Federal Reserve policy also show that its behaviour was not stable throughout the sample. These results suggest that the reasons for holding Bitcoin may not be explained by return and risk measures alone. Investor behaviour may also have played a role.

5. CONCLUSION

From January 2022 to December 2024, Bitcoin, Gold and the S&P 500 produced quite different results. Bitcoin recorded the highest average monthly return, but it also had by far the highest volatility. When risk is taken into account, Gold came out slightly higher than Bitcoin. Gold's annualized Sharpe ratio was 0.653, compared with 0.618 for Bitcoin. The gap was larger for the Sortino ratio, with Gold at 1.385 and Bitcoin at 1.109. This shows that Bitcoin's higher return also came with greater variation in its monthly performance. There was also a clear difference in how the assets moved with the S&P 500. Bitcoin's correlation with the S&P 500 was 0.571, more than twice Gold's correlation of 0.243. Bitcoin's beta changed considerably as well. In the six-month period ending in March 2024, the beta was −0.86. Only three months later, it had risen to above 4. This large increase took place after the approval of spot Bitcoin ETFs in January 2024. The beta later fell again as the Federal Reserve moved towards its first rate cut in the final quarter of 2024. Gold did not show the same changes. Its beta stayed around zero for most of the study and only became moderately negative towards the end of 2024. The results therefore point to different behaviour from Bitcoin and Gold during the period studied. Bitcoin offered a much higher return, but it also had greater volatility and a stronger relationship with the S&P 500. Gold had a lower return but had better risk-adjusted results and remained less connected to movements in equities. Bitcoin's beta also changed

substantially during the sample, meaning that its relationship with equities was not constant. These findings are specific to the 36 months examined and may look different during another period with different economic and monetary conditions.

These results also help explain why the studies discussed in the literature review reached different conclusions about Bitcoin. Some studies found that Bitcoin could act as a safe haven, while others found that its relationship with equities was weaker than Gold over shorter periods. The results from this study suggest that these findings do not necessarily contradict each other. Bitcoin's relationship with the S&P 500 changed during the 2022–2024 period, so its behaviour could look different depending on when it was measured. The increase in beta after the January 2024 spot Bitcoin ETF approval was one of the largest changes in the sample and marked an important change in its relationship with equities. For portfolio diversification, the results show a different pattern for Bitcoin and Gold. Bitcoin's higher correlation with the S&P 500 means that it did not provide the same level of separation from equities as Gold during this period. Its large changes in beta also make its diversification effect less consistent over time. At the same time, Bitcoin's higher returns show why investors may still have been interested in holding it despite these risks. The behavioural analysis in Section 4 provides one possible explanation for this. Bitcoin's unusually large positive returns and its reaction to changes in Federal Reserve policy are consistent with the idea that investor behaviour can affect demand for the asset. However, the data used in this study does not show who was buying or selling Bitcoin or why they made those decisions. The behavioural explanation should therefore be treated as a possible interpretation of the results rather than as something directly proven by the study.

There are four main limitations to consider when looking at these results. First, the study uses only 36 monthly observations. This is a relatively short period compared with many studies in finance. However, the period was chosen deliberately because it covers the rapid changes in U.S. monetary policy between 2022 and 2024. This means the results are useful for understanding this particular period, but they may not apply in the same way during more stable market conditions. Second, the rolling beta analysis does not cover the first five months of the sample. A six-month period is needed to calculate the first beta, so the rolling results begin in June 2022. The early part of the 2022 rate-hiking cycle is therefore only included in the descriptive statistics and correlation analysis. The beta analysis cannot show whether Bitcoin or Gold had a different relationship with the S&P 500 during these first few months. Third, the methods used in this study show relationships between the variables but do not prove that one caused another. For example, the increase in Bitcoin's beta after the January 2024 ETF approval occurred around the same time as the approval, but the analysis cannot show that the ETF approval itself caused the change. The same applies to the relationship between changes in interest rates and asset prices. Other factors could also have affected these movements. Finally, the analysis is limited to the three assets and the risk-free benchmark used in the study. It does not include some of the more advanced methods used in the literature, such as GARCH models, wavelet coherence analysis or short event studies. These methods could provide more information about changes in volatility and the immediate response to specific policy announcements. The monthly approach used in this study is not designed to capture these short-term effects in the same level of detail. Future research could extend the sample beyond December 2024. This would make it possible to see whether Bitcoin's higher sensitivity to the equity market continued after the ETF approval or whether the relationship changed again as institutional participation in Bitcoin developed.

6. APPENDIX

6.1 Appendix A: Full Monthly Return Data (January 2022–December 2024)

Table -A1: S&P 500, Bitcoin, and Gold Monthly Returns

Month	S&P 500	Bitcoin	Gold
Jan 2022	-5.50%	-16.90%	-1.84%
Feb 2022	-3.22%	12.24%	6.19%
Mar 2022	3.83%	5.43%	1.52%
Apr 2022	-8.99%	-17.21%	-2.12%
May 2022	0.04%	-15.70%	-3.11%
Jun 2022	-8.78%	-37.77%	-1.66%
Jul 2022	9.24%	17.74%	-2.33%
Aug 2022	-3.83%	-14.08%	-3.08%

Sep 2022	-8.92%	-3.09%	-3.01%
Oct 2022	7.26%	5.48%	-1.70%
Nov 2022	4.57%	-16.23%	8.27%
Dec 2022	-6.06%	-3.61%	3.11%
Jan 2023	5.80%	39.83%	5.42%
Feb 2023	-2.45%	0.04%	-5.29%
Mar 2023	3.68%	23.01%	7.88%
Apr 2023	1.64%	2.79%	1.04%
May 2023	0.31%	-6.87%	-1.04%
Jun 2023	6.39%	11.97%	-2.39%
Jul 2023	3.11%	-4.08%	2.36%
Aug 2023	-1.55%	-11.29%	-1.23%
Sep 2023	-5.35%	3.99%	-4.68%
Oct 2023	-2.12%	28.55%	7.37%
Nov 2023	8.72%	8.82%	2.84%
Dec 2023	4.61%	12.06%	1.12%
Jan 2024	2.12%	0.72%	-1.23%
Feb 2024	4.84%	43.76%	0.21%
Mar 2024	3.06%	16.62%	9.87%
Apr 2024	-4.23%	-15.00%	2.01%
May 2024	4.94%	11.35%	1.56%

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Jun 2024	3.08%	-7.11%	-0.16%
Jul 2024	0.94%	3.10%	5.20%
Aug 2024	2.00%	-8.75%	2.34%
Sep 2024	2.46%	7.39%	5.30%
Oct 2024	-0.91%	10.86%	4.21%
Nov 2024	5.40%	37.36%	-3.50%
Dec 2024	-2.62%	-3.14%	-1.08%

Table -A2: 3-Month Treasury Bill Monthly Annualized Yield and Federal Funds Effective Rate

Month	**TB3MS (%)**	**FEDFUNDS (%)**
Jan 2022	0.15	0.08
Feb 2022	0.33	0.08
Mar 2022	0.44	0.20
Apr 2022	0.76	0.33
May 2022	0.98	0.77
Jun 2022	1.49	1.21
Jul 2022	2.23	1.68
Aug 2022	2.63	2.33
Sep 2022	3.13	2.56
Oct 2022	3.72	3.08
Nov 2022	4.15	3.78
Dec 2022	4.25	4.10

Jan 2023	4.54	4.33
Feb 2023	4.65	4.57
Mar 2023	4.69	4.65
Apr 2023	4.92	4.83
May 2023	5.14	5.06
Jun 2023	5.16	5.08
Jul 2023	5.25	5.12
Aug 2023	5.30	5.33
Sep 2023	5.32	5.33
Oct 2023	5.34	5.33
Nov 2023	5.27	5.33
Dec 2023	5.24	5.33
Jan 2024	5.22	5.33
Feb 2024	5.24	5.33
Mar 2024	5.24	5.33
Apr 2024	5.24	5.33
May 2024	5.25	5.33
Jun 2024	5.24	5.33
Jul 2024	5.20	5.20
Aug 2024	5.05	5.05
Sep 2024	4.72	4.72

Oct 2024	4.51	4.51
Nov 2024	4.42	4.64
Dec 2024	4.27	4.48

6.2 Appendix B: Risk-Free Rate Derivation

The 3-Month Treasury Bill monthly risk-free rate used throughout Sections 4.2 through 4.6 was derived from Table A2 using the two-step conversion described in Section 3.3: the annualized discount rate was first converted to an annualized investment yield using the Treasury's bond-equivalent yield formula, then compounded down to a monthly rate. The resulting monthly risk-free rate series had a sample mean of 0.335 percent, used consistently as Rf in all Sharpe and Sortino ratio calculations.

6.3 Appendix C: Full 6-Month Rolling Beta Series

Table -C1: Rolling Beta, Bitcoin and Gold vs. S&P 500 (June 2022–December 2024)

Month	**Bitcoin Beta**	**Gold Beta**
Jun 2022	2.318	0.201
Jul 2022	2.267	-0.016
Aug 2022	2.445	0.055
Sep 2022	1.841	-0.014
Oct 2022	1.889	0.022
Nov 2022	1.632	0.172
Dec 2022	0.824	0.080
Jan 2023	1.268	0.330
Feb 2023	1.068	0.338
Mar 2023	1.465	0.310
Apr 2023	2.031	0.664
May 2023	3.430	0.554
Jun 2023	3.713	0.786
Jul 2023	2.043	0.652

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Aug 2023	3.462	0.243
Sep 2023	0.804	0.308
Oct 2023	-0.066	0.035
Nov 2023	0.123	0.146
Dec 2023	0.063	0.292
Jan 2024	0.182	0.262
Feb 2024	0.418	0.196
Mar 2024	-0.859	-0.446
Apr 2024	2.695	0.031
May 2024	4.246	-0.027
Jun 2024	4.294	-0.016
Jul 2024	4.284	-0.077
Aug 2024	2.668	0.090
Sep 2024	2.365	-0.073
Oct 2024	-0.370	-0.638
Nov 2024	3.617	-1.321
Dec 2024	3.770	-0.318

6.4 Appendix D: Indexed Asset Price Series (Base = 100, January 2022)

Computed by compounding each month's return in Table A1 onto the prior month's indexed value, as described in Section 3.4. Used to construct Figure 2.

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