Can Bitcoin be used as an inflation hedge like Gold?

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Abstract

This project investigates whether Bitcoin can serve as an inflation hedge similar to gold by analyzing price behavior, volatility, trading activity, and portfolio impact during market crises. Using historical data from 2013 to early 2025, we applied descriptive analytics, clustering, association rule mining, and time series modeling to compare the two assets under various market conditions.

Statement of the Research Questions & Hypotheses

This study discusses whether Bitcoin performs similar risk hedging properties as gold, and further research on its potential for market capital flows and portfolio optimization. To achieve this, we formulate the following three research questions and their corresponding hypotheses. We begin by studying Bitcoin's hedging function during market crises. Historically, gold has been viewed as a hedging asset in times of financial market volatility, and its price tends to rise during crises with low volatility. In contrast, the market performance of Bitcoin, an emerging asset, remains controversial.

Therefore, we address Research Question 1 (RQ1): Does Bitcoin perform similar hedging asset characteristics as gold during market crises? In order to test this, we propose the following hypotheses, H0(Null Hypothesis): Bitcoin does not exhibit similar safe-haven characteristics to gold during market crises, meaning its price does not increase consistently, or its volatility is not significantly different from that of gold. HA(Alternative Hypothesis): Both gold and Bitcoin exhibit an upward price trend during market crises, but Bitcoin’s volatility is significantly higher than gold’s, indicating greater market instability. Furthermore, we hypothesize that the classification of market conditions for Bitcoin and gold can be identified using clustering analysis, H0: K-Means clustering fails to differentiate Bitcoin and gold’s market states during crises, or Bitcoin does not fall into the same hedging asset category as gold. *H*A: K-Means clustering successfully classifies Bitcoin and gold into distinct market states during crises, allowing us to assess whether Bitcoin aligns with gold as a hedging asset.
Next, we analyze the pattern of capital flows between Bitcoin and gold during market crises. Market hedging assets are not only reflected in price increases, but also involve the stability of capital inflows. While gold's market capitalization and trading volume usually rise during crises, indicating that investors seek safe assets, it is still unknown whether Bitcoin will be able to exhibit similar capital flow characteristics.

Therefore, we address Research Question 2 (RQ2): Do the market capitalization and trading volumes of Bitcoin and gold exhibit different capital flow characteristics during market crises?

We define the following hypotheses, H0: Bitcoin and gold exhibit no significant differences in market capitalization and trading volume behavior during market crises. *H*A: Gold's market capitalization and trading volume remain relatively stable and increase during crises, whereas Bitcoin's market capitalization and trading volume exhibit greater volatility, reflecting stronger speculative behavior. Additionally, we investigate whether Bitcoin and gold's trading patterns differ during crises using association rule analysis. H0: Bitcoin and gold follow similar trading patterns during market crises, indicating no fundamental difference in their role as assets. HA: Association rule analysis reveals significant differences in Bitcoin and gold's trading behavior during crises, with Bitcoin exhibiting greater short-term volatility and speculative activity compared to gold.

Finally, we discuss the hedging role of Bitcoin and gold in portfolios. If Bitcoin has similar hedging properties as gold, then including it in a portfolio may improve the hedging effect. Therefore, we address Research Question 3 (RQ3): Do Bitcoin and gold provide the best hedging strategy in a portfolio? We define the following hypotheses, H0: A portfolio containing Bitcoin and gold does not provide superior risk-adjusted returns compared to a portfolio with only gold or other traditional assets during market crises. HA: A portfolio containing Bitcoin and gold offers enhanced risk-adjusted returns during market crises, and time series analysis, such as ARIMA models, can optimize hedging strategies.

Data and its Suitability

We use two financial time series datasets:
- Bitcoin (BTC): Includes daily price, market capitalization, and trading volume (sourced from btc-usd-max.csv).
- Gold: Daily gold prices extracted from a historical dataset (Prices.xlsx), manually processed and exported as CSV.
These assets are chosen because Bitcoin is widely considered a digital alternative to gold, often referred to as "digital gold". Comparing their trends, returns, and volatilities provides insight into their financial behavior and risk properties.

We began by reading the daily price data for Bitcoin and gold, ensuring consistent date formatting and aligning both datasets from December 27, 2013, onward. We renamed the columns for clarity (e.g., btc_price, gold_price) and merged the datasets based on matching dates. To facilitate further analysis, we calculated daily returns using price differences and computed 30-day rolling volatility to capture recent price fluctuations. Finally, we visualized the time series of prices, returns, and volatility, which helps illustrate the market dynamics of Bitcoin and gold over time.

Justification of Data Suitability

- Financial Relevance: Bitcoin and gold are representative digital and traditional assets.
- Data Completeness: Daily data with minimal missing values.
- Analytical Potential: Suitable for return modeling and co-movement analysis.

Analytical Techniques

Clustering Analysis

In order to deepen the analysis of the behavioral differences between Bitcoin and gold under the varying market conditions, we trained the K-Means algorithm to create asset type classifiers that characterize asset behavior with three features: daily returns, rolling volatility, and trading volume percentage change. We determined whether these two assets had a similar or divergent dynamic, especially concerning crisis events, such as the COVID outbreak and the inflation shocks in 2022 and 2023.

We performed agglomerative clustering under two scenarios, with K set to 2 and 3. In order to simplify the data presentation and interpretation, PCA (Principal Component Analysis) was employed to compress the feature space and integrate the clustering results on a two-dimensional plane.

The data showed this distinction, which was made between Bitcoin and gold, clearly. When K was chosen as both 2 and 3, gold continued to form clusters with lower volatility and higher stability, which fit with the traditional characterization of gold as a safe-haven asset. The case with Bitcoin was the opposite. It was mostly found in high-volatility clusters, especially during the periods of crisis, giving it an asset analogy of speculative or high-risk investments.

This is visually backed up by the time series graphs in the case of Bitcoin prices, which saw steep falls and sharp recoveries, while gold trended steadily and upwards. Nevertheless, Bitcoin's behavior under stress was less consistent and stable compared to gold, which showed these inconsistencies. This clustering thus confirmed the findings of the other sections, with Bitcoin behaving in a more unstable manner, while gold was offering more stability and consistency.

These implications indicate that, in spite of some surface similarities among Bitcoin and gold, their market behavior in real time was extremely different. The clustering analysis adds the quantitative aspect to the finding that Bitcoin does not yet possess the traits that make it a safe haven like gold.

Association Rule Mining

In addition, to evaluate whether Bitcoin and gold serve as safe-haven assets during financial crises, we selected association rule mining using the Apriori algorithm as one of our analytical techniques. This method is well suited to uncovering hidden co-occurrence patterns among categorical variables, especially in settings where multiple financial indicators interact in

complex, non-linear ways. Unlike traditional time series or regression models, Apriori is non-parametric and exploratory, enabling the discovery of "if-then" rules without assuming linearity or fixed dependent variables.

This method also directly supports our three research questions. For RQ1, which asks whether Bitcoin or gold behaves like a safe-haven asset during crises, Apriori reveals if their stability (e.g., gold_Stable) frequently co-occurs with market calm (e.g., LowVolatility), as captured by high-confidence, high-lift rules. For RQ2, which compares market behavior across crisis and non-crisis periods, Apriori enables a structural comparison of rule frequency and strength between regimes. For RQ3, which investigates whether specific combinations of asset behaviors predict volatility, Apriori efficiently captures multi-variable antecedents (e.g., btc_Up + HighVolume) and their association with outcomes like HighVolatility.

We transformed continuous variables into interpretable bins (e.g., btc_Up, gold_Down, HighVolume) to match Apriori's requirement for categorical, basket-form data. This preprocessing made it possible to extract interpretable behavioral rules and allowed us to analyze the dynamics of asset relationships over time in a visually and statistically tractable way. Eventually, Apriori offered a clear framework to examine whether and when Bitcoin or gold function as volatility buffers, so that it fits with our hypothesis-driven analysis of safe-haven behavior.

Results: In the crisis period, March to June 2020, most association rules pointed strongly toward HighVolatility as a common consequence, regardless of whether Bitcoin or gold trended up, down, or remained stable. For example, the rule {gold_Stable} => {HighVolatility} had a confidence of 1.0 and lift ≈ 1.0, suggesting frequent but uninformative co-occurrence, as shown in the figure. This indicates that both assets were moving with, rather than buffering against, systemic risk during crisis windows, so that these results directly contradict the traditional expectation that gold functions as a stabilizing asset during financial stress.

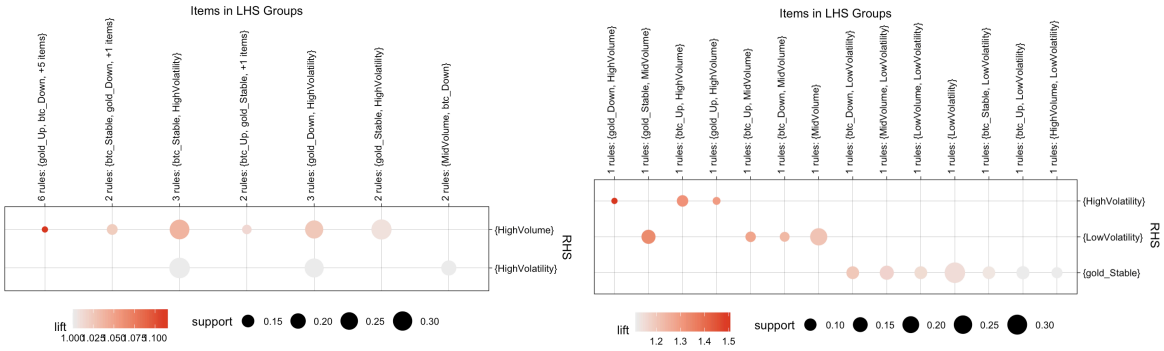
	lhs <chr>		rhs <chr>	support <dbl>	confidence <dbl>	coverage <dbl>	lift <dbl>	count <int>
[1]	{MidVolume}	=>	{HighVolatility}	0.10344828	1	0.10344828	1	9
[2]	{btc_Down}	=>	{HighVolatility}	0.27586207	1	0.27586207	1	24
[3]	{gold_Down}	=>	{HighVolatility}	0.28735632	1	0.28735632	1	25
[4]	{btc_Stable}	=>	{HighVolatility}	0.33333333	1	0.33333333	1	29
[5]	{gold_Stable}	=>	{HighVolatility}	0.35632184	1	0.35632184	1	31
[6]	{gold_Up}	=>	{HighVolatility}	0.35632184	1	0.35632184	1	31
[7]	{btc_Up}	=>	{HighVolatility}	0.39080460	1	0.39080460	1	34
[8]	{HighVolume}	=>	{HighVolatility}	0.89655172	1	0.89655172	1	78
[9]	{btc_Down, gold_Down}	=>	{HighVolatility}	0.05747126	1	0.05747126	1	5
[10]	{btc_Down, gold_Stable}	=>	{HighVolatility}	0.11494253	1	0.11494253	1	10

In contrast, non-crisis periods revealed a different rule structure, with several high-confidence, high-lift rules pointing to LowVolatility. For example, {gold_Stable, MidVolume} and {btc_Up, MidVolume} => {LowVolatility} showed lifts around or above 1.28, suggesting these conditions signaled market calm, as shown in the figure. This indicates that while Bitcoin and gold can act

as safe-haven assets, this effect is largely limited to non-crisis periods, directly addressing RQ1. The clear shift in rule patterns between crisis and non-crisis periods supports RQ2, showing that asset-volatility relationships depend on market regimes. Additionally, rules with multi-variable triggers, such as {btc_Up, MidVolume}, address RQ3 by showing how specific asset combinations can help predict volatility.

	lhs <chr>		rhs <chr>	support <dbl>	confidence <dbl>	coverage <dbl>	lift <dbl>	count <int>
[1]	{MidVolume}	=>	{LowVolatility}	0.20862801	0.6190976	0.33698727	1.213311	590
[2]	{gold_Down, HighVolume}	=>	{HighVolatility}	0.05056577	0.7222222	0.07001414	1.506227	143
[3]	{gold_Up, HighVolume}	=>	{HighVolatility}	0.05410184	0.6219512	0.08698727	1.297108	153
[4]	{btc_Down, MidVolume}	=>	{LowVolatility}	0.06753890	0.6303630	0.10714286	1.235389	191
[5]	{btc_Down, LowVolatility}	=>	{gold_Stable}	0.10572843	0.6528384	0.16195191	1.203538	299
[6]	{btc_Up, HighVolume}	=>	{HighVolatility}	0.08663366	0.6330749	0.13684583	1.320307	245
[7]	{btc_Up, MidVolume}	=>	{LowVolatility}	0.07390382	0.6551724	0.11280057	1.284011	209
[8]	{gold_Stable, MidVolume}	=>	{LowVolatility}	0.13224894	0.6824818	0.19377652	1.337532	374

Both figures clearly show how the rule patterns differ between crisis and non-crisis periods. In the crisis period, most rules are linked to HighVolatility, with low lift values—meaning the asset movements were common but not very informative. This suggests that during crises, the market behaved more chaotically, and neither Bitcoin nor gold provided clear signals. In contrast, the non-crisis period reveals stronger and more focused rules pointing to LowVolatility, especially when assets like gold stayed stable or Bitcoin moved up under moderate volume. These clearer patterns help explain when and how these assets may act as safe havens.



During crises, 60 rules were generated but none were strong, and common triggers like btc_Stable or gold_Stable offered little predictive value. In contrast, the non-crisis period produced only 14 rules, but 8 were strong and often pointed to LowVolatility. This suggests asset behavior is easier to interpret and market volatility more predictable during stable periods.

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Number of rules generated during crisis period:  60
Number of rules generated during non-crisis period:  14
Number of strong rules during crisis period:  0
Number of strong rules during non-crisis period:  8
Top LHS items in crisis-period rules:

    btc_Stable         btc_Up    gold_Stable        gold_Up HighVolatility
            16             16             16             16             15

Top LHS items in non-crisis-period rules:

LowVolatility     MidVolume    HighVolume        btc_Up      btc_Down
            7             5             4             3             2

   gold_Stable  LowVolatility HighVolatility
             7             4              3
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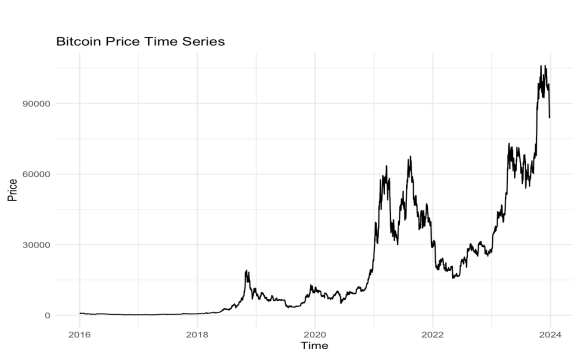
Time Series

In this section, we further explore whether Bitcoin can serve as an effective inflation hedge like gold. Since asset prices are constantly changing over time and their movements and volatility are clearly time-dependent, we choose to use time series analysis. This approach not only reveals the dynamic trend of prices over time, but also helps us to identify whether they are stable over time, predictable, and resilient to external shocks.

Since Bitcoin did not perform well during the crisis time in the previous two parts of the analysis, we determine whether the price series of Bitcoin and gold is a smooth series by using ADF and KPSS. The smoothness of the prices is a key prerequisite for evaluating whether it can be used as a “store of value” or not. It is also very important for the next step of ARIMA modeling, which has strict requirements on the smoothness of the input data. Because the original series is not smooth, we transform it into a smooth series by logarithmic transformation and difference operation, so that it can meet the modeling premise of ARIMA model.

In the results section of our analysis, we first compare the price time series of Bitcoin and Gold from 2016 to present. The visualization shows that the price of gold has moved steadily and slowly upwards, while the price of Bitcoin has shown dramatic fluctuations and lacks a clear long-term trend.



To test the stationarity of Bitcoin's price series during the crisis period (March–June 2020), we applied both the ADF test and the KPSS test. The two tests gave contradictory results on the original series: the ADF test suggested stationarity, while the KPSS test indicated non-stationarity. Due to this inconsistency, we treated the series by applying a logarithmic transformation followed by first-order differencing. After this processing, both tests agreed that the transformed series was stationary. Therefore, we proceeded with ARIMA modeling based on the stationary log-differenced series.

For ARIMA model fitting, Bitcoin's price series was best modeled with an ARIMA(0,1,0) structure. While the residuals showed no significant autocorrelation—indicating the model was statistically sound—the model's error remained high. This reflects Bitcoin's inherent price volatility and low predictability. On the other hand, gold followed a similar ARIMA(0,1,0) model but included a drift term. Its significantly lower error rates and better fit suggest that gold prices are more stable and more accurately predictable using this model.

Conclusion

Module	Method	Key Findings	Recommendation
Descriptive Analysis	Descriptive stats & time series plots	Bitcoin shows high volatility and non-normal return distribution; gold is more stable.	Investors should be cautious of Bitcoin's volatility.
Clustering Analysis	K-Means clustering, PCA visualization	Bitcoin and gold behave differently under crisis conditions; clusters are clearly separated.	Bitcoin does not yet match gold's safe-haven role during crises.
Association Rule Mining	arules package, volume & market	Bitcoin trading patterns are more speculative; gold	Gold is more suitable for defensive

	cap tests	shows more consistent rules.	positioning.
Time Series & Portfolio	ARIMA forecasting	Gold portfolios show lower risk and more stable forecasts; mixed portfolios have higher return but higher volatility.	Prioritize gold for risk-averse portfolios during crises; use Bitcoin sparingly.

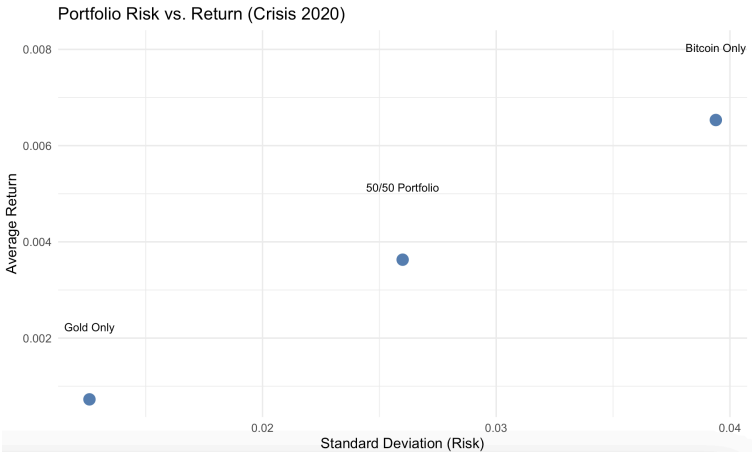
Our study sought to find out if Bitcoin, a fixed-supply decentralized digital asset, is an efficient hedge against inflation, similar to gold, which has been referred to as a traditional safe-haven asset over decades. Using a combination of statistical tests, clustering analysis, association rule mining, and time series forecasting on data from 2013 to 2025, we assessed the performance of Bitcoin and gold during crisis periods such as the COVID-19 crash (2020) and the 2022–2023 inflationary shocks.

Our findings suggest that while Bitcoin does exhibit some features of a hedging instrument, such as high returns in some market shocks, it also has high volatility and speculation that distinguish it radically from gold. Specifically, during the 2020 crisis, the average return of Bitcoin was higher than that of gold but with much greater volatility and volatile trading volume. Gold, however, had a consistent price trend with lower volatility and more predictable market behavior.

Clustering analysis also assists in solidifying such differentiation. During clustering of asset behavior across returns, volatilities, and volumes, Bitcoin and gold never clustered together, especially under the scenario of distress in markets. Such splitting affirms the phenomenon that both assets respond differently to external shock. Price behavior in Bitcoin is apparently driven by sentiment in markets and speculative trades rather than macroeconomic factors—somewhat differentiated from gold, whose price goes up under the influence of inflation and uncertainty in the economy.

In our rule mining study of the trading behavior of Bitcoin, its patterns revealed strong but non-repeatable behavioral rules in its data with high lift but low support. This is contrary to that of gold, which was more stable and repetitive in trading patterns. The variance also emphasizes that Bitcoin is behaving more as a high-risk, high-reward asset instead of a store of value.

The portfolio analysis was also informative. A portfolio made up entirely of Bitcoin yielded the highest average return but also highest risk, quantified by standard deviation. Portfolios made up entirely of gold gave the worst returns but also lowest volatility. Of particular interest is that a 50/50 Bitcoin-gold portfolio resulted in a compromise, yielding more returns than pure gold but minimizing the volatility over an all-Bitcoin investment. This reflects the virtues of diversification but also presents the trade-off that investors must consider when adding Bitcoin to an inflation-hedging approach.



In conclusion, our research shows that Bitcoin is not yet playing the role of a reliable core inflation hedge such as gold. While it may have a niche for growth or speculative portfolios, its volatility, regulatory status, and behavioral uncertainty make it unsuitable as a core defense. Gold remains the safer haven for those looking for protection from inflation and economic recession.

We recommend that institutional and individual investors treat Bitcoin as a speculative complement, not a substitute, for traditional hedging assets like gold. Bitcoin can be used tactically to enhance portfolio returns during favorable market cycles, but its inclusion should be limited and accompanied by robust risk controls. For risk-averse or long-term portfolios, gold should remain the primary asset for inflation protection.

Policymakers and financial analysts should continue to monitor Bitcoin's evolving role in financial markets, but with cautious skepticism. Its current market behavior does not yet support positioning it as a reliable tool for safeguarding wealth during macroeconomic disruptions. Future developments in regulation, adoption, and market maturity may change this, but for now, our analysis concludes that Bitcoin cannot be treated as "digital gold" in the context of inflation hedging.

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