Research Article

Comparative Volatility Analysis of Gold and Bitcoin as Conventional and Digital Assets (2020–2025)

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Abstract: This study examines the comparative volatility of gold and Bitcoin over the period January 2020 to August 2025, using monthly data and employing descriptive statistics, the Augmented Dickey-Fuller (ADF) test, GARCH (1,1), and the Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model estimated with EViews 13. The results show that Bitcoin is characterized by extreme and persistent volatility, reflecting its speculative nature, whereas gold remains stable and functions as a conventional safe-haven asset. Correlation analysis indicates that the relationship between gold and Bitcoin is generally weak but dynamic, as the strength and direction of their co-movements change across different market conditions. These findings highlight the potential role of gold as a hedge and Bitcoin as a speculative diversifier, offering insights for portfolio diversification and risk management. These results also suggest that investors should carefully consider their risk tolerance and investment horizon when allocating assets between traditional and digital commodities.

Keywords: Bitcoin; Gold; Portfolio Diversification; Return; Safe Haven

1. Introduction

The global financial landscape in recent years has been shaped by increasing uncertainty, marked by the COVID-19 pandemic, geopolitical tensions, and inflationary pressures. In this context, the role of safe haven assets has become increasingly relevant. Gold has long been recognized as a stable investment capable of preserving value during periods of market turmoil (Baur & McDermott, 2010; Bouri et al., 2020). The defensive nature of gold makes it an attractive choice for risk-averse investors. Conversely, Bitcoin, as the largest cryptocurrency by market capitalization, has gained widespread attention due to its decentralized nature, high liquidity, and extreme volatility.

Figure 1. Gold and Bitcoin Prices from 2020 to 2025

Numerous studies indicate gold continues to act as a reliable safe-haven asset, while Bitcoin remains contested due to its elevated volatility and speculative characteristics (e.g., Urs et al., 2023; Zhang & Li, 2024).

Several studies have examined gold and Bitcoin from the perspective of hedging and portfolio diversification. Baur and McDermott (2010) and Bouri et al. (2020) reaffirm the role of gold as a stable asset during times of crisis. Conversely, studies by Akhtaruzzaman et al. (2020) and Guesmi et al. (2019) suggest that Bitcoin has the potential to serve as a diversifier, although its speculative nature limits its safe haven role (Chemkha et al., 2021; Bouri et al., 2020).
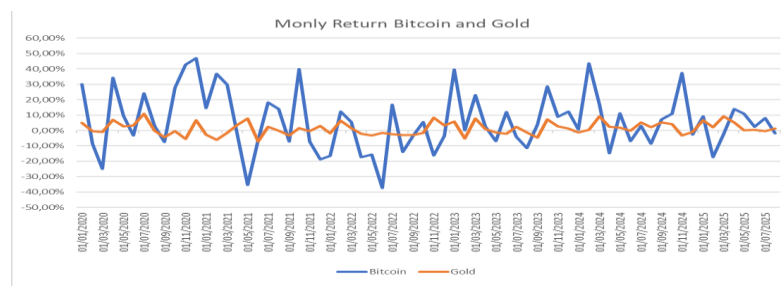
Figure 2. Percentage Returns of Gold and Bitcoin from January 2020 to August 2025.
Source: Investing.com

On the other hand, gold returns are relatively stable with minor fluctuations, generally ranging between –10% and 10%. This strongly reinforces the role of gold as a traditional stable asset, whereas Bitcoin reflects the characteristics of a speculative asset with the potential for high returns, albeit accompanied by significant risk (Gutama, 2025).

However, most prior studies rely on limited data periods or focus on specific crisis episodes. Few have comprehensively compared gold and Bitcoin over an extended period that includes the post-pandemic era and recent geopolitical conditions. Moreover, advanced methodological approaches such as DCC-GARCH remain rarely applied to measure the dynamic correlation between the two assets. Furthermore, much of the existing literature examines gold and Bitcoin's functions as safe haven assets or diversifiers only partially, without investigating how their relationship evolves over the long term across crisis, recovery, and normal phases. This study addresses that gap by providing a dynamic perspective on the evolution of their volatility and dependence between 2020 and 2025 (Rusmita, Filianti, Mayasani, & Samad, 2024).

This research aims to analyze and compare the returns, volatility, and dynamic correlations of gold and Bitcoin over a longer observation period, namely from January 2020 to August 2025. The Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model is employed to capture the volatility characteristics and dynamic interdependence between the two assets (Engle, 2002; Akhtaruzzaman et al., 2021; Widjaja et al., 2024; Bahloul et al., 2023).

The contribution of this study lies in providing a deeper understanding of the distinct characteristics of gold and Bitcoin as investment assets, particularly within the context of global uncertainty. The findings are expected to assist investors, portfolio managers, and policymakers in formulating more optimal diversification and risk management strategies.

2. Literature Review
Return and Volatility Theory
Modern Portfolio Theory (MPT), developed by Markowitz (1952), serves as a fundamental framework in investment management. This theory emphasizes the importance of diversification in balancing expected returns and risks. Investment risk is generally measured through volatility, which is often represented by the variance of asset returns. As financial data exhibits the phenomenon of volatility clustering, ARCH and GARCH models have been developed to capture the time-varying nature of volatility (Engle, 2002; Akhtaruzzaman et al., 2021). Thus, this theory provides a foundational basis for analyzing risk and returning across various investment instruments, including stocks, gold, and digital assets such as Bitcoin.

Safe Haven and Hedging Concepts
A safe haven asset is defined as an instrument that can preserve or increase its value when markets are under stress (Baur & McDermott, 2010). Gold has long been recognized as a safe haven, with strong empirical evidence of its role in protecting investor wealth during market crises (Bouri et al., 2020; Chemkha et al., 2021). On the other hand, several studies have examined the role of digital assets such as Bitcoin as a potential safe haven, although the findings remain mixed and inconsistent (Akhtaruzzaman et al., 2021; Widjaja et al., 2024). The concept of hedging is closely related to that of a safe haven, as both are employed to minimize portfolio risk and volatility.

Bitcoin vs. Gold

Bitcoin, as a digital asset, is characterized by its speculative nature due to extreme volatility and relatively short historical track record. Some studies suggest that Bitcoin exhibits behavior like that of commodities or currencies (Akhtaruzzaman et al., 2020; Guesmi et al., 2019), while other evidence highlights uncertainties regarding its role as a safe haven (Akhtaruzzaman et al., 2021; Widjaja et al., 2024). In contrast, gold consistently demonstrates greater stability, particularly during times of market distress. These differing characteristics make the comparison between Bitcoin and gold particularly relevant, especially in the context of portfolio diversification and risk protection.

DCC-GARCH Method

The Dynamic Conditional Correlation–Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model, introduced by Engle (2002), allows for the analysis of time-varying correlations among assets. This model has been widely applied in financial literature due to its flexibility in capturing changing interdependencies, particularly under conditions of non-constant volatility. Previous studies have confirmed the effectiveness of the DCC-GARCH model in identifying dynamic correlations between gold, Bitcoin, and other financial assets (Akhtaruzzaman et al., 2021; Widjaja et al., 2024; Bahloul et al., 2023).

3. Research Method

Research Type and Approach

This study adopts a quantitative research design with an explanatory method. This approach is employed to explain the relationship between the volatility and correlation of Bitcoin and gold through empirical testing of time-series data. The model applied is the Dynamic Conditional Correlation-Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH), which can capture heteroskedastic behavior and the dynamic correlation between financial assets.

Data and Data Sources

The data consists of daily prices of Bitcoin (BTC/USD) and gold (XAU/USD) over the period from January 2020 to August 2025, obtained from Investing.com. Daily prices are transformed into logarithmic returns using the following equation:

$$R_t = \ln\ (P_t\ /\ P_{t-1}) \tag{1}$$

Where R_t represents the daily return at time t, P_t denotes the closing price at time t, and $P_{t-1}1$ is the closing price in the previous period. This transformation is employed to obtain data that are stationary in the mean and more suitable for volatility analysis.

Analytical Technique

The analysis was conducted in several stages. First, descriptive statistics were employed to illustrate the characteristics of the returns for each asset. Second, a stationarity test was carried out using the Augmented Dickey-Fuller (ADF) to ensure that the return series were stationary. Third, the ARCH-LM test was performed to identify the presence of ARCH effects. Subsequently, the volatility of each asset was estimated using the univariate GARCH (1,1) model. Once the assumptions were satisfied, the dynamic correlation between Bitcoin and gold was estimated using the DCC-GARCH model. All data processing and estimations were conducted using the EViews 13 software.

4. Results and Discussion

Based on the estimation results using the DCC-GARCH model, the volatility of gold and Bitcoin exhibited distinct patterns throughout the 2020–2025 period. Bitcoin displayed higher volatility with sharp fluctuations, whereas gold demonstrated a more stable level of volatility. These findings underscore the fundamental differences between digital and conventional assets, in which Bitcoin is more strongly influenced by speculative factors and global market sentiment, while gold consistently functions as a safe haven asset.

The return analysis further reveals that Bitcoin offers greater return opportunities but with substantially higher risk, whereas gold provides more stable returns with relatively smaller fluctuations. This condition reinforces the understanding that Bitcoin can be positioned as a high-risk asset, while gold remains relevant as a hedging instrument and a stabilizer in diversified portfolios.

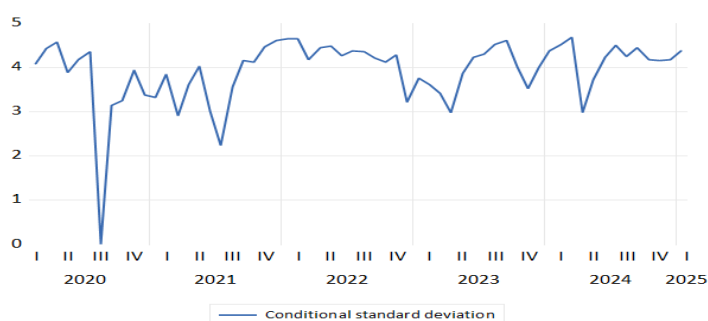**Descriptive Statistics of Bitcoin and Gold Returns**
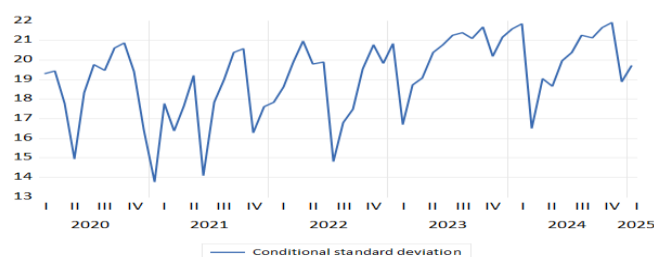
Figure 3. Volatility of Bitcoin Returns Based on Conditional Standard Deviation.
Source: Processed Data, 2025

Furthermore, the estimation of the DCC-GARCH model indicates that the dynamic correlation between gold and Bitcoin is not constant but rather varies according to global market conditions. In early 2020, when the COVID-19 pandemic triggered turmoil in financial markets, the correlation between the two assets was low and even negative, reaffirming the role of gold as a safe haven. The period from 2021 to mid-2022 exhibited a moderate correlation, reflecting similar responses to global monetary policies, particularly the U.S. Federal Reserve's interest rate adjustments. However, during 2023–2024, the correlation weakened again and turned negative in several quarters, suggesting greater potential for portfolio diversification. These findings strengthen the evidence of gold's role as a hedge asset, while Bitcoin serves as a high-risk diversification instrument with significant return potential.

As shown in Figure 2, Bitcoin's volatility, measured through the conditional standard deviation (CSD), displayed sharp fluctuations throughout the observation period. Significant spikes occurred in Q3–Q4 2020, Q2 2021, Q1 2022, Q2–Q4 2023, and Q4 2024. The peak CSD values exceeded 0.21, reflecting heightened risk and market uncertainty during these periods. This pattern indicates the phenomenon of volatility clustering, in which high-volatility periods tend to be followed by subsequent high-volatility episodes. Contributing factors include cryptocurrency market sentiment, regulatory changes, and global macroeconomic conditions. Although periods of declining volatility were observed, Bitcoin's volatility consistently remained higher than that of conventional assets such as gold, confirming its nature as a speculative asset with elevated risk levels.

Figure 4. Volatility of Bitcoin Returns Based on Conditional Standard Deviation.
Source: Processed Data, 2025

The descriptive statistics reveal notable differences in the return characteristics of Bitcoin and gold. Bitcoin exhibits a higher mean return compared to gold; however, this is accompanied by a substantially larger standard deviation, indicating its high volatility. The skewness and kurtosis values of Bitcoin suggest a non-normal return distribution with fat tails, while gold appears relatively more stable with a return distribution closer to normality. These findings are consistent with the inherent nature of the two assets: Bitcoin behaves as a speculative asset, whereas gold maintains its role as a more stable safe haven asset.

Correlation Analysis

Table 1. Correlation Analysis.

Correlation	Covariance RETURN_GOLD	RETURN_BITCOIN
RETURN_GOLD	3.946799	
	1.000000	
RETURN_BITCOIN	0.195782	1.534635
	0.079551	1.000000

Pearson correlation analysis was conducted to examine the linear relationship between the returns of gold and Bitcoin. The result shows a weak but positive correlation coefficient of 0.195782 ($\approx$ 0.20), indicating that the two assets tend to move in the same direction, but the strength of their co-movement is relatively low. This finding suggests that while gold and Bitcoin share some common drivers in the financial market, their return dynamics are largely independent.

This weak correlation aligns with the theoretical expectation that gold, as a conventional safe-haven asset, behaves differently from Bitcoin, which functions more as a speculative digital asset. The low degree of correlation further emphasizes the diversification benefits of combining the two assets in a portfolio. Consistent with prior literature (e.g., Guesmi et al., 2019; Bahloul et al., 2023), investors may exploit this weak dependence to optimize the risk return trade-off.

Stationarity and Heteroskedasticity Tests

The Augmented Dickey-Fuller (ADF) test results indicate that both gold and Bitcoin returns are stationary at the return level. This is essential, as non-stationary data can lead to biased estimates in time series models. With stationary data, the volatility estimates can be interpreted with greater validity.

Furthermore, the heteroskedasticity test using the ARCH-LM test reveals the presence of significant ARCH effects in both assets. This implies that the variance of gold and Bitcoin returns is not constant but instead depends on the variance of previous periods. In other words, the data exhibit time-varying volatility. This finding provides the basis for employing the GARCH (1,1) model, which can capture conditional heteroskedasticity.

Volatility Analysis with GARCH (1,1)

The estimation of the GARCH (1,1) model shows that Bitcoin exhibits much higher volatility with sharper fluctuations compared to gold, which tends to be more stable. This is evident from the average volatility of Bitcoin, which reached approximately 0.21, substantially higher than gold's 0.04. This finding is consistent with Bouri et al. (2020) and Dyhrberg (2016), who documented that Bitcoin is highly sensitive to external shocks such as market sentiment, regulatory announcements, and changes in global liquidity, unlike gold which maintains relative stability. Similarly, Chemkha et al. (2021) emphasized that Bitcoin's volatility clustering makes it a speculative asset, while gold continues to serve as a safe haven during turbulent periods.

Both the ARCH and GARCH parameters are statistically significant for the two assets, confirming the presence of volatility clustering where high volatility periods tend to be followed by subsequent high-volatility periods. This phenomenon is more pronounced in Bitcoin, suggesting that Bitcoin's price turbulence can persist for a longer duration compared to gold. These results are consistent with prior literature describing Bitcoin as a speculative instrument with inherently high volatility.

Dynamic Correlation with DCC-GARCH

The DCC-GARCH model was employed to analyze the dynamic relationship, meaning that the correlation between gold and Bitcoin is time-varying rather than constant. In other words, the strength and direction of their co-movements change over different market conditions, reflecting shifts in investor behavior, liquidity, and external shocks. The results show that correlations fluctuated between –0.15 and +0.35 during 2020–2025, confirming that the interdependence of these two assets evolves over time instead of remaining static.

From 2021 to 2023, the correlation strengthened to around 0.3–0.35, reflecting Bitcoin's partial integration into global financial markets. However, during the geopolitical uncertainties of 2024, the correlation weakened again, suggesting that gold continued to serve as a hedge asset, whereas Bitcoin remained more influenced by market speculation and external factors such as monetary policy.

Overall, this pattern highlights that combining gold and Bitcoin in a portfolio can provide diversification benefits, as their relationship does not always move in the same direction.

Implications and Discussion

These findings confirm the fundamental differences between conventional assets (gold) and digital assets (Bitcoin). Bitcoin offers high return opportunities but entails substantial speculative risks due to its extreme volatility. In contrast, gold consistently remains a stable asset widely utilized by investors as a safe haven and a tool for portfolio diversification.

The practical implications of these findings are as follows:

a. Hedging Strategy: Investors can utilize gold to hedge portfolios against extreme Bitcoin volatility.
b. Portfolio Diversification: The low to negative correlations suggests that combining the two assets can improve the risk–return trade-off.

    c.   Investor Profiles: Conservative investors are better positioned to increase gold allocations, whereas aggressive investors may take on greater exposure to Bitcoin to pursue higher returns.

    d.   Theoretical Implications: The findings support modern portfolio theory (Markowitz), which posits that combining assets with low correlations can optimize diversification.

5. Conclusions

This study confirms that gold and Bitcoin exhibit distinct characteristics over the 2020–2025 period. Gold consistently functions as a safe haven asset with low and stable volatility, whereas Bitcoin demonstrates speculative behavior with high volatility and greater return potential. The estimation of the GARCH(1,1) model highlights the presence of volatility clustering in both assets, which is more pronounced in Bitcoin. Meanwhile, the DCC-GARCH results reveal that the correlation between gold and Bitcoin is dynamic, ranging from negative to moderately positive.

From a practical perspective, these findings provide several key implications. First, gold remains relevant as a hedging instrument, particularly during periods of market turmoil. Second, Bitcoin may serve as a high-risk diversification asset, suitable for aggressive investors seeking higher returns. Third, combining gold and Bitcoin in a portfolio can help balance risk and return, in line with the principles of modern portfolio diversification.

For future research, it is recommended to expand the scope of analysis by incorporating additional instruments such as crude oil, government bonds, or global stock indices to obtain a more comprehensive view of cross-asset interactions. Furthermore, alternative approaches such as Copula-GARCH or BEKK-GARCH models may be employed to capture more complex dynamics of correlations. Such extensions are expected to further enrich the literature on the integration of conventional and digital assets within the framework of risk management and investment strategies.

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