

**SAFE-HAVEN AND DIVERSIFICATION ROLES OF GOLD AND
BITCOIN: EVIDENCE FROM FINANCIAL MARKETS**

FINAL PROJECT

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**By
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Student ID: 29123360
(Master of Business Administration Program)**



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ABSTRACT

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This study investigates the safe-haven and diversification roles of Bitcoin and gold in global financial markets between 2015 and 2025. Amid various periods of uncertainty, such as the COVID-19 pandemic, the Russia and Ukraine conflict, and the global tariff war in 2025, investors increasingly seek assets that can protect their portfolios from downside risk. Gold has historically served this purpose as a defensive, low-volatility asset. Bitcoin, however, has gained popularity for its decentralized structure and limited supply, raising questions about its role in modern portfolio strategies. The study uses quantitative methods including GARCH(1,1) to measure volatility, quantile regression to assess downside performance, and Sharpe ratio analysis to evaluate risk-adjusted returns. Monthly return data was obtained from Investing.com. The GARCH results reveal that gold shows more stable and persistent volatility patterns, reinforcing its traditional function as a safe-haven. Bitcoin, on the other hand, reacts more aggressively to market shocks and exhibits higher volatility. Quantile regression results confirm that Bitcoin experiences steeper losses during the 5th and 10th percentile periods, typically associated with market stress. Bitcoin's returns fell by -24.94% and -16.70% at the 5th and 10th quantiles, respectively. Gold's corresponding losses were much lower, at -5.48% and -3.29%. These findings confirm that gold offers better downside protection in turbulent conditions. In the context of portfolio diversification, Bitcoin demonstrates value. Despite its volatility, its weak correlation with gold (0.0752) reduces overall portfolio risk. A 50:50 Bitcoin-gold portfolio recorded the highest Sharpe ratio (0.3296), compared to Bitcoin-only (0.3125) and gold-only (0.1459) portfolios. This implies that including both assets enhances the risk-return trade-off. In conclusion, gold remains a reliable safe-haven asset, especially during periods of financial stress. Bitcoin, while not dependable on its own during downturns, offers diversification benefits when combined with gold. This study supports a mixed-asset strategy in which investors allocate gold for capital protection and Bitcoin for potential return enhancement. The findings are aligned with Modern Portfolio Theory and provide practical insights for investors navigating uncertain financial environments.

Keywords: Bitcoin, gold, safe-haven asset, portfolio diversification, volatility, Sharpe ratio, quantile regression

ABSTRAK

PERAN SAFE-HAVEN DAN DIVERSIFIKASI EMAS DAN BITCOIN: BUKTI DARI PASAR KEUANGAN

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Penelitian ini mengkaji peran emas dan Bitcoin sebagai aset safe-haven serta alat diversifikasi dalam pasar keuangan global selama periode 2015 hingga 2025. Di tengah berbagai ketidakpastian seperti pandemi COVID-19, konflik Rusia dan Ukraina, serta perang tarif global pada tahun 2025, investor semakin mencari aset yang mampu melindungi portofolio mereka dari risiko penurunan. Emas secara historis berperan sebagai aset defensif dengan volatilitas rendah, sedangkan Bitcoin, meskipun sangat fluktuatif, menjadi sorotan karena sifatnya yang terdesentralisasi dan pasokan yang terbatas. Penelitian ini menggunakan pendekatan kuantitatif, termasuk model GARCH(1,1) untuk mengukur volatilitas, regresi kuantil untuk mengevaluasi kinerja saat tekanan pasar, serta analisis rasio Sharpe untuk menilai imbal hasil yang disesuaikan dengan risiko. Data return bulanan dikumpulkan dari Investing.com. Hasil GARCH menunjukkan bahwa emas memiliki pola volatilitas yang lebih stabil dan persisten, memperkuat perannya sebagai aset safe-haven. Sebaliknya, Bitcoin lebih responsif terhadap guncangan pasar dan menunjukkan volatilitas yang jauh lebih tinggi. Hasil regresi kuantil menunjukkan bahwa Bitcoin mengalami penurunan tajam pada kuantil ke-5 dan ke-10, yang mencerminkan kondisi pasar yang penuh tekanan. Return Bitcoin turun sebesar -24,94% dan -16,70% pada masing-masing kuantil tersebut, sedangkan penurunan return emas lebih ringan, yaitu -5,48% dan -3,29%. Temuan ini mengonfirmasi bahwa emas memberikan perlindungan yang lebih baik terhadap risiko penurunan selama periode gejolak pasar. Dalam konteks diversifikasi portofolio, Bitcoin menunjukkan manfaat positif. Meskipun volatil, korelasinya yang lemah dengan emas (0,0752) membantu mengurangi risiko portofolio secara keseluruhan. Portofolio campuran antara Bitcoin dan emas dengan komposisi 50:50 menghasilkan rasio Sharpe tertinggi (0,3296), dibandingkan dengan portofolio Bitcoin saja (0,3125) dan emas saja (0,1459). Ini menunjukkan bahwa menggabungkan kedua aset tersebut dapat meningkatkan keseimbangan risiko dan imbal hasil. Kesimpulannya, emas tetap menjadi aset safe-haven yang andal, terutama selama tekanan pasar keuangan. Bitcoin, meskipun tidak cukup andal sebagai pelindung tunggal saat krisis, tetap memberikan manfaat dalam meningkatkan efisiensi portofolio jika dikombinasikan dengan emas. Studi ini mendukung strategi alokasi aset campuran di mana emas digunakan untuk perlindungan nilai dan Bitcoin untuk potensi pertumbuhan. Temuan ini sejalan dengan prinsip Teori Portofolio Modern dan memberikan wawasan praktis bagi investor dalam mengelola portofolio di tengah kondisi pasar yang tidak menentu.

Kata kunci: Bitcoin, emas, aset safe-haven, diversifikasi portofolio, volatilitas, rasio Sharpe, regresi kuantil

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Finally, I acknowledge that this project may have its limitations, and I genuinely welcome constructive feedback and suggestions. I hope this work may offer valuable insights and benefits to future readers and researchers.

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Chapter I Introduction

I.1 Background

The need for safe-haven assets that can maintain value during economic downturns has increased due to rising uncertainty in international financial markets. Gold has long been seen as a dependable safe-haven investment, offering stability in times of crisis. It often holds its value or even rises when other assets, such as stocks, suffer major declines (Baur & McDermott, 2010). In contrast, Bitcoin has shown characteristics more similar to risky assets than to traditional safe havens (Adrian et al., 2022). Despite this, economists often compare Bitcoin to gold because of several shared traits. Both assets gain value largely from their scarcity and the high cost of production. They are also not tied to any government or specific country, and both are mined by several independent operators and company (Dyhrberg, 2016). Bitcoin and gold, although from different asset classes, are increasingly studied together because they share key features such as scarcity and decentralization (Baur et al., 2024). Bitcoin's fixed maximum supply of 21 million coins is often compared to the natural scarcity of gold (Chemkha et al., 2021). Both assets are independent of any central authority, making them attractive during times of market instability (Shahzad et al., 2019). Many researchers refer to Bitcoin as "digital gold" due to these similarities (Baur et al., 2024). Furthermore, both gold and Bitcoin have been observed to retain or even increase their value in times of financial crisis, highlighting their potential as safe-haven assets (Chemkha et al., 2021). Despite these similarities, there are significant differences: gold is a tangible asset with relatively low volatility, while Bitcoin is digital and highly volatile (Shahzad et al., 2019). This combination of shared characteristics and contrasting qualities makes the comparison between gold and Bitcoin especially relevant for analyzing portfolio diversification and resilience across various market conditions (Baur et al., 2024).

Events such as the 2008 Global Financial Crisis, the COVID-19 pandemic in 2020, and the global tariff conflict started by the United States in 2025 have created serious disruptions in financial markets. During such times, investors often shift their portfolios toward safer assets to reduce exposure to risk (Baur & Lucey, 2010). However, Bitcoin's performance during crises has been inconsistent, sparking debate among researchers and investors about its true role as a safe haven. Beyond its potential for downside protection, Bitcoin is also being examined for its ability to improve portfolio diversification, thanks to its unique return behavior and historically low correlation with traditional financial assets.

This study aims to explore whether Bitcoin and gold serve as safe-haven assets and whether they can help diversify portfolios in global financial markets over the period from 2015 to 2025. Through empirical analysis across various market conditions, the research evaluates whether Bitcoin can act as a complement or even a substitute for gold in protecting investor portfolios.

I.2 Business Issue

In the last ten years, global financial markets have faced increasing volatility, driven by persistent inflation and rising geopolitical tensions, including the global tariff conflict launched by the United States in 2025. These disruptions have made investors more interested in assets that can offer protection during uncertain times. Gold has traditionally played this role, acting as a safe-haven asset during financial crises (Baur & McDermott, 2010). However, the rise of Bitcoin as a digital, decentralized, and limited-supply asset has raised new questions about its possible role in modern portfolio strategies.

In 2024, the U.S. Securities and Exchange Commission approved 11 spot Bitcoin exchange-traded funds (ETFs), including those managed by major firms such as BlackRock and Fidelity. This led to a major increase in Bitcoin's price, which more than doubled and crossed the \$100,000 mark (Reuters, 2024). These ETFs attracted over \$36 billion in investments and

together held more than one million Bitcoin, making them the largest combined holders of the asset globally (The Wall Street Journal, 2024). This wave of institutional involvement pushed Bitcoin deeper into the mainstream financial system.

Still, even with its rising popularity, Bitcoin remains highly volatile and has shown mixed performance during past financial crises. This raises doubts about its reliability as a safe-haven asset (Adrian et al., 2022). For both institutional and retail investors, it is important to understand how Bitcoin behaves under financial stress and whether it can complement gold in a diversified portfolio. This study aims to analyze the safe-haven and diversification roles of Bitcoin and gold between 2015 and 2025, offering practical insights for asset allocation decisions.

I.3 Research Questions & Objectives

I.3.1 Research Questions

1. Which asset, Bitcoin or gold, offers stronger safe-haven properties during periods of market stress?
2. Can Bitcoin complement gold in a diversification strategy despite its speculative characteristics?
3. Does a portfolio that combines Bitcoin and gold provide better risk-adjusted returns than holding either asset individually?

I.3.2 Research Objectives

1. To examine the safe-haven characteristics of Bitcoin and gold during periods of financial market stress.
2. To assess the impact of Bitcoin on portfolio risk and diversification when combined with gold across varying market conditions.
3. To evaluate the risk-adjusted performance of portfolios that combine Bitcoin and gold, compared to holding each asset individually.

I.4 Research Scope and Limitation

1. This research focuses on comparing gold and Bitcoin as safe-haven assets within the context of global financial markets.
2. It analyzes how these two assets behave during periods of financial stress to assess their ability to protect portfolio value.
3. The study covers the period from 2015 to 2025, which includes key events such as Bitcoin's adoption phases, the COVID-19 pandemic, and the Russia-Ukraine war.
4. Bitcoin's shorter history compared to gold may limit the assessment of its long-term performance as a safe-haven asset.
5. The research deliberately excludes other alternative assets such as Ethereum, silver, and real estate in order to maintain a focused comparison between Bitcoin and gold.
6. Bitcoin's high price volatility and speculative nature create uncertainty when evaluating its potential as a stable safe-haven asset.
7. The impact of ongoing and future regulatory changes in the cryptocurrency market may influence asset behavior in ways that cannot be fully captured through historical analysis.

Chapter II Literature Review

II.1 Theoretical Foundation

II.1.1 Safe-Haven Asset

A safe-haven asset refers to a financial instrument that holds or increases its value when markets are facing uncertainty or severe stress. Investors often turn to these assets to protect their capital during times when riskier markets, such as equities, experience sharp declines. Safe havens act as a shield against system-wide risks and are especially useful during financial crises, economic slowdowns, or major geopolitical events.

Key features of safe-haven assets include strong liquidity, independence from general market trends, and low or negative correlation with high-risk assets during periods of turmoil. As explained by Baur and Lucey (2010), a strong safe haven tends to move in the opposite direction of stock markets during crises, while a weaker one may simply show no correlation. These assets help reduce portfolio volatility and limit losses during unstable market conditions. In recent years, the importance of safe havens has grown due to major events like the COVID-19 pandemic, the Russia–Ukraine conflict that cause a global inflation pressures. During these periods, investors increased their exposure to traditional safe-haven options such as gold and U.S. Treasury bonds, as well as to emerging alternatives like Bitcoin. However, the safe-haven role of digital assets is still under debate. Smales (2019) points out that changing market conditions and investor behavior can affect the performance of both traditional and new safe-haven assets. Similarly, Ciner et al. (2013) argue that the way assets behave during crises may vary depending on the country and type of shock involved, meaning that safe-haven effectiveness is often context-specific.

Understanding when and how an asset functions as a safe haven is crucial for developing strong investment strategies. This study builds on these theoretical ideas to assess the behavior of Bitcoin and gold under market stress, contributing to the broader discussion on portfolio protection and risk management.

II.1.2 Hedging

Hedging is a fundamental concept in investment management, referring to the process of reducing potential losses by taking positions in assets that tend to move in the opposite direction of the primary holdings (Baur & Lucey, 2010). In portfolio construction, investors employ hedging to mitigate the impact of negative price movements in specific assets or markets, thereby lowering overall portfolio risk (Shahzad et al., 2020). Unlike diversification, which aims to spread risk by investing in a variety of unrelated asset classes, hedging involves selecting instruments with a proven tendency to counterbalance losses from other positions (Wang et al., 2019). The effectiveness of a hedge is usually assessed by the degree of negative or low correlation with the main portfolio asset, especially during periods of heightened market volatility (Shahzad et al., 2020). In contrast, a safe haven is defined as an asset that preserves or increases its value strictly during episodes of financial turmoil, rather than across all market conditions (Ji et al., 2020). Gold has traditionally fulfilled both functions, serving as a hedge against inflation and currency fluctuations, while also providing safe-haven protection during crises such as financial crashes or geopolitical uncertainty (Shahzad et al., 2020). Recent empirical research has examined whether Bitcoin can serve a similar role. Some findings suggest that Bitcoin's weak correlation with stocks and bonds allows it to function as a hedge or diversifier under normal market conditions (Wang et al., 2019). However, Bitcoin's extreme price volatility and tendency to move in sync with equities during times of stress often undermine its effectiveness as a hedge or safe haven (Conlon & McGee, 2020). Overall, the literature indicates that while Bitcoin may offer diversification and limited hedging benefits, it does not yet match gold's established status as a reliable hedge and safe-haven asset in global investment portfolios (Ji et al., 2020).

II.1.3 Gold

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XAUUSD, Real-time Currencies:XAUUSD, M



Figure II.1 Historical Price of Gold (2015-2025)

Gold has long been regarded as a safe-haven asset and a store of value. A safe haven is defined as an asset that retains or increases in value during market turbulence. Gold qualifies based on its tendency to exhibit negative correlation with equities in times of financial stress (Baur & Lucey, 2010).

Its physical scarcity, durability, and universal recognition contribute to its role as a long-term store of value. Historically, gold served as the foundation of monetary systems such as the gold standard and the Bretton Woods agreement, anchoring currencies to a fixed value and ensuring stability (Arslanalp, 2023).

Empirical studies confirm gold's performance during financial shocks. During the 2008 global financial crisis, gold acted as a strong safe haven as global equities collapsed (Baur & McDermott, 2010). In the COVID-19 pandemic, gold prices rose sharply after initial liquidation pressures, reinforcing its defensive role (Akhtaruzzaman et al., 2021). Similar price surges were observed during geopolitical conflicts such as the Russia and Ukraine war in 2022.

While short-term drawdowns may occur, particularly during liquidity squeezes, gold consistently regains its value and strengthens portfolio stability over time. These attributes affirm its continued relevance in modern risk management and diversification strategies.

II.1.4 Cryptocurrency

Cryptocurrencies are digital financial assets that operate on decentralized networks using blockchain technology. The first and most widely adopted cryptocurrency is Bitcoin, introduced in 2008 as a peer-to-peer electronic cash system that functions without central authorities such as banks or governments. Bolt and Van Oordt (2019) explain that Bitcoin relies on a public ledger known as the blockchain, which records transactions in a secure and transparent manner. A notable feature of cryptocurrencies is their decentralized nature, meaning they are not issued or regulated by central banks. Bitcoin, for instance, has a fixed supply cap of 21 million coins, making its scarcity comparable to that of gold.

Cryptocurrencies are typically used as speculative investments and, to a lesser extent, as alternative currencies. While they are theoretically capable of facilitating borderless transactions, Bolt and Van Oordt (2019) note that their usage in everyday commerce remains limited due to their high price volatility and regulatory uncertainty. Most investors purchase cryptocurrencies like Bitcoin not for transactional purposes, but rather to seek capital appreciation. From a financial perspective, the appeal of cryptocurrencies lies in their potential to diversify portfolios. Koutmos et al. (2021) observed that Bitcoin demonstrated hedging capabilities during periods of financial uncertainty, although such benefits were often offset by the asset's considerable volatility.

Recent empirical research has also explored whether Bitcoin functions as a safe-haven or an inflation hedge. Choi and Shin (2021) found that Bitcoin responds positively to inflation shocks, suggesting a potential role as an inflation hedge. However, they also concluded that Bitcoin fails to provide protection during periods of heightened financial stress, limiting its

reliability as a safe-haven asset. This conclusion is supported by Ustaoglu (2022), who reported that Bitcoin's safe-haven performance is weak and inconsistent, particularly across emerging markets. Despite these limitations, some studies indicate that Bitcoin can still contribute to portfolio diversification when combined with traditional safe-haven assets such as gold. Yae and Tian (2024), for example, reported that Bitcoin and gold exhibited differing performance patterns during periods of market turbulence, making them complementary in some portfolio strategies.

In conclusion, cryptocurrencies like Bitcoin represent a unique class of financial instruments that combine decentralization, algorithmic monetary policy, and blockchain-based transparency. Their dual function as both investment assets and speculative instruments has drawn widespread attention from investors and researchers alike. While Bitcoin does not consistently act as a safe haven, it may offer limited inflation protection and diversification advantages in specific market conditions. As such, the study of cryptocurrencies remains a critical area of inquiry in modern finance, particularly in relation to portfolio construction and macroeconomic dynamics.

II.1.5 Bitcoin

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Bitcoin, Investing.com:BTCUSD, M



Figure II.2 Historical Price of Bitcoin (2015-2025)

Bitcoin was introduced by Nakamoto in 2008 as a decentralized digital currency that enables peer-to-peer transactions without the involvement of financial intermediaries. It operates through blockchain technology, which is a distributed ledger secured by cryptographic methods and maintained by a network of nodes using a consensus mechanism called proof-of-work. This system ensures that all transactions are publicly verifiable, cannot be altered, and are protected from censorship.

In the Bitcoin network, each transaction is broadcast, verified through digital signatures, and recorded in blocks. These blocks are connected in chronological order using hash functions, forming a continuous chain of data. The network accepts the longest valid chain, which represents the greatest amount of computational work. This process helps prevent double-spending and maintains a trusted agreement across the system.

Unlike fiat currencies, Bitcoin is not controlled by any central authority. It has a fixed supply of 21 million coins and relies on block rewards and transaction fees to encourage miners to maintain the network. This limited supply model resembles the scarcity of precious metals, which is why Bitcoin is often considered a potential store of value.

Due to its transparency, global reach, and independence from central banks, Bitcoin is frequently compared to gold. This comparison has led to increasing interest in evaluating Bitcoin's role as a safe-haven asset and its usefulness in portfolio diversification, particularly during times of financial market stress.

II.1.6 Portfolio Diversification

Portfolio diversification is a basic investment strategy that helps reduce risk by spreading capital across different types of assets. The main idea is that various asset classes tend to react differently to changes in the market. When one asset performs poorly, another may hold its value or even increase, which helps to lower the overall volatility of the portfolio.

Modern Portfolio Theory, introduced by Markowitz in 1952, explains that an efficient portfolio is one that offers the highest possible return for a given level of risk. The benefits of diversification are most evident when the selected assets have low or negative correlations, especially during periods of financial stress. In this setting, combining traditional assets like gold with newer options such as Bitcoin could improve the risk-adjusted return of a portfolio. Gold is well known for its protective qualities during times of market uncertainty. Bitcoin, while more volatile, has shown unique return behaviors that may work well alongside gold under specific conditions. Understanding how these two assets interact, especially through their correlation, is important for determining their combined role in building a more stable and effective portfolio. This study uses this approach to explore whether Bitcoin and gold, either separately or together, can support portfolio performance and stability during financial crises.

II.1.7 Modern Portfolio Theory (MPT)

Modern Portfolio Theory (MPT), introduced by Harry Markowitz in 1952, remains one of the most influential frameworks in the field of finance. It provides a mathematical approach to asset allocation, focusing on how investors can construct portfolios that optimize expected return relative to risk. According to Markowitz, each portfolio can be plotted in a two-

dimensional space, where the vertical axis represents expected return and the horizontal axis represents standard deviation or risk. Han et al. (2024) explain that the foundation of MPT relies on two inputs: expected returns and the covariance matrix of asset returns. By solving a mean-variance optimization problem, investors can identify the combination of assets that achieves the maximum utility based on their risk preferences.

A central element of MPT is the role of asset correlation in managing risk. The total risk of a portfolio is not merely the sum of the risks of individual assets but is also influenced by how those assets move in relation to each other. When two assets are not perfectly correlated, combining them can reduce overall portfolio volatility. This principle is the basis for diversification. According by Triki and Ben Maatoug (2021) assets with low or negative correlations improve portfolio stability, particularly during periods of market stress. Gold, for instance, has often been used for its low correlation with equities and its ability to preserve value during financial downturns. Similarly, Yae and Tian (2024) emphasize that Bitcoin historically exhibited weak correlation with traditional markets, making it a candidate for diversification despite its high volatility. In practical terms, adding an asset that behaves differently from existing holdings allows investors to achieve a more favorable balance between risk and return.

In recent years, researchers have extended MPT to evaluate the impact of including alternative assets such as Bitcoin and gold. Henriques and Sadorsky (2018) used a constrained mean-variance optimization framework to compare portfolios containing gold, Bitcoin, and traditional assets. Their findings suggest that portfolios including Bitcoin often achieved higher Sharpe ratios than those relying solely on gold. However, this benefit was not without risk, as Bitcoin's elevated volatility can negatively affect downside protection. Gorman and Huguen (2024) provide further nuance by showing that Bitcoin's correlation with equities has increased in the post-COVID-19 era, thereby reducing its diversification potential.

Gold remains relatively consistent in its role. Triki and Ben Maatoug (2021) find that gold continues to serve as a hedge in portfolios, especially during geopolitical uncertainty. When combined, Bitcoin and gold offer a complementary relationship. Bitcoin contributes growth potential due to its high average returns, while gold offers stability during economic turbulence. Han et al. (2024) confirm that portfolios incorporating both Bitcoin and gold alongside equities and bonds tend to improve the risk-return profile more effectively than portfolios with traditional assets alone. This combined approach reflects the flexibility of MPT in adapting to new financial instruments and changing market conditions.

Modern Portfolio Theory in conclusion provides a structured approach to building efficient investment portfolios by balancing expected return with risk. The theory's emphasis on diversification and asset correlation remains highly relevant in contemporary finance. As the financial landscape evolves, incorporating non-traditional assets like Bitcoin and gold within the MPT framework enables investors to pursue enhanced risk-adjusted returns. Nevertheless, the effectiveness of such strategies depends on the stability of asset relationships over time. If correlations shift due to macroeconomic changes or market integration, the diversification benefits may diminish. For this reason, ongoing empirical evaluation remains essential when applying MPT to dynamic and emerging asset classes.

II.1.8 Sharpe Ratio

The Sharpe ratio is a key measure of risk-adjusted return introduced by William F. Sharpe. It quantifies how much excess return an investor earns per unit of risk taken, calculated as the portfolio return minus the risk-free rate, divided by the standard deviation of returns. This metric allows for direct comparison between different assets or portfolios, regardless of their volatility levels (Malhotra et al., 2023).

The Sharpe ratio is widely used in portfolio evaluation, particularly when comparing assets like Bitcoin and gold, which differ greatly in both risk and return. Bitcoin tends to offer higher

returns, but with greater volatility, while gold provides more stability. The Sharpe ratio helps assess which asset delivers better compensation for the risk assumed. According to Pho et al. (2021), Bitcoin can enhance returns but also raises portfolio risk, while gold acts as a stabilizer. Zhang (2024) further found that combining both assets often results in a more balanced Sharpe ratio, supporting the idea that diversification improves overall portfolio efficiency.

Other performance metrics also exist, such as the Sortino ratio which only considers downside volatility, and the Treynor ratio which evaluates return based on market risk measured by beta. However, the Sharpe ratio remains the most comprehensive when assessing total risk (Malhotra et al., 2023).

In summary, the Sharpe ratio is essential for evaluating the efficiency of single assets or diversified portfolios. In this study, it is used to compare Bitcoin-only, gold-only, and 50:50 Bitcoin–gold portfolios, helping identify which offers the most favorable risk-return trade-off. Although this research primarily employs quantitative methods to analyse the volatility and safe-haven properties of gold and Bitcoin, the interpretation of results is consistently linked to major macroeconomic events and shifts in investor sentiment throughout the 2015 to 2025 sample period. Macroeconomic variables such as changes in monetary policy, inflation rates, and geopolitical tensions are acknowledged as critical factors influencing the dynamics of both assets (Ji et al., 2020). In addition, variations in market sentiment driven by news, market panic, or optimism are considered essential in understanding the behaviour and correlation patterns of gold and Bitcoin (Liu & Tsyvinski, 2021). Therefore, while the models are statistical, the research explicitly situates its findings within the broader context of prevailing macroeconomic conditions and investor sentiment during significant global events.

II.2 Conceptual Framework

The conceptual framework of this study focuses on evaluating the volatility, safe-haven properties, and diversification benefits of Bitcoin and gold, both individually and in

combination. Monthly return data from 2015 to 2025 is used to analyze Bitcoin-only, gold-only, and 50-50 Bitcoin–gold portfolios. Volatility is estimated using the GARCH(1,1) model, while safe-haven behavior under market stress is examined through quantile regression at the 5th and 10th percentiles. Descriptive statistics are applied to observe return distribution patterns, and the Sharpe ratio is used to compare risk-adjusted performance across the three portfolios. The analysis adopts Modern Portfolio Theory to assess whether the mixed portfolio offers superior diversification.

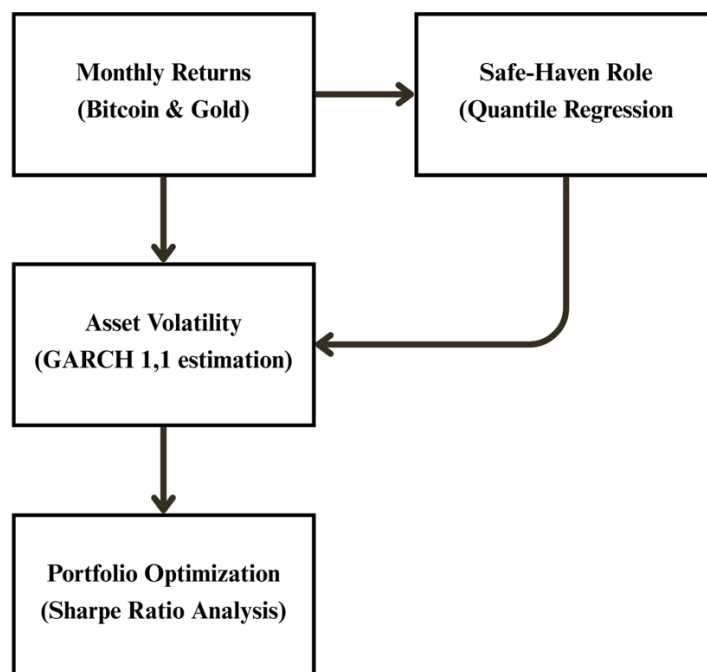


Figure II.3 Conceptual Framework

II.3 Previous Research

II.3.1 Conlon et al. (2020)

Conlon et al. (2020) examined whether cryptocurrencies could serve as safe-haven assets for global equity markets during the COVID-19 bear market. The study focused on Bitcoin, Ethereum, and Tether, and assessed their downside risk using Modified Value-at-Risk (MVaR)

and Conditional Value-at-Risk (MCVaR). The analysis covered several major global indices, including the MSCI World, S&P 500, FTSE 100, FTSE MIB, IBEX, and CSI 300.

The results showed that Bitcoin and Ethereum generally failed to reduce downside risk in most of the markets studied. In fact, portfolios that included either cryptocurrency often experienced higher downside exposure. The only exception was the CSI 300 index in China, where small allocations to Bitcoin and Ethereum slightly improved portfolio resilience. Specifically, Bitcoin allocations of up to 16 percent and Ethereum allocations of up to 14 percent offered limited downside protection.

Tether, a stablecoin pegged to the U.S. dollar, consistently lowered downside risk across all indices. However, its overall usefulness is questioned due to concerns about its peg reliability and potential exposure to systemic risk. The authors concluded that Bitcoin and Ethereum are not dependable safe-haven assets during times of severe market stress like the COVID-19 crisis. Rather than offering protection, these assets tend to increase portfolio risk. While Tether showed more stable behavior, its benefits may overlap with those of holding cash or government bonds. These findings raise doubts about the belief that cryptocurrencies can serve as effective safe havens during global financial crisis.

II.3.2 Feng et al. (2022)

Feng et al. (2022) applied a Time-Varying Parameter Vector Autoregression (TVP-VAR) model to examine whether gold or Bitcoin acted as safe-haven assets during the COVID-19 pandemic. The study focused on how gold and Bitcoin prices influenced oil and stock markets between 2019 and 2021. It also used the Iterative Cumulative Sum of Squares (ICSS) method to detect structural breaks in market behavior, based on changes in global infection rates.

The results showed that gold maintained its safe-haven qualities during the pandemic, especially in periods of increased uncertainty. These periods included spikes in global cases and announcements of major developments related to the virus. In contrast, Bitcoin did not

behave as a safe haven. Its responses to market shocks were generally positive and marked by high volatility, which reflects its speculative nature.

The study also found that both gold and Bitcoin worked as effective hedges against oil prices before the pandemic began. However, only gold provided protection for the stock market during the crisis. Gold showed clear safe-haven behavior, while Bitcoin became more positively correlated with stock markets, limiting its usefulness as a diversifier during stressful periods.

The authors concluded that gold remains a dependable safe-haven asset. Bitcoin's role, in comparison, is more uncertain and speculative, offering little protection during global financial shocks such as the COVID-19 crisis.

II.3.3 Będowska-Sójka and Kliber (2021)

Będowska-Sójka and Kliber (2021) explored whether gold, Bitcoin, and Ether could function as safe-haven assets during different periods of market instability. The study used a Bayesian Dynamic Conditional Correlation Multivariate Stochastic Volatility (DCC-MSV) model to analyze daily return data from August 2015 to April 2020. The assets were examined in relation to major equity indices such as the S&P 500, DAX, STOXX600, and FTSE250.

The findings showed that gold acted as a strong safe haven in some cases, particularly during events like the Brexit referendum and the trade tensions of 2019. However, gold did not offer the same protection during the COVID-19 crisis, as its conditional correlation with equity markets became positive, suggesting that it moved more closely with stocks during this period. Bitcoin and Ether did not show strong safe-haven characteristics in any of the events studied. Still, both cryptocurrencies displayed weak safe-haven behavior in certain situations, especially in European markets. The study concluded that no asset provided consistent safe-haven protection across all episodes of financial stress.

While gold retained some defensive traits, mainly in European markets, the safe-haven potential of Bitcoin and Ether was limited and highly dependent on the specific context. These results highlight the changing nature of safe-haven behavior and the importance of using flexible portfolio strategies.

II.3.4 Guesmi et al. (2019)

Guesmi et al. (2019) investigated how Bitcoin performs in terms of portfolio diversification and hedging when combined with traditional financial assets such as gold, oil, and stock indices. The study used several multivariate GARCH models, including the VARMA(1,1)-DCC-GJR-GARCH framework, to analyze volatility spillovers and interactions across different asset classes. The dataset covered the period from 2012 to 2018.

The results showed that Bitcoin has strong volatility connections with other financial assets. This suggests that including Bitcoin in a portfolio can help reduce overall risk. One important finding was that holding a short position in Bitcoin could help hedge risks in markets such as oil, emerging equities, and currencies. Portfolios that combined Bitcoin with gold, oil, and stocks had lower variance compared to portfolios made up of only traditional assets

Although Bitcoin is known for its high volatility, the study concluded that it can still serve a useful role in portfolio management, particularly in environments with changing risk levels. These results support the view that Bitcoin, despite being speculative, can contribute to risk reduction strategies when properly managed.

II.3.5 Shahzad et al. (2019)

Shahzad et al. (2019) used a bivariate cross-quantilogram method to assess the safe-haven characteristics of Bitcoin, gold, and a broad commodity index in relation to global and regional stock markets. The study introduced a new approach to defining strong and weak safe havens by focusing on the behavior of asset returns at extreme quantiles. The analysis covered the

period from July 2010 to February 2018 and included stock indices from both developed and emerging markets, as well as from the United States and China.

The results showed that none of the assets studied could be considered strong safe havens under severe market conditions. However, Bitcoin, gold, and commodities all showed weak safe-haven behavior in certain situations. For instance, gold acted as a weak safe haven in developed markets, while Bitcoin displayed similar behavior only in the Chinese market.

The study also revealed that safe-haven relationships are not constant over time. Using rolling-window analysis, the researchers found that these relationships changed depending on market conditions. Although Bitcoin shares some features with gold, such as limited supply and independence from central authorities, it does not offer the same level of consistent protection. The findings suggest that Bitcoin may offer temporary protection in specific markets during periods of stress, but it cannot fully replace gold's long-established role in global investment strategies.

II.3.6 Klein et al. (2018)

Klein et al. (2018) examined whether Bitcoin could be considered the new gold by comparing the two assets in terms of volatility patterns, correlation behavior, and portfolio performance. The study used advanced econometric techniques, including the BEKK-GARCH and FIAPARCH models, to analyze time-varying correlations and the effects of asymmetric volatility. The data covered the period from 2011 to 2017.

The results showed that Bitcoin and gold behave very differently. Bitcoin was found to have higher volatility and did not consistently show safe-haven qualities. During times of financial stress, Bitcoin often moved in the same direction as stock markets. In contrast, gold had negative correlations with equity indices during market downturns, confirming its traditional role as a safe-haven asset. The study also found that the correlation between Bitcoin and gold was unstable and changed frequently throughout the sample period.

From a portfolio point of view, gold was shown to improve risk-adjusted returns, especially during periods of financial instability, by providing hedging benefits. Bitcoin, on the other hand, did not offer strong downside protection and only gave limited diversification advantages in certain cases. The authors concluded that Bitcoin acts more like a speculative asset rather than a reliable safe haven or hedge. These findings suggest that investors should be cautious when including Bitcoin in portfolios that aim for stability.

II.3.7 Bouri et al. (2017)

Bouri et al. (2017) used a Dynamic Conditional Correlation (DCC) model to assess whether Bitcoin acts as a hedge, safe haven, or diversifier when compared to various global financial assets. These included stock indices, commodities, gold, bonds, and the U.S. dollar index. The study was based on both daily and weekly data collected between July 2011 and December 2015.

The findings show that Bitcoin mainly functions as a diversifier. It does not behave consistently as a hedge or a safe haven, except during extreme market events in specific regions. For example, during severe equity market downturns in certain Asian countries, Bitcoin showed some safe-haven characteristics at the weekly frequency. However, this effect was much weaker in the daily data, suggesting that Bitcoin's safe-haven potential depends on the time frame and market conditions.

The study concluded that Bitcoin's role in managing portfolio risk is limited when compared to traditional safe-haven assets like gold. While Bitcoin may offer some diversification benefits, its high volatility and unstable correlations reduce its reliability as a hedge during periods of financial uncertainty.

II.3.8 Dyhrberg (2015)

Dyhrberg (2015) used GARCH and EGARCH models to study and compare the volatility patterns of Bitcoin, gold, and the U.S. dollar. The research found that Bitcoin shares features

with both currencies and commodities. It displays volatility clustering and reacts asymmetrically to market shocks, which is similar to how gold behaves. While Bitcoin does not fully meet the standard definition of a safe-haven asset, the study suggests that it may still be useful for managing risk and diversifying portfolios, particularly during periods of market decline. Dyhrberg also notes that Bitcoin may function as a partial hedge, although its ability to act as a stable store of value is not yet equal to that of gold. These findings support the idea that both Bitcoin and gold are relevant for volatility modeling and can serve as a basis for further analysis of their roles in investment strategies.

Although many previous studies have examined the safe-haven and diversification roles of Bitcoin and gold, several features make this research different. Most earlier studies used data that ended before or during the early stages of the COVID-19 pandemic. In contrast, this study extends the observation period up to January 2025. This allows the analysis to include recent events such as the post-pandemic economic recovery, the Russia–Ukraine conflict. These developments offer a more updated view of how Bitcoin and gold behave under financial pressure.

This study also takes a more integrated approach by combining safe-haven evaluation and portfolio diversification within a single framework. While earlier research often focused on only one of these topics, this analysis uses volatility modeling, quantile regression, and Sharpe ratio calculations to examine both the individual behavior of assets and their combined impact on portfolios. This multi-method strategy provides a deeper understanding of how risk is distributed and how the two assets interact.

Another important difference is the specific focus on the combination of Bitcoin and gold as a two-asset portfolio. Unlike studies that involve a broader range of assets, this research looks closely at whether Bitcoin and gold can work together to reduce risk and improve returns. The

aim is to explore whether this pairing can serve as a practical strategy for handling uncertainty in today's financial markets.

These features set this study apart and show its contribution to the literature on alternative assets. By offering fresh data and a comprehensive analysis, the research delivers useful insights for portfolio management in times of global instability.

Chapter III Research Methodology

III.1 Research Design

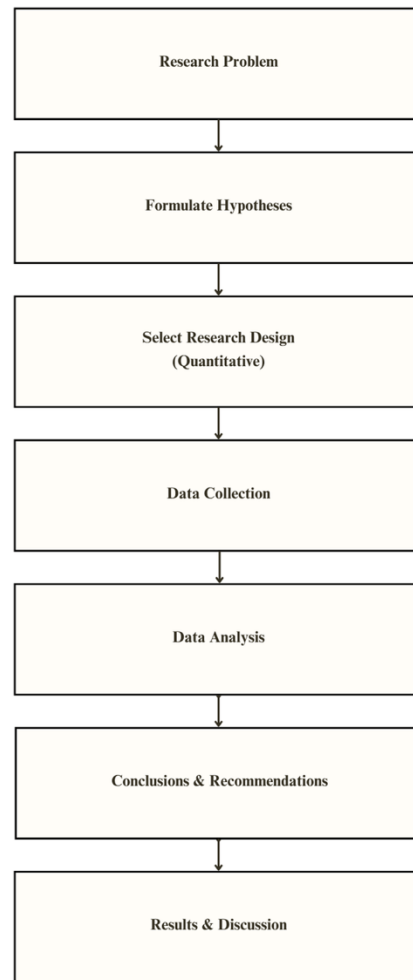


Figure III.1 Research Design

This study uses a quantitative research design based on secondary time-series data to explore the behavior of Bitcoin and gold under different market conditions. A quantitative approach is suitable for this topic because it allows the use of econometric models to examine volatility, market extremes, and portfolio performance over time. This method also supports the development of objective and data-based conclusions through statistical analysis and hypothesis testing (Creswell and Creswell, 2018).

The study applies a multi-method empirical framework that includes GARCH models for volatility analysis, quantile regression for measuring asset behavior during times of financial stress, and Sharpe ratios for evaluating portfolio performance. These techniques are chosen

because they are well-suited to financial time-series data and can provide insights into asset performance during extreme conditions, as well as assess risk-adjusted returns.

The research focuses on monthly return data for Bitcoin and gold covering the period from 2015 to 2025. The aim is to compare the safe-haven properties and diversification potential of each asset. This design also supports hypothesis testing related to asset behavior during periods of market instability and their contribution to overall portfolio stability. By combining these methods, the study offers a broader and more detailed understanding of the role that Bitcoin and gold can play in modern investment strategies.

III.2 Data Collection Method

This research obtained historical data from publicly accessible websites that provide relevant financial information. The sources used for collecting the historical data include the following:

No	Data	Website
1.	Bitcoin Price	Investing.com
2.	Gold Price	Investing.com

Table III.1 Sources of Bitcoin and Gold Price Data

This study uses monthly closing price data for Bitcoin and gold over the period from January 2015 to January 2025. The dataset captures a range of financial conditions, including periods of economic expansion, global uncertainty, and major crisis events such as the COVID-19 pandemic, the Russia–Ukraine conflict, and the global tariff war introduced by the United States in 2025. These events provide a strong foundation for examining how the two assets perform under both stressful and recovering market environments.

The data are obtained from Investing.com, a source chosen for its consistency and reliability. Monthly frequency is selected to highlight long-term patterns while reducing the impact of short-term price changes. This level of granularity is well-suited for analyzing safe-haven behavior and evaluating the diversification benefits of Bitcoin and gold.

III.3 Data Analysis Method

This section is organized into three detailed subsections, each describing the econometric method applied to evaluate the behavior of Bitcoin and gold under varying market conditions. These methods are chosen for their ability to capture the characteristics of financial time-series data, model volatility patterns, analyze asset behavior during stressful periods, and assess portfolio-level performance.

By combining GARCH models, quantile regression, and portfolio diversification analysis, the study conducts a thorough investigation into whether Bitcoin and gold display safe-haven properties and whether their combination can enhance risk-adjusted returns. The use of these approaches supports the overall goal of identifying how effective each asset is during financial uncertainty and in the context of portfolio management.

III.3.1 GARCH (Generalized Autoregressive Conditional Heteroskedasticity)

The purpose of applying the GARCH model in this study is to measure and compare the changing volatility of Bitcoin and gold returns over time. This analysis is important for evaluating the stability of each asset under different market conditions and understanding their risk profiles. The results help determine whether either asset shows volatility patterns that align with the characteristics of a safe-haven asset.

The GARCH model, introduced by Bollerslev in 1986, is an extension of the earlier ARCH model. It includes both autoregressive terms and lagged values of past conditional variances. This structure is useful for capturing volatility clustering, a common feature in financial time-series data where periods of high price movement are typically followed by further large changes, while calm periods tend to continue with smaller movements.

Formula:

The standard GARCH(1,1) model consists of a mean and a variance equation:

Mean equation: $r_t = \mu + \varepsilon_t$

Variance equation: $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1}$

Where:

r_t is the return at time t

h_t is the conditional variance

ε_t is the error term

$\alpha_0 > 0, \alpha_1 \geq 0, \beta_1 \geq 0$ are parameters to be estimated

This model helps explain how past returns and past levels of volatility influence current volatility. It is especially useful for examining how Bitcoin and gold respond to market shocks and whether their volatility continues over time, which is an important factor in assessing their safe-haven potential (Bollerslev, 1986).

III.3.2 Quantile Regression

This study uses quantile regression to investigate whether Bitcoin and gold act as safe-haven assets during times of financial distress by analyzing their behavior at lower return quantiles, such as the 0.05 and 0.10 levels. This method offers a more detailed understanding of how these assets perform under extreme market conditions by focusing on the tails of the return distribution, rather than just the average outcome. It is particularly useful for examining how assets respond differently during periods of market stress.

Quantile regression, first introduced by Koenker and Bassett in 1978, estimates the conditional quantile of a dependent variable based on certain explanatory factors. Unlike ordinary least squares (OLS), which models the average effect, quantile regression reveals how independent variables influence various parts of the distribution. This makes the method especially suitable for risk assessment and for identifying whether an asset shows defensive qualities under extreme conditions.

Formula:

$$Q_y(\tau | X) = X'\beta(\tau)$$

Where:

$Q_y(\tau | X)$ is the conditional quantile of Y given X at quantile τ

X is a vector of explanatory variables

$\beta(\tau)$ is the vector of quantile-specific coefficients

This method is especially useful for examining how Bitcoin and gold behave during severe market downturns, which is essential for evaluating their potential as safe-haven assets.

III.3.3 Portfolio Diversification Analysis

To examine the portfolio diversification aspect of this study, the research uses the principles of Modern Portfolio Theory (MPT), introduced by Markowitz in 1952. The main goal is to evaluate whether including Bitcoin and gold in a portfolio helps reduce overall risk, especially under varying market conditions.

MPT is based on the idea that investors prefer to avoid risk and aim to build portfolios that offer the highest possible return for a given level of risk. In this approach, the expected return of the portfolio is calculated as a weighted average of the returns of the individual assets. The level of risk is measured by the portfolio's variance or standard deviation, which reflects how asset returns move together.

Formula:

Portfolio Expected Return: $E(R_p) = w_1E(R_1) + w_2E(R_2)$

Portfolio Variance: $\sigma_p^2 = \sum \sum w_i w_j \text{Cov}(R_i, R_j)$

Where:

$E(R_p)$: Expected portfolio return

w_1 : Weight of asset 1 in the portfolio

$E(R_1)$: Expected return of asset 1

$\text{Cov}(R_i, R_j)$: Covariance between assets i and j

To assess the diversification potential of Bitcoin and gold, this study analyzes Sharpe ratios, and the risk-adjusted returns of portfolios that include and exclude these assets, the evaluation is based on historical monthly return data.

This approach helps to identify whether Bitcoin complements or substitutes gold, not only in terms of safe-haven characteristics but also in its ability to enhance overall portfolio efficiency (Markowitz, 1952).

III.3.4 Hypothesis Model

H1:	Gold demonstrates stronger safe-haven properties than Bitcoin during periods of market stress
H2:	Bitcoin can serve as a diversification complement to gold despite its speculative nature
H3:	Portfolio that combines Bitcoin and gold provides better risk-adjusted returns than holding either asset individually

Table III.2 Research Hypotheses

Hypothesis testing in this study is carried out using a combination of GARCH models, quantile regression, and portfolio performance analysis. The GARCH model is applied to understand volatility patterns over time, while quantile regression is used to examine how the assets behave during periods of market stress. Additionally, the Sharpe Ratio is calculated to assess whether Bitcoin and gold can improve risk-adjusted returns in a portfolio.

This combined methodological approach offers empirical evidence on the safe-haven properties of each asset and their overall contribution to portfolio diversification. The decision to use a 50:50 allocation between gold and Bitcoin is supported by both portfolio theory and empirical evidence. Modern Portfolio Theory states that the optimal portfolio weights are derived from the assets' expected returns, variances, and their correlation, with the aim of achieving the best risk-return trade-off (DeMiguel et al., 2009). In situations where the investor does not have a strong preference or reliable forecasts, an equal-weighted portfolio is widely used as a practical and unbiased diversification approach (DeMiguel et al., 2009). Many studies use a 50:50 allocation as a neutral benchmark, since it avoids overweighting either asset and

clearly demonstrates the contribution of each to the overall portfolio (Baur & Hoang, 2021). The results of this research confirm that the 50:50 combination provided the highest Sharpe ratio among all tested allocations, indicating that it offered the most attractive balance of risk and return during the sample period (Henriques, 2022). Furthermore, several professional analysts and industry reports recommend a balanced allocation between gold and Bitcoin to capture both the defensive qualities of gold and the growth potential of Bitcoin, especially in uncertain economic environments (CoinShares, 2025), it is important to emphasise that the safe-haven and hedging properties of gold and Bitcoin observed in this study are not static, but can fluctuate in response to changing macroeconomic conditions and evolving market sentiment. During periods such as the COVID-19 pandemic and geopolitical crises, significant shifts in monetary policy and investor psychology have been found to influence both the volatility and the correlation structure of these assets (Ji et al., 2020). As a result, the effectiveness of gold and Bitcoin as risk management tools must always be interpreted within the context of broader economic and sentiment-driven developments. This recognition also highlights the need for future research to consider more explicit macroeconomic or sentiment-based variables to further enhance the robustness of empirical findings (Liu & Tsyvinski, 2021).

Chapter IV Result and Discussion

IV.1 Descriptive Statistics

This section presents a comparison between Bitcoin and gold by analysing their monthly return data from January 2015 to January 2025. It covers how major global events such as the COVID-19 pandemic and the Russia–Ukraine war influenced the monthly returns of both assets, highlighting key periods of volatility and stability. The section also examines summary statistics including average returns, variation, and data distribution to provide a comprehensive overview of the performance and behaviour of Bitcoin and gold across different market conditions. These findings provide important context for the volatility and risk-return analysis in the subsequent sections.

IV.1.1 Global Events Impact on Monthly Returns of Bitcoin and Gold

To examine how global events influence the behaviour of financial assets, this section explores the monthly return fluctuations of Bitcoin and gold during key global crises. Figure IV.1 illustrates the comparative movements of both assets from January 2015 to January 2025, highlighting the volatility of Bitcoin relative to the relatively stable trajectory of gold. Notable spikes and downturns correspond to specific global events.

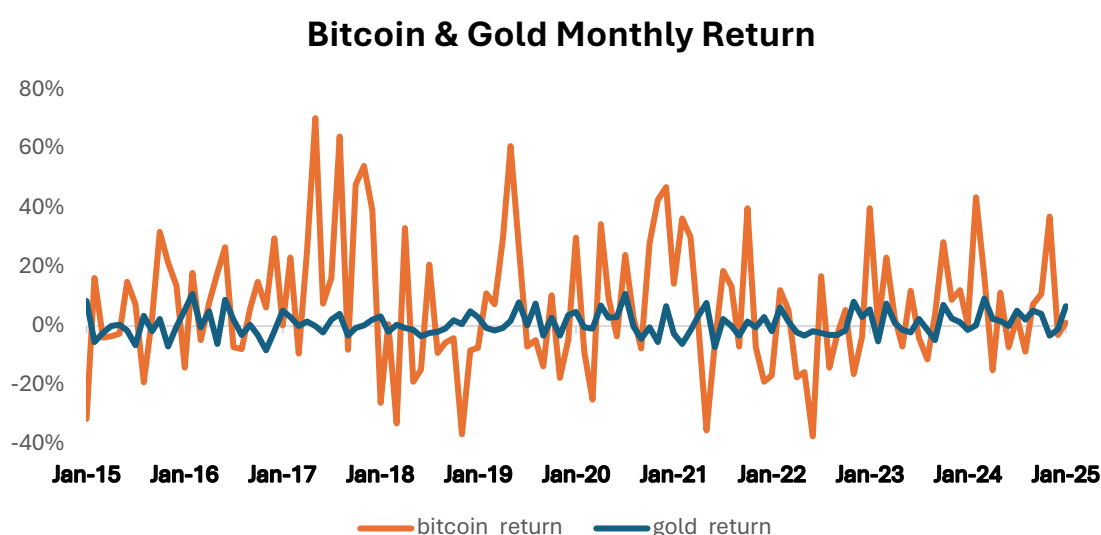


Figure IV.1 Monthly Return of Bitcoin and Gold

In the early months of the COVID-19 pandemic, global financial markets were shaken by extreme uncertainty and a sudden need for liquidity. In February 2020, investor sentiment turned negative as COVID-19 fears grew, prompting outflows from risky assets like Bitcoin, which recorded a monthly return of -8.62%, while gold decreased slightly by -0.32% (Corbet et al., 2020). The crisis peaked in March 2020, when investors moved aggressively to liquidate holdings in all asset classes to raise cash, leading to a sharp sell-off. During this period, both Bitcoin and gold suffered losses, but their performance was clearly different: Bitcoin declined by -24.94%, while gold fell only -0.86%. This gap demonstrates that gold was much more resilient and maintained its function as a safe-haven asset, even as markets experienced severe stress (Baur & Hoang, 2021). Cheema et al. (2020) also showed that gold tends to experience much smaller losses than riskier assets like Bitcoin when financial markets are in turmoil, largely due to gold's reputation as a reliable store of value. In contrast, Bitcoin's higher volatility and speculative appeal make it more vulnerable to sharp declines when risk aversion increases in global markets (Conlon & McGee, 2020). By April 2020, markets began to recover, supported by massive monetary stimulus from central banks. This policy response restored confidence and drove investors to seek higher returns. As a result, Bitcoin rebounded strongly with a monthly return of +34.56%, while gold also increased by +6.94%, reflecting renewed demand for both assets as hedges against ongoing uncertainty (Conlon & McGee, 2020).

During the Russia–Ukraine conflict in February 2022, geopolitical uncertainty triggered heightened demand for safe-haven assets. Both Bitcoin and gold posted positive monthly returns: Bitcoin rise by +12.18% and gold by +6.20%, indicating that investors were seeking protection against possible financial instability (Baur & Hoang, 2021). In March 2022, gold maintained a positive return (+1.54%), while Bitcoin continued to rise (+5.41%), suggesting that both assets remained attractive amid persistent geopolitical risks (Henriques, 2022).

However, by April 2022, returns turned negative for both: Bitcoin fell by -17.30% and gold by -2.11%. This decline can be attributed to profit-taking after initial gains, reduced panic as the situation evolved, and a partial return of funds to riskier assets. The sharper drop in Bitcoin once again illustrates its greater sensitivity to changes in investor sentiment and market volatility (Conlon & McGee, 2020).

In January 2024, following the approval of eleven US Bitcoin Spot ETFs, Bitcoin recorded a positive monthly return of +0.73%, reflecting initial optimism and increased inflows from institutional and retail investors. Gold, on the other hand, posted a negative return of -1.23% during the same month, indicating that the market reaction was concentrated in digital assets rather than traditional safe havens (Bloomberg, 2024). The momentum intensified in February 2024, as Bitcoin surged by +43.66%, driven by sustained investor enthusiasm and expanding ETF inflows that further legitimised its role in mainstream portfolios. Gold showed only a slight increase of +0.30%, underscoring that the significant market gains were specific to Bitcoin and linked directly to the growing accessibility and demand created by the new ETF products (Reuters, 2024). Research and industry reports confirm that the approval of spot Bitcoin ETFs not only enhanced market confidence but also accelerated capital allocation into Bitcoin, with limited impact on unrelated safe-haven assets such as gold (CoinShares, 2024).

Event	Month	Bitcoin Return (%)	Gold Return (%)
Covid-19 Outbreak	2020-03	-24.94	-0.86
Covid-19 Rebound	2020-04	34.56	6.94
Russia-Ukraine War Starts	2022-02	12.18	6.20
Russia-Ukraine Aftershock	2022-03	5.41	1.54
Russia-Ukraine Correction	2022-04	-17.30	-2.11
US Bitcoin Spot ETF Approved	2024-01	0.73	-1.23
ETF-Driven Bitcoin Rally	2024-02	43.66	0.30

Table IV.1 Key global events and the monthly returns of Bitcoin and gold

IV.1.2 Summary Statistics of Bitcoin and Gold Returns

To examine the average performance and fluctuations of each asset, Table 1 shows the descriptive statistics of monthly returns for both Bitcoin and gold.

Statistic	Bitcoin	Gold
Mean	0.0692	0.0079
Standard Deviation	0.2149	0.0404
Minimum	-0.3732	-0.0819
Maximum	0.7038	0.1090
Skewness	0.4964	0.3171
Kurtosis	0.1201	-0.3162
Observations	121	121

Table IV.2 Descriptive Statistics of Bitcoin and Gold Monthly Returns

Monthly return data across 121 periods highlights key differences between Bitcoin and gold in terms of return and risk. Bitcoin recorded an average monthly return of 0.0692. Gold showed a lower mean return of 0.0079, indicating stronger return potential for Bitcoin. However, Bitcoin also showed greater volatility, with a standard deviation of 0.2149 compared to gold's 0.0404. The lowest return for Bitcoin was negative 0.3732, while gold's minimum was negative 0.0819, reflecting Bitcoin's exposure to deeper losses during adverse market conditions. On the other end, Bitcoin reached a maximum return of 0.7038, which was significantly higher than gold's peak of 0.1090. Both assets displayed positive skewness, with values of 0.4964 for Bitcoin and 0.3171 for gold, indicating more frequent large positive outcomes. Kurtosis values also differed, with Bitcoin at 0.1201, suggesting occasional extreme movements, and gold at negative 0.3162, pointing to a more regular distribution pattern. In conclusion, Bitcoin delivered higher potential for return but involved substantially greater risk, while gold remained relatively stable and aligned with its historical function as a safe-haven asset.

This finding is consistent with the research of Klein et al. (2018), who observed that Bitcoin offers higher returns alongside extreme volatility, while gold retains its value more effectively during market stress, confirming its role as a safe-haven asset

IV.2 GARCH Model – Volatility Analysis

This section discusses the results of the GARCH(1,1) model, which is used to examine how the monthly returns of Bitcoin and gold change over time. The model helps to evaluate the level of risk in each asset and assess whether they act as safe-haven assets during times of market instability.

IV.2.1 GARCH(1,1) Estimation for Bitcoin and Gold

The GARCH(1,1) model was applied to measure the changing volatility of Bitcoin and gold. It considers how previous periods of volatility and market shocks affect current volatility, which makes it appropriate for studying financial time-series data.

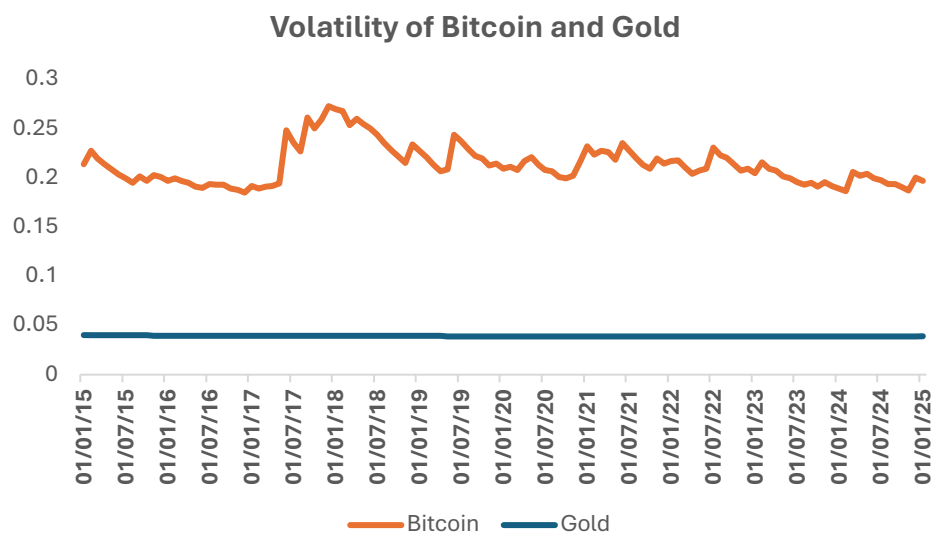


Figure IV.2 GARCH(1,1) Estimated Volatility of Bitcoin and Gold (2015–2025)

As shown in Figure IV.2, Bitcoin demonstrates significantly higher and more dynamic volatility compared to gold, which remains consistently low and stable throughout the period. This result is in line with Bouri et al. (2021), who found that Bitcoin exhibits time-varying volatility and is more responsive to market shocks, while gold maintains its traditional role as a stable safe-haven asset.

The results are summarized in the table below:

Asset	μ (mu)	ω (omega)	α_1 (alpha1)	β_1 (beta1)
Bitcoin	0.0666	0.0055	0.0626	0.8160
Gold	0.0079	0.000065	3.901330e-11	0.9568

Table IV.3 GARCH(1,1) Estimation Results for Bitcoin and Gold

These values represent the estimated coefficients of the GARCH(1,1) model for each asset:

Mu (μ): The average return

Omega (ω): The long-run average volatility

Alpha1 (α_1): The impact of recent news or shocks on current volatility

Beta1 (β_1): The persistence of past volatility over time

IV.2.2 Volatility Persistence Comparison

Volatility persistence is measured by the sum of α_1 and β_1 . A higher sum indicates that volatility remains for a longer period after a shock

Bitcoin: $\alpha_1 + \beta_1 = 0.0626 + 0.8160 = 0.8786$

Gold: $\alpha_1 + \beta_1 = 3.90 \times 10^{-11} + 0.9569 = 0.9569$

IV.2.3 Implication for Safe-Haven Reliability

The GARCH results show clear differences in how Bitcoin and gold respond to volatility over time. Gold has a very low alpha and a high beta, which suggests that its volatility does not change much when market shocks occur. This supports gold's reputation as a safe-haven asset, since it tends to stay stable during times of financial stress. Bitcoin shows a higher alpha and a lower beta. This means it reacts more quickly to new market information, leading to higher volatility. As a result, Bitcoin is less dependable as a safe-haven asset during crisis periods.

These results support the view that gold remains a traditional safe-haven asset. In contrast, Bitcoin's more reactive and unstable nature makes it less suitable for protecting investment portfolios during periods of market uncertainty.

This finding is supported by Yae and Tian (2024), who concluded that Bitcoin's extreme volatility and strong reaction to market news undermine its reliability as a safe haven, whereas gold maintains its stability and value under uncertain market conditions

IV.3 Quantile Regression: Safe-Haven Behavior

This section looks at whether Bitcoin and gold can act as safe-haven assets by examining their performance in the lowest parts of the return distribution through quantile regression. This method helps to see how each asset behaves during sharp market declines, specifically focusing on the 5th and 10th percentiles of returns.

IV.3.1 Bitcoin and Gold Returns in Lower Quantiles (5% and 10%)

To understand how each asset reacts during market stress, quantile regression was applied at the 5th and 10th percentiles. These levels reflect times when the market is under heavy pressure.

Asset	5 th Quantile Coefficient	10 th Quantile Coefficient
Bitcoin	-0.2494	-0.1670
Gold	-0.0548	-0.0329

Table IV.4 Quantile Regression Results (5th & 10th Percentiles)

The regression results reveal that Bitcoin faces strongly negative returns at both the 5th and 10th percentiles. At the 5th quantile, the coefficient of -0.2494 suggests that Bitcoin typically loses about 24.94 percent during the worst market conditions. At the 10th percentile, the loss is around 16.70 percent. These outcomes highlight Bitcoin's weakness during times of financial stress.

Gold also shows negative coefficients, but the values are much smaller which is -5.48 percent at the 5th percentile and -3.29 percent at the 10th percentile. This suggests that while gold is not completely unaffected during downturns, its losses are much milder compared to Bitcoin.

IV.3.2 Interpretation across Quantiles and Market Stress Condition

The quantile regression results show clear differences in how Bitcoin and gold behave during periods of market stress. Bitcoin experiences sharp drops at the lowest quantiles, which shows

its weak ability to protect investors during crises. The large negative coefficients suggest that Bitcoin often moves along with the broader market when conditions are poor, making it an unreliable safe-haven asset.

On the other hand, gold also shows some losses in the lower percentiles, but the drops are smaller. This suggests that gold is more stable and better at holding value when markets are under pressure, which matches its long-standing role as a safe asset during economic downturns.

In summary, the findings support the idea that gold provides stronger downside protection in times of financial stress, while Bitcoin lacks the characteristics of a true safe-haven asset. This conclusion is further reinforced by the research of Ben Ameer et al. (2024), who employed quantile regression and found that Bitcoin exhibits large negative returns during market crashes, while gold experiences only mild losses. Similarly, Kumar and Padakandla (2022) demonstrated that gold consistently provided downside protection at the lower quantiles during the COVID-19 crisis, whereas Bitcoin's performance was unstable and failed to meet the criteria of a reliable safe haven. In addition, Long et al. (2021) observed that Bitcoin tends to move alongside declining markets during periods of uncertainty, while gold maintains a negative correlation with risk assets, confirming its effectiveness in protecting investors during downturns.

IV.4 Portfolio Diversification

This section examines how well Bitcoin, gold, and a mix of both improve portfolio performance. The focus is on the Sharpe Ratio, which measures return in relation to risk. The goal is to see whether combining the two assets offers better risk-return results through diversification.

IV.4.1 Portfolio Expected Return and Risk (Markowitz Model)

This section applies the formal principles of Modern Portfolio Theory (MPT), developed by Markowitz (1952), to examine the risk and return characteristics of a portfolio comprising Bitcoin and gold. While previous sections discussed the performance of each asset in isolation, the focus here shifts to evaluating their combined behaviour when allocated equally in a portfolio.

The aim is to assess whether diversification between these two assets leads to a more efficient investment outcome. Specifically, the expected return and risk (measured by standard deviation) of the portfolio are calculated using historical data from 2015 to 2025. The analysis assumes a balanced allocation, with 50 percent invested in Bitcoin and 50 percent in gold. Monthly average returns and standard deviations for each asset are taken from the descriptive statistics presented in Section IV.1, while the correlation coefficient between the two is assumed to be moderately positive, reflecting typical market conditions during the observed period.

By quantifying the risk-return profile of this mixed portfolio, this section seeks to provide empirical support for the diversification benefits proposed by MPT, particularly in the context of combining a volatile digital asset with a traditionally stable store of value.

The expected return of a two-asset portfolio can be determined using the following formula:

$$E(R_p) = w_1 E(R_1) + w_2 E(R_2)$$

Where:

$E(R_p)$ represents the expected return of the portfolio

w_1 and w_2 are the weights of bitcoin and gold

$E(R_1)$ and $E(R_2)$ represent the expected returns of Bitcoin and gold

Assuming an equal-weighted portfolio ($w_1=w_2=0.5$), with average monthly returns of 6.92% for Bitcoin and 0.79% for gold, the expected portfolio return is calculated as follows:

$$E(R_p) = (0.5 \times 0.0692) + (0.5 \times 0.0079) = 0.03855$$

The expected monthly return of the portfolio is 3.855%

To measure the risk associated with the portfolio, the standard deviation is derived from the following variance formula:

$$\sigma_p^2 = w_1^2 \cdot \sigma_1^2 + w_2^2 \cdot \sigma_2^2 + 2 \cdot w_1 \cdot w_2 \cdot \rho \cdot \sigma_1 \cdot \sigma_2$$

Where:

ρ = Pearson Correlation

σ_1 and σ_2 are the standard deviations of Bitcoin and gold returns

w_1 and w_2 are the weights of bitcoin and gold

Based on the descriptive statistics in Section IV.1, $\sigma_1 = 0.2149$ and $\sigma_2 = 0.0404$, The Pearson Correlation coefficient between Bitcoin and gold monthly returns from 2015 to 2025 is 0.0752, indicating a very weak positive linear relationship. This suggests that the two assets are largely uncorrelated, supporting the foundational assumptions of Modern Portfolio Theory (Markowitz, 1952).

The Portfolio Risk formula is calculated as follows:

$$\sigma_p^2 = (0.5^2 \times 0.2149^2) + (0.5^2 \times 0.0404^2) + 2 \times 0.5 \times 0.5 \times 0.0752 \times 0.2149 \times 0.0404$$

$$\sigma_p^2 = 0.01288 \gg \sigma_p = \sqrt{0.01228} = 0.1108$$

To analyze the effect of this low correlation on portfolio risk, the standard deviation of a 50/50 portfolio was calculated using the Markowitz variance formula. The resulting portfolio volatility was 0.1108, which is substantially lower than Bitcoin's individual volatility (0.2149) and only modestly higher than that of gold (0.0404). This outcome demonstrates that even a minimal correlation coefficient can significantly reduce total portfolio risk, offering a clear diversification advantage. The result is consistent with Bhuiyan et al. (2023), who found

Bitcoin and gold exhibit weak co-movement under normal conditions. Similarly, Yae and Tian (2024) emphasised the distinct financial behaviour of Bitcoin and gold, which contributes to their low covariance. Overall, the combined empirical evidence and calculated risk reduction underscore the utility of blending these assets to enhance portfolio efficiency.

IV.4.2 Sharpe Ratio Comparison

To assess how each asset performs in terms of risk-adjusted return, Sharpe Ratios were calculated for three types of portfolios: one with only Bitcoin, one with only gold, and one with an even 50/50 mix of both. The risk-free rate used in this analysis is taken from the average monthly compounded yield of the U.S. 10-Year Treasury Bond from January 2015 to January 2025, which is around 0.2044% per month.

Portfolio	Sharpe Ratio
Bitcoin Only	0.3125
Gold Only	0.1459
50/50 Mixed	0.3296

Table IV.5 Sharpe Ratios of Bitcoin, Gold, and Mixed Portfolios

The Bitcoin-only portfolio shows a Sharpe Ratio of 0.3125, which suggests a fairly strong return when adjusted for its high risk. In comparison, the gold-only portfolio has a lower Sharpe Ratio of 0.1459, highlighting its position as a safer but lower-yielding asset.

The 50/50 mixed portfolio reaches the highest Sharpe Ratio of 0.3296. This suggests that blending Bitcoin and gold improves risk-adjusted performance, even though gold has lower returns on its own. The result shows how diversification can make a portfolio more efficient.

IV.4.3 Diversification Impact and Risk-Return Profile

The analysis of the mixed portfolio shows that holding both Bitcoin and gold brings real diversification benefits. While Bitcoin offers higher returns on its own, it also carries much greater risk. Gold, in contrast, provides more stable returns with less volatility.

The higher Sharpe Ratio in the mixed portfolio suggests that combining these two assets creates a better balance between risk and return. This improvement mainly comes from the fact that

Bitcoin and gold do not move in the same direction all the time. Because of this weak correlation, the overall risk of the portfolio is lower compared to holding just one asset.

The effect of diversification helps reduce total portfolio risk without cutting returns by the same amount, which increases risk-adjusted performance. These results support the idea that, even though Bitcoin is more speculative, it can still play a helpful role in a portfolio when combined with gold.

In summary, the portfolio findings suggest that splitting investments between Bitcoin and gold leads to a stronger risk-return profile. This confirms the view that diversification between the two improves overall investment performance. These results are further supported by Shahzad et al. (2019), who showed that Bitcoin delivers higher returns while carrying greater risk, whereas gold provides stability. A portfolio that includes both assets becomes more efficient in terms of Sharpe Ratio. Similarly, Symitsi and Chalvatzis (2019) found that including both Bitcoin and gold significantly enhances portfolio performance. This improvement is attributed to their low correlation, which contributes to a more balanced risk-return trade-off. In addition, Pal and Mitra (2019) emphasized that the weak correlation between Bitcoin and gold allows them to complement each other effectively in a portfolio. As a result, the overall risk is reduced and the portfolio achieves better risk-adjusted outcomes compared to holding either asset alone.

IV.5 Hypothesis Discussion

This section reviews the hypotheses stated in Chapter I by drawing conclusions from the findings discussed earlier. Each hypothesis is examined one by one, and its acceptance or rejection is based on the results from volatility analysis, quantile regression, and portfolio performance indicators.

IV.5.1 Hypothesis 1: Safe-Haven Superiority of Gold

Hypothesis 1 (H1): Gold consistently demonstrates stronger safe-haven properties than Bitcoin during financial stress. This hypothesis is supported by the quantile regression results presented

in Section IV.3. The analysis showed that gold had smaller negative coefficients at both the 5th and 10th percentiles of returns when compared to Bitcoin. Specifically, Bitcoin recorded coefficients of -0.2494 at the 5th percentile and -0.1670 at the 10th, reflecting significant losses under stressed market conditions. In contrast, gold's coefficients were -0.0548 and -0.0329 , indicating milder drawdowns.

These findings confirm that gold offers more effective downside protection during financial turbulence, reinforcing its reputation as a traditional safe-haven asset. In contrast, Bitcoin showed greater sensitivity to market downturns, reducing its reliability in times of stress. This conclusion is further supported by Fabris and Ješić (2023), who used quantile regression to demonstrate that gold provides stronger downside protection during financial stress, while Bitcoin tends to move with the broader market. Therefore, Hypothesis 1 is accepted.

IV.5.2 Hypothesis 2: Bitcoin as a Diversification Complement

Hypothesis 2 (H2): Bitcoin can serve as a diversification complement to gold, improving the portfolio's risk-return balance. This hypothesis is supported by the findings in Section IV.4. The portfolio that combined Bitcoin and gold in equal weights achieved a Sharpe Ratio of 0.3296 , which is higher than the Sharpe Ratios of the Bitcoin-only (0.3125) and gold-only (0.1459) portfolios.

The improved Sharpe Ratio shows that Bitcoin, despite its higher volatility, can enhance the performance of a gold-based portfolio. This benefit comes from the weak correlation between the two assets, which helps lower overall risk more effectively than holding either one alone. This result aligns with the findings of Bhuiyan et al. (2023), who demonstrated that Bitcoin and gold exhibit low correlation, and that combining the two assets enhances diversification and improves the portfolio's overall risk-return trade-off. Therefore, Hypothesis 2 is accepted.

IV.5.3 Hypothesis 3: Portfolio Performance Enhancement

Hypothesis 3 (H3): A Bitcoin-gold mixed portfolio yields higher risk-adjusted returns than Bitcoin-only or gold-only portfolios. This hypothesis is directly supported by the Sharpe Ratio comparison. Among the three portfolio types, the 50/50 Bitcoin-gold portfolio recorded the highest Sharpe Ratio, reflecting the strongest risk-adjusted performance.

This result confirms that combining Bitcoin and gold improves portfolio efficiency through diversification. Since the mixed portfolio outperforms both Bitcoin-only and gold-only portfolios in balancing risk and return, the evidence clearly supports the hypothesis. This conclusion is further supported by Bakry et al. (2021), who found that portfolios combining Bitcoin with other assets achieved higher Sharpe Ratios, confirming that a Bitcoin–gold mix can outperform individual-asset portfolios in terms of risk-adjusted returns. Therefore, Hypothesis 3 is accepted.

IV.6 Implementation Plan & Justification

This research highlights the importance of using a dual asset investment strategy that includes both Bitcoin and gold, based on data from 2015 to 2025. Gold regularly acts as a safe asset during times of economic stress. It keeps its value and serves as a strong protection. These features support its role in lowering risk in investment portfolios (Baur & Hoang, 2021). On the other hand, Bitcoin, even though it is more volatile, offers good benefits for portfolio diversification. Since it does not move the same way as gold, Bitcoin can improve overall returns without raising risk too much. Combining Bitcoin with gold does not take away gold's role as a safe asset. Instead, it helps improve returns. This idea follows Modern Portfolio Theory, which supports mixing assets that do not move together to get better risk and return results (Henriques, 2022). This research also shows through Sharpe ratio tests that portfolios holding both Bitcoin and gold perform better than those holding only one asset. The combination helps investors benefit from Bitcoin's growth while keeping the balance and safety that gold provides. But instead of sticking with a fixed 50:50 split, investors can do better

by using flexible strategies. These include adjusting the mix of Bitcoin and gold based on what is happening in the market. For example, during uncertain times like the COVID-19 pandemic, it would be wise to increase gold to 70 percent (Conlon & McGee, 2020). During positive events such as Bitcoin ETF approval, Bitcoin could be raised to 70 percent (CoinShares, 2024). Another method is volatility-based allocation, where more money is put into the asset that is more stable. If Bitcoin becomes very volatile, the mix could shift to 70 percent gold and 30 percent Bitcoin (Hung et al., 2022). If Bitcoin becomes more stable, it could rise to 40 to 50 percent of the portfolio (Morris, 2025). A third method is momentum-based investing. This means giving more weight to the asset that has gone up recently. When Bitcoin is rising, its share could go as high as 80 to 100 percent. If it is falling, gold would become the larger share (Grayscale Investments, 2023).

To turn these ideas into action, investors should slowly bring both assets into their portfolios, using the flexible strategies. This plan should fit their long-term goals and comfort with risk. Bitcoin's share should stay under control to avoid sudden losses, while gold should keep its job of providing safety.

The plan should begin with detailed reviews by portfolio managers. Gold can be added through exchange-traded funds or by owning it directly. Bitcoin can be added using trusted investment platforms or legal financial products. To make sure this works well, investors need to keep checking performance, watching risks, and rebalancing when needed.

This dual asset strategy, with added flexible tools, is useful for large funds and experienced individual investors who want more stable returns. By using gold for safety and Bitcoin for growth, this strategy builds a stronger and more balanced portfolio. The results from this study show clearly that using both assets, and adjusting their mix as conditions change, leads to better outcomes than using only one. With regular reviews and smart changes, this flexible plan can help investors face market risks more confidently.

Chapter V Conclusion and Recommendation

V.1 Summary of Findings

The study examined the roles of gold and Bitcoin as safe-haven and diversification assets using quantitative methods to test three main hypotheses: (H1) gold consistently demonstrates stronger safe-haven properties than Bitcoin; (H2) Bitcoin complements gold in diversification strategies; and (H3) a combined portfolio of gold and Bitcoin offers better risk-adjusted returns than single-asset portfolios.

The analysis began with descriptive statistics, highlighting gold's stable and low volatility returns, compared to Bitcoin's higher and more unpredictable volatility. GARCH volatility analysis further demonstrated Bitcoin's higher volatility, supporting gold's suitability for risk-averse investors, particularly during financial instability (Dyhrberg, 2016). Quantile regression analysis at extreme market downturns (5th and 10th quantiles) confirmed that gold experienced limited losses during financial stress, strongly supporting hypothesis H1 (Chemkha, 2021). Conversely, Bitcoin showed notably larger losses, indicating its unreliability as a consistent safe-haven. Portfolio diversification analysis using the Sharpe ratio revealed that combining Bitcoin and gold improved risk-adjusted returns significantly, thus validating hypotheses H2 and H3. In summary, the study confirmed gold's reliability as a safe-haven asset, highlighted Bitcoin's diversification benefits, and demonstrated the advantages of their combination to enhance overall portfolio efficiency.

V.2 Implications

These findings align with Modern Portfolio Theory (Markowitz, 1952), emphasizing portfolio risk reduction by combining assets with low correlations. This study contributes to existing literature by illustrating how traditional assets (gold) and emerging digital assets (Bitcoin) can jointly enhance portfolio risk-return characteristics. Additionally, it broadens the understanding of safe-haven assets by integrating digital assets known for their distinct volatility profiles.

Practically, investors, both individual and institutional, should prioritize gold for capital preservation during market volatility (Chemkha, 2021). Bitcoin, despite its volatility, can enhance diversification benefits when carefully included in portfolios. Portfolio managers should clearly define asset allocation policies, where gold serves as the primary asset for capital protection and Bitcoin functions as a complementary asset for growth-oriented diversification. Effective portfolio management will involve setting risk boundaries, regular volatility monitoring, and enforcing strict governance to manage risks associated with each asset (Klein, 2018).

V.3 Implementation and Recommendations

The study recommends adopting a dynamic investment strategy combining gold and Bitcoin. Gold should dominate the portfolio, especially during increased market uncertainty, due to its proven safe-haven capabilities (Chemkha, 2021). Bitcoin's inclusion should be controlled, focusing primarily on diversification to enhance returns. Portfolio rebalancing should be performed regularly, ideally quarterly, adjusting asset proportions according to market conditions. During heightened volatility, increasing gold's proportion can protect against potential losses (Będowska Sójka, 2021). Conversely, during periods of lower volatility, cautiously increasing Bitcoin's allocation may enhance returns, provided exposure remains within acceptable risk limits. Institutional investors should ensure robust governance and compliance, restricting Bitcoin investments to regulated financial instruments like ETFs or secured custodial products.

V.4 Limitations and Future Research

Despite these contributions, the study has limitations. It exclusively analyzed gold and Bitcoin, excluding other potential assets such as government bonds, equities, commodities, or stablecoins. Future research should include these additional assets for a comprehensive diversification analysis (Klein, 2018). Additionally, the dataset concludes in January 2025, and

given cryptocurrency market volatility and evolving regulations, future studies should extend the analysis period to account for emerging dynamics. Methodologically, the study employed static models (GARCH and quantile regression); dynamic models such as dynamic conditional correlation (DCC) or copula-based methods could provide deeper insights into evolving asset relationships (Będowska Sójka, 2021). Lastly, future research could examine macroeconomic influences, including inflation, interest rate changes, and monetary policies, to better understand their impacts on safe-haven and speculative behaviors of gold and Bitcoin. Such analyses would offer more detailed guidance for investment strategies under diverse economic scenarios.

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Appendix A. Risk Free Rate

Date	Rate	Date	Rate
01/01/25	0.00370842	12/01/19	0.00158527
12/01/24	0.00373242	11/01/19	0.00146645
11/01/24	0.00341592	10/01/19	0.0013959
10/01/24	0.00349936	09/01/19	0.00137949
09/01/24	0.00310154	08/01/19	0.00124067
08/01/24	0.00320056	07/01/19	0.00165731
07/01/24	0.00330026	06/01/19	0.00165731
06/01/24	0.00358833	05/01/19	0.00176036
05/01/24	0.00367721	04/01/19	0.00206309
04/01/24	0.00382036	03/01/19	0.00198404
03/01/24	0.00343919	02/01/19	0.00223645
02/01/24	0.0034777	01/01/19	0.00216812
01/01/24	0.0032078	12/01/18	0.00221124
12/01/23	0.00316595	11/01/18	0.00246059
11/01/23	0.00353864	10/01/18	0.00258704
10/01/23	0.00401514	09/01/18	0.00251897
09/01/23	0.00373802	08/01/18	0.00235265
08/01/23	0.00335891	07/01/18	0.00243544
07/01/23	0.00324721	06/01/18	0.00235265
06/01/23	0.00314583	05/01/18	0.00235265
05/01/23	0.00298871	04/01/18	0.00242976
04/01/23	0.00281678	03/01/18	0.00225596
03/01/23	0.00284909	02/01/18	0.0023559
02/01/23	0.00321584	01/01/18	0.0022332
01/01/23	0.00287897	12/01/17	0.00198241
12/01/22	0.00317642	11/01/17	0.00199056
11/01/22	0.00296048	10/01/17	0.00196039
10/01/22	0.00331393	09/01/17	0.00192858
09/01/22	0.00313617	08/01/17	0.00175055
08/01/22	0.0026251	07/01/17	0.00189349
07/01/22	0.00218847	06/01/17	0.00190002
06/01/22	0.00248006	05/01/17	0.00182
05/01/22	0.00234372	04/01/17	0.00188778
04/01/22	0.00241597	03/01/17	0.00196936
03/01/22	0.00193347	02/01/17	0.00197589
02/01/22	0.0015058	01/01/17	0.00203213
01/01/22	0.00147465	12/01/16	0.00201583
12/01/21	0.00125135	11/01/16	0.00197018
11/01/21	0.00120531	10/01/16	0.00150908
10/01/21	0.00129162	09/01/16	0.00132201
09/01/21	0.00123491	08/01/16	0.00130558
08/01/21	0.0010827	07/01/16	0.00120038
07/01/21	0.00101597	06/01/16	0.00122093
06/01/21	0.00121518	05/01/16	0.00152957
05/01/21	0.00130805	04/01/16	0.00151645
04/01/21	0.00134501	03/01/16	0.00146317

03/01/21	0.00144184	02/01/16	0.00143692
02/01/21	0.00116501	01/01/16	0.00158855
01/01/21	0.00088815	12/01/15	0.00187145
12/01/20	0.00076015	11/01/15	0.00182164
11/01/20	0.00069897	10/01/15	0.00177098
10/01/20	0.00072543	09/01/15	0.00168022
09/01/20	0.00056988	08/01/15	0.00182654
08/01/20	0.00058644	07/01/15	0.00180448
07/01/20	0.00044309	06/01/15	0.00193674
06/01/20	0.00054669	05/01/15	0.00175218
05/01/20	0.00054254	04/01/15	0.00168022
04/01/20	0.00053675	03/01/15	0.00159182
03/01/20	0.00055497	02/01/15	0.00164913
02/01/20	0.00096404	01/01/15	0.00135568
01/01/20	0.0012456	AVERAGE	0.00204424

Appendix B. R Script

```
-----  
# CHAPTER IV.1: Descriptive Statistics  
-----
```

```
-----  
# STEP 1: Install e1071  
-----
```

```
install.packages("e1071")  
library(e1071)
```

```
-----  
# STEP 2: Calculate Summary Statistics  
-----
```

```
summary_stats <- data.frame(  
  Statistic = c("Mean", "Standard Deviation", "Minimum", "Maximum", "Skewness",  
"Kurtosis", "Observations"),  
  Bitcoin = c(  
    mean(data$bitcoin_return, na.rm = TRUE),  
    sd(data$bitcoin_return, na.rm = TRUE),  
    min(data$bitcoin_return, na.rm = TRUE),  
    max(data$bitcoin_return, na.rm = TRUE),  
    e1071::skewness(data$bitcoin_return, na.rm = TRUE),  
    e1071::kurtosis(data$bitcoin_return, na.rm = TRUE),  
    length(data$bitcoin_return)  
  ),  
  Gold = c(  
    mean(data$gold_return, na.rm = TRUE),  
    sd(data$gold_return, na.rm = TRUE),  
    min(data$gold_return, na.rm = TRUE),  
    max(data$gold_return, na.rm = TRUE),  
    e1071::skewness(data$gold_return, na.rm = TRUE),  
    e1071::kurtosis(data$gold_return, na.rm = TRUE),  
    length(data$gold_return)  
  )  
)  
  
print(summary_stats)
```

```
-----  
# CHAPTER IV.2: GARCH Model - Volatility Analysis  
-----
```

```
-----  
# STEP 1: Install and Load Required Packages ("rugarch" and "readxl")  
-----
```

```
install.packages("rugarch")  
library(rugarch)
```

```

install.packages("readxl")
library(readxl)

-----
# STEP 2: Import Excel File
-----
# Read Excel file
data <- read_excel("master_dataset.xlsx")

# Check data
head(data)

-----
# STEP 3: Convert Returns to Time Series
-----
btc_ret <- as.numeric(data$bitcoin_return)
gold_ret <- as.numeric(data$gold_return)

-----
# STEP 4: Specify GARCH(1,1) Model
-----
# Bitcoin
btc_spec <- ugarchspec(variance.model = list(model = "sGARCH", garchOrder = c(1,1)),
                      mean.model = list(armaOrder = c(0,0), include.mean = TRUE),
                      distribution.model = "norm")

# Gold
gold_spec <- ugarchspec(variance.model = list(model = "sGARCH", garchOrder = c(1,1)),
                      mean.model = list(armaOrder = c(0,0), include.mean = TRUE),
                      distribution.model = "norm")

-----
# STEP 5: Fit the Models
-----
btc_fit <- ugarchfit(spec = btc_spec, data = btc_ret)
gold_fit <- ugarchfit(spec = gold_spec, data = gold_ret)

-----
# STEP 6: View GARCH Results
-----
# Bitcoin GARCH coefficients
coef(btc_fit)

# Gold GARCH coefficients
coef(gold_fit)

# Full summary
show(btc_fit)
show(gold_fit)

```

```
-----  
# STEP 7: Plot Volatility  
-----
```

```
plot(btc_fit, which = 3) # Conditional standard deviation (volatility)  
plot(gold_fit, which = 3)
```

```
-----  
# CHAPTER IV.3: Quantile Regression  
-----
```

```
-----  
# STEP 1: Install packages  
-----
```

```
install.packages("quantreg")  
library(quantreg)
```

```
-----  
# STEP 2: Run quantile regression at 5% and 10% for Bitcoin and Gold  
-----
```

```
# 5th percentile regression  
bitcoin_qr_5 <- rq(bitcoin_return ~ 1, tau = 0.05, data = data)  
gold_qr_5 <- rq(gold_return ~ 1, tau = 0.05, data = data)
```

```
# 10th percentile regression  
bitcoin_qr_10 <- rq(bitcoin_return ~ 1, tau = 0.10, data = data)  
gold_qr_10 <- rq(gold_return ~ 1, tau = 0.10, data = data)
```

```
-----  
# STEP 4: Regression results  
-----
```

```
summary(bitcoin_qr_5)  
summary(gold_qr_5)  
summary(bitcoin_qr_10)  
summary(gold_qr_10)
```

```
-----  
# CHAPTER IV.4: Portfolio Diversification  
-----
```

```
-----  
# STEP 1: Calculate mean and standard deviation of returns  
-----
```

```
mean_btc <- mean(data$bitcoin_return)  
sd_btc <- sd(data$bitcoin_return)
```

```
mean_gold <- mean(data$gold_return)  
sd_gold <- sd(data$gold_return)
```

```
-----  
# STEP 2: Set risk-free rate  
-----
```

```
risk_free <- 0.00204424 # 0.2044% monthly
```

```
-----  
# STEP 3: Calculate Sharpe Ratios for Bitcoin and Gold  
-----
```

```
sharpe_btc <- (mean_btc - risk_free) / sd_btc  
sharpe_gold <- (mean_gold - risk_free) / sd_gold
```

```
-----  
# STEP 4: Calculate Sharpe Ratio for 50/50 Portfolio  
-----
```

```
# Mean return of the mixed portfolio (50/50)  
mean_mixed <- (mean_btc + mean_gold) / 2
```

```
# Portfolio standard deviation with equal weights  
cov_btc_gold <- cov(data$bitcoin_return, data$gold_return)
```

```
sd_mixed <- sqrt((sd_btc^2 + sd_gold^2) / 4 + cov_btc_gold / 2)
```

```
# Sharpe Ratio for the mixed portfolio  
sharpe_mixed <- (mean_mixed - risk_free) / sd_mixed
```

```
#Result  
sharpe_btc  
sharpe_gold  
sharpe_mixed
```

Appendix C. Historical Price of Bitcoin (2015-2025)

Published on Investing.com, 10/Jan/2025 - 8:32:37 GMT, Powered by TradingView.
Bitcoin, Investing.com:BTCUSD, M



Appendix D. Historical Price of Gold (2015-2025)

Published on Investing.com, 10/Jun/2025 - 8:38:11 GMT, Powered by TradingView.
XAU/USD, Real-time Currencies:XAU/USD, M

