ERASMUS UNIVERSITY ROTTERDAM
ERASMUS SCHOOL OF ECONOMICS
Bachelor Thesis Economics & Business
Specialization: Financial Economics

Bitcoin and Ethereum still cannot replace Precious Metals.

Comparison of volatility, correlation, and portfolio performance

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Finish date: 7 July 2024

The views stated in this thesis are those of the author and not necessarily those of the supervisor, second reader, Erasmus School of Economics or Erasmus University Rotterdam.

ABSTRACT

This article replicates the strategy method of Klein et al. (2018) in the paper 'Bitcoin is the New Gold,' testing the volatility, correlation, and portfolio performance of Gold and Bitcoin from 01/07/2011 to 31/12/2017. Since then, Bitcoin and cryptocurrencies in general have seen great advancements. The data of Bitcoin, Ethereum, Gold, and Silver from 1/1/2018 to 1/4/2024 will be analyzed here. Using Klein et al. (2018) method, Gold is still a superior asset in terms of volatility, being a hedging tool and a safe haven. However, I find that Bitcoin and Ethereum performed more similarly to Gold than during the previous period in terms of correlation to indexes.

Keywords: Bitcoin, Gold, Cryptocurrencies, Hedge

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CHAPTER 1 Introduction

This study will provide valuable insights into the difference between precious metals and cryptocurrencies as investment assets, exploring the unique traits, patterns, and roles of each within diversified investment portfolios. The integration of traditional finance with rising digital assets has generated noteworthy attention and discussion among investors, regulators, and academics in recent times. This study is critical given the current state of the financial markets, where cryptocurrencies, best exemplified by Bitcoin, have become viable alternatives to or additions to more conventional safe-haven assets like gold. For instance, investors often hold assets perceived to retain value and act as hedges against market volatility during economic uncertainty, political instability, or inflationary pressures. Precious metals have always served as a reliable safe haven, valued for their inherent worth, rarity, and established reputation as a store of wealth (*Gold as a Strategic Asset*, 2024). The most recent example of this is how Gold has been creating all-time high prices since economic uncertainties like Covid 19, the Russian-Ukraine war, and Israel Hamas war. The rise of cryptocurrencies has brought about new options, with supporters claiming that because digital assets like Bitcoin have similar scarcity, durability, and decentralization qualities, they are desirable options for financial risk hedging. By conducting a comparative analysis, this study aims to shed light on the properties, correlation structures, hedging capabilities, and potential implications of incorporating cryptocurrencies and precious metals into diversified investment strategies in recent years. This will provide valuable insights for investors, portfolio managers, and policymakers navigating the complexities of modern financial markets. Therefore, the research question is how do the properties, correlation structures, and hedging capabilities of cryptocurrencies compare to those of traditional precious metals?

The methodology from the paper 'Bitcoin is the New Gold' by Klein et al. (2018) will be replicated in this study to analyze the properties of conditional variance, perform dynamic correlation modeling, and compare portfolio-based outcomes. Klein et al. (2018) provide a comparative analysis of Bitcoin, Gold, and other traditional investment assets over the period from 01/07/2011 to 31/12/2017. They found that Gold and Bitcoin perform oppositely as safe assets in times of market distress and Bitcoin shows no evidence of stable hedging capabilities. However, since 31/12/2017 the market capitalization of Bitcoin has grown from 237 billion dollars to 1.372 trillion dollars. The cryptocurrency market has seen surging institutional adoption, decentralized finance platform emergence, regulatory advancements, and proliferation of new cryptocurrencies and blockchain applications, driving exponential growth and reshaping the financial landscape. One example is the approval of 11 spot Bitcoin exchange-traded funds by the USA Securities and Exchange Commission (SEC) (Wade, 2024). The formal approval from regulatory bodies provides reassurance to investors that Bitcoin investments are secure, while the recent rally serves as evidence of its undeniable success.

Moreover, major macroeconomic events have since affected the financial market majorly. For example, the COVID-19 pandemic, the Russian-Ukraine war, and the Israel-Hamas war. The financial market in general fluctuates because of uncertainties and it definitely affects the price of precious metals and cryptocurrencies. With a more recent dataset, covering the period from January 1, 2018, to April 1, 2024, this paper will capture the changes in the properties of different investment assets since the publication of 'Bitcoin is not the new Gold' (Klein et al., 2018). Current major macroeconomic events will also be included to analyze the investment assets' behavior in different states of the economy.

CHAPTER 2 Theoretical Framework

2.1 Method and Theories

To perform the comparison between precious metals and cryptocurrencies as investment assets, we examined cryptocurrency, exemplified by Bitcoin and Ethereum; precious metal, exemplified by Gold and Silver and variables that reflect broader economic influences, exemplified by WTI oil, S&P500 and MSCI World. Similar to the paper by Klein et al. (2018), the Asymmetric Power ARCH (Ding et al., 1993) and the Fractionally Integrated APARCH (Tse, 1998) Model is used to characterize the volatility structure of assets. These two models focus on asymmetry and long memory. Asymmetry volatility is when negative (positive) returns are linked to an upward (downward) revision of the conditional volatility (Engle & Ng, 1993; Zakoian, 1994). Financial time series' long memory, is the ability to capture long-lasting autocorrelation effects in conditional returns or volatility, that is, autocorrelation effects that slowly decay (Baillie, 1996). This study will also perform a first-order autoregressive model on the asset's returns, rt, with t-distributed errors of zero mean with conditional variance h Correlation of assets to financial markets is taken into consideration based on the BEKK-GARCH framework (Engle & Kroner, 1995). This model is efficient in compromising between parameter dimension and the size of the sample. This model will examine mainly the correlation between Gold, Silver, Bitcoin, and Ethereum to S&P 500. Knowing this information, the hedge and safe haven capabilities of cryptocurrencies are tested. The theories of hedge, diversifier, and safe haven are given in (Baur & Lucey, 2010). A hedge is an asset, which is uncorrelated or negatively correlated with another asset or portfolio on average, serving as a form of protection against adverse price movements. A diversifier, is an asset that is not perfectly, positively correlated with another asset or portfolio, helping to spread and potentially reduce risk. A safe haven is an asset that remains uncorrelated or negatively correlated with another asset or portfolio specifically during times of market stress or turmoil, providing a critical buffer in such periods. Finally, the investigation of hedging capabilities is implemented. Calculating the time-varying weight w_t, and historical value of risk, we can evaluate a two-component portfolio, consisting of an index and Gold, Silver, Bitcoin, or Ethereum.

2.2 Hypothesis

Because of the recent ETF approval and the high market capitalization for Bitcoin, my hypothesis was that precious metal, exemplified by Gold and Silver, and Cryptocurrency, exemplified by Bitcoin and Ethereum, will perform similarly in times of market distress and have hedging capabilities. This can be observed after performing BEKK-GARCH, Bitcoin and Ethereum negatively correlate in times of market distress (S&P500). Gold will show a similar result of negative correlation with market turmoil (S&P500). In the portfolio comparison, during times of distress, like when the returns of the index are in a Value-at-Risk quantile, we expected Bitcoin and Ethereum to have

significantly higher average returns compared to a sole investment in the index. With the expectation of Bitcoin and ETH being more stable and less volatile, I also expect model APARCH to fit best with these cryptocurrencies.

CHAPTER 3 Data

In this analysis, 7 assets' time series are included: cryptocurrency prices in USD: Bitcoin, Ethereum (ETH); precious metal in USD per oz: Gold, Silver; economy reflector prices: West Texas Intermediate (WTI), S&P500, MSCI World. 1/1/2018 to 1/4/2024 is the period that the time series covers and synchronizes. Returns are calculated using this formula, where P are the daily closing prices, $r_t = 100 * \log (P_t / P_{t-1})$. The closing price for all assets is taken from investing.com. Since Bitcoin and ETH are traded on the weekend also, unlike traditional assets, only data during the week is included in the analysis. 1570 data points are observed at the end. Figure 1. displays the price trends of Bitcoin and gold from January 2018 to January 2024. Bitcoin exhibits high volatility with sharp peaks and troughs, reflecting significant price fluctuations. In contrast, gold demonstrates steady growth and greater stability. Both assets show an overall upward trend over the analyzed period.

Figure 1

Prices of Gold and Bitcoin from January 2018 to April 2024, n = 1570.

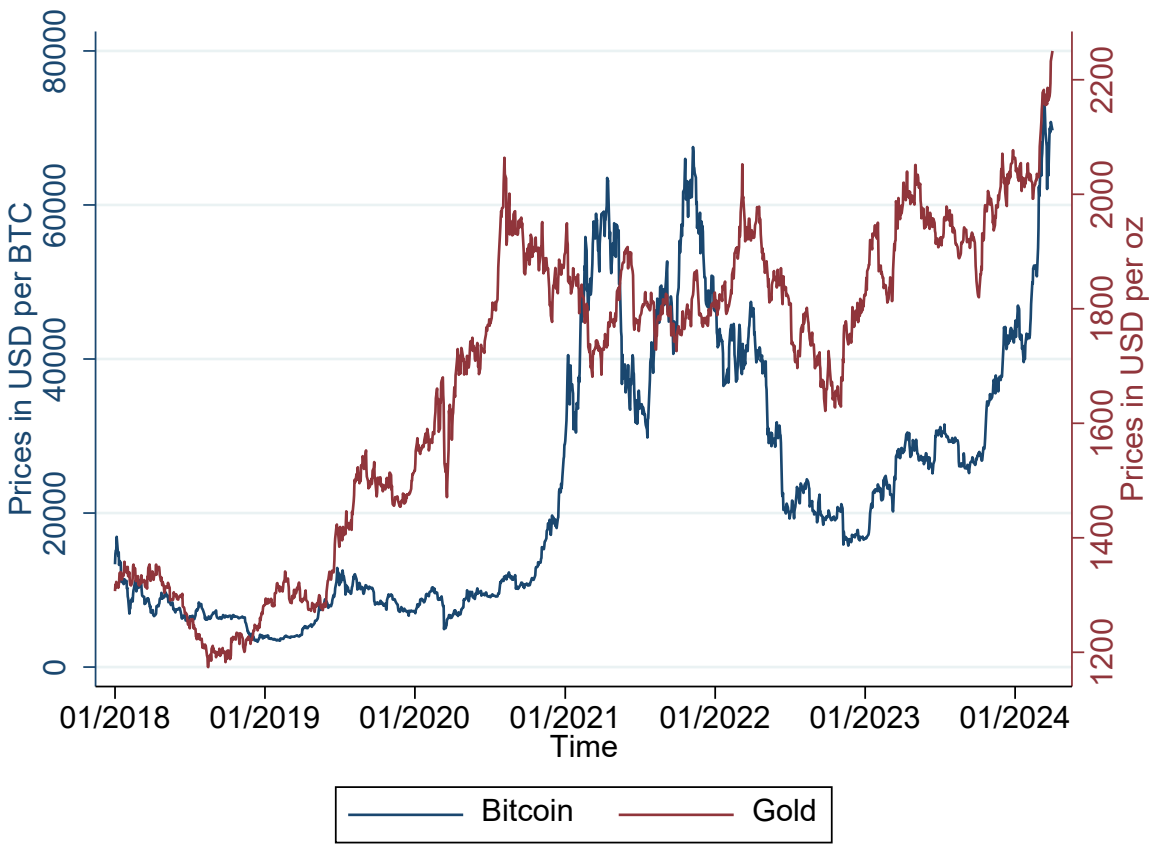


Table 2

Descriptive statistics for Bitcoin and financial daily return time series for Jan 3, 2018 to Apr 1, 2024, n = 1570 observations.

	Bitcoin	ETH	Gold	Silver	WTI	S&P500	MSCI World
Mean	0.0991	0.0896	0.0341	0.0241	0.0211	0.0424	0.0310
Std. dev.	4.4372	5.7677	0.8836	1.7847	3.1776	1.2886	1.2275
Min.	-48.0904	-57.9873	-5.8975	-16.2015	-41.7654	-12.7657	-12.0786
Max.	19.3756	34.9939	4.2968	8.8348	40.3522	8.9671	8.7061
Skewness	-1.0985	-0.8184	-0.3209	-0.5255	-1.9033	-0.8061	-1.0849
Kurtosis	14.7563	13.1477	6.3763	11.6035	58.0654	17.0418	18.8117
Normality Test	409.07***	330.98***	124.01***	255.05***	769.45***	369.01***	443.30***
Ljung Box (25)	40.1091**	52.0335***	32.4916	44.6668***	129.1470***	322.2284***	274.2694***
ARCH (25)	24.572	46.487***	108.406***	191.341***	200.659 ***	556.712***	518.731***
ADF	-41.889***	-39.327***	-38.381***	-38.388***	-33.637***	-46.748***	-45.637***

Table 2 contains the descriptive statistics and some time series tests. The mean of crypto currencies' return is significantly higher than those of traditional assets. However, the return of Bitcoin when compared to the paper 'Bitcoin is not the new Gold' is significantly lower, decreasing from 0.4037 to 0.0991 (Klein et al., 2018). All other assets have a slightly positive mean of return, ranging from 0.0211 to 0.0424. Bitcoin and ETH also show the highest results for standard deviation compared to other conventional assets. All assets show no normality distributed after the three tests Skewness, Kurtosis, and Normality test. The Ljung-Box suggests autocorrelations in returns for all assets, except for Gold. The ARCH test suggests autocorrelations in volatility for all assets, except for Bitcoin. Finally, the ADF test rejects the hypothesis of a unit root and suggests all assets' time series are stationary.

Figure 2 compares the return of Bitcoin and Gold and illustrates the difference in volatility level between the two assets. Bitcoin's return shows a higher volatility level compared to the less extreme volatility level of Gold. Figure 3 compares the kurtosis of both Gold and Bitcoin in a histogram. Bitcoin tails are much more definite than tails of Gold.

Table 3 shows the pairwise Pearson correlations of all 7 assets. Bitcoin shows the highest correlations to ETH, both being cryptocurrencies and lowest toward WTI. However, the Bitcoin correlation between all assets is positive. Similarly, Gold and Silver show the highest correlation toward each other, and the lowest is WTI, with all correlations being positive. Compared to Gold, Bitcoin has a significantly higher correlation to S&P500 and MSCI World. This can result in Bitcoin

being a less effective hedging instrument. However, only the average correlation to the whole sample is accounted for.

Figure 2

Plots of the daily return series of Gold and Bitcoin

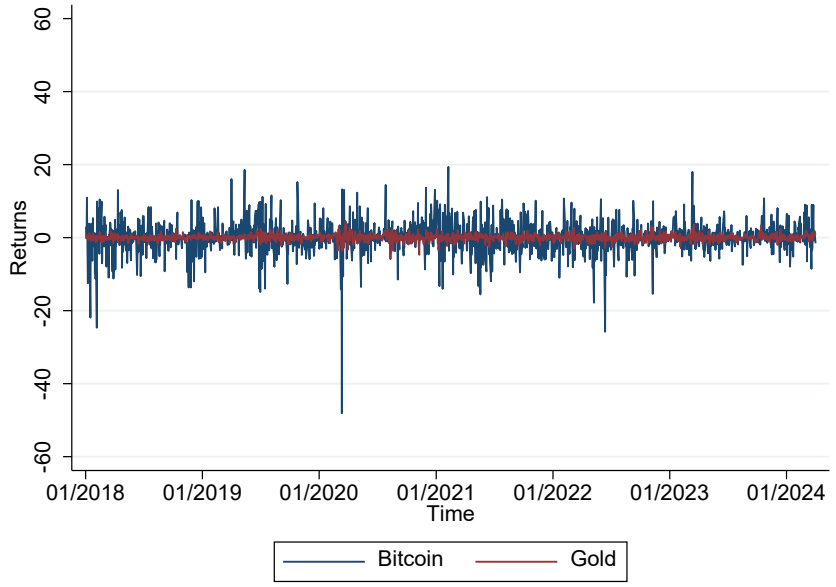


Figure 3

Resulting histogram of Gold and Bitcoin

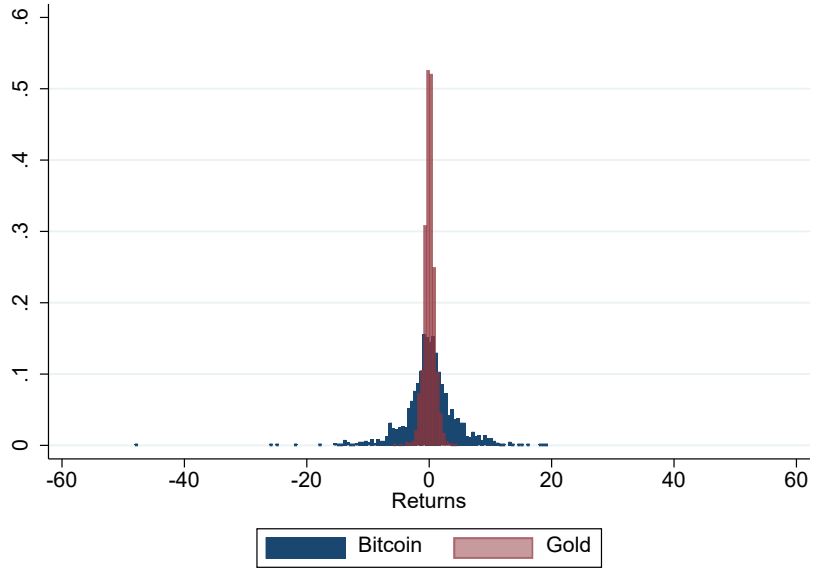


Table 3

Unconditional pairwise Pearson correlation matrix for the sample period from Jan 3, 2018, to Apr 1, 2024, n = 1570 observations.

	Bitcoin	ETH	Gold	Silver	WTI	S&P500	MSCI World
Bitcoin	1.0000						
ETH	0.8164	1.0000					
Gold	0.1275	0.1217	1.0000				
Silver	0.1803	0.1814	0.7720	1.0000			
WTI	0.0888	0.1097	0.0766	0.1695	1.0000		
S&P500	0.2806	0.3012	0.0795	0.2362	0.2641	1.0000	
MSCI World	0.3009	0.3252	0.1189	0.2764	0.2741	0.9826	1.0000

CHAPTER 4 Method

In this study, we replicate the method of examining Bitcoin, Gold, and other assets from the paper 'Bitcoin is not the new Gold' by Klein et al. (2018). This is divided into 3 sectors, Properties of conditional variance, Dynamic correlation modeling, and Portfolio-based comparison.

4.1 Properties of conditional variance

First, (Generalized) Autoregressive Conditional Heteroskedasticity models are used to describe the volatility structure of the assets. Two models are then employed for volatility regression to illustrate long memory and the leverage effect. Specifically, the Fractionally Integrated APARCH (FIAPARCH) model (Tse, 1998) and the Asymmetric Power ARCH (APARCH) model (Ding et al., 1993) are employed. Formally, a first order autoregressive model on the asset's returns, r, with Student's t distributed errors of zero mean with conditional variance h which then reads:

$r_t = \Theta_0 + \Theta_1 r_{t-1} + \varepsilon_t,$

$\varepsilon_t = \sqrt{h_t}\,\eta_t$

The summarized definitions for both models are provided in Table 1 of the paper 'Bitcoin is not the new Gold' (Klein et al., 2018).

Table 1
Overview of univariate conditional variance models.

Model	Definition	Asymmetry	Long memory
APARCH(1,1)	$h_t^{\delta/2} = \omega + \alpha(\lvert\varepsilon_{t-1}\rvert - \gamma\varepsilon_{t-1})^{\delta} + \beta h_{t-1}^{\delta/2}$	Yes	Indirectly
FIAPARCH(1,*d*,1)	$h_t^{\delta/2} = \omega + (1 - \beta L - (1 - \phi L)(1 - L)^{d})(\lvert\varepsilon_t\rvert - \gamma\varepsilon_t)^{\delta} + \beta h_{t-1}^{\delta/2}$	Yes	Yes

4.2 Dynamic correlation modeling

The multivariate comparison of the properties of Bitcoin, Ethereum, Gold, and Silver in terms of indexes, S&P500. Let R be a k-dimensional vector of observations at time t, denoted as:

$R_t = \mu_t + \varepsilon_t$

$\varepsilon_t = H_t^{1/2}\xi_t$

With Baba-Engle-Kraft-Kroner (BEKK- GARCH) model (Engle & Kroner, 1995), the matrix process H_t, the $(k \times k)$-sized conditional variance matrix, will be determined. The conditional variance-covariance matrix defined by the BEKK model is defined as:

$$\mathbf{H}_t = \mathbf{C}^T\mathbf{C} + \mathbf{A}_1^T\varepsilon_{t-1}\varepsilon_{t-1}^T\mathbf{A} + \mathbf{G}^T\mathbf{H}_{t-1}\mathbf{G}$$

$$= \begin{bmatrix} c_{11} & 0 \\ c_{12} & c_{22} \end{bmatrix}\begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix} + \mathrm{diag}[a_{11}, a_{12}]^T \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{1,t-1}\varepsilon_{2,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix}$$

$$\mathrm{x}\ \mathrm{diag}[a_{11}, a_{12}] + \mathrm{diag}[g_{11}, g_{22}]^T\mathbf{H}_{t-1}\mathrm{diag}[g_{11}, g_{22}],$$

We calculate the pairwise correlation between Bitcoin, Ethereum, Gold, and Silver to S&P500 by setting k = 2, with a focus on links to other markets. We then apply the BEKK to centralized residuals. The correlation charts in Section 4 are smoothed using a Savitzky-Golay filter (Savitzky & Golay, 1964).

4.3 Portfolio-based comparison

The hedging capabilities of Bitcoin, Ethereum, and Gold, an ex-post portfolio-based comparison with three steps:

1. Calculating weights w_t of two-component minimum-variance portfolio, Bitcoin, Ethereum, Gold to S&P500 and MSCI World. The optimization of the weights is defined with:
   $\min \; w_t' \, \mathbf{H}_t w_t$
   $s.t \quad w_t' 1_k = 1$
   where $\mathbf{H}_t$ covariance matrix is obtained with the BEKK model in section 2.2

2. Value-of-Risk (VaR_q) of S&P500 and MSCI World over the period is defined by taking empirical quantile q at 1%, 5%, and 10% of the returns r of the corresponding index. After listing the return of the indexes, to find VAR_q of 0.01, the $\lceil T \times 0.01 \rceil$-th return is calculated. Time in distress can be defined as:
   $t^* := \{t | \, r_t < VaR_q$

3. Lastly, a two-component portfolio of Bitcoin, Ethereum or Gold, and S&P500 or MSCI World is evaluated. The portfolio return is calculated with the weights w_t from the previous steps. Focusing on the time of distress (t*), the mean portfolio during this time is defined. This approach tests the ability of Bitcoin, Ethereum, Gold, and Silver to be a hedging tool or a temporary hedging tool, meaning lower the impact of distressed times on S&P500 and MSCI World.

CHAPTER 5 Results & Discussion

5.1 Comparison of conditional variance dynamics

AR(1)-FIAPARCH and -APARCH, with Student's t, distributed errors with ν degrees-of-freedom, the models are first used to observe the univariate volatility of the seven assets.

The cryptocurrencies group (Bitcoin, ETH) and precious metals group (Gold, Silver) are similar in terms of the sign of gamma (γ), the leverage parameter, in the APARCH model. As they are all negative signs, if the previous day was positive, they are more prone to have a higher volatility. Similar to the findings in 'Bitcoin is not the new Gold,' this phenomenon is identified as the inverse leverage effect. In contrast, assets like WTI, S&P500, and MSCI World exhibit a positive gamma, indicating that if the previous day was negative, volatility is likely to be higher. The power parameters δ for Bitcoin, Ethereum, and Gold are similarly characterized by values greater than 1 (Klein et al., 2018). Other assets of Silver, WTI, S&P500, and MSCI World, having δ smaller than 1. The ARCH (25) test diminishes all autocorrelation structures in the volatility for all 7 assets, except for Silver.

Table 4

*Estimation results from APARCH model with n = 1570 observations. Statistically significant parameters are indicated with asterisk *, **, *** for 10%, 5%, and 1% level of significance.*

	Bitcoin	ETH	Gold	Silver	WTI	S&P500	MSCI World
Θ_0	0.0895	0.1026	0.0409**	0.0253	0.1600***	0.0695***	0.0519***
Θ_1	-0.0545**	-0.0701***	-0.0002	-0.0178	0.0186	-0.0099	-0.0080
ω	0.1194*	0.1209	0.0168**	0.0138***	0.0875***	0.0400	0.0337***
α	0.1338***	0.1082***	0.0575***	0.0497***	0.0952***	0.1182***	0.1041***
β	0.9039***	0.9121***	0.9336***	0.9563	0.8904***	0.8786	0.8907
γ	-0.0744	-0.0833	-0.2876*	-0.1470	0.4714***	1.0000	0.9879
δ	1.131***	1.0271***	1.4785**	0.9383**	0.9589***	0.8635***	0.9059***
ν	2.7553***	3.1071***	5.2060***	4.3447***	5.3362***	6.7935***	7.0574***
LL	-4300.53	-4720.196	-1908.823	-2892.784	-3503.578	-2143.754	-2094.134
BIC	8659.931	9499.257	3876.512	5844.434	7066.022	4346.373	4247.134
Jarque Bera	15293.9381***	3787.0445***	223.0307***	603.5866***	110000.2219***	1789.6448***	826.4687***
Ljung Box (25)	33.2936	40.392**	20.2647	34.3626	37.0866*	29.5228	29.7626
ARCH (25)	18.5029	23.3945	19.7198	86.0785***	1.1664	16.7016	14.2983

In the FIAPARCH model, gamma keeps the same sign and effects similar to the gamma in the APARCH model. Bitcoin and ETH have small ν which corresponds to the higher kurtosis of 14.756 and 13.1477 in Table 2. While Gold and Silver show a larger ν, corresponding to the lower kurtosis of 6.3763 and 11.6035. Similar to the APARCH model, δ is the same for the three assets, from 1-1.4.

The other assets have a δ smaller than 1. However, the ARCH test for the FIAPARCH model is not rejected for Silver, WTI, S&P500, and MSCI World.

Lastly, when comparing the BIC values of the two models, BIC in the APARCH model is smaller for Gold, Silver, WTI, and MSCI World, which purely model asymmetry. The other three assets, Bitcoin, Ethereum, and S&P500, are better modeled with FIAPARCH, which adds long-term memory. The highly volatile history of cryptocurrencies might be the cause of long-term memory. This result is very similar to that of the paper 'Bitcoin is not the new Gold' (Klein et al., 2018).

Table 5

*Estimation results from the FIAPARCH model with n = 1570 observations. Statistically significant parameters are indicated with asterisk *, **, *** for 10%, 5%, and 1% level of significance*

	Bitcoin	ETH	Gold	Silver	WTI	S&P500	MSCI World
Θ_0	0.0899	0.1234	0.0403	0.0288	0.1568*	0.0702**	0.0481***
Θ_1	-0.0555**	-0.0702***	-0.0001	-0.0149	0.0198	-0.0135	-0.0070
ω	0.0498	0.0457	0.0118	0.0134	0.0839	0.0376	0.0305***
α	0.3048	0.3656	0.1394	0.0497***	-0.8065	-0.7607	0.1951
d	0.2002***	0.3304***	0.2902***	0.1943***	0.2056***	0.0928	0.2749***
β	0.9073***	0.9331***	0.9293	0.9463***	0.8765***	0.8697***	0.8873
γ	-0.0877***	-0.0658***	-0.2589	-0.1428***	0.4414***	0.9222	0.9606***
δ	0.9475***	0.9687***	1.6240	0.7666	1.0302***	0.6354	0.9071***
ν	2.7108***	3.2439***	5.3116	4.2966***	5.4255***	4.5258***	8.5525***
LL	-4296.60	-4720.8304	-1911.0295	-2898.3239	-3509.6502	-2153.0146	-2097.4087
BIC	8644.15	9422.6080	3903.0061	5877.5949	7100.2076	4232.6091	4275.7646
Jarque Bera	9466.95***	7198.6004***	223.0307***	4933.1522***	190358.3005***	2916.6114***	16516.0549***
Ljung Box (25)	33.9073	42.2228**	32.5003	46.4226	118.4102***	76.0286***	265.7883***
ARCH (25)	25.6762	49.5353	29.7198	93.7395***	277.2551***	70.2053***	646.0820***

5.2 Correlation of Bitcoin, Ethereum, Gold, and Silver to financial market

The dynamic correlation of Gold, Bitcoin, Ethereum, and Silver to S&P500 is estimated using the BEKK-GARCH model. For S&P500, two short periods of market distress with shock-like declines of S&P500. The first market distress period is from 03/12/2019 to 01/04/2020, which is connected to the start of the COVID-19 pandemic. The next market distress period is from 01/09/2023 to 01/01/2024, which is connected to the Ukraine-Russia conflict. The definitions for safe haven and diversifier from (Baur & Lucey, 2010) in their paper “Is Gold a Hedge or a Safe Haven? An Analysis

of Stocks, Bonds and Gold" are used. Firstly, the correlation between Gold and S&P500 is plotted in Figure 4. The blue shade signified the market distress period. An important observation from Figure 4. is that the correlation decreases to negative values during the market distress period. We can also observe that the correlation increases to a positive value when the market recovers. The lowest value of Gold and S&P500 correlation during the first distress period (03/12/2019 to 01/04/2020) is -0.5154. Safe-haven behavior of Gold is shown in this graph as the non-smoothed BEEK-Correlation drops significantly from 0.3-0.4 within a few days during the distressed period. In Figure 7, the correlation between Silver and S&P 500 can be observed. The general trend and direction are similar to Gold. During times of distress, the dynamic correlation of Silver and S&P500 has a less significant transition from positive to negative and is more positive on average over the period. This classifies Silver as a safe haven but also a diversifier since the average correlation is larger than 0. Moreover, the Silver correlation is less volatile, containing fewer spikes in both directions. Over the observed period, the highest non-smoothed value is 0.6217 and the lowest non-smoothed value is -0.4314.

Figure 5 shows that Bitcoin maintains a predominantly positive correlation to S&P 500 as highlighted by the green-shaded areas throughout the observed period. This is different from the findings in 'Bitcoin is not the new Gold,' which state that Bitcoin experiences rapid shifts between positive and negative values (Klein et al., 2018). Because of this, Bitcoin can be seen more as a diversifier rather than a hedging tool. Similar to Gold, Bitcoin exhibits a decrease in correlation during periods of market distress. However, the decrease in Bitcoin's correlation is less pronounced than Gold, with the lowest value during the first market distress of -0.2067. This indicates that while Bitcoin does negatively respond to market turmoil, its response is generally more muted, showing fewer negative values. Therefore, Bitcoin can be considered as a safe haven but only for a brief period. Bitcoin values contain spikes, especially in the positive direction, with the highest non-smoothed value being 0.7790 and the lowest non-smoothed value being -0.5756. Based on Figure 6, we can say that the correlation of Ethereum and Bitcoin to S&P 500 is moderately similar in terms of volatility and overall trend. However, during periods of market distress, Ethereum tends to show a more dramatic shift from positive to negative correlations, containing more negative values. Even though this suggests that Ethereum might be more sensitive to market downturns than Bitcoin, the negative value is still not significant enough to classify Ethereum as a consistent safe haven.

Figure 4

Dynamic correlations of Gold and S&P 500 returns obtained with the BEKK-GARCH between January 4, 2018 and April 1, 2024, n = 1569.

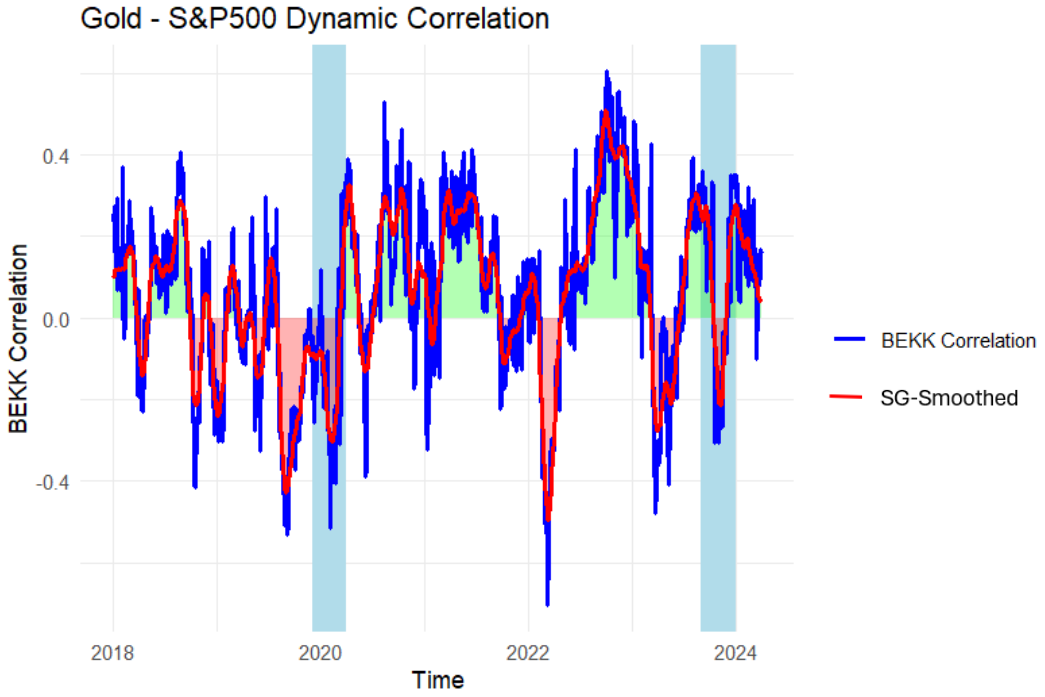


Figure 5

Dynamic correlations of Bitcoin (BTC) and S&P 500 returns obtained with the BEKK-GARCH between January 4, 2018 and April 1, 2024, n = 1569.

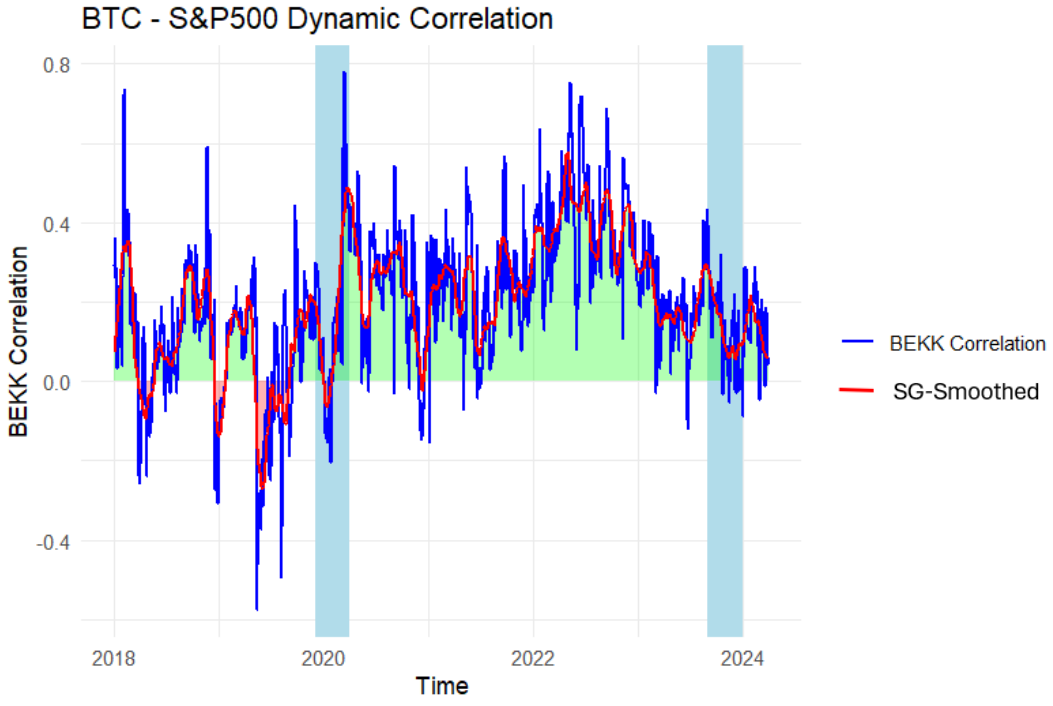


Figure 6

Dynamic correlations of Ethereum (ETH) and S&P 500 returns obtained with the BEKK-GARCH between January 4, 2018 and April 1, 2024, n = 1569.

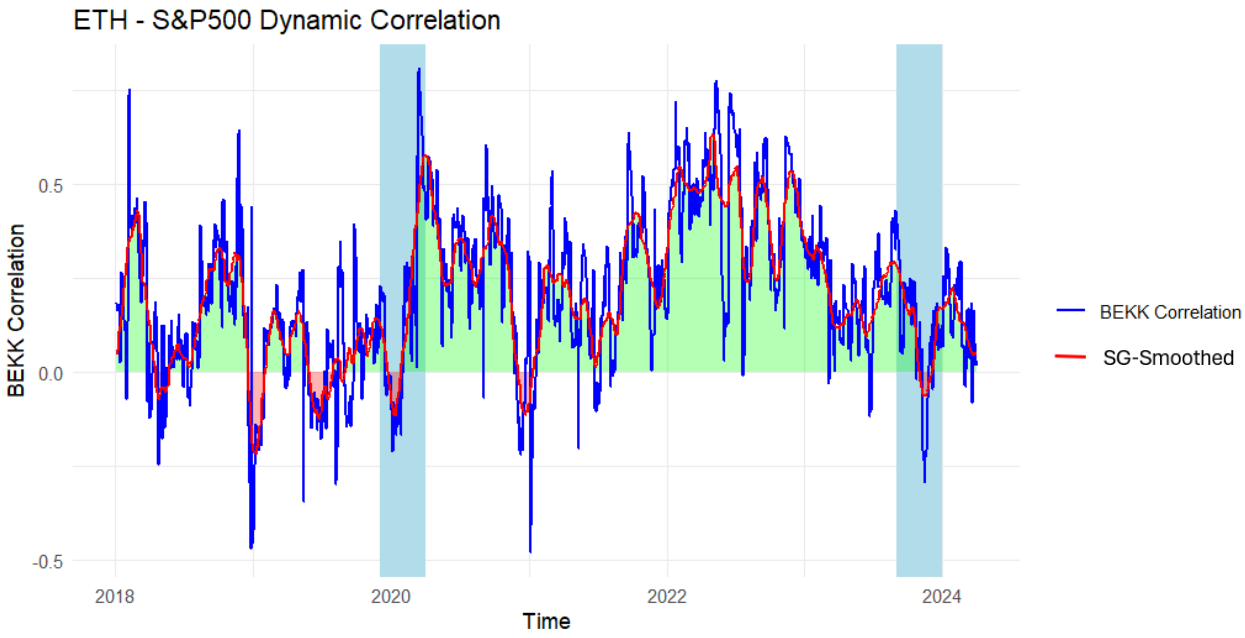
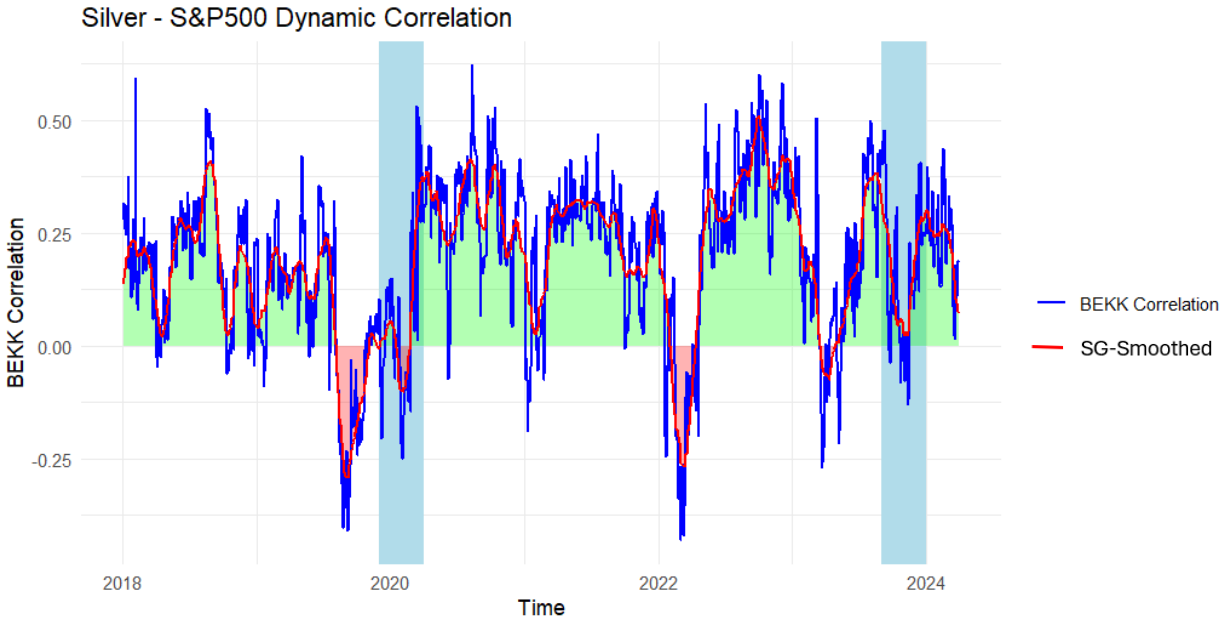


Figure 7

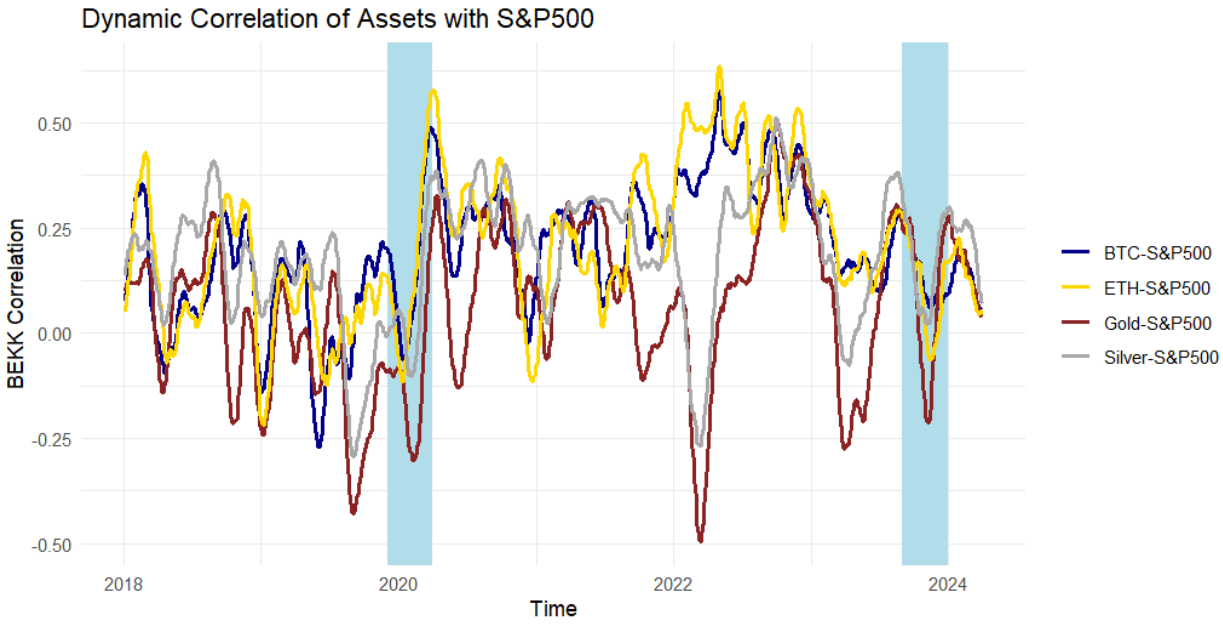
Dynamic correlations of Silver and S&P 500 returns obtained with the BEKK-GARCH between January 4, 2018 and April 1, 2024, n = 1569.



For better trend visualization, Figure 8. contains all four assets', Gold, Silver, Bitcoin, and Ethereum, smoothed correlation with S&P500. All four assets show a drop in correlation between the two periods of distress and a positive recovery after the period. This result is different from the mirror effects observed in the paper 'Bitcoin is not the new Gold' (Klein et al., 2018). Gold shows the most significant drops from positive to negative. However, Ethereum surprisingly shows a slightly more negative correlation with S&P500 than Silver. Finally, Bitcoin's correlation with S&P500 drops the least, showing that it is weaker in hedging capabilities when compared to other assets.

Figure 8

Smoothed correlations of Bitcoin, Ethereum, Silver, and Gold returns with S&P 500, returns obtained with the BEKK-GARCH between January 4, 2018 and April 1, 2024, n = 1569.



5.3 Portfolio-based test of hedging property

In this last section, the hedging properties of Bitcoin (BTC), Ethereum(ETH), and Gold will be analyzed. The portfolios we considered are BTC/S&P500, ETH/S&P500, Gold/S&P500, BTC/ MSCI World, ETH/MSCI World, and Gold/MSCI World.

As mentioned in the methodology section, the first step will be to calculate the weights over time of each component in the portfolios. Panel A of Table 6 displays the values of these weights. For a more effective visualization, the weights of Bitcoin, Ethereum, and Gold with S&P500 can also be observed in Figure 9. Similar to the findings of (Klein et al., 2018), Gold in this period also has a high variation within the 2 component portfolios of both indices. The high extreme values of Gold can reach higher than 1, meaning to borrow additional funds to invest; the low extreme values of Gold are to sell short the asset. The average Gold weight is 57.5% in the portfolio Gold/S&P500 and 56.61% in

the portfolio Gold/MSCI World. In Figure 9, we can observe that the two cryptocurrencies have a small proportion in the portfolios of both indices. Bitcoin weight averages 1.46% in portfolio BTC/S&P500 and 0.6% in portfolio BTC/MSCI World. The average value of Ethereum weight is even negative. We can obtain various short positions for the two cryptocurrencies. The extreme values of Bitcoin and Ethereum can reach as low as -0.5720, showing the great investment opportunity with liquid future exchange.

The second step is to calculate the Value at risk for the two indices, S&P500 and MSCI World. The results are displayed in Panel B of Table 6. S&P500 values for all three quantiles q, 1%, 5%, and 10% are slightly higher than those of MSCI World.

Finally, to determine the portfolios' returns as a whole with a focus on the time of distress, we use the weights from Step 1 to calculate the return. The mean return, volatility, and average return during times of turmoil of portfolios can be observed in Panel C of Table 6. The comparison of the 100% investment in an index and minimum variance portfolios are provided to observe the hedging properties of Bitcoin, Ethereum, and Gold.

For Bitcoin, over the whole period, the minimum variance portfolio BTC/S&P500 has a return, that is slightly lower return than S&P500 only, and volatility, which is slightly higher. The same effect can be seen in the minimum variance of portfolio BTC/MSCI World. Under times of distress, the two portfolios' returns are mostly slightly better, showing a minor hedging effect. Only the combination with MSCI World under 1% Value at Risk shows a lower return. However, when compared to the effective hedging effects of Gold, this is not significant. Overall, with the findings of a minimum variance portfolio, Bitcoin is not an effective hedging tool.

For Ethereum, the minimum variance portfolio ETH/S&P500 shows a higher return and volatility over the whole period. However, the portfolio ETH/MSCI World shows a lower return and higher volatility over the whole period. Under the time of distress of the two quantiles 0.01 and 0.05, both ETH/S&P500 and ETH/MSCI World show lower returns. The two portfolios show slightly higher returns in quantile 0.1, but this is not significant. Ethereum shows similarity to Bitcoin in terms of not being an effective hedging tool with increases in volatility and lower returns during times of turmoil.

For gold, being a traditional hedging asset, Gold clearly shows properties for superior hedging effects. Over the whole period, both portfolios, Gold/S&P500, and Gold/MSCI World, show an increase in return and a decrease in volatility. During times of turmoil, the return portfolio with Gold is significantly better for all three quantiles. The increase in return in time of distress ranges from, 0.45

to 1.6392. Compared to the small enhancements of Bitcoin, Gold is a much more effective hedging tool. Unlike findings (Klein et al., 2018), Gold returns also increased over the whole period (January 4, 2018 and April 1, 2024). A reason might be that the period considered in that paper is relatively more stable. In general, Gold is a good component of a portfolio for all periods, providing hedging properties, increases in return, and decreases in volatility.

The ex-post portfolio analysis shows that Gold is a better hedging tool for equity investments, compared to Bitcoin and Ethereum.

Table 6

Statistic for the minimum variance portfolio for BTC, ETH, Gold.

Panel A: Descriptive statistics of the portfolio weights

	S&P500			MSCI World		
	BTC	ETH	Gold	BTC	ETH	Gold
Mean	0.0146	-0.0056	0.5750	0.0063	-0.0147	0.5661
Std. dev.	0.0610	0.0530	0.1815	0.0566	0.0532	0.1776
Min.	-0.4936	-0.5720	-0.0368	-0.4881	-0.5075	0.0197
Max.	0.3870	0.2585	1.0709	0.4355	0.1772	1.1021

Panel B: Value at risk measure

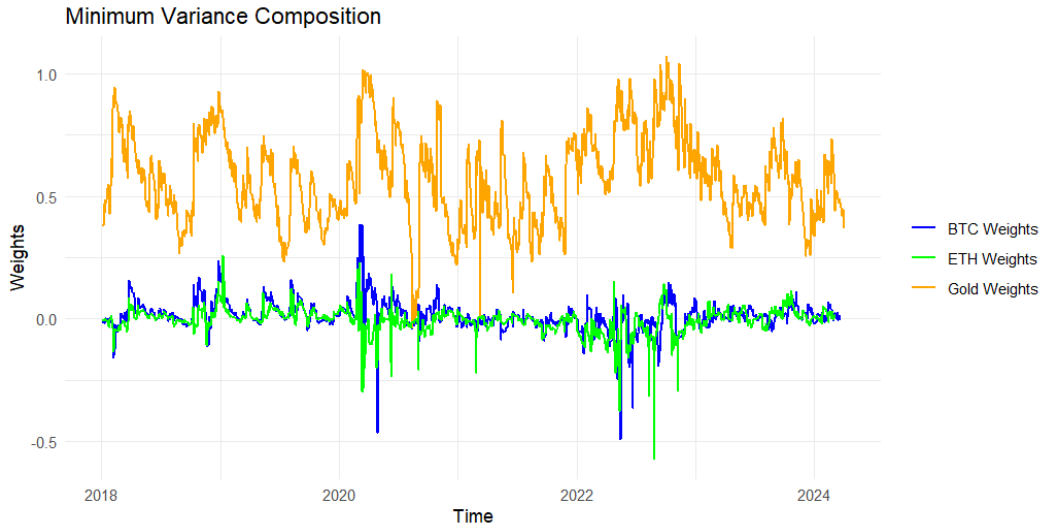
	S&P500	MSCI World
$VaR_{0.01}$	-3.6300	-3.3246
$VaR_{0.05}$	-1.9167	-1.7604
$VaR_{0.10}$	-1.2627	-1.2318

Panel C: Hedging properties

	S&P500	BTC	ETH	Gold	MSCI	BTC	ETH	Gold
Return	0.0408	0.0334	0.0503	0.0439	0.0359	0.0327	0.0260	0.0384
Volatility	1.263499	1.3919	1.3146	0.7098	1.1644	1.2931	1.2189	0.7130
Return| $VaR_{0.01}$	-3.5813	-3.5336	-3.6350	-1.9421	-3.2458	-3.2991	-3.3949	-1.8908
Return| $VaR_{0.05}$	-1.9145	-1.9078	-1.9338	-1.0770	-1.7337	-1.7292	-1.7395	-1.0939
Return| $VaR_{0.10}$	-1.2352	-1.2284	-1.1943	-0.7627	-1.2163	-1.2132	-1.2034	-0.7663

Figure 9

Time-varying weights of minimum-variance portfolios for Gold/S&P500, BTC/S&P500, ETH/S&P500.



CHAPTER 6 Conclusion

The anwser to the research question, “how do the properties, correlation structures, and hedging capabilities of cryptocurrencies compare to those of traditional precious metals?”, is as follows. Based on the data from 1/1/2018 to 1/4/2024 and using the methodology from the paper 'Bitcoin is not the new Gold,' we are able to conclude that, even though Bitcoin and Ethereum have become less volatile and negatively correlated with indexes during times of market distress, the properties of Bitcoin and Ethereum still differ from those of precious metals like Gold and Silver (Klein et al., 2018). The cryptocurrency fits best with the models of FIAPARCH, which allows for long-term memory. While model APARCH fits best with the precious metals group. From the BEKK-GARCH correlation, we are able to observe that both cryptocurrencies and precious metals have a drop in correlation with S&P500 during times of market turmoil. However, only Gold can be classified as an effective hedging tool and a safe haven with an average correlation smaller than 0 for both the market distress period and the whole period. The reason for this is that over the whole period, Bitcoin, Silver, and Ethereum showed a positive correlation to S&P500. The drop of these assets is also less significant than Gold, making it a less effective hedging tool. Finally, from the minimum portfolio, the hedging capabilities of portfolios that include Gold are tremendously better than those with cryptocurrencies. The volatility, average portfolio returns, and returns under market distress all show results in favor of Gold.

Bitcoin and Ethereum have become more stable and perform more like precious metals under several circumstances, but still not as reliable as precious metals in terms of hedging. In future times, more research should be carried out on the subject, especially after Bitcoin have become an ETF in 2024. The period considered in this paper is still the extreme growth period of Bitcoin, which is one of the limitation of this paper. However, with new regulatory decisions on Bitcoin and Cryptocurrencies, I believe Bitcoin will be more stable with fewer spikes in both price and returns. This will make Bitcoin and cryptocurrency, in general, a better option as a safe haven or hedging tool.

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