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Bitcoin, Gold and Crude Oil versus the US Dollar – A GARCH Volatility Analysis

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Abstract. *The aim of this study is to compare and contrast the volatility of different asset classes namely Bitcoin, gold and crude oil against the US dollar, using the symmetric GARCH (1,1) model. Furthermore, this study examines which of the three assets provide the lowest volatility and identifies if the univariate GARCH (1,1) model can suitably forecast the volatility of the foreign exchange market, commodity market and cryptocurrency market. More specifically, this study uses only estimates from a symmetric GARCH model for the XAU/USD, WTI/USD and BTC/USD financial assets. Although the literature on the volatility of different assets is extensive, it neglects to detect the severe economic recession that is approaching. Considering that powerful nations purchased substantial quantities of gold in order to back their national currency, supremacy of the US dollar is under significant attack. Experts in international relations have claimed that it is essential to have a single, extremely influential national economy to exhibit stability and operate smoothly. Specifically, the international monetary system functioned under the theory of hegemonic stability. Given the fact that gold still remains the safe haven asset during periods of financial and economic distress, central banks are purchasing gold at a rapid pace with Russia and China leading the way. Furthermore, the demand for precious metals has also increased while the US dollar is struggling to keep its supremacy as BRICS reserve currency is seeking to replace it in the future. The daily data encompassing the necessary information for February 2012 - February 2020 is acquired from "Investing.com", reaching 7193 observations. This study will enrich the literature associated with volatility forecasting of different asset classes during financial and economic turmoil while also raising awareness of the economic threats that could follow.*

Keywords: bitcoin, gold, oil, volatility, GARCH (1,1)

Introduction

Bitcoin is an online communication protocol that facilitates electronic payments using the virtual currency. The number of transactions using the Bitcoin payments system has massively increased since its inception in 2009 (Bohme et al, 2015).

The virtual currencies market has grown enormously in terms of the consumer base, the number of new currencies and transaction frequency. The development of virtual currencies is astonishing considering that no virtual currency existed outside of online gaming communities. However, economists, policy makers and entrepreneurs encountered great challenges and opportunities from the disruption caused in the monetary market. The development of Bitcoin forces investors and stakeholders to consider the virtual currency a new asset class worth investing into. Therefore, by classifying Bitcoin, an investor will understand the dynamics and capabilities it might have in the portfolio analysis and market risk management (Dyhrberg, 2015).

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Due to the advantage of the Bitcoin, economists and legislators have been eager to define whether it is a stock, commodity, currency or even a property in an economic context (Forbes, 2020). Glaser et al. (2014) concentrated on Bitcoin's ability as a medium of exchange. Although the Bitcoin is fairly liquid as one can exchange any currency for bitcoin at any time, due to its scarcity, it encounters liquidity limitations such as several commodities. Additionally, according to Bohme et al. (2015), transactions could record up to an hour delay which significantly reduces the liquidity possibilities. However, unless an address is used on an exchange that implements KYC (Know Your Customer), bitcoin protocol does not restrict transfers to embargoed countries or individuals that could be found on watch-lists as the identities of its users are not known. Compared to the bank transactions, this process offers a massive flexibility and speed of international transactions. According to Glaser et al. (2014), the majority of its owners use their bitcoin investments for speculation rather than a means of payment. Thus, bitcoin should be treated as an asset rather than a currency.

Nowadays, economists are interested in comparing the value of Bitcoin, the oil price and gold against the US dollar to find the most profitable investment especially during times of geopolitical crisis. Both gold and bitcoin derive their high value from the expensive extraction costs and their scarcity. Similarly, both assets are mined by several companies or independent operators as neither of these assets are controlled by a government. During the gold standards period, mainly gold was used as a medium of exchange. However, due to liquidity problems, this medium of exchange was abandoned and replaced (Dyhrberg, 2015). Similar issues appeared for Bitcoin as well since its user base massively expanded and the supply for this virtual currency could not cope with the demand. Therefore, bitcoin became extremely expensive and according to the Internal Revenue Service, bitcoin will not be treated as a currency or security but as a property (Forbes, 2020). Moreover, it must be noticed that the governments can no longer obstruct the trend of cryptocurrencies (Independent, 2019).

In certain aspects bitcoin and gold are different. Gold is mainly used for its negative correlation with the US dollar which makes it perfect for hedging and its store of value abilities whereas bitcoin's abilities are yet to be determined (Klein, 2018). According to Forbes (2013), bitcoin is similar to the US dollar as both of these two assets are primarily used as a medium of exchange with limited intrinsic value. The vital difference between the two assets is the fact that the US dollar is endorsed by the government in which people trust whereas bitcoin is introduced by the private sector. Thus, the government cannot control or influence the supply side (Dyhrberg, 2015).

An inverse relationship exists between the US dollar and crude oil since 2002 as gradually rising oil prices have been accompanied by the depreciation of the US dollar. However, this relationship became evident in 2008 when the US dollar fell to a historical low, while the crude oil price reached an all-time high (Czech National Bank, 2011). On the other hand, gold and crude oil largely move in tandem, although with occasional disconnects. Higher gold and oil prices are usually the result of geopolitical tensions and instability. Thus, when the markets are uneasy, investors tend to turn to one of the safest assets, gold. In other words, a high demand for gold occurs when a high risk exists in the energy world (OpenMarkets, 2019).

However, since 1967, central banks have been purchasing gold at a rapid pace with Russia and China leading the way in recent years. Such influential buyers can signal that some countries are determined to diversify their national reserves, gradually moving away from the US dollar. According to the World Gold Council, the collected data confirms this hypothesis as demand for precious metals has significantly increased and surpassed the annual quantity in the past 55 years. It is extremely concerning when central banks decide to invest in gold since other profitable

opportunities are available. This change of position would indicate geopolitical tensions, uncertainty and mistrust especially after the United States imposed sanctions on Russia's dollar reserves (Financial Times, 2022).

It is very important to observe that the last time this level of gold purchasing was seen radically transformed the global monetary system. During the same year, European central banks purchased significant volumes of gold from the US, causing a disturbance related to the gold price. Due to the devaluation of the US dollar together with the British pound, investors were forced to switch their attention to gold. As a result, the downfall of the London Gold Pool of reserves accelerated the demise of the Bretton Woods System which associated the value of the US dollar with precious metals. The example of Russia and China purchasing gold was followed by other nations such as Qatar, Turkey and Uzbekistan (Financial Times, 2022).

The dominance of the US dollar concerning investment flows and global trade is facing new serious threats as numerous nations show an inclination for alternative currencies. Countries like China, Russia, India and Brazil are trying to settle more business dealings in non-dollar denomination with proposals to use local currencies and gold-backed stablecoin. Therefore, the threat of a BRICS (Brazil, Russia, India China, South Africa) reserve currency replacing the US dollar represents a significant transformation. Additionally, the US dollar has been recognised as the world's reserve currency due to its supremacy in cross border trades, particularly for oil and other commodities (Markets Insider, 2023). As a result, if Saudi Arabia agrees to accept renminbi for its oil rather than the US dollar, it would enhance the 'petro-yuan' trading already occurring between Russia and China. This transformation could aid the Chinese currency and over time, replace the US dollar especially if other countries will choose to take this path (BNP Paribas, 2023).

This paper examines the fluctuations in the volatility of bitcoin, gold and oil prices against the US dollar and which of the three assets could be considered as safe haven in periods of economic and financial turmoil. This study uses only forecasts from a symmetric GARCH model, namely the GARCH (1,1) model introduced by Engle (2001), for the Bitcoin (BTC), crude oil (WTI) and gold (XAU) against the US dollar between February 2012 and February 2020. It must be mentioned that the US dollar was selected for comparison purposes as it is the world's reserve currency which facilitates world commerce. Furthermore, the decision of the European central banks to change their position and invest in gold is very worrying as radical transformation of the global monetary system could be approaching. Considering that powerful nations purchased substantial quantities of gold in order to back their national currency, how long until the dominance of the US dollar ends?

Literature review

Volatility forecasting is vital in assessing the riskiness of an investment within the financial markets as its price significantly fluctuates according to the evaluation of volatility. The measurement of volatility becomes also critical in portfolio management. Therefore, portfolio managers and option traders find the assessment of volatility extremely valuable as it assists them in making profits while minimizing the risk of an investment. Volatility always exists in financial time series. It has been observed that volatility tends to significantly rise during critical economic events such as financial crises, recessions and oil crises. According to Poon (2005), volatility is described as the spread of the likely result of an uncertain variable. Essentially, volatility is associated with risk of the investment. Levine (1991) detailed that economic development could be achieved through the elimination of firm's impulsive liquidation of capital (Darie, 2022).

Chan et al. (2003) identified that over decades, the stock markets have been strongly associated with the national economies through foreign direct investments, capital flows, international trade and technological progress. Black (1976) laid down the theoretical grounding of the volatility of stock returns which states that the leverage effect is the main cause for stock return volatility. However, the absence of conclusiveness in the returns of the stock market has led to the foundation of numerous models evaluating the leverage effect such as the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. These models became very popular due to their ability to efficiently capture volatility clustering and leverage effect (Darie, 2022).

Raju and Ghosh (2004) identified that the volatility captured within a securities exchange represents the central focus point of policymakers as instability within the securities market influences growth prospects and acts as a barrier for investments. According to Franses and Van Dijk (1996), the GARCH approach eliminates the setback of time-dependent volatility for longer durations. A number of research papers attempted to test whether the efficient market hypothesis holds. More specifically, several researchers assessed whether excessive stock price fluctuations appear as a consequence of alterations to the fundamentals, speculative bubbles and insufficient knowledge. However, one important research paper to note was the paper of Chen et al. (1986) which identified that asset returns are determined by economic factors and much less than changes to asset fundamentals (Darie, 2022).

Experts in international relations have claimed that it is essential to have a single, extremely influential national economy to exhibit stability and operate smoothly. Specifically, the international monetary system functioned under the theory of hegemonic stability. As a result, two precedents already exist that support this theory. One of the examples describes British supremacy over the international economies during the 19th century in which the classical gold standard was introduced. A more recent example considered is the safeguarding of the economic framework established in Bretton Woods that lasted for approximately 25 years, ending in 1971. Since then, the United States has been acknowledged as the most powerful nation in the world. Assessing the outcomes provided by the two examples, it was established that the instability regarding the value of gold was strongly connected with the absence of hegemonic supremacy (Eichengreen, 1987).

This literature review reveals the gap between the existent literature reviews on similar topics and the current perspectives of the international economies.

Methodology

Based on Darie (2022), in this section the GARCH models are described both from a financial and statistical perspective. By adding to the model of linear regression the conditional equation, both volatility clustering as well as the leverage effect become components of the Generalized Autoregressive Conditional Heteroskedasticity methodology. This study presents the symmetric GARCH model that assists in investigating the main features of volatility. As stressed in our preceding papers, its computation is determined by the maximum likelihood function which highlights the correctness of the time span and how the observation frequency impacts volatility over long-term.

As Darie (2022) describes that returns provided by the GARCH methodologies are regarded as the estimates generated by a stochastic procedure with time-dependent volatility since they take into account more detailed assumptions concerning the conditional distributions contrary to modeling the dataset characterized by a single unconditional distribution. Thus, conditional distributions are subject to the time at which they are identified, adequately emphasizing the autoregressive process of the conditional variance.

This study uses only symmetric GARCH (1,1) for examining the fluctuations in the volatility of bitcoin, gold and oil prices against the US dollar and which of the three assets could be considered as safe haven in periods of economic and financial distress. In order to accomplish this, Excel Solver will be used to maximize the log likelihood function (LLF). Even though, various mathematical expressions describing the GARCH (1,1) approach have been accepted, this research paper utilizes the form endorsed by Alexander (2001).

The formula describing the GARCH (1, 1) procedure is explained below:

$$\sigma_t^2 = \omega + \alpha u_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (1)$$
$$\omega > 0;\ \alpha, \beta \geq 0$$

Where ω signifies the constant of the model; α, β signify the GARCH error coefficient and the GARCH lag coefficient respectively while conditional variance is captured by σ_t^2 as relevant past information could be beneficial for estimating one period ahead. In contrast, the unconditional variance generated by the GARCH (1, 1) procedure remains constant over a mentioned time span. As such, it neglects to identify any price fluctuations over medium and long time periods. The approach used to compute the unconditional variance is shown below:

$$Var(u_t) = \frac{\omega}{1-(\alpha_1+\beta)} \quad (2)$$

As it remains constant granted that $\alpha_1 + \beta$ is strictly lower than 1, the unconditional variance can simply capture today's volatility for the entire time span and disregards any significant shocks. Although both of them provide close estimations, the unconditional variance is only recommended for a quick evaluation.

Generally, the GARCH methodologies are regularly using daily or intraday observations to identify the consequences of volatility clustering as they fade away once returns are observed during long time intervals. The GARCH parameters as well as the maximum LLF can be easily calculated by Excel Solver.

It is crucial to collect an adequate number of observations to operate the LLF properly. Therefore, the dataset must incorporate at least a few years of daily observations to guarantee good convergence of the methodology. As a result, the daily data encompassing the necessary information for February 2012 - February 2020 is acquired from Investing.com (2020a, b, c), reaching 7193 daily observations.

According to Darie (2022), in any GARCH model, the volatility estimation at the end of the sample period is the 1-day-ahead volatility forecast on that day. However, the GARCH long-term volatility can be very different from the 1-day-ahead. More explicitly, the GARCH parameter estimates can be used to generate the term structure volatility forecasts and forward daily volatility forecasts. Generally, the formula used to determine the forward daily variance day T+S to day T+S+1 is shown below:

$$\widehat{\sigma_{T+S+1}^2} = \hat{\omega} + (\hat{\alpha} + \hat{\beta})\widehat{\sigma_{T+S}^2} \quad (3)$$

Using the above formula, the forward daily variance forecasts can be determined. Furthermore, using these forward daily variance forecasts, a forecast for the GARCH term structure of volatilities can also be determined. In other words, to obtain a forecast for the average volatility over different time periods. The average volatility falls as the forecast time horizon rises. GARCH volatility term structure forecasts converge to their long-term average (i.e. unconditional) volatility. However, the long-term volatility for the estimated unconditional volatility from a GARCH model is not very accurate as it is very difficult to forecast exactly the long-term volatility.

The utilization of the ARCH/GARCH methodologies is backed by the autocorrelation assessment. Hence, the existence of autocorrelation among observations was determined by the Box-Pierce examination, commonly known as the Q test (Darie, 2022). Time series residuals could be discovered once the ARCH (p, q) analysis is finalized.

The considered methodology to establish the existence of autocorrelation is shown below:

$$Q = n \sum_{k=1}^{h} \quad r_k^2 \quad (4)$$

Where Q, n, m and h signify the Box-Pierce evaluation, the total number of observations, the number of parameters and the maximum lag taken into consideration. In this case, the Box-Pierce investigates the following two hypotheses:

H_0: Prices are not impacted by historical economic events

H_1: Prices are impacted by historical economic events

The findings of these tests will be shown in the results and discussion section.

Results and discussions

The following figures illustrate the autocorrelation between each of three assets compared with the US dollar.

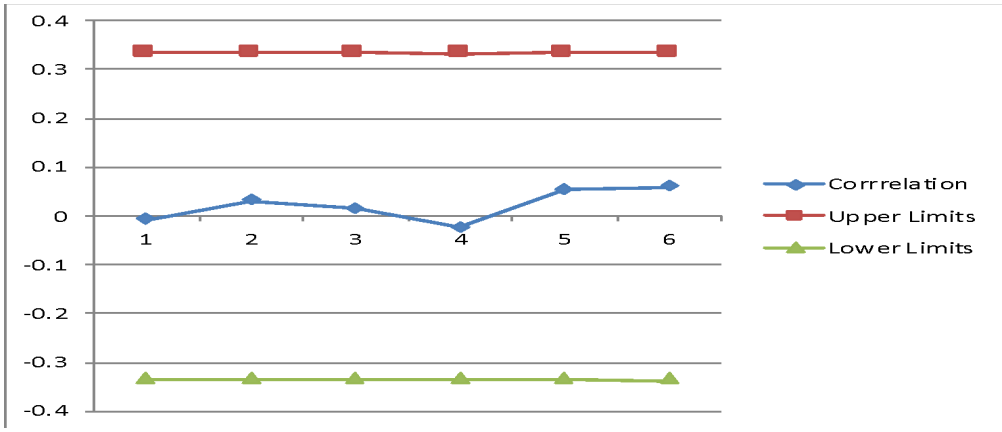


Figure 1. BTC/USD autocorrelation between February 2012 to February 2020

Source: Author's own research results.

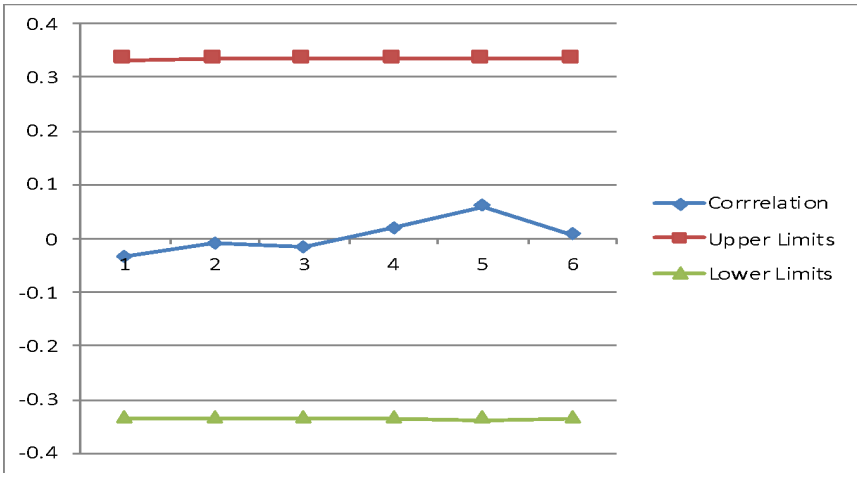


Figure 2. WTI/USD autocorrelation between February 2012 to February 2020

Source: Author's own research results.

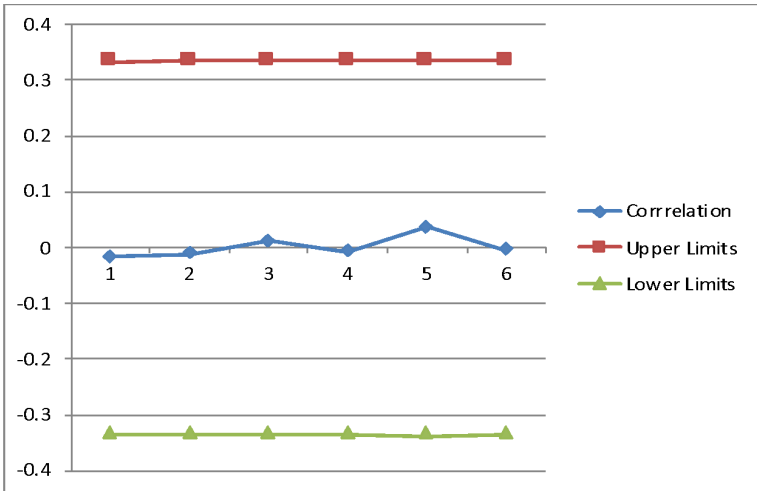


Figure 3. XAU/USD autocorrelation between February 2012 to February 2020

Source: Author's own research results.

Figures 1, 2 and 3 presented above show the autocorrelation in returns for bitcoin, oil and gold against the US dollar for the period February 2012 to February 2020. It is clearly illustrated in figure 1, 2 and 3, that bitcoin, oil and gold have an inverse relationship against the US dollar. Since all three figures display an inverse relationship with the US dollar, an investor would consider the safest and most profitable investment when switching its funds from the US dollar. However, it must be mentioned that investors must be cautious with bitcoin as it is not regulated by any government. As mentioned above, the Box-Pierce examination will also indicate the presence of autocorrelation.

The methodology proposed by Box-Pierce exhibits a Chi-square distribution with (h-m) degrees of freedom unless the residuals are white noise. Therefore, the r_k value dictates the size of the Box-Pierce statistic. More specifically, the closer to 0 is the r_k value, the smaller the Box-Pierce statistic. Similarly, the larger the r_k value, the larger the Box-Pierce statistic.

This research paper analyzes only the first six lags as it is sufficient to compute the Box-Pierce statistic. Therefore, the complete procedure assessing the three pairs, namely BTC/USD, WTI/USD and XAU/USD from February 2012 to February 2020 is shown below:

$$Q_{BTC/USD} = 2925 \sum_{k=1}^{6} r_k^2 = 24.17$$

$$Q_{WTI/USD} = 2171 \sum_{k=1}^{6} r_k^2 = 49.93$$

$$Q_{XAU/USD} = 2097 \sum_{k=1}^{6} r_k^2 = 4.08$$

The Box-Pierce examination provides a solution that will be compared with the Chi-square (χ^2) statistic of 12.6, considering 5% significance level and 6 degrees of freedom. Hence, the result of the test proved to be greater than 12.6 for BTC/USD and WTI/USD pairs and lower than 12.6 for XAU/USD pair at 5% significance level. This demonstrates that prices are impacted by historical economic events with regards to BTC/USD and WTI/USD pairs. Therefore, H_1 is the accepted hypothesis for the two pairs while for XAU/USD pair, H_0 is the accepted hypothesis as prices are not impacted by historical economic events. Thus, when it comes to different investment opportunities, the autocorrelation represents an effective way to select the most appropriate

investment. Similar to portfolio selection, choosing the pair that is less correlated decreases the risk of the investment. Therefore, switching to gold seems to be the most appropriate selection after performing the autocorrelation test for each pair. However, the final decision will be made after also applying the GARCH (1,1) model for each pair.

Table 1. Calculation and maximization of log likelihood function using Excel Solver

BTCUSD	GARCH (1,1)	WTIUSD	GARCH (1,1)	XAUUSD	GARCH (1,1)
Feb 2012 - Feb 2020		**Feb 2012 - Feb 2020**		**Feb 2012 - Feb 2020**	
ω	1.34E-03	**ω**	2.00E-04	**ω**	5.84E-05
α	0.0000	**α**	0.6292	**α**	0.3545
β	1.0000	**β**	0.3708	**β**	0.6455
α+β	1.0000	**α+β**	1.0000	**α+β**	1.0000
LT Vol	40174247.53%	**LT Vol**	10247600.20%	**LT Vol**	8375426.76%
LogL	2500.9423	**LogL**	3411.0311	**LogL**	8742.9869
Unconditional Vol (i.i.d)	67.85%	**Unconditional Vol (i.i.d)**	25.80%	**Unconditional Vol (i.i.d)**	14.67%

Source: Author's own research results.

Note: $\sigma_t^2 = \omega + \alpha u_{t-1}^2 + \beta \sigma_{t-1}^2$ – was used for parameter estimation

The parameter estimates for BTC/USD, WTI/USD and XAU/USD pairs using the GARCH (1,1) model between February 2012 and February 2020 are shown in Table 1. More explicitly, there is a fairly low persistence and high reaction to the level of volatility for the WTI/USD while a relatively high persistence and low reaction for XAU/USD. In other words, investor seem to have learned from the 2008 oil crisis (CNBC, 2018) and regard gold as the safest asset. This analysis reveals that there is maximum persistence and no reaction for the BTC/USD since bitcoin is not regulated by the government and it does not offer any hedging capabilities.

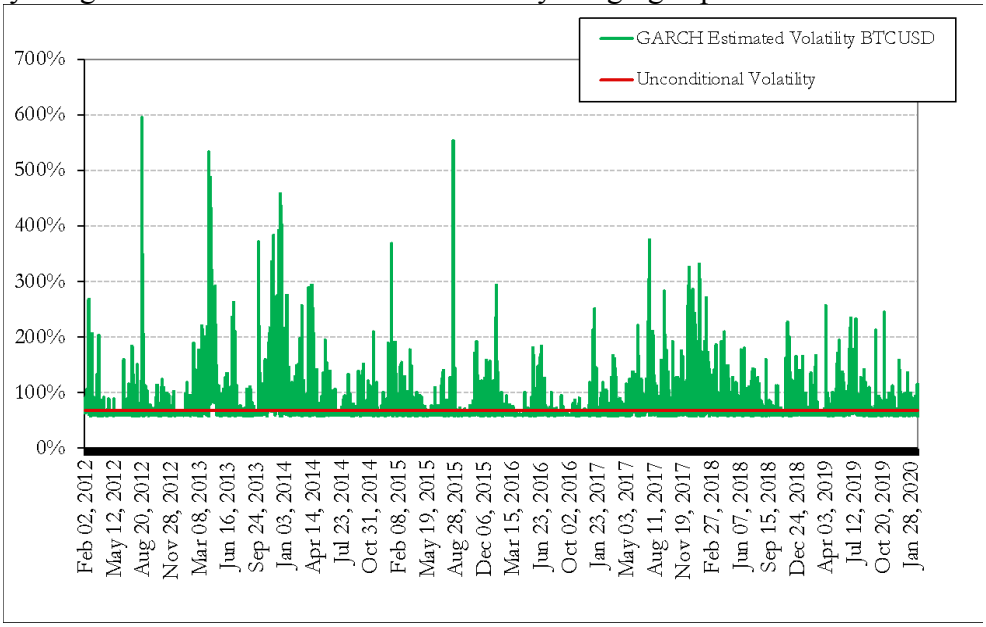


Figure 4. GARCH (1,1) estimated volatility versus unconditional volatility for BTC/USD between February 2012 - February 2020

Source: Author's own research results.

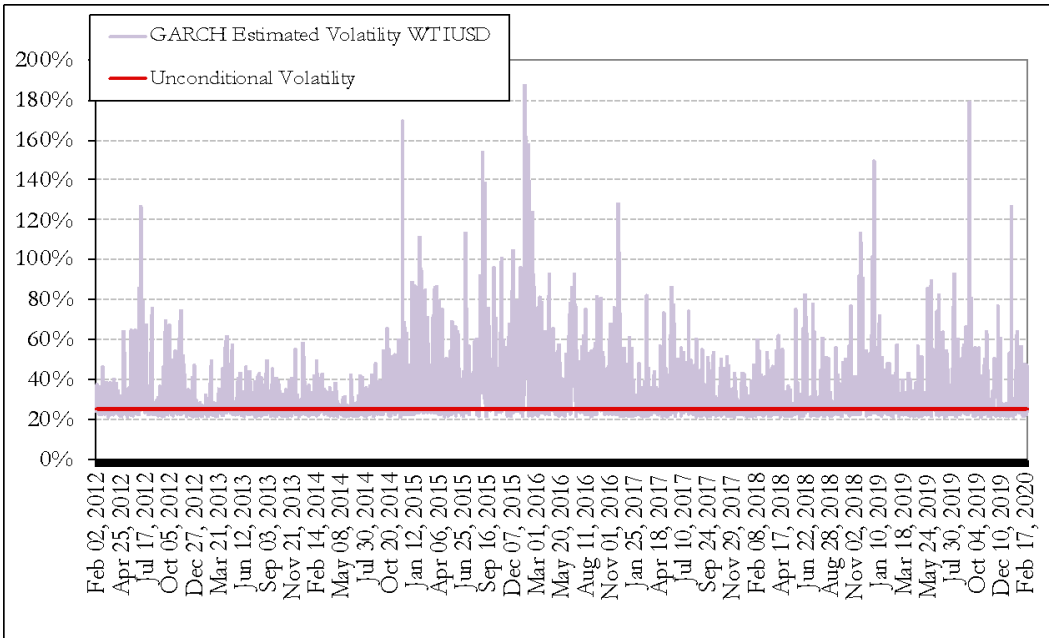


Figure 5. GARCH (1,1) estimated volatility versus unconditional volatility for WTI/USD between February 2012 - February 2020

Source: Author's own research results.

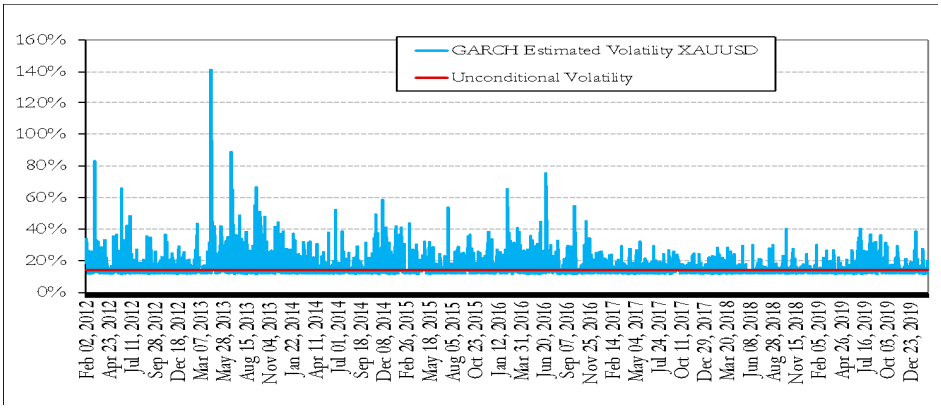


Figure 6. GARCH (1,1) estimated volatility versus unconditional volatility for XAU/USD between February 2012 - February 2020

Source: Author's own research results.

Although the three assets have an inverse relationship against the US dollar, gold provides a much larger stability than both bitcoin and crude oil since fluctuations in the volatility of gold are considerably lower. Therefore, as presented in figure 5 and 6, investors would rather switch to gold than oil, when the markets drop. Since bitcoin has become increasingly scarce, its value significantly rose. However, investors still consider that bitcoin is not regarded as a means of payment, but it is used only for speculation purposes unless it will be properly regulated and endorsed by the governments. Thus, as presented in figure 4, bitcoin is highly volatile and does not seem to mimic the trend of any other asset.

Given the fact that gold still remains the safe haven asset during periods of financial and economic turmoil, central banks are purchasing gold at a rapid pace with Russia and China leading the way. The example of Russia and China purchasing gold was followed by other nations such as

Qatar, Turkey and Uzbekistan. Furthermore, the demand for precious metals has also increased while the US dollar is struggling to keep its supremacy as BRICS reserve currency is seeking to replace it in the future. In the meantime, if Saudi Arabia agrees to accept renminbi for its oil rather than the US dollar, it would enhance the 'petro-yuan' trading already occurring between Russia and China. This transformation could aid the Chinese currency over time and convince other nations to adopt for international trades.

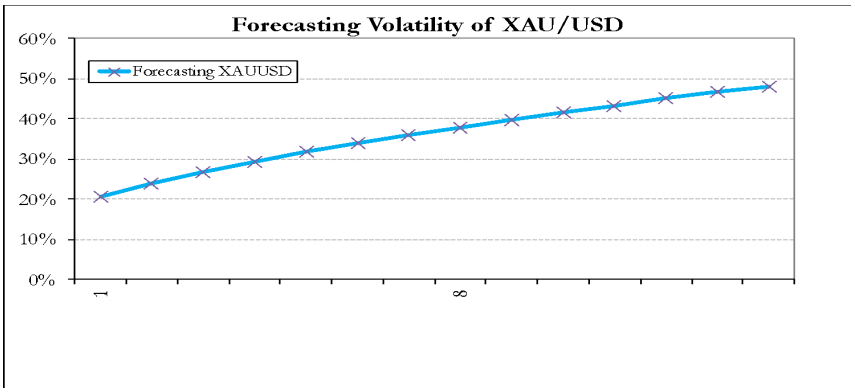


Figure 7. Forecasting the volatility of XAU/USD pair for the next 14 days

Source: Author's own research results.

Since gold still remains the safe haven asset, figure 7 forecasted its volatility over the next fourteen days. More specifically, from 21st February 2020 to 13th March 2020. The purpose of figure 7 is to capture the trend of XAU/USD volatility for the mentioned period. It can be seen that the volatility of the XAU/USD pair will increase in the next fourteen days. Since the volatility of gold will surge, one would expect that gold will be heavily traded during the mentioned time span. Please note that it is very difficult to accurately forecast volatility for more than 1 day ahead.

The results provided by this research paper are in line with the conclusion of Chan et. al., (2003) which emphasizes that the financial markets are strongly connected to the domestic economies, thru foreign direct investments, international trade, capital injections, and technological advancement. Furthermore, the results of this research paper are in line with the conclusions of Chen et al. (1986) and Darie (2022) which highlight that asset returns are determined by economic factors, excluding bitcoin as it is not regulated and represents a speculative asset.

Conclusion

The results of this paper are in line with those of Chen et al. (1986), Chan et. al. (2003), Darie (2022), Dyhrberg (2015), Klein (2018) and Eichengreen (1987). This research paper reveals that gold still remains the asset to which most investors switch to in turbulent economic and financial distress while bitcoin is perceived as a speculative asset. Although both crude oil and gold have an inverse relationship against the US dollar, gold provides a much larger stability than the crude oil whereas bitcoin is only regarded as a means of speculation.

Furthermore, the decision of the European central banks to change their position and invest in gold is very worrying as radical transformation of the global monetary system could be approaching. Considering that powerful nations purchased substantial quantities of gold in order to back their national currency, supremacy of the US dollar is under significant attack. Experts in international relations have claimed that it is essential to have a single, extremely influential national economy to exhibit stability and operate smoothly. Specifically, the international monetary

system functioned under the theory of hegemonic stability. Thus, a fierce attack on the economic hegemony of the US appears to be occurring.

As a result, this research paper concludes that the GARCH (1,1) approach is able to efficiently perform volatility forecasts for bitcoin, gold and crude oil, especially during economic and financial turmoil than using unconditional volatility as the volatility provided by the GARCH (1,1) approach is conditioned on its past values of itself. However, a key limitation of the GARCH (1,1) approach is the overestimation of volatility attributed to the slow response to large isolated oscillations. Another important limitation is the fact that Excel Solver provides inferior results than similar platforms and forecasts should not be made for more than 1 day ahead as they become unreliable.

This research paper will enrich the literature associated with volatility forecasting of different asset classes during financial and economic turmoil while also raising awareness of the economic risks. Additionally, it would be interesting to test the same or other GARCH model using intra-day observations in order to increase the number of observations for the same time span while also increasing the accuracy of the model.

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