Econometrics Project

The Effects of Gold, Stock Markets and Twitter Economic Uncertainty on Bitcoin Prices & Volatility

Due Date: Thursday, 5th January 2023

This essay uses empirical analysis to measure the effects of gold, the VIX and Twitter-based Economic Uncertainty (Baker, 2021) on the price of Bitcoin by conventional ARCH & GARCH, Simple Asymmetric ARCH, Nonlinear ARCH and Exponential GARCH estimations. The period examined covers from June 2011 to November 2022. The econometric outcomes suggest that Bitcoin returns, and volatility are strongly and positively influenced by gold returns. On the other hand, its revealed that the crypto currency is negatively influenced by the S&P500 volatility index (VIX) and Twitter-based Economic Uncertainty index, but to a smaller degree. Evidence suggests that the Exponential GARCH specification provides the best fit for the estimations. The purpose of this study is to analyse the nature of Bitcoin as a speculative asset and to assess Bitcoin's interplay with other financial instruments in order for investors to make more informed investments in Bitcoin based off the macroeconomy.

Connor Hayes

B9005198

Introduction

Bitcoin is a digital currency originally created in 2009 to solve the issue of double spending by incorporating blockchain technology (Nakamoto, 2008). As well as the speed, security and low cost of peer-to-peer transactions, Bitcoin's main appeal as a medium of exchange is its decentralised nature. Without the need for any central authorities, Bitcoin transactions are conducted and confirmed through blockchain nodes which maintain a record of transactions (Bai, 2018). Decentralisation prevents a concentration of power that could enable a single organisation to gain control and influence the market (Böhme, 2015). This aspect of Bitcoin sparked a significant amount of interest from investors on the back of the 2008 financial crisis. The price of Bitcoin grew immensely at the end of 2017, but this was unrivalled compared to the bull run in 2021 where Bitcoin reached a peak market capitalisation of $1.28 trillion (GlobalData, 2022). Cryptocurrencies became mainstream during the covid-19 pandemic and it's possible that the economic uncertainty at the time may have driven investors to look for alternative, safe-haven investments (Al-Nassar, 2022). By comparing the volume of exchange-traded Bitcoins to the volume of transactions within the Bitcoin network, Glaser, Zimmerman, Haferkorn, Weber, and Sterling (2014) concluded that Bitcoin is primarily regarded as a speculative asset, rather than a means of exchange. Brière, Oosterlinck, and Szafarz (2015) also observed that Bitcoin can significantly improve the diversification of an investment portfolio since its correlation to traditional assets and alternative securities is low. In order for Bitcoin to become a successful, long-term investment tool, it is important for investors to recognise the macroeconomic implications on Bitcoin. In this study I will model macroeconomic effects on Bitcoin with the value of gold, stock market volatility and economic uncertainty as the independent variables.

The emergence of Bitcoin as a safe-haven security has ignited comparisons of Bitcoin to gold. As well as being decentralised, Bitcoin and gold also have a limited supply and are relatively rare. In financial terms, gold is universally considered to be a diversifier as it is hedged against stocks and bonds. Moreover, in periods of extreme stock market decline, gold is a safe haven (Baur, 2010). Although early research from Dyhrberg (2015), Selmi and Bouoiyour (2018), suggests that Bitcoin is an efficient hedge against stock markets, more recent papers have found that gold is a significantly more affective safe haven asset compared to the crypto currency (Kyriazis, 2020) (Sharma, 2022). The most prominent measure of stock market volatility is the CBOE Volatility Index, also known as the VIX. The VIX is a measure of the market's expectation of volatility in the following 30 days based on the prices of stock options of the S&P500. Stock market volatility is often associated with the level of uncertainty or confidence in the market, as stock market returns tend to be more volatile in periods of recession (Schwert, 1989). Consequently, the VIX is commonly referred to as the fear index. The final, and defining variable employed in the model is the Twitter-based economic uncertainty (TEU) measure (Baker, 2021). Using keywords such as 'uncertainty' and 'economy', the index measures the weekly volume of Tweets related to economic uncertainty on the platform. The index is a modern-age measure of economic uncertainty and has been successfully incorporated in a number of macroeconomic studies (Becerra, 2020) (Behera, 2021) (Lang, 2022). In spite of this, the index has yet to be integrated into a study on Bitcoin's interconnectedness with the macroeconomy using ARCH & GARCH analysis.

To estimate the volatility of Bitcoin based on Gold, the VIX and Twitter-based Economic Uncertainty, I will use a number of ARCH & GARCH specifications. Starting with the conventional Auto Regressive Conditional Heteroskedasticity (ARCH) and the Generalised Auto Regressive Conditional Heteroskedasticity (GARCH) estimations. I will then employ Simple Asymmetric ARCH, Nonlinear ARCH and EGARCH. Finally, to determine which model is most appropriate for conducting the estimations, I will employ AIC & BIC tests. The structure of this essay includes 4 parts. Part 1 is a literature review of previous studies on the effects of Gold, the stock market & economic uncertainty on the volatility of Bitcoin returns using ARCH & GARCH models. Part 2 gives an overview of the data and methodology of the econometric estimations. Part 3 displays the

outcome of the empirical results and the economic implications of the findings. Finally, part 4 gives a conclusion of the research and thought to future investigation.

1. Literature Review

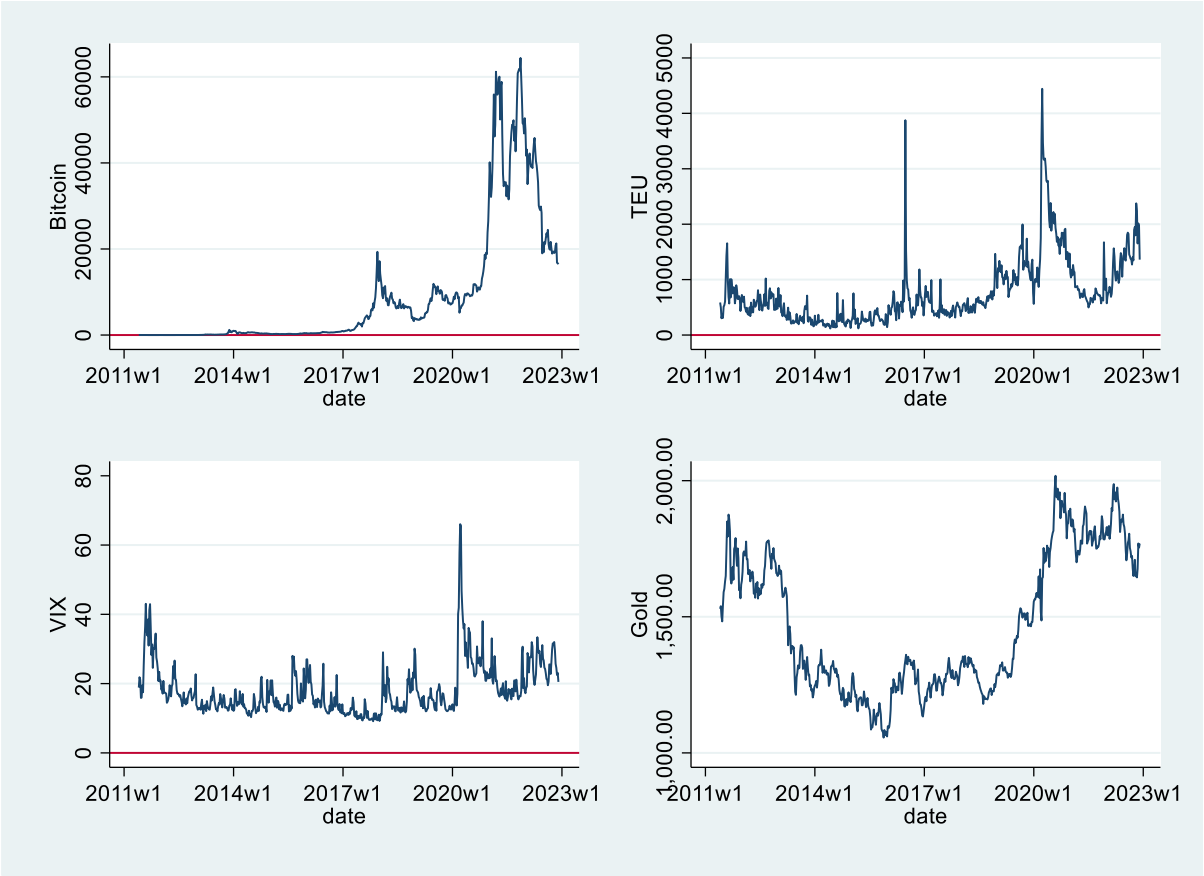
A number of studies have examined the volatility of Bitcoin returns with alternative financial instruments using ARCH & GARCH analysis. In 2016, Dyhrberg produced one of the earliest academic papers to investigate the potential of bitcoin as a speculative asset by adopting an asymmetric GARCH approach. Dyhrberg's results demonstrated the advantages of bitcoin to risk-averse investors in anticipation of market downturns. The study highlighted Bitcoin's sensitivity to the federal funds rate and the crypto-currency's large volatility persistence indicating similarities to gold. Dyhrberg concluded that Bitcoin is somewhere between gold and the US dollar. Baur (2018) replicates Dyhrberg's study with conventional GARCH and asymmetric GARCH estimations and concludes that Dyhrberg's interpretations are misleading as the models cannot answer her proposed research question. Baur extends Dyhrberg's original analysis and concludes that Bitcoin exhibits noticeably different returns, volatility, and correlation characteristics when compared to gold and the US dollar. Therefore, Bitcoin as a speculative asset is unique and is different to traditional financial assets. This is supported by Al-Khazali's (2018) study on the impact of positive and negative macroeconomic news surprises on the returns and volatility of gold and Bitcoin prices. Using the same specifications as Baur (2018), Al-Khazali suggests that gold is different to Bitcoin. In particular, gold returns and volatility routinely respond to unexpected macroeconomic news, whereas Bitcoin prices and volatility are less affected by unexpected macroeconomic news. Al-Khazali concludes that the reactions of gold and Bitcoin to the macroeconomy is asymmetric. In 2019, Pal and Mitra use conditional volatility estimates from various GARCH models to calculate the best hedge ratios between bitcoin and other financial assets. They discovered that gold offers a better safe-haven asset compared to Bitcoin.

Numerous academic papers have also examined the relationship between Bitcoin and economic uncertainty using different modelling techniques. In 2019, Al-Yahyaee uses a wavelet approach to measure co-movements between Bitcoin, the VIX, the U.S. Economic Policy Uncertainty Index (EPU), the Crude Oil Volatility Index (OVX), and the Geopolitical Risk Index (GPR). Al-Yahyaee provides evidence that the connection between Bitcoin and the VIX alters over time and over frequencies. Furthermore, it is revealed that there is a link between the EPU index, Bitcoin and the VIX at different frequencies. Similarly, Aysan (2019) supports that Bitcoin returns and volatility can be forecasted using the Global Geopolitical risks (GPR) index. Price volatility and return on investment for Bitcoin are positively and adversely correlated with the GPR, according to the results of Ordinary Least Squares (OLS) estimations (Aysan, 2019). To conclude, Aysan suggests that Bitcoin can be used to hedge against global geopolitical risks. Finally, the most relevant academic paper on the effects of gold, stock markets and economic uncertainty on Bitcoin was produced by Nikolaos Kyriazis in 2020. Kyriazis adopts conventional ARCH & GARCH, Simple Asymmetric ARCH, Asymmetric GARCH and Nonlinear ARCH specifications to examine the relationship between Bitcoin, gold, the VIX and a Geopolitical Risk Index (Iacoviello, 2020). Kyriazis found that the VIX and gold have a positive impact on Bitcoin returns and volatility. Whereas the Geopolitical Risk Index exhibits a negative impact on Bitcoin. Using AIC & BIC tests, Kyriazis concludes that the Simple Asymmetric ARCH model is the best suited model for the estimation.

2. Data and Methodology

Each data set consists of weekly data for the period of June 2011 to November 2022. The data for Bitcoin, the VIX & gold were all downloaded from Investing.com and the Twitter-based uncertainty data can be acquired from www.policyuncertainty.com (Baker, 2021). Each data series is transformed into the logarithmic differences. Figure 1 shows the value of each variable over the period tested. As you can see in Fig. 1, Bitcoin has been extremely volatile and saw sudden spikes

Figure 1. Bitcoin, Gold, TEU and VIX values for the period June 2011 to November 2022.



in value followed by prolonged periods of decline. Gold has been in a state of steady recovery since 2012 and reached a high of $2,018 during the Covid-19 pandemic as investors looked for short-term safe-haven securities to protect their money in anticipation of an economic downturn (Lahiani, 2021). The VIX also displays these periods of upswings and downturns.in the economy, as the index becomes more volatile at the same points as gold. The VIX and the TEU index are very similar, although the TEU has significantly bigger upswings. This is reflected in Table 1 as the standard deviation for the TEU index is over 80 times greater than the VIX. There is also a sharp rise in the TEU index in June 2016 when Brexit was confirmed, highlighting the index's sensitivity to shifts in economic uncertainty.

Table 1 displays how much more volatile Bitcoin is compared to Gold and also how Bitcoin has a substantially higher average market price. Furthermore, by investigating the variable's kurtosis, the VIX is the most leptokurtic of all the variables. Whereas gold has a more uniform distribution with a kurtosis of 1.7. The correlations between the variables are shown in Table 2. The returns of

Table 1. Descriptive statistics.

	Bitcoin	**Gold**	**VIX**	**TEU**
Mean	9205.704	1468.756	18.131	759.319
Max	64398.6	2018	66.04	4443.068
Min	2.2	1056.2	9.14	119.047
Standard Deviation	14884.88	253.292	7.337	584.447
Skewness	2.004	0.367	2.118	2.16
Kurtosis	6.098	1.708	10.498	9.695

Bitcoin are weakly correlated to the returns of Gold in a positive manner. There is a greater correlation between Bitcoin and the VIX, though it is still a weak correlation and by a negative sign. Therefore, greater volatility in the S&P 500 is expected to result in higher Bitcoin returns. Bitcoin is also negatively related to the TEU, but the size of the correlation is small. It should also be noted that there is a weak correlation between Gold and the indexes. The weakest correlation among the pairs of variables belongs to the VIX and the TEU.

Table 2. Correlation Matrix.

	Bitcoin	**Gold**	**VIX**	**TEU**
Bitcoin	1			
Gold	0.0546	1		
VIX	-0.0889	0.0299	1	
TEU	-0.0179	0.0425	0.0119	1

In regard to the methodology, five ARCH and GARCH models have been used for the econometric estimations. Firstly, the conventional ARCH model (Engle, 1982):

$$h_t^2 = \omega + au_{t-1}^2$$

And the conventional GARCH model (Bollerslev, 1986):

$$h_t^2 = \omega + au_{t-1}^2 + \beta h_{t-1}^2$$

Moreover, The Simple Asymmetric ARCH model is employed (Engle R. F., 1993):

$$h_t = \omega + a(u_{t-1} + \gamma)^2$$

And the Nonlinear ARCH specification (Engle R. F., 1993):

$$h_t = \omega + a|u_{t-1}|^y$$

Finally, estimation by Nelson's EGARCH model is employed (Nelson, 1991):

$$\log(h_t) = \omega + a|u_{t-1}| + \gamma u_{t-1} + \beta\, log(h_{t-1})$$

where h_t stands for the standard deviation, u equals the residuals, a is the coefficient of the residuals, ω is the fixed term, β represents the coefficient of the lagged variance in the GARCH models and γ is the asymmetry or nonlinear nature of volatility.

To determine which model is best suited to produce the estimation, the Akaike Information Criteria (Akaike, 1974) and the Information Bayesian Criterion (Schwarz, 1978) are employed:

$$AIC = 2k - 2nL\left(\widehat{\widehat{\theta}}\right)$$

$$BIC = k\ln n - 2\ln L\left(\widehat{\widehat{\theta}}\right)$$

Where n is the number of observations, k denotes the number of unknown parameters, Θ represents the vector of unknown parameters and $\widehat{\widehat{\theta}}$ is their maximum-likelihood estimates.

3. Econometric Results

Part 1

Prior to conducting the estimations, I examined the returns of Bitcoin (from June 2011 to November 2022) for effects of autocorrelated heteroskedasticity. Figure 2's visualisation of the returns for Bitcoin shows evidence of volatility clustering. This is made more apparent when I regress the returns of Bitcoin and plot the square of the residuals, as shown in Figure 3. After testing the square of the

Figure 2.

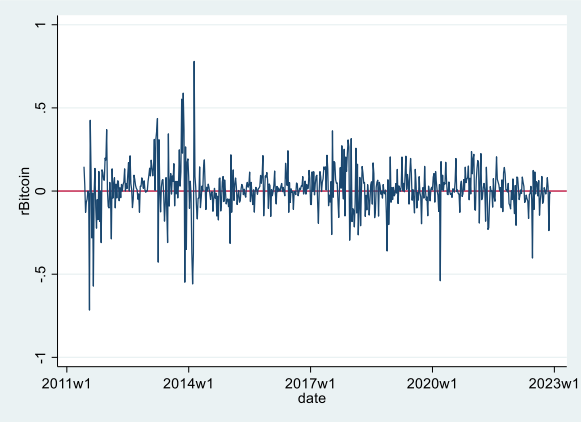
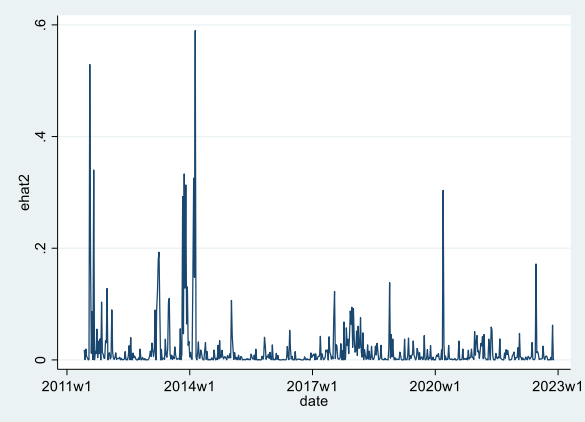


Figure 3.



residuals for autocorrelation and partial autocorrelation, two statistically significant lagged values were detected, as shown in the correlograms below (Figure 4 & 5). Engle's LM test also recognised ARCH effects in the returns of Bitcoin for the period June 2011 to November 2022 (Engle R. F., A general approach to Lagrange multiplier model diagnostics., 1982).

Figure 4.

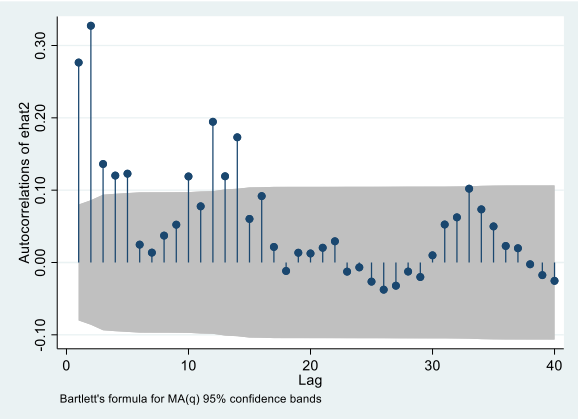
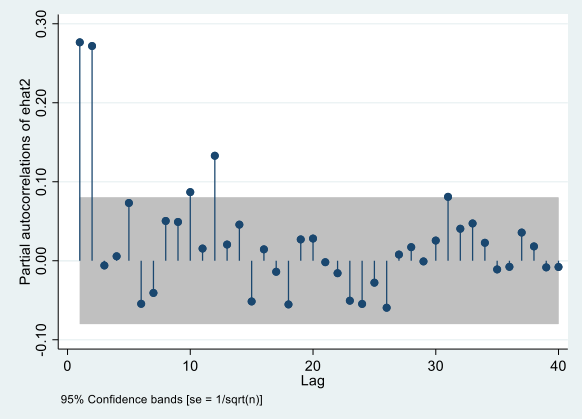


Figure 5.



Part 2

Empirical analysis based on the effects of gold, the VIX and Twitter-based Economic Uncertainty on the price of Bitcoin by conventional ARCH & GARCH, Simple Asymmetric ARCH, Nonlinear ARCH and EGARCH estimations are presented in Table 3. According to the conventional ARCH methodology, Gold exerts a medium positive impact on the price of Bitcoin. Although, this is not statistically significant due to the size of the coefficient which represent high levels of volatility. Moreover, the VIX and the TEU index both exert a statistically significant negative effect on Bitcoin returns. With the VIX (-0.112) having a bigger impact on Bitcoin compared to the TEU (-0.016).

Table 3. Econometric results

	ARCH	GARCH	Simple Asymmetric ARCH	Nonlinear ARCH	EGARCH
Gold	**0.4772363**	**0.5552797**	**0.4936148**	**0.4913938**	**0.8184011**
	(0.166)*	(0.159)*	(0.164)*	(0.163)*	(0.112)*
VIX	**-0.112**	**-0.1092773**	**-0.1767706**	**-0.1771064**	**-0.1344**
	(0.031)	(0.029)	(0.021)	(0.021)	(0.024)
TEU	**-0.0162551**	**-0.0186116**	**-0.186955**	**-0.18738**	**-0.0197024**
	(0.015)	(0.016)	(0.016)	(0.015)	(0.014)
Constant	**0.0040399**	**0.0077621**	**0.0050473**	**0.0050124**	**0.0117751**
	(0.004)	(0.005)	(0.006)	(0.005)	(0.005)
Variance Equation	**0.2199311**	**0.6507548**	**0.0284037**	**0.2681963**	**0.7996904**
	(0.047)	(0.048)	(0.010)	(0.045)	(0.047)
Constant	**0.0094017**	**0.00317**	**0.0085833**	**0.0072231**	**-0.4997469**
	(0.000)	(0.001)	(0.001)	(0.001)	(0.119)*
Log Likelihood	**421.5551**	**428.5976**	**426.2404**	**426.2253**	**434.9835**

* Denotes statistically nonsignificant

Moreover, in the GARCH estimations, gold produces a greater impact on Bitcoin returns (0.555) with a positive medium influence, however the result remains statistically nonsignificant. The GARCH results for the VIX and the TEU are almost identical to the ARCH estimation, with the variables again exerting a statistically significant negative & weak effect on Bitcoin. It should also be noted that under the ARCH and GARCH specifications, the constant term is less than 1% and is statistically significant.

The Simple Asymmetric & Nonlinear ARCH results closely resemble those of the standard ARCH & GARCH findings with just small differences in the coefficients. There is a slight increase in the negative impact of the VIX on Bitcoin in the Simple Asymmetric & Nonlinear ARCH results. Although the size of the impact on Bitcoin is still weak, it is statistically significant. There is also a deviation in the Simple Asymmetric ARCH variance equation when compared to the other estimations as the variance equation is quite low (0.028). The Simple Asymmetric ARCH model also has the most statistically significant variance equation at 1%. The Simple Asymmetric & Nonlinear ARCH findings reveal that the TEU's negative effect on Bitcoin has substantially increased and is statistically significant. The overall size of the impact on Bitcoin returns is still relatively weak. Additionally, the gold estimation is still nonsignificant in the Nonlinear ARCH model.

The Exponential GARCH estimations appear to be the most noteworthy of all the results. The coefficient for gold is 30% more under the EGARCH method compared to the rest of the estimations. The EGARCH results support that an increase in gold by 100% would increase Bitcoin by 81.84011%. Although the result may not be statistically reliable, the EGARCH level of volatility for gold has moved closer to the level of significance and is the smallest out of the other models (0.112). In the EGARCH model, the VIX exerts a weak negative impact on the returns for Bitcoin which is consistent with the rest of the estimations. Also, the TEU index has a very slight negative influence on Bitcoin in the EGARCH model, similar to the conventional ARCH & GARCH findings. Interestingly,

the EGARCH model has the greatest variance equation (0.7996904), and also possesses the only statistical nonsignificant constant by a significant margin (0.119). Despite this, the EGARCH model has the largest log likelihood with 434.9835.

It should be noted that the variance equation components are all statistically significant. This demonstrates that the models employed are appropriate for the estimations, as discovered in Part 1 of the Econometric analysis. The AIC & BIC information confirms that the EGARCH model best captures the influence of gold, the VIX, and the TEU index on Bitcoin returns. Nelson (1991) created the EGARCH model to account for asymmetric impacts between positive and negative financial asset returns over time. Since the EGARCH model is best suited for the purpose of our estimations, the volatility of Bitcoin, when influenced by gold, stock markets & economic uncertainty, is asymmetric. Based on the best fitting model, we can conclude that gold has a strong and positive impact on the price of Bitcoin and that Twitter-based seemingly has an extremely weak and negative impact on Bitcoin. We may also draw the conclusion that stock market activity in the short run can marginally reduce Bitcoin returns.

The results of the econometric estimations have substantial economic and financial implications. Firstly, the strong positive link between gold and Bitcoin supports the safe-haven capabilities of Bitcoin in times of prolonged market decline, as suggested by Dyhrberg (2015), Selmi and Bouoiyour (2018). Therefore, Bitcoin could function as an efficient hedge in investment portfolios. Secondly, the Twitter-based Economic Uncertainty index having less of an effect on Bitcoin volatility may be due to the decentralised nature of cryptocurrencies. And thus, Bitcoin is less likely to respond to shifts in economic outlook or announcements from central authorities. Finally, the negative impact of US stock market volatility on Bitcoin can be attributed to speculation from investors. For example, when the stock market is more volatile, traders have more opportunities to make profits in the short run. In which case, investors may sell their Bitcoin and instead look for shares on the stock market. Alternatively, if the stock market stagnates there is less opportunity for short-term profits, and investors may look to the crypto market for greater growth opportunities.

4. Conclusion

The purpose of this study is to investigate the nature of Bitcoin as a speculative asset and to assess Bitcoins interrelationship with other complex financial instruments. I have investigated the impact of traditional macroeconomic indicators on the price and volatility of Bitcoin. The variables examined include the values of gold, the S&P 500 Volatility Index, and the Twitter-based Economic Uncertainty index (Baker, 2021) using weekly data from June 2011 to November 2022. To study the interrelationship by econometric means, I employ the conventional ARCH, conventional GARCH, Simple Asymmetric ARCH, Nonlinear ARCH & EGARCH estimations. It is revealed that the EGARCH specification is the most suited model to produce estimations for the volatility of Bitcoin as the pattern of Bitcoin's volatility are appear asymmetric.

The econometric results provide evidence that gold has a sizable, positive impact on the cryptocurrency's volatility. This supports the idea of Bitcoin as a hedge in periods of economic distress since the asset appears to move in the same direction as gold which is universally accepted as a safe haven asset. Moreover, the estimations also highlight a negative impact of the S&P 500 Volatility Index on the returns of Bitcoin. This reinforces the concept of Bitcoin as a safe haven because the cryptocurrency seemingly moves in the opposite direction to the largest stock market, a key characteristic of hedged investments. The empirical results also display a profoundly weak impact of Twitter-based Economic Uncertainty on Bitcoin returns which may reflect the cryptocurrencies inherently decentralised nature which makes it unresponsive to changes in a central authority's policy. Whatsoever, the Twitter-based Economic Uncertainty has a negative impact on the volatility of Bitcoin. Thereby, economic uncertainty on the social media platform reduces profitability opportunities of investing in Bitcoin.

This research should help contribute to a framework for Bitcoin as a conventional long-term investment. Given the macroeconomic implications on Bitcoin illustrated, risk-averse investors should feel more comfortable investing in Bitcoin over an increased time horizon. Alternative methodology approaches should be used in future to provide further analysis on bitcoin as a financial asset. Additionally, the crypto currency should be evaluated alongside a larger sample of traditional assets and also include more innovative indices that reflect the macroeconomy.

References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE transactions on automatic control, 19(6)*, 716-723. Retrieved from https://ieeexplore.ieee.org/abstract/document/1100705/?casa_token=tNJDyG9hkwAAAAAA:o9ASr5kXJekjgWNatGz2tTFLku0lKKsbOwuQXw4E7iAT4bfJBa9lI2vO8ebYyiL1t8C02D57TQ1B

Al-Khazali, O. E. (2018). The impact of positive and negative macroeconomic news surprises: Gold versus Bitcoin. *Economics Bulletin, 38(1)*, 373-382. Retrieved from http://www.accessecon.com/Pubs/EB/2018/Volume38/EB-18-V38-I1-P36.pdf

Al-Nassar, N. S. (2022). In search of hedges and safe havens during the COVID‒ 19 pandemic: Gold versus Bitcoin, oil, and oil uncertainty. *The Quarterly Review of Economics and Finance*. Retrieved from https://www.sciencedirect.com/science/article/pii/S1062976922001247

Al-Yahyaee, K. H.-J. (2019). Can uncertainty indices predict Bitcoin prices? A revisited analysis using partial and multivariate wavelet approaches. *The North American Journal of Economics and Finance, 49*, 47-56. Retrieved from https://www.sciencedirect.com/science/article/pii/S1062940818306703

Aysan, A. F. (2019). Effects of the geopolitical risks on Bitcoin returns and volatility. *Research in International Business and Finance, 47*, 511-518. Retrieved from https://www.sciencedirect.com/science/article/pii/S0275531918306810

Bai, C. (2018). State-of-the-art and future trends of blockchain based on dag structure. *International workshop on structured object-oriented formal language and method*, 183-196. Retrieved from https://link.springer.com/chapter/10.1007/978-3-030-13651-2_11

Baker, S. R. (2021). *Twitter-derived measures of economic uncertainty.* Retrieved from http://policyuncertainty.com/media/Twitter_Uncertainty_5_13_2021.pdf

Baur, D. G. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *Financial review, 45(2)*, 217-229. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1540-6288.2010.00244.x?casa_token=G8JMu2A2xRcAAAAA:jpARQmrH-YFjKlz0CYhBmR11OMsLRGp2o5eJihGKITOWUZavVCsfsTkJLxMKtWdGyIAhsC2J2tf-_u0

Baur, D. G. (2018). Bitcoin, gold and the US dollar–A replication and extension. *Finance research letters, 25*, 103-110. Retrieved from https://www.sciencedirect.com/science/article/pii/S1544612317305093

Becerra, J. S. (2020). Twitter-Based Economic Policy Uncertainty Index for Chile. *Central Bank of Chile, (883)*, 1-25. Retrieved from https://www.bancaditalia.it/pubblicazioni/altri-atti-convegni/2020-bi-frb-nontraditional-data/sagner_paper.pdf

Behera, C. &. (2021). he connectedness between Twitter uncertainty index and stock return volatility in the G7 countries. *Applied Economics Letters*, 1-4. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/13504851.2021.1963656?casa_token=_IDw5pLcF54AAAAA:0lvC8KhQOSITWHxZfHIKfVYPLSBGeF5TeEpdS3dlMLISs6amzzNspL_kHSYhDRe7JWmaUEP6PInj

Böhme, R. C. (2015). Bitcoin: Economics, technology, and governance. *Journal of economic Perspectives, 29(2)*, 213-238. Retrieved from https://www.aeaweb.org/articles?id=10.1257/jep.29.2.213

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics, 31(3)*, 307-327. Retrieved from https://www.sciencedirect.com/science/article/pii/0304407686900631

Briere, M. O. (2015). Virtual currency, tangible return: Portfolio diversification with bitcoin. *Journal of Asset Management, 16(6)*, 365-373. Retrieved from https://link.springer.com/article/10.1057/jam.2015.5

Dyhrberg, A. H. (2016). Bitcoin, gold and the dollar–A GARCH volatility analysis. *Finance Research Letters, 16*, 85-92. Retrieved from https://www.sciencedirect.com/science/article/pii/S1544612315001038

Engle, R. F. (1982). A general approach to Lagrange multiplier model diagnostics. *Journal of Econometrics, 20(1)*, 83-104. Retrieved from https://www.sciencedirect.com/science/article/pii/030440768290104X

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the econometric society*, 987-1007. Retrieved from https://www.jstor.org/stable/1912773

Engle, R. F. (1993). Measuring and testing the impact of news on volatility. *The journal of finance, 48(5)*, 1749-1778. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1540-6261.1993.tb05127.x

Glaser, F. Z. (2014). *Bitcoin - asset or currency? revealing users' hidden intentions. Revealing Users' Hidden Intentions.* ECIS. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2425247

GlobalData. (2022). *Bitcoin's Market Capitalization History (2013 – 2022, $ Billion).* Retrieved from https://www.globaldata.com/data-insights/cards-amp-payments/bitcoins-market-capitalization-history/

Hood, M. &. (2013). Is gold the best hedge and a safe haven under changing stock market volatility? *Review of Financial Economics, 22(2)*, 47-52. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1016/j.rfe.2013.03.001?casa_token=BmKfdkaWK_4AAAAA:nnldInvKSzkhnxfoHC-nDOmvO9cChL34_QlWZmPmZIZ4zpG8uQjrvPS0U7cy76_ZM9WtleG6nJR9Rww

Iacoviello, M. &. (2020). *Geopolitical risk (GPR) index.* Retrieved from https://www.matteoiacoviello.com/gpr2019.htm

Kyriazis, N. A. (2020). Is Bitcoin similar to gold? An integrated overview of empirical findings. *Journal of Risk and Financial Management, 13(5)*, 88. Retrieved from https://www.mdpi.com/705514

Kyriazis, N. A. (2020). The Effects of Gold, Stock Markets And Geopolitical Uncertainty On Bitcoin Prices And Volatility. *Global Economy Journal, 20(04)*, 1-15. Retrieved from https://www.worldscientific.com/doi/abs/10.1142/S2194565920500207

Lahiani, A. M.-W. (2021). The safe-haven property of precious metal commodities in the COVID-19 era. *Resources Policy, 74, 102340*. Retrieved from https://www.sciencedirect.com/science/article/pii/S0301420721003494

Lang, Q. L. (2022). Oil futures volatility predictability: evidence based on Twitter-based uncertainty. *Finance Research Letters, 47, 102536.* Retrieved from https://www.sciencedirect.com/science/article/pii/S1544612321004992

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. *Decentralized Business Review, 21260*. Retrieved from https://www.debr.io/article/21260.pdf

Nelson, D. B. (1991). Conditional heteroskedasticity in asset returns: A new approach. *Econometrica: Journal of the econometric society*, 347-370. Retrieved from https://www.jstor.org/stable/2938260

Pal, D. &. (2019). Hedging bitcoin with other financial assets. *Finance Research Letters, 30*, 30-36. Retrieved from https://www.sciencedirect.com/science/article/pii/S1544612318303714

Schwarz, G. (1978). Estimating the dimension of a model. *The annals of statistics*, 461-464. Retrieved from https://www.jstor.org/stable/2958889

Schwert, G. W. (1989). Why does stock market volatility change over time? *The journal of finance, 44(5)*, 1115-1153. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1540-6261.1989.tb02647.x

Selmi, R. M. (2018). Is Bitcoin a hedge, a safe haven or a diversifier for oil price movements? A comparison with gold. *Energy Economics, 74*, 787-801. Retrieved from https://www.sciencedirect.com/science/article/pii/S0140988318302524

Sharma, U. &. (2022). Are gold, USD, and Bitcoin hedge or safe haven against stock? The implication for risk management. *Review of Financial Economics*. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1002/rfe.1160?casa_token=fxeZQXT1_cMAAAAA:F2Hbl8OFv2NuT9IJCLdfW5PzJzX6dA9ThLHWb-Y3DMAy_kfztajn8Q-pbZo43qAuO1JTTcDzw2pBmMA

Wu, S. T. (2019). Does gold or Bitcoin hedge economic policy uncertainty?. *Finance Research Letters, 31*, 171-178. Retrieved from https://www.sciencedirect.com/science/article/pii/S1544612318308894