An Empirical Analysis on Impacts of the Covid-19 Pandemic on Returns, Volatility and Hedging Performance of Cryptocurrencies

Jinyan Wang*

Department of Mathematics, Boston University, Boston, MA 02215, United States

*Corresponding author. Email: jinyan@bu.edu

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Abstract: As the Covid-19 pandemic breaks out and devastates economic markets, investors have been looking for a save heaven asset to avoid risks and uncertainties imposed by the pandemic. Cryptocurrencies, a digital asset that has gained traction in recent decades, have been examined by many scholars on their capability of hedging. Therefore, this paper will empirically examine the impact of the COVID-19 pandemic on cryptocurrency returns and volatility, with a particular focus on bitcoin and daily cases of COVID-19. The study applies time series models, including ARMAX and GARCH, to examine how Covid-19 impacts the Bitcoin returns and volatility. The study also uses the VAR model to investigate the hedging capability of Bitcoin on the stock market. The findings of the research demonstrate that Covid-19 has no substantial impact on Bitcoin returns but its impacts on Bitcoin volatility are significant. The findings also reveal that the larger the percentage of portfolio investments in bitcoin, the larger the magnitude and the shorter the duration of the shock of the Covid-19 pandemic will be. The study suggests that investors should not consider cryptocurrencies as a hedge option at the beginning of Covid-19 breakout but can consider that later to decrease portfolio volatility.

1. Introduction

The Covid-19 outbreak was initially identified in Wuhan, China, in December 2019, and then slowly spreads around the world. In March 2020, World Health Organization (WHO) declared it as a global pandemic (WHO, 2020). Around 435 million people are infected, and 5.95 million deaths were reported. As a result of the pandemic, financial activity has stagnated and other economic activities have been adversely affected. Governments began imposing restrictions such as travel bans to try to contain the virus.

In finance, researchers' attention to the impact of COVID-19 on financial markets is rapidly increasing. An increasing attention is being paid to cryptocurrency market which has witnessed a traction in recent years among investors. For example, the Bitcoin price was below $1000 before February 2017; however, it skyrocketed to $20,000 in December 2017 and then witnessed a subsequently decline to $8000 in February 2018. After that, its price averaged around $7000 in 2019.

During the Covid-19 pandemic, a price bubble has been observed in the Bitcoin market when its price has been around $24,000 in December 2020. The huge volatility in Bitcoin prices has raised a significant amount of literature investigation on its capability of heading and whether it can serve as a safe haven.

The present research has contributed to the existing literature sources in many ways. First, prior researches have explored the relationship between Covid-19 and cryptocurrencies. A study by Shahoo applied the linear Toda and Yamamoto and nonlinear Diks tests to examine the relationship of cryptocurrencies with Covid-19. The findings show a unidirectional causal relation from Covid-19 cases and deaths to cryptocurrency price returns. These results suggest that past Covid-19 cases growth rate helps to predict its returns [1].

Moreover, Vidal-Tomás examined the market transitions of 69 long-lived cryptocurrencies by using a network approach to analyse the cryptocurrency system during the Covid-19 pandemic. He found

that Covid-19 pandemic exercise a significant influence on the cryptocurrency market during a short period from 12 March 2020 to 1 April 2020 and then recovered to its initial state after July 2020 as COVID-19 was gradually contained [2]. Whereas studies were conducted by examining the behavioural characteristics of cryptocurrencies during a pandemic. Yarovaya et al. leveraged volatility signature tests to examine herding in cryptocurrency markets in the time of Covid-19 pandemic. Their research shows that the herding behaviour in cryptocurrency markets was not caused by the Covid-19 pandemic. Instead, the herding behaviours remain contingent on up and down market days [3]. Other research looks at the impacts of Covid-19 on cryptocurrencies from the perspective of market efficiency. For example, Minif et al. quantified the self-similarity intensity of cryptocurrency returns during COVID-19 pandemic and studied the level of market efficiency of cryptocurrencies through multifractal analysis to analyse the herding biases. Their research detected the existence of herding behaviour in the top five cryptocurrencies and indicated that most cryptocurrencies are multi-fractal before the pandemic and Covid-19 positively impacted on cryptocurrency market efficiency [4].

Second, existing kinds of literature also explored the hedging possibility of cryptocurrencies. A study by Demir et al. used wavelet coherence analysis to examine the relationship between cryptocurrencies and the number of Covid-19 cases and deaths to explore whether cryptocurrencies can be considered as a hedging option against Covid-19. Their research suggests a negative relationship between cryptocurrencies and the number of cases and endorses the hedging capability of cryptocurrencies against Covid-19 market uncertainty [5].

Moreover, Corbet et al. investigated whether cryptocurrencies can function as a haven during a crisis. They analyzed the relationship between the largest cryptocurrencies and this time-varying understanding of the magnitude of economic shocks in a rapidly escalating pandemic by using GARCH modelling. Their empirical results found that cryptocurrencies functioned as a store of value and can be considered as a safe haven asset evidenced by the growth in returns during the pandemic [6]. In addition, more studies went beyond only examining cryptocurrencies but comparing the impacts of the pandemic on cryptos with the impacts on other markets, such as stock, gold, and currency markets. More specifically, Caferra and Vidal-Tomás used the wavelet coherence approach and Markov switching autoregressive model to examine the behaviour of cryptocurrencies and stock markets during the Covid-19 pandemic. Their research results showed a financial contagion and indicated that the price dynamics of a market is highly correlated with the type of the market [7].

Furthermore, Yousaf and Ali leveraged the VAR-BEKK-AGARCH model to explore the return and volatility spillovers between S&P500 and cryptocurrencies. The study shows a one-way transmission in returns from S&P 500 to cryptocurrencies assets during the pandemic. It suggested that portfolio managers decrease investments in S&P 500 for the portfolios of S&P 500/BTC, S&P 500/ETH and S&P 500/LTC during the COVID-19 period [8].

Not only for that, González et al. used a nonlinear autoregressive distributed lag method to explore the asymmetric interdependence between cryptocurrency and gold returns. Research has shown that cryptocurrencies have a significant asymmetric response to gold returns during periods of economic turmoil, with their connectivity increasing [9]. In addition, Umar and Gubareva used wavelet analysis to study the impact of Covid-19 pandemic on volatility in major edicts and cryptocurrency markets during January and May 2020. Their research shows a high degree of consistency between the price movements of the COVID-19 Panic Index and the Bloomberg Galaxy Crypto Index. The report suggests that cross-currency hedging strategies may not work during the COVID-19 crisis [10].

Furthermore, Lahmiri and Berkiros used Rosenstein's method to compare the degree of stability and unstability between cryptocurrency and international stock markets. Their research discovered that the cryptocurrency market has gained more instability and more volatility while that of equity has not been affected. It suggested that investing in cryptocurrencies during Covid-19 pandemic could be considered riskier as opposed to equities [11]. However, what draws scholars most attention is those studies that exploited the relationship between Covid-19 and cryptocurrencies to see whether the prediction is possible for cryptocurrencies. For instance, Flite et al. used heterogeneous autoregressive models to examine the cryptocurrency volatility modelling and forecasting issues on high-frequency

data. Their studies suggest that the extended HAR model appears to be the best-performing model and outperforms the other models for volatility prediction for both crisis and non-crisis periods [12].

As such, existing studies tried to expand the literature by examining the dynamics between Covid-19 pandemic and cryptocurrencies or whether cryptocurrency prices are able to predicted by Covid-19 cases. Though a lot of studies find that COVID-19 pandemic had a negative effect on cryptocurrency market, this does not mean market activities in cryptocurrency markets should be ceased. Instead, whether cryptocurrencies can be leveraged as a heading opportunity for portfolio returns and volatility remains unstudied.

Therefore, the rest of the paper is designed as the following. Section 2 briefly explains the methodology, including model designs, equations, and functions. It states how data were prepared and what calculations were performed. Section 3 presents and summarizes model outputs. Section 4 describes the findings in context, explores the reasons why such findings occur and compare results with previous studies. The last section simply makes a conclusion.

2. Math and equations

2.1. Data Source

Data for Covid-19 cases in this paper are derived from www.OurWorldinDathistory.org, an authoritative scientific online publication that portrays the economic and environmental history of our world. They sourced daily confirmed cases from COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.

Data for Bitcoin, S&P 500 and gold prices are derived from Yahoo Finance, a platform that provides financial news, data, and commentary including stock quotes, press releases, and financial reports. All derived asset price data are from the first year of Covid-19 outbreak in order to better explore how the pandemic influenced asset returns and volatility.

2.2. Unit Root Test

Unit root tests are tests for stationarity in a time series. A time series has stationarity if its mean and variance remain constant. Unit roots are one cause for non-stationarity.

2.3. ARMAX Model

ARMAX model is an Autoregressive Moving Average model with extra input that incorporates other explanatory variables based on the ARMA model. It uses past time series values and past disturbances to predict the future while examining the contributions of other explanatory variables to dependent variables. The ARMAX model is designed as follows:

$$x_t = \phi_i x_{t-i} + a_i - \sum_{i=1}^{q} \theta_i a_{t-i} + \gamma_{K_1} x_{K,t-1} + \cdots + \gamma_{K_{q_k}} x_{K,t-q_K} \quad (1)$$

Where $\{x_t\}$ is the response variable at different time lags with coefficients $\varphi_i \{a_t\}$ is white noise with its coefficients θ_i, $\{x_t\}$ is the exogenous variable at different time lags with coefficients γ_i

2.4. VAR Model

Vector autoregressive model is a model that uses all current variables in the model to regress several lagged variables of all variables. VAR model is often used to predict interrelated time series systems and analyse the dynamic influence of random disturbance on the variable system. The Var model is designed as follows:

$$Y_t = c + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{q} \beta_i X_{t-j} + e_t \quad (2)$$

Where c is the model mean, Y_{t-i} is the lagged values of the response variable with coefficients a_i and X_t represents the exogenous variables and its own lagged values and coefficients β_i as well as e_t is the white noise.

2.5. ARMA-GARCH Model

ARMA-GARCH model is a model that examines the mean and the volatility of the independent variable. ARMA process aims to find the conditional mean. GARCH model aims to determine the conditional variance of the process. The ARMA-GARCH Model is designed as follows:

$$Y_t = \mu + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{i=1}^{q} \beta_i \varepsilon_{t-i} + \varepsilon_t + \omega + \sum_{i=1}^{p} \alpha_i {\varepsilon^2}_{t-i} + \sum_{i=1}^{q} \beta_i {\sigma^2}_{t-i} \quad (3)$$

Where μ is the model mean, Y_{t-i} is the lagged values of the response variable with coefficients a_i. ε_t is the white noise with coefficients β_i and ${\sigma^2}_t$ is the conditional variance with its own lagged values and coefficients β_i (β_i is different from the coefficients of white noise)

3. Math and equations

3.1. ARMAX Model Experimental Results

An ARMAX model is adopted to examine the long-term relationship between logarithmic returns of bitcoin and logarithmic Covid-19 cases. The model results show that the external distractions, the logarithm of Covid-19 cases, have no significant effect on the rate of return of Bitcoin. In other words, they have no long-term relationship.

Table 1. ARMAX Summary Statistics

Variables	Coef.	Std. Err
Covid-19 Cases	-0.0004	0.0088
AR (-5)	0.0032	0.0689
MA (-4)	0.1603**	0.0727
Constant	0.0622**	0.0008

Note: Coef and Std. Err stands for coefficients and standard deviation of AR (5) and MA (4) models.

3.2. ARMA-GARCH Model Experimental Results

An ARMA-GARCH model is used to evaluate how logarithmic Covid-19 cases influenced the variability of logarithmic bitcoin rate of returns. The model results suggest that from the mean value equation of ARMA, the rate of return of bitcoin has no significant relationship with its historical rate of return and has no significant bearing on its past random disturbance as well.

From the variance equation of ARCH model results, the conditional heteroscedasticity sequences of the logarithmic rate of returns of bitcoin are significantly correlated. In other words, today's disturbance is significantly related to the disturbance term of the past four years. This means that under the framework of ARCH model, a large disturbance tends to be followed by another large disturbance, that is, there is a volatility clustering effect in the logarithmic rate of return of bitcoin.

Moreover, since logarithmic Covid-19 cases are included in the variance equation of ARCH model, the model results indicate that the logarithmic Covid-19 cases significantly affects the volatility of logarithmic rate of returns of bitcoin at a significance level of 0.1.

Table 2. ARMA-GARCH Summary Statistics

Variables	Coef.	Std. Err
Covid-19 Cases	-0.5050*	0.2714
ARCH	0.2480***	0.0531
GARCH	0.7175***	0.0465
Constant (mean)	-0.0002	0.0027
Constant (variance)	-7.0442***	0.6460

3.3. VAR Model Experimental Results

3.3.1 VAR Stability

As the roots of the companion matric show, all the eigenvalues lie inside the unit circle. Thus, VAR model satisfies the stability condition. In other words, the ripple effect exerted by the Covid-19 epidemic on the VAR model equation of bitcoin rate of returns will gradually disappear as time goes by.

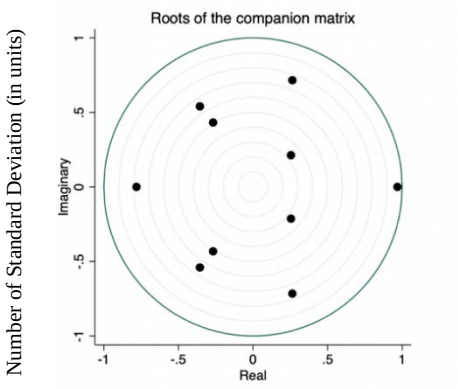

Figure 1. Characteristic Values of the VAR models in Unit Circle

3.3.2 Impulse Response Analysis

The impulse response function studies the response of endogenous variables to random disturbance. It is used to describe the impact of a shock on the current and future values of an endogenous variable. Therefore, as the impulse response figure demonstrates, the Covid-19 pandemic has had a significant impact on bitcoin's logarithmic returns in terms of timing and magnitude. Bitcoin rate of returns is positively impacted by less than 0.01 unit of the standard deviation of new additions to Covid-19 cases. The logarithmic rate of return of bitcoin is largely negatively impacted in the following 2nd period. After that, the impact on bitcoin rate of returns is becoming slighter. As time passed, the impact of the number of new additions to Covid-19 cases on the Bitcoin rate of return tended to zero.

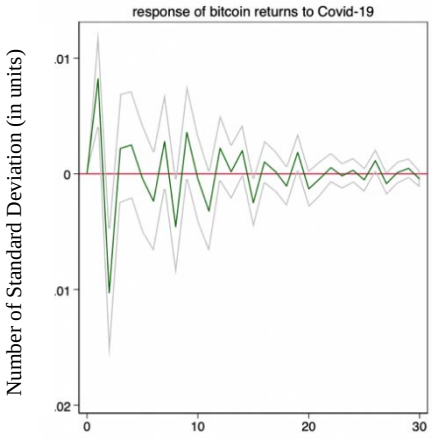

Figure 2 Response of late of logarithmic bitcoin returns to logarithmic Covid-19 cases

To investigate whether cryptocurrency can serve as hedging for S&P 500 and whether it influences the dynamic relationship between S&P 500 and Covid-19 cases, three portfolios were constructed. Portfolio (A) invests 5% of capital in bitcoin and 95% in S&P 500 index fund. Portfolio (B) allocates 20% of capital into bitcoin and 80% into S&P 500 index funds. Portfolio (C) allocates 100% capital into S&P 500. As the impulse response figures show below, the logarithmic return of portfolio (A) and Portfolio (C) received a very similar shock from the pandemic and were both significantly impacted in the first and second periods. The shock decreases in magnitude after 4th period but experienced another shock in the 10th period and does not die out after 27th period.

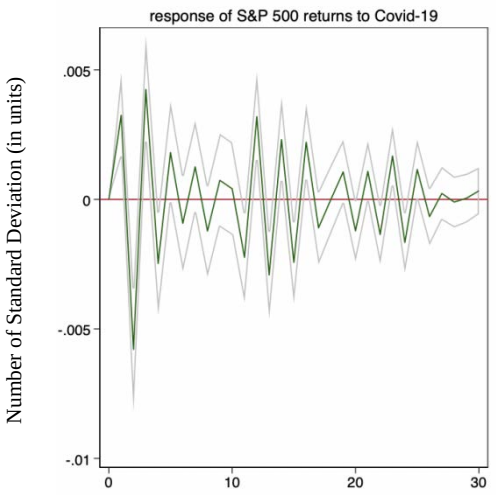

Figure 3 Response of late of the portfolio (C) to logarithmic Covid-19 cases

Note: the x-axis represents the periods after the shock and the y-axis represents the number of standard deviations

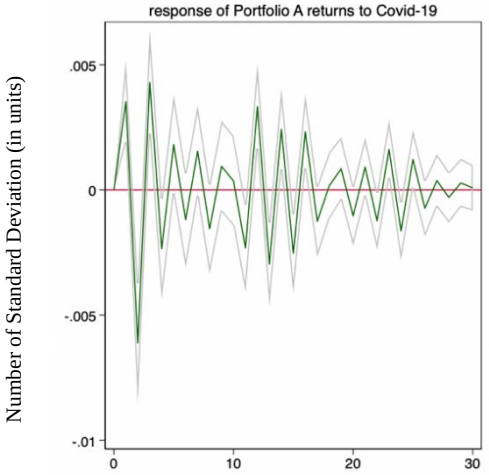

Figure 4 Response of late of the portfolio (A) to logarithmic Covid-19 cases

However, the impact portfolio (B) received has a larger magnitude in the first few periods than a portfolio(A) and (C). But it lasts shorter as it starts to die out on the 18th period and does not experience any larger shock later. As the model results indicate, the larger the percentage of investments in cryptocurrency, the larger the magnitude of the shock at the beginning but shorter the duration will be.

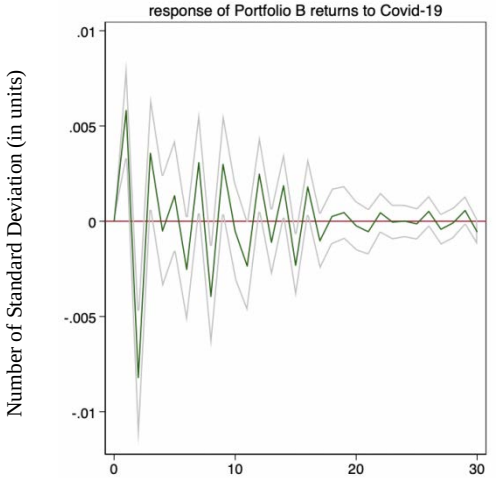

Figure 5 Response of late of the portfolio (B) to logarithmic Covid-19 cases

4. Discussion

To investigate how Covid-19 pandemic affects the returns and volatility of cryptocurrency and whether cryptocurrency can serve as good hedging for stock investments, several time series models were performed. First, results from ARMAX models suggest that the exogenous variable, Covid-19 daily cases, does noy significantly impacts the return of Bitcoin. In other words, these two variables have no long-term relationship. This finding might be because the outbreak of Covid-19 only impacted the operation of real economies and people's expectations of the future outlook, while cryptocurrencies like Bitcoin have no physical assets as a support, so their asset returns were not greatly affected.

Second, outputs from ARMA-GARCH model show that the logarithmic rate of return of bitcoin has no significant relationship with its past returns and random disturbance. This uncorrelation might be because the bitcoin asset itself is too volatile to correlate with own past returns. It also reveals that the conditional heteroscedasticity sequences of logarithmic rate of returns of bitcoin are significantly correlated and the rate of return of bitcoin has a volatility clustering effect. This effect may be attributed to the dependence of variance of bitcoin across time, and a large disturbance of bitcoin tends to be followed by another large one. Moreover, the exogenous variable, logarithmic Covid-19 daily cases, impacts volatility of the logarithmic rate of returns of bitcoin. This impact might be because Covid-19 pandemic increased investors' uncertainty about all assets and the price of bitcoin as a result experienced larger variations and therefore an increase in volatility.

Third, model results from VAR suggest that all VAR systems are stable. In other words, the ripple effect exerted by the Covid-19 epidemic on the VAR model equation of bitcoin rate of returns, portfolio (A), portfolio (B) and portfolio (C) will gradually disappear as time goes by. The model results indicate that the Covid-19 pandemic had a big impact on bitcoin's logarithmic returns in terms of timing and magnitude while as time passed, this impact tended to zero. To might be because as investors slowly digest the news of the outbreak, they began to incorporate the shock of pandemic into asset pricing. As a result, investment certainty gradually recovers, leading to the increasing stability of asset prices and decreasing impacts of the shock.

Besides, from the outputs of VAR models on the portfolio (A), (B) and (C), the stock market experienced a longer duration of a shock than cryptocurrencies. This might be because the pandemic continued to exercise shock on businesses, which imposed investment uncertainty continuously and therefore the shock lasts longer. Compared to cryptocurrencies since they are not backed by any real assets so the shock on them dies out soon.

By comparing their impulse response figures, we can conclude that the larger the percentage of bitcoin investments, the larger the magnitude of the shock while the shorter the duration of the pandemic. To explain, since portfolio (B) invests more in bitcoin and therefore it will experience larger volatility but shorter impacts duration. This phenomenon may betoken that investors should not consider cryptocurrencies as a hedge for their portfolio at the beginning of the shock while can consider it later to offset portfolio volatility.

Compared to previous studies, the existing literature only sheds light on the relationship between the Covid-19 pandemic and cryptocurrencies, or whether there is any specific herding behaviour in cryptocurrencies. Though some of the studies provided insights on whether cryptocurrencies can serve as a good hedging candidate, they failed to investigate how cryptocurrencies would influence the dynamics between assets returns and Covid-19 pandemic, such as the expected length of time and magnitude that the pandemic would have on assets. This research provides critical insights for investors who want to seek or avoid risks and quantify them by including cryptocurrency into their portfolios to maximize returns and minimize volatility.

5. Conclusion

The study examined the long-term relationship between Covid-19 and cryptocurrencies and investigated the potential hedging performance of cryptocurrencies on the stock market by using time series models. The study found that Covid-19 exercised a significant influence on the volatility of

cryptocurrencies prices but not on their returns. The study also suggests that cryptocurrency has volatility clustering and is significantly affected by its past volatility. By creating three portfolios A, B, C which invest a different proportion of capital into cryptocurrencies and S&P 500, findings reveal that the larger the percentage of investments in cryptocurrency, the larger the magnitude of the shock but shorter the duration of the shock will be.

On the one hand, the study suggests that under Covid-19 pandemic, investors should not consider cryptocurrencies as a hedging candidate for their portfolio at the beginning of the shock while can consider that later as an option to offset investment volatility. On the other hand, this research also provides critical insights for those investors who want to actively seek and quantify risks to maximize their returns by including cryptocurrency in their portfolios. However, this study can be greatly improved by taking other cryptocurrencies assets and latest data of Covid-19 cases into consideration for a better judgment on the hedging capability of cryptocurrencies on the stock market.

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