Yield and Fluctuation of Cryptocurrency under the Covid-19 Pandemic: Empirical Research based on Ethereum

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Abstract. The Covid-19 pandemic has caused one of the most severe systematic shocks to global financial markets as investors discovered the sudden slumps in major global stocks indexes in March 2020. However, at the same time, the pandemic also accelerated the rise of decentralized finance and cryptocurrencies as the public began to shift their investments from traditional stock markets to the newly emerged fintech markets as the decentralized financial market's risks hedging ability are believed to be better during global emergencies. Although it's tempting to attribute these observed phenomena solely to the Covid-19 pandemic, other political shocks such as the US 2020 election and China's crypto crackdown in 2021 also exacerbated the uncertainties and thus should be considered as potential reasons for the observations. Through theoretical analysis on financial and political economics as well as empirical modeling utilizing Stata17, this report has constructed a time series ARMA-GARCH model quantifying the relationship between Ethereum's investment return and potential factors including the daily new confirmed cases of Covid-19 and other policy changes, and discovered for the first time that the rise of Ethereum's investment return is majorly caused by the two aforementioned policy changes, and the rapid infection of Covid-19 only caused a short-term rise in Ethereum's investment return whereas the daily new infection numbers of the later stage only caused fluctuations to the Ethereum trading market. Based on the findings, the article made recommendations for both policy makers and investors on crypto investments during the fintech era.

Keywords: Financial Economics; Decentralized Finance; Cryptocurrency; Ethereum; Covid-19.

1. Introduction

In 2020, shortly after the Covid-19 virus became a global pandemic, the stock market all over the world had slumped whereas the price of cryptocurrencies including Ethereum skyrocketed. Specifically, on March 16th, 2020, the Dow Jones Industrial Average of the US dropped 2977.1 points, which is the worst drop since the "Black Monday" in 1987 [1]. In addition, other major global stock markets such as the FTSE Index of the UK and the Japanese Nikkei Index also suffered huge losses [2]. However, the price of different cryptocurrencies skyrocketed almost at the same time as the stock market slumped. For example, the price of Bitcoin even peaked at around $63,000 in April 2020 and the price of Ethereum also increased significantly [3]. For a long time, the public speculates that such a rise in Ethereum's price is caused by the risk hedging behavior of investors when facing uncertainties caused by the pandemic. Indeed, such beliefs are in line with the Misesian view of money since cryptocurrencies, in contrast to fiat money, have market-driven prominence rather than only government-endowed values [4]. Additionally, the maximum cap of most cryptocurrencies is preset which well prevents inflation and enhanced their risk hedging abilities during uncertainties caused by the pandemic. However, as the world enters a period with more crisis, it is highly possible that other uncertainties such as the US 2020 election and China's crypto crackdown in 2021 also contribute to investors' fear over an uncertain future or caused damage to the rise of decentralized finance. As a result, this paper includes a time-series analysis and modeling of the investment return of Ethereum after the beginning of the Covid-19 pandemic and analyzed the effect of the aforementioned external political events on Ethereum through the use of Stata 17.

In the article "*The Relationship Between Cryptocurrencies and Covid-19 Pandemic*", the authors Ender Demir et al confirmed that cryptocurrencies do serve a hedging role during the Covid-19 pandemic by analyzing the daily price of Bitcoin, Ethereum, and Ripple in US dollars using both the ARDL and Wavelet model [5]. The authors concluded that although Covid-19 infection numbers and the price of cryptocurrencies do have a causal relationship, at the beginning of the pandemic, cryptocurrencies do behave like traditional assets since it's negatively correlated with the Covid-19 daily new infections and deaths. However, the authors discovered that as governments began to inflict strict restriction policies against the virus and the public's concern deepened, the relationship between the infection and death number of Covid-19 and price of cryptocurrencies becomes positive given non-traditional assets like cryptocurrencies can mitigate some of those concerns. The conclusion of this article according to its authors is in accordance with the point of view of Goodell and Goutte's article in 2020. Finally, the authors of this article suggested that among all cryptocurrencies, Bitcoin's price has the most apparat correlation with the spread of Covid-19 whereas Ethereum and Ripple's correlation with the spread of Covid-19 is much weaker. So, the authors encouraged investors to add cryptocurrencies into portfolios given that they can not only hedge the risks of the pandemic, but also serve as a means of payment and money transfers under more severe circumstances.

In addition to the previous article, the article "*Covid-19 Pandemic and Cryptocurrencies Market: An Empirical Analysis from a Linear and Non-Linear Relationship*" written by Pradipta Kumar Sahoo goes a step further to find out what type of relationship is between the spread of Covid-19 and the price of cryptocurrencies [6]. First, the author used the Toda Yamamoto causality test to check the causation of the linear relationship and the result suggests that Covid-19's infection and death numbers have a unidirectional relationship with the cryptocurrency returns. In addition, when conducting the DP non-linear granger causality test after partial out the linear dependent part, the author found that the infection and death of Covid-19 can non-linearly cause the change in the cryptocurrency's return. However, when considering the NP-structural break into the test, the author had found that the relationship between the infection and death of Covid-19 and the cryptocurrency's return cannot be confirmed. As a result, the author does urge investors to check the internal news of Covid-19's growth, the recent Covid-19 global trend, and the macroeconomics conditions before making the investment given the high riskiness of the asset despite its ability to hedge for certain risks caused by the pandemic.

In contrast to the theoretical focuses of the previous articles, Christy Dwita Mariana et al have taken a more applied focus in the article "*Are Bitcoin and Ethereum Safe-Heavens for Stocks During the Covid-19 Pandemic?*" [7]. First, the authors have calculated the dynamic correlation between both Bitcoin and Ethereum with the S&P500 index and found that they have become more negative during the pandemic than before, suggesting both coins could be classified as safe heavens. Moreover, by comparing Bitcoin and Ethereum's dynamic correlation and that of gold, the authors have discovered that the two cryptocurrencies are even more risk averse than gold. In addition, through running the OLS regression with Newey-West robust estimator after finishing the corrected-DCC test, the authors have come up with a prediction equation of the return of cryptocurrencies at time t based on various regressors including Covid-19 infections, gold price, stock market index, cryptocurrency's price in previous days, etc. Finally, the authors concluded that in the short run, both Bitcoin and Ethereum are safe havens for stocks, and Ethereum is even more risk averse than Bitcoin during extreme stock market downturns despite its higher return volatility than Bitcoin. However, the authors also warn that the slump of S&P500, FTSE-100, and Nikkei-225 is not fully caused by the Covid-19 outbreak given that economists have repeatedly warned against a possible economic recession far before the start of the pandemic. In addition, the authors also hypothesized that in the long run, regulatory barriers and policy changes could post more uncertainties to the risk-averse attributes of these assets, suggesting that the actual risk hedging ability of Ethereum could be smaller than what the model suggests.

The three articles above well summarized the relationship between the spread of Covid-19 and the price of cryptocurrencies including Ethereum. However, all the previous researchers' dataset contains a time window that is relatively short and failed to incorporate the exogenous factors including policy changes in key economic entities such as the US and China following the 2020 election and the crackdown of cryptocurrencies in 2021 respectively. Since the fear of Covid-19 uncertainties in 2020 is interwoven with the fear of uncertainty caused by political violence and potential chaos after the

US 2020 election, so, it is important to separate the effect of the US 2020 election on Ethereum's price and the effect of the pandemic [8]. Additionally, starting in May 2021, the Chinese government began its crackdown on cryptocurrencies banning both trading and mining of cryptocurrencies, causing cryptocurrencies' prices to tumble [9]. Such policy change on the world's second-largest economic entity and by then the world's largest crypto miner could potentially make the investment return of Ethereum differ both in the short run and in the long run [10]. As a result, this report will take one step further to partial out the effect of those exogenous factors and get the true relationship between the spread of Covid-19 and the investment return of Ethereum to fill in the gap of the previous research.

The following parts of this paper are organized as follows: Part 2 is research design, which contains data sources, unit root test, and model specification. Part 3 is empirical results and analysis which contains the vector autoregression, impulse and response, and regression results. Part 4 is discussion, which contains the main research findings and some recommendations for policymakers as well as investors. Finally, Part 5 is the conclusion of this paper.

2. Research Design

2.1 Collection & Creation of the Dataset

To fully understand the risk aversion attitude of investors amid the global pandemic, data points from the start of the pandemic until the present should all be included daily. So, the time-series dataset includes the time window between January 24th, 2020, the next day after the World Health Organization's Director-General convened an emergency committee on Covid-19, and July 19th, 2022, when this research had started [11].

The explanatory variable of this time-series dataset is the daily closing price of Ethereum measured in US dollars downloaded from Yahoo Finance [12]. To improve the stationarity of data and avoid problems such as heteroskedasticity, Ethereum's daily closing price has been changed to the logarithm value. Afterward, the logarithm value of the exogenous variable is generated, and the logarithm value of Ethereum's rate of return is generated from the differences.

Given that at the beginning of the Covid-19 outbreak, the daily new confirmed cases in China and that for the rest of the world exhibits significantly different patterns since China was initially the epicenter of this global health emergency when the rest of the world were not severely influenced, so, instead of only including the world's daily new confirmed cases, this report will include the daily new confirmed cases of China and that of the overseas. Thus, the two key regressors in this experiment are the daily new confirmed cases of China and the daily new confirmed cases for the rest of the world both being collected from the website East Money Information [13].

Additionally, to partial out the effect on Ethereum's logarithm rate of returns caused by policy changes, this report uses dummy variables to represent the key events (the US 2020 election and China's crackdown on cryptocurrencies in 2021) that happened within this time window in the regression analysis shown in the later parts. Since the result of the US 2020 election both lead to huge policy changes and an acute threat to the political stability of a major global economic entity, it is highly probable that such changes could influence the rate of return on Ethereum. As a result, the first dummy variable called "dummy" which represents the policy changes before and after November 3rd, 2020, the date of the US election is created. Additionally, in 2021, the Chinese government issued the "*Notice on Preventing Bitcoin Risks*" and "*The Announcement of Preventing Token Issuance and Financing Risks*", which directly bans the mining, transaction, and hype of all cryptocurrencies among Chinese citizens and Chinese financial entities, Ethereum's price and its investment returns experienced a sudden dip [14]. So, the dummy variable "policy 1" which represents the first week after China's ban on cryptocurrencies, and "policy 2" which represents all the dates after China's policy change is then created to partial out both the short-term and long-term effect on Ethereum's logarithm rate of return caused by China's ban.

2.2 Unit Root Test

Before starting the model building and regression analysis, this research performs an augmented Dickey-Fuller test to check for the stationarity of the time series data points. First, the following hypothesis test is being performed:

Ho: The variables contain unit roots, and thus are non-stationary

Ha: The variables are generated by a stationary process

Table 1. ADF test

Variables	t-statistic	p-value
Price		
ETH	0.9851	0.9851
NCC, China	-4.530	0.0013***
NCC, overseas	-3.007	0.1300
Yield		
ETH	-7.847	0.0000***
NCC, China	-8.677	0.0000***
NCC, overseas	-13.592	0.0000***

Since the p-value for the price of Ethereum and daily new confirmed cases out of China are both over 0.1, the rejection of the null hypothesis failed, suggesting that Ethereum's logarithm price series is non-stationary.

However, the p-value for all the variables within the series of Ethereum's logarithm yield are all 0.00, which are all statistically significant, suggesting that the variables in Ethereum's logarithm yield series are stationary. So, the research will precede with the logarithm yield of Ethereum's series.

2.3 ARMA Model Specifications

To predict the future yield of the logarithm value of Ethereum based on the actual values and the disturbances of Ethereum's past yields, the ARMA (p, q) model should then be considered.

$$x_t = \phi_0 + \sum_{i=1}^{p} \phi_i x_{t-i} + a_t - \sum_{i=1}^{q} \theta_i \, a_{t-i} \tag{1}$$

The ARMA model as shown above, which is used to predict economic relationships, is the combination of the AR model and the MA model. Within the AR portion, all the characteristic roots must have the absolute value of their norm of vector to be smaller than one to be considered stationary. Additionally, given that MA is the linear combination of the white noises, the MA portion is naturally stationary.

2.4 VAR Model Specifications

The vector autoregression model, as displayed below, is a model that combines multiple economic variables in forecasting.

$$\begin{pmatrix} \gamma_{1t} \\ \gamma_{2t} \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} \\ \beta_{21} \end{pmatrix} y_{1,t-1} + \cdots + \begin{pmatrix} \beta_{1p} \\ \beta_{2p} \end{pmatrix} y_{1,t-p} + \begin{pmatrix} \gamma_{11} \\ \gamma_{21} \end{pmatrix} y_{2,t-1} + \cdots + \begin{pmatrix} \gamma_{1p} \\ \gamma_{2p} \end{pmatrix} y_{2,t-p} + \begin{pmatrix} \varepsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \tag{2}$$

Through combining all the variables of interest, the forecast would then be mutually consistent, and thus a multivariate time series is created. In addition, given the vector autoregression model is not completely based on financial economics, it made it possible for researchers to add additional explanatory variables into the regression freely.

2.5 ARMA-GARCH Model Settings

The GARCH function is adopted when conditional heteroskedasticity exists within the model. Since the GARCH function could be viewed as the infinite order of ARCH model, and GARCH model has the relatively flexible setting, so the GARCH model could be used in various circumstances.

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \cdots + \alpha_q\varepsilon_{t-q}^2 + \gamma_1\sigma_{t-1}^2 + \cdots + \gamma_p\sigma_{t-p}^2 \tag{3}$$

The ARMA (p, q) model and the GARCH function are displayed above as equations one and three respectively, and they are used to create the ARMA-GARCH model which is setting the mean equation of the GARCH model as the ARMA process which is then used to predict the yield rate and volatility of Ethereum for this report.

3. Empirical Result & Analysis

3.1 VAR Model Specifications

To determine the number of lags within the vector autoregression model, the following tests are performed, and the number is determined based on the information guidelines.

Table 2. VAR identification

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1641.19				.008076	3.69481	3.70098	3.71096
1	-1483.8	314.78	9	0.000	.005786	3.36135	3.38605	3.42596
2	-1413.21	141.18	9	0.000	.005038	3.22295	3.26616	3.33601
3	-1389.44	47.552	9	0.000	.004874	3.18975	3.25148	3.35125
4	-1366.65	45.579	9	0.000	.004725	3.15876	3.23901	3.36872
5	-1271.87	189.56	9	0.000	.003897	2.966	3.06477	3.22441
6	-1113.27	317.2	9	0.000	.002784	2.62982	2.74711*	2.93668*
7	-1104.8	16.942	9	0.050	.002788	2.63101	2.76681	2.98632
8	-1094.51	20.584*	9	0.015	.00278*	2.62811*	2.78243	3.03186
9	-1091.09	6.8401	9	0.654	.002815	2.64065	2.81349	3.09285
10	-1084.55	13.07	9	0.159	.00283	2.64619	2.83754	3.14684
11	-1077.51	14.085	9	0.119	.002843	2.65059	2.86046	3.19969
12	-1074.67	5.687	9	0.771	.002883	2.66442	2.89281	3.26198

The vector autoregression model's identification information as displayed in Table 2 above suggests that the result of the likelihood ratio test, FPE, and the AIC values are all significant, indicating that a model with eight lags is appropriate.

After building the vector autoregression model, the residual of the model is then tested to find out if autocorrelation exists and if they follow the normal distribution through the VAR stability test.

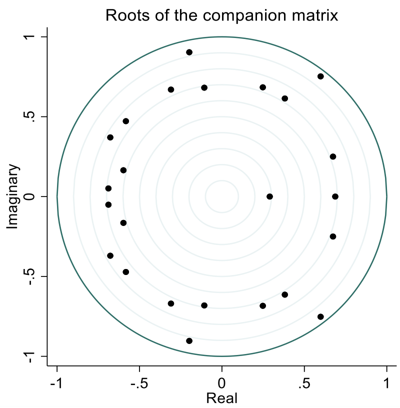

Figure 1. VAR stability

The roots of the companion matrix as displayed in Figure 1 above show that all the eigenvalues lie within the region enclosed by the unit circle. Thus, the vector autoregression method is a stationary process.

3.2 Impulse & Response

The impulse diagram as displayed in Figure 2 below demonstrates the effect of the overseas' total Covid-19 daily confirmed cases on Ethereum's rate of return on the left and China's total Covid-19 daily confirmed cases' effect on Ethereum's rate of return on the right.

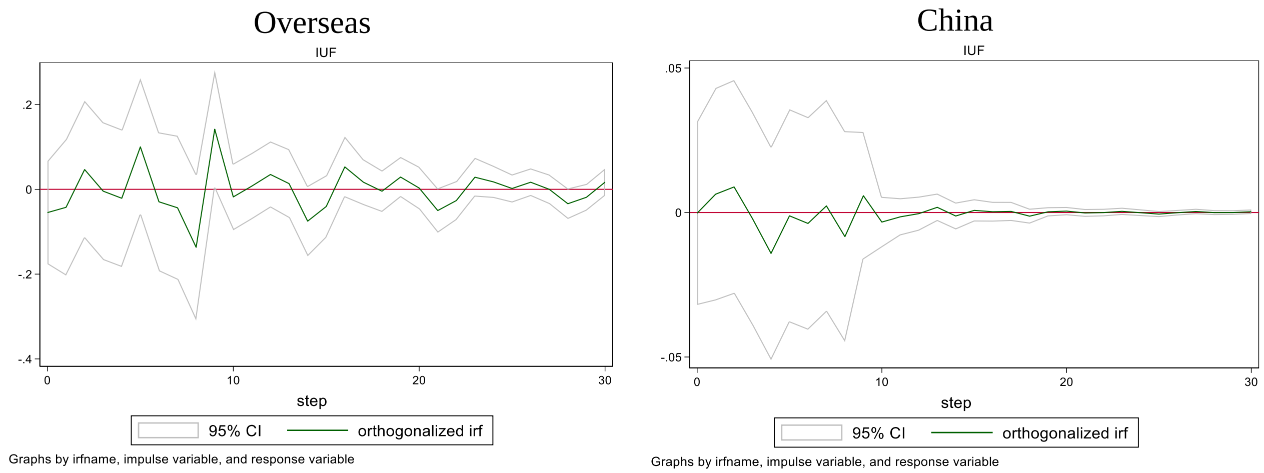

Figure 2. Impulse and Response

Starting from the basic facts, it can be found that after the outbreak of the Covid-19 pandemic in early 2020, the global economic growth declined, and various index indicators reflecting the performance of the financial market have fallen sharply, indicating that the Covid-19 pandemic has a huge impact on the financial market. However, the fundamental properties of cryptocurrencies determined that their value is relatively different and independent compared to other types of financial assets. In addition, the panic caused by external risks such as the rapid spread of Covid-19 has driven investors' risk hedging behavior, and the price of Ethereum has risen sharply in the short term in response.

However, in the long run, the relationship between the Covid-19 pandemic and the price of Ethereum needs to be further verified. Judging from the estimation results of the impulse response graphs as demonstrated above, when the growth rate of daily new logarithmic diagnoses outside of China increased by 1 unit during the period of t=0, the yield of Ethereum fluctuated in the short term with an amplitude of about 10%. In terms of orders of magnitude, changes in the growth rate of China's logarithmic daily new diagnoses have less impact on Ethereum's yield. From the perspective of the time effect, both the overseas pandemic and the impact of the Chinese local epidemic on Ethereum's yield are only short-termed, and both effects will decay over time.

In conclusion, this article argues that the impact of the Covid-19 outbreak on Ethereum's yields is completely different in the short run and the long run. From the aforementioned results, the outbreak is more of a short-term shock that raises Ethereum's prices. However, in the long run, as long as there is no new large-scale pandemic, the yield of Ethereum will only fluctuate due to the impact of the Covid-19 pandemic, instead of further pushing up its price.

3.3 ARMA

To determine the order of the ARMA model, the order determination method using the autocorrelation function and the partial autocorrelation function is used.

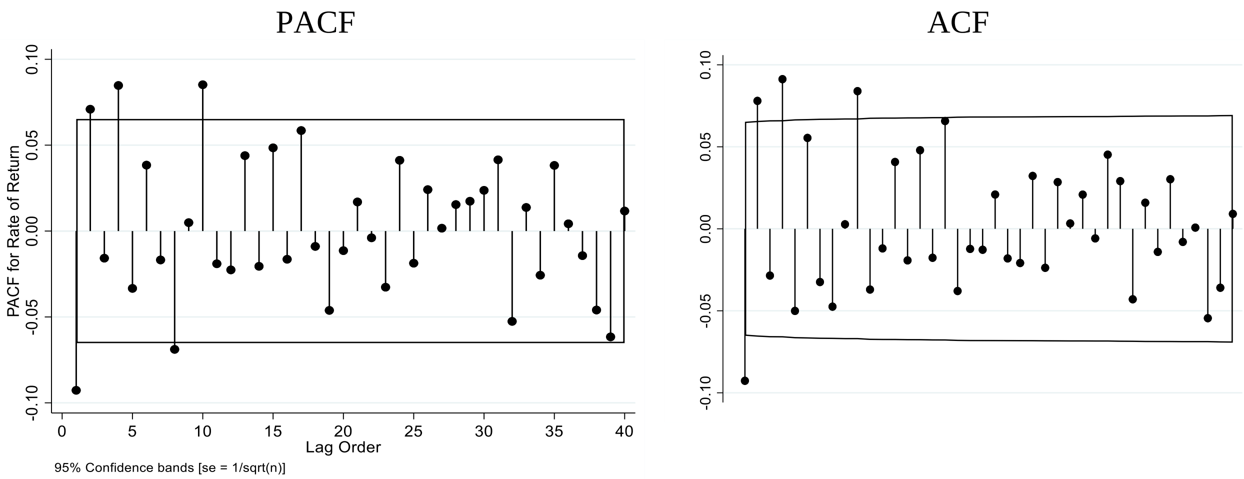

Figure 3. PACF and ACF

As displayed in Figure 3 above, the PACF and ACF model shows that under the 95% confidence interval, the 1^{st}, 2^{nd}, and 4^{th} lag order in both PACF and ACF are out of the upper or the lower boundaries, and thus a model with one lag for both the AR and MA portion should be used for simplicity.

3.4 ARMA-GARCH Estimation Result

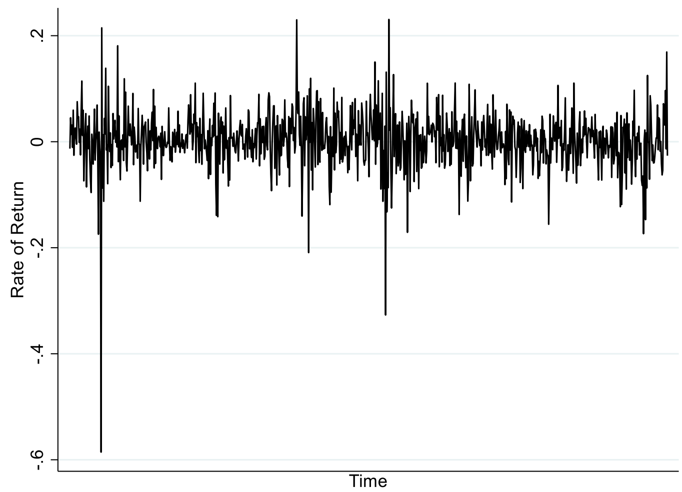

Figure 4. Yield trend

From the time series chart of Ethereum as displayed in Figure 4, the volatility of Ethereum's yields is clustered but whether this effect is statistically significant requires further testing.

From the estimation results of the variance equation, both the ARCH term and the GARCH term are statistically significant, indicating that there is obvious conditional heteroskedasticity in the return of Ethereum, so GARCH modeling can be carried out.

After the US election, the daily volatility of Ethereum's yields increased significantly, around 0.45, under all significant levels.

In addition, on May 18, 2021, the China Internet Finance Association, the China Banking Association, and the China Payment and Clearing Association announced "*The Announcement of Preventing Token Issuance and Financing Risks*." Accordingly, this paper additionally sets dummy variables policy 1 and policy 2. Policy 1 represents the data points within one week of the announcement, and policy 2 indicates all the data points after the announcement date. It can be seen from Table 3 above that this policy significantly increased the volatility of Ethereum's yields in the short term, but this effect parish in the long term.

In addition, after controlling for these two factors, this paper further examines the impact of the Covid-19 pandemic on the volatility of Ethereum's returns. It can be found that both the new daily confirmed cases in China and that overseas have no significant impact on the volatility of Ethereum.

Table 3. ARMA-GARCH estimation results, variance equation

	(1)	(2)	(3)
Dummy	0.4572**	0.4529*	0.4490**
	(0.2204)	(0.2490)	(0.2175)
Policy 1	3.7998***	3.7222***	3.8118***
	(0.5013)	(0.5235)	(0.5058)
Policy 2	0.5106**	-0.4852**	-0.5229**
	(0.1987)	(0.1955)	(0.2021)
NCC, China		-0.3928	
		(0.5156)	
NCC, Overseas			0.0732
			(0.1032)
ARCH (-1)	0.1173***	0.1185***	0.1165***
	(0.0123)	(0.0127)	(0.0124)
GARCH (-1)	0.8352***	0.8272***	0.8350***
	(0.0171)	(0.0189)	(0.0171)
Constant	-8.7956***	-8.7308***	-8.7987***
	(0.2957)	(0.3485)	(0.2994)

4. Discussion

The main finding of this research is that the increase in the rate of return of Ethereum is majorly affected by Covid-19 at the beginning of the pandemic and by the policy changes such as the result of the US 2020 election and the crypto crackdown initiated by China in 2021. Although the spread of Covid-19 influences the return of Ethereum in the beginning, as the pandemic stabilizes and the Covid-19 became the new normal, its increases only contribute to the fluctuations of Ethereum's return.

The first finding of this report is similar to all the previous reports since the better ability of cryptocurrencies including Ethereum to hedge against uncertainties over that of traditional assets proven by previous researchers are proven again. However, when adding the dummy variables measuring the political factors into the ARMA-GARCH model, the result of this research which declines any relationship between the two is in direct contrast to the article written by Pradipta Kumar Sahoo who has proven both linear and non-linear relationships between the spread of Covid-19 and the price of all cryptocurrencies using data points only from 2020. Finally, this research has also partially proven the hypothesis that the long-term risk hedging ability of cryptocurrencies could be hampered by regulatory barriers and policy changes posted by Christy Dwita Mariana et al since the research result of this paper suggests that China's crypto crackdown in 2021 at least contributed to the increased turbulence of Ethereum's investment returns in the short run.

For policymakers, protecting the legal rights of investors and ensuring the financial security of a country are two of the many important objectives. Since this research has found that the turbulence in the investment returns of Ethereum is mostly caused by the outbreak of Covid-19 in the beginning and enhanced by the US 2020 election's results, policymakers should then rapidly respond to all the black swan events and prevent shock therapies in policy changes during power transaction from happening to ease of fear of investors when facing uncertainties. Additionally, the result of this research also suggests that policymakers should prepare for the short-term turbulence in the cryptocurrency market when imposing new regulations. Since the anonymity and untraceability of such currencies may fuel illegal activities, more regulations on them could be beneficial for society in the long term, but such behavior would cause short-term turbulences which harm the rights of investors. As a result, policymakers should adopt a more gradualist approach when announcing bans to provide a time window for investors to respond and minimize losses instead of implementing a policy without any prior policy warnings.

For investors, the result of this research suggests that Ethereum is a currency that could hedge against risks in the short run when the whole market faces systematic uncertainties. Although such risk hedging abilities vanish in the long run, investors are still encouraged to distribute a small portion of their portfolio to Ethereum or other cryptocurrencies. In addition, investors are strongly encouraged to pay close attention to the economic and financial policy of their home country and that of the major global economic entities as strong turbulence in the investment returns will occur after sudden policy changes.

5. Conclusion

In conclusion, this research has discovered that the price of Ethereum was pushed up in an early stage of the pandemic due to investors' risk hedging behaviors. However, in the long run, after adding the dummy variables representing the US 2020 election and China's crypto crackdown in 2021, we discovered that the spread of Covid-19 does not significantly contribute to the turbulence of Ethereum's investment returns, and the US 2020 election result increased the turbulence of Ethereum's investment returns whereas the crypto crackdown of China in 2021 only have short-run effects in that aspect.

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