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Herding behavior in cryptocurrency market before and during COVID-19

Comportamiento gregario en el mercado de criptomonedas antes y durante la COVID-19

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Abstract

This research was conducted to investigate herding behavior in the cryptocurrency market before and during the Covid-19 pandemic. This study used secondary data in the form of monthly price movements of five cryptocurrencies with the largest capitalization values; Bitcoin (BTC), Ethereum (ETH), Cardano (ADA), Tether (USDT), and Binance Coin (BNB), as well as cryptocurrency hedge funds data between January 2013 - December 2022. The data was then analyzed using the Cross-Sectional Absolute Deviation (CSAD) formula to find potential herding behavior. The results of this study indicate that there was no herding behavior in the cryptocurrency market either before or during the Covid-19 pandemic; investors tended to be rational in carrying out investment actions and not imitate or be influenced by the actions of other investors, and they paid attention to fundamental and technical information before making investment decisions.

JEL Code: F30, G10, G15
Keywords: cryptocurrency; herding behavior; Covid-19; cross-sectional absolute deviation (CSAD); bitcoin

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Resumen

Esta investigación se realizó para investigar el comportamiento gregario en el mercado de criptomonedas antes y durante la pandemia de Covid-19. Este estudio utilizó datos secundarios en forma de movimientos mensuales de precios de cinco criptomonedas con los valores de capitalización más altos: Bitcoin (BTC), Ethereum (ETH), Cardano (ADA), Tether (USDT) y Binance Coin (BNB), así como datos de fondos de cobertura de criptomonedas entre enero de 2013 y diciembre de 2022. Los datos se analizaron posteriormente mediante la fórmula de Desviación Absoluta Transversal (CSAD) para identificar un posible comportamiento gregario. Los resultados de este estudio indican que no hubo comportamiento gregario en el mercado de criptomonedas ni antes ni durante la pandemia de Covid-19; los inversores tendieron a ser racionales al realizar inversiones y a no imitar ni dejarse influenciar por las acciones de otros inversores, y prestaron atención a la información fundamental y técnica antes de tomar decisiones de inversión.

Código JEL: F30, G10, G15
Palabras clave: criptomoneda; comportamiento gregario; Covid-19; desviación absoluta transversal (CSAD); bitcoin

Introduction

The Covid-19 pandemic has significantly affected investors and the stock market. This statement is supported by research conducted by Ali et al. (2020) that during the last three months of the Covid -19 pandemic, 30 percent of total wealth on global stock exchanges disappeared into thin air. Due to the pandemic, many working in the economic sector suffered considerable losses, which has also impacted the economy as a whole. As time passed, many investors showed interest in other investment alternatives, especially cryptocurrency. (Ben Khelifa et al., 2021). Investors observed that the value of fiat money continues to experience inflation. With this in mind, many people chose to invest their assets in the form of investment funds backed by cryptocurrencies to maintain and reduce the risk of diminished value and inflation. Many believed in cryptocurrency because it could be a new alternative for investors to secure funds amid rising inflation in the value of fiat money.

Massive investor interest in cryptocurrencies led to a spike in cryptocurrency prices during the unstable, Covid-19-affected period (Jalal et al., 2021). Cryptocurrency is a digital currency used as a relatively low-cost transaction tool and can even be used as an asset. Cryptocurrency transactions utilize blockchain technology that can make the transaction safer, faster and easier. Due to its simplicity, many novice investors choose cryptocurrency as one of their asset options without considering the risks that will come. Many of the average novice investors are millennials and traders who have money but want to make profits quickly without financial literacy in the capital market, especially in the cryptocurrency market.

A spike in cryptocurrency prices usually fuels doubts about whether the surge is a speculative bubble. Several factors can cause speculative bubbles in cryptocurrency prices. First, there is a difference

between the market value of an asset and its intrinsic value, since cryptocurrency prices are usually higher than their fundamental value. Second, there are lots of 'waste' in the digital currency market, which may lead to major fluctuations in cryptocurrency prices (Cheah et al., 2018; Zhang et al., 2018). Third, cryptocurrency is believed to be a globally accepted payment method, leading to significant increases in prices (Chaim & Laurini, 2019). In this case, many investors need more knowledge about cryptocurrencies. This statement is supported by Cagli (2019), who stated that the average investor needs more knowledge about cryptocurrencies.

Historical data showed that there were many instances of speculative bubbles related to cryptocurrency, creating a pattern of herding behavior in the cryptocurrency market. Herding behavior is a phenomenon when investors imitate what other investors may do. They do not make investment decisions based on fundamental or technical factors but instead based on the moves made by other, more established investors. In this case, those herding investors believe that other investors have adequate information on investment instruments, and their movements are good to be used as reference. Herding behavior may occur when investors do not have sufficient information about instruments, including cryptocurrency, especially during uncertain circumstances (Bouri et al., 2019). Some investors believe that cryptocurrency can be a good investment in the future. This statement is supported by research by Lee et al. (2018), Cheng et al. (2019), Mensi et al. (2019), which showed that cryptocurrencies may provide better rate of return compared to traditional investments.

Various studies that have been conducted on cryptocurrency tend to focus on the potential of cryptocurrency as a hedge, paving the way for a new wave of investment funds, namely cryptocurrency hedge funds or joint investment funds in the crypto market, especially during the Covid-19 pandemic (Corbet et al., 2020; Demir et al., 2020; Goodell & Goutte, 2021; Mariana et al., 2021; Baur & Hoang, 2021; Corbet et al., 2020; Będowska-Sójka & Kliber, 2021; Bouri et al., 2017; Conlon & McGee, 2020). Although many studies have been conducted on cryptocurrencies, research on herding behavior in the cryptocurrency market is still inaccurate because it does not fully represent the cryptocurrency market and only focuses on Bitcoin. In contrast, this study used five cryptocurrencies: Bitcoin (BTC), Ethereum (ETH), Cardano (ADA), Tether (USDT), and Binance Coin (BNB), which may represent almost the entirety of the cryptocurrency market, especially during the period before and during the Covid-19 pandemic.

The problem of this research is whether herding behavior occurred in the cryptocurrency market before and during the Covid-19 pandemic. Thus, this research aimed to analyze whether there was herding behavior in the cryptocurrency market before and during the Covid-19 pandemic. It is hoped that this research will be helpful for investors and researchers who are interested in the same field and as a basis

for development for further research, and can assist investors in making investment decisions, preventing them from being influenced by herding behavior and inaccurate previous research.

Literature review

Herding in financial markets during covid-19

A large cluster of Covid-19 was first discovered in Wuhan, China, in December 2019. It fueled anxiety and put the global financial markets in turmoil, even though the pandemic status was not made official until March 2020. Stock price movements started to show a downtrend pattern at the beginning of the Covid-19 pandemic. One of the reasons for this decline in share prices was the weakening of the currency exchange rate, a crucial variable in stock price movements. The depreciation of the rupiah exchange rate can impact the rate of return on investment in companies (Shiyammurti et al., 2020). When the financial market is experiencing a downtrend, it provides an opportunity for investors to buy stocks at low prices.

Many novice investors are millennials willing to spend money to gain experience rather than save, one of which is by investing. Investment is investing funds for a certain period, both long-term and short-term, to get future profits (Tambunan, 2020). According to Hellen et al. (2018), there are two forms of investment; investment in tangible assets that can be seen in physical forms (property, land, and gold) and investment in financial assets, which are intangible (stocks, bonds, and mutual funds). The Covid-19 pandemic has significantly impacted the real sector; the decline in purchasing power and demand made it difficult to sell property and land or get cash from them (Fahrika & Roy, 2020).

Therefore, another way for investors to survive is to change strategies and new methods. Investors can diversify their assets by investing in banks or financial instruments, one of which is the cryptocurrency market, which can act as a hedge for other assets (Mariana et al., 2021). During the Covid-19 pandemic, the number of capital market investors increased significantly. Indonesian Central Securities Depository (KSEI) (2022) states that in 2021, the number rose 93 percent, and in August 2022, it reached 9.54 million investors. This statement can provide new strategies and perspectives for investors to find other investment alternatives, one of which is investing in the capital market (Kartal et al., 2021).

By doing this, the millennial generation feels that if they get profits, they can have passive income, boosting interest to invest in the market. When stock prices were low, many investors flocked to buy stocks without adequate analysis and knowledge. In this case, many investors bought stocks through the recommendations of friends/relatives/confidants, one of which is through influencers. Influencers are people who have thousands or even millions of followers on social media and whose actions can have an

impact on their followers. In other words, when influencers recommend a stock, many people believe it without analyzing whether the stock is healthy.

This trust can arise because the profits obtained by influencers are enormous, and the action of showing off their wealth has primarily led people to believe their stock 'pompom'. A stock pompom is an act of a person who can incite others to be interested in a stock by recommending good information about the company's stock (Pahlevi, 2021). Thus, stock pompom information can trigger herding behavior patterns. The same applies to cryptocurrency markets (Bouri et al., 2019).

Herding in cryptocurrency market

Cryptocurrency is a digital currency guaranteed by cryptography that can be used as a transaction tool in various countries and as an asset because cryptocurrency offers advantages, including not requiring bank intermediation for direct validation and settlement in making transactions, relatively low transaction rates, and high level of anonymity (Panagiotidis et al., 2018). With cryptography, the currency is difficult to counterfeit and manipulate, making cryptocurrency easily accepted by the public.

During the Covid-19 pandemic, financial markets experienced a significant decline, while the cryptocurrency market thrived thanks to the spike of Bitcoin, whose capitalization rose from USD 260 billion in May 2019 to USD 1 trillion (Rahmawati, 2021). The soaring Bitcoin proved that cryptocurrency assets strengthened in price amid the Covid-19 pandemic. Therefore, this can be the reason for the increasing use of digital currencies, one of which is the number of cryptocurrency market investors, which has increased in recent years (Urom et al., 2020). Cryptocurrency can be an option for many people to diversify their assets amid global financial crisis and lack of trust in the financial system (Lee et al., 2018). The phenomenon proved that cryptocurrency can also be used as a hedge during a pandemic (Putra et al., 2022). This statement is in line with Klein et al. (2018), which stated that another alternative to gold as a hedge is cryptocurrency because of the higher rate of return compared to gold.

On February 8, 2019, the Indonesian government, through (BAPPEBTI) the Commodity Futures Trading Regulatory Agency (2020), and the Minister of Trade Regulation (PERMENDAG) formalized cryptocurrency as a commodity in Commodity Futures Trading (PBK). This regulation allows investors to take their first steps in digital financial markets, especially cryptocurrency (Luxmana & Oktafiyani, 2022).

Herding behavior

Herding is the behavior of investors who invest in a way that tends to follow the steps of other investors in investing without fundamental analysis or adequate knowledge, forming an inefficient market (Rahayu et al., 2019). In short, herding can be interpreted as a group of investors who tend to follow the behavior of other investors (Renoldy & Sitinjak, 2018). In this case, patterns of herding behavior can be found in the capital market, especially in the cryptocurrency market, which experienced an uptrend during the Covid-19 pandemic. Herding consists of 2 types, namely: intentional herding and unintentional herding.

Intentional herding occurs when an investor deliberately imitates the actions of other investors and ignores the information they already have. (Pranyoto et al., 2020). Meanwhile, unintentional herding occurs when a group of investors is stuck in the same situation with the same information, leading them to make the same decision (Setiawan et al., 2018). In a herding pattern, investors take irrational actions in which investors do not make their investment decisions based on available reports but instead on the decisions of other investors (Pranyoto et al., 2020).

During the time of uncertainty, like during Covid-19 pandemic, investors may take irrational actions such as herding in various markets, including the cryptocurrency market. This is supported by research conducted by Kaiser & Stöckl, (2020); Kallinterakis & Wang, (2019); Kumar, (2020); da Gama Silva et al. (2019); Vidal-Tomas et al. (2019); Ballis & Drakos, (2020). So, the hypothesis that can be drawn for this research are:

H1 : Herding behavior occurs in the cryptocurrency market

H1a : Herding behavior occurred in the cryptocurrency market before Covid-19

H1b : Herding behavior occurred in the cryptocurrency market during Covid-19

Methods

The approach used in this study was quantitative, and the data processed was secondary data. The data was taken from the historical monthly closing data of 5 cryptocurrencies with large market capitalization values; Bitcoin (BTC), Ethereum (ETH), Cardano (ADA), Tether (USDT), and Binance Coin (BNB), which can represent almost 50 percent of the capitalization value on cryptocurrency market. The data were obtained from investing.com, and the data collected were from July 2013 to December 2022. In addition, this research used historical monthly closing data of cryptocurrency hedge fund index from eurekahedge.com. Regarding data frequency, the rule of thumb for conducting regression analysis requires a minimum of 30 observations. Almost all instruments studied in this study have a minimum of 30

observations, except Cardano (Cardano was introduced in September 2017, much later than the other instruments).

Operational definition

In this study, the actual returns/simple returns of the cryptocurrency instruments studied were measured using the following formula (Rechtiawan & Robiyanto, 2021):

$$RC_{it} = \frac{P_{it} - P_{it-1}}{P_{it-1}} \quad (1)$$

Information:

RC_{it} = Return of cryptocurrency i in period t

P_{it} = price of cryptocurrency i in period t

P_{it-1} = price of cryptocurrency i in period t-1

The study did not estimate log-returns since returns used were not used directly in equations. Simple (actual) returns were converted into squared (SMR) and absolute (AMR) forms. This method was also used several previous studies, such as Alexakis et al. (2023); Chang et al. (2000).

Analysis method

Herding behavior in cryptocurrencies can be calculated using the Cross-Sectional Absolute Deviation (CSAD) formula by measuring the dispersion between the return index and the return market (Haryanto et al., 2020). The formula was used because the formula can measure herding behavior more consistently and competently than other formulas. The formula was also used by Alexakis et al. (2023); Chang et al. (2000); Haykir & Yagli (2022). Meanwhile, the formula used to calculate CSAD was as follows (Haykir & Yagli, 2022):

$$CSAD_t = \frac{1}{n}\sum_{i=1}^{n} |R_{it} - R_{mt}| \quad (2)$$

Information:

R_{it} = return cryptocurrency i in period t

R_{mt} = market return represented by a cryptocurrency hedge fund in period t

n = number of samples

The next step was to calculate the regression analysis, which could be done using the following formula (Ballis & Drakos, 2020):

$$CSAD_t = \propto + y_1|R_{m,t}| + y_2(R^2{}_{m,t}) + \epsilon_t \quad (3)$$

Information:

$\propto$ = intercept variable or constant (C)

y_1 = regression coefficient of Absolute Market Return (AMR) or linear relationship

y_2 = regression coefficient of Squared Market Return (SMR) or non linear relationship

$R_{m,t}$ = market return represented by a cryptocurrency hedge fund return in period t

ϵ_t = standard error

Herding behavior may occur due to uptrend and downtrend patterns in financial markets. Therefore, the most suitable formula to determine whether herding behavior occurs in the cryptocurrency market is the Cross-Sectional Absolute Deviation (CSAD) formula. A pattern of herding behavior can be identified when the coefficient y_2 (SMR) is negative and significant, and vice versa (Haryanto et al., 2020).

Results and discussion

Descriptive statistical analysis

Table 1 shows the result of calculating descriptive statistics on 5 cryptocurrencies, which contain minimum, maximum, average, median, and standard deviation calculations from Bitcoin (BTC), Ethereum (ETH), Cardano (ADA), Tether (USDT), and Binance Coin (BNB).

Table 1
Results of Descriptive Statistics

Before Covid-19						
Variables	Number of Observations	Average	Median	Maximum	Minimum	Standard Deviation
$CSAD_{Bitcoin}$	80	0.081021	0.050331	0.655763	0.000186	0.101865
$AMR_{Bitcoin}$	80	0.109671	0.032116	4.053043	-0.336712	0.499471
$SMR_{Bitcoin}$	80	0.258381	0.014106	16.42716	2.43E-06	1.834035
$CSAD_{Tether}$	32	0.178234	0.115912	0.785190	0.003042	0.177000
AMR_{Tether}	32	0.040586	-0.054954	0.795091	-0.336712	0.250546
SMR_{Tether}	32	0.062459	0.012991	0.632170	2.43E-06	0.127745
$CSAD_{Ethereum}$	46	0.222232	0.128583	1.875985	0.004674	0.293868
$AMR_{Ethereum}$	46	0.081993	0.040805	0.810930	-0.336712	0.246274
$SMR_{Ethereum}$	46	0.066055	0.013347	0.657607	2.43E-06	0.140553
$CSAD_{Binance}$	26	0.172217	0.129598	0.581102	0.002067	0.150204
$AMR_{Binance}$	26	-0.021329	-0.063347	0.438007	-0.336712	0.175154
$SMR_{Binance}$	26	0.029954	0.011580	0.191850	2.43E-06	0.047975
$CSAD_{Cardano}$	25	0.171883	0.127718	0.840877	0.004295	0.182495
$AMR_{Cardano}$	25	-0.019765	-0.066262	0.438007	-0.336712	0.178580
$SMR_{Cardano}$	25	0.031006	0.012006	0.191850	2.43E-06	0.048658
During Covid-19						
Variables	Number of Observations	Average	Median	Maximum	Minimum	Standard Deviation
$CSAD_{Bitcoin}$	34	0.078804	0.063930	0.219179	0.002485	0.066192
$AMR_{Bitcoin}$	34	0.045490	0.043596	0.358655	-0.198628	0.170369
$SMR_{Bitcoin}$	34	0.030241	0.016598	0.128633	0.000103	0.032419
$CSAD_{Tether}$	34	0.149183	0.128645	0.357156	0.010567	0.090555
AMR_{Tether}	34	0.045490	0.043596	0.358655	-0.198628	0.170369
SMR_{Tether}	34	0.030241	0.016598	0.128633	0.000103	0.032419
$CSAD_{Ethereum}$	34	0.135600	0.086800	0.464289	0.006823	0.122658
$AMR_{Ethereum}$	34	0.045490	0.043596	0.358655	-0.198628	0.170369
$SMR_{Ethereum}$	34	0.030241	0.016598	0.128633	0.000103	0.032419
$CSAD_{Binance}$	34	0.232117	0.100199	3.385867	0.006018	0.581589
$AMR_{Binance}$	34	0.045490	0.043596	0.358655	-0.198628	0.170369
$SMR_{Binance}$	34	0.030241	0.016598	0.128633	0.000103	0.032419
$CSAD_{Cardano}$	34	0.277879	0.159045	2.431780	0.006603	0.427276
$AMR_{Cardano}$	34	0.045490	0.043596	0.358655	-0.198628	0.170369
$SMR_{Cardano}$	34	0.030241	0.016598	0.128633	0.000103	0.032419

Source: Various sources, processed
Notes:
CSAD refers to Cross-Sectional Absolute Deviation
AMR refers to Absolute Market Return
SMR refers to Squared Market Return

Based on the results of the descriptive statistical calculations in Table 1 it can be seen that CSAD, which had the highest average rate of return, was 0.222232 on Ethereum, while for AMR and SMR, it was 0.109671 and 0.258381 in Bitcoin during the pre-Covid-19 period. However, during Covid-

19, the average rate of return on the highest CSAD was 0.277879 on Cardano, while for AMR and SMR, it was 0.045490 and 0.030241 against all 5 types of cryptocurrency markets.

Multicollinearity test results

Furthermore, a multicollinearity test was carried out to determine whether the independent variables had a high correlation.

Table 2
Multicollinearity Test Results

Before Covid-19	
Variables	Centered VIF
$AMR_{Bitcoin}$	5.944252
$SMR_{Bitcoin}$	5.944252
AMR_{Tether}	2.451776
SMR_{Tether}	2.451776
$AMR_{Ethereum}$	2.600628
$SMR_{Ethereum}$	2.600628
$AMR_{Binance\ Coin}$	1.149633
$SMR_{Binance\ Coin}$	1.149633
$AMR_{Cardano}$	1.147286
$SMR_{Cardano}$	1.147286
During Covid-19	
Variables	Centered VIF
$AMR_{Bitcoin}$	1.836288
$SMR_{Bitcoin}$	1.836288
AMR_{Tether}	5.961134
SMR_{Tether}	5.961134
$AMR_{Ethereum}$	1.943979
$SMR_{Ethereum}$	1.943979
$AMR_{Binance\ Coin}$	3.812934
$SMR_{Binance\ Coin}$	3.812934
$AMR_{Cardano}$	4.095732
$SMR_{Cardano}$	4.095732

Source: Various sources, processed
Notes:
AMR refers to Absolute Market Return
SMR refers to Squared Market Return

The conclusion that can be drawn in Table 2 is that if the Centered VIF value <10, then there is no multicollinearity problem; it can be seen that all values in Table 2. are free from multicollinearity problems before and during Covid-19.

Regression test results

Before the regression analysis, Augmented Dickey-Fuller tests were conducted. The results of Augmented Dickey-Fuller tests are presented in Table 3.

Table 3
Augmented Dickey-Fuller (ADF) Test Result

Variable	Augmented Dickey-Fuller (ADF) Statistic	Probability
$AMR_{Bitcoin}$	-10.99109	0.000000
$SMR_{Bitcoin}$	-9.654877	0.000000
AMR_{Tether}	-6.129991	0.000000
SMR_{Tether}	-7.332943	0.000000
$AMR_{Ethereum}$	-10.91407	0.000000
$SMR_{Ethereum}$	-5.976516	0.000000
$AMR_{Binance}$	-11.896921	0.000000
$SMR_{Binance}$	-6.400812	0.000000
$AMR_{Cardano}$	-5.768243	0.000000
$SMR_{Cardano}$	-5.533128	0.000000

Source: Various sources, processed.

Based on Table 3, no unit root was found in the data. Furthermore, a regression test is carried out to determine whether there are indications of herding behavior, as shown in Table 4.

The results of the regression calculations for every cryptocurrency are presented as follows:

Bitcoin

$$CSAD = 0.065532 + 0.133760\ AMR + 0.003173\ SMR + \epsilon_t \quad (4)$$

Table 4. shows that the AMR variable has a significant relationship at the 1 percent level, but the SMR variable is insignificant to the dependent variable. This can be seen through the probability value of the SMR variable, which is equal to 0.7716 (> 0.05). In Table 4, it can be seen that the SMR coefficient value is 0.003173, which is positive and not significant. The data show no indication of herding behavior or a non-linear relationship that occurred to Bitcoin before Covid-19. Thus, H1 and H1a are rejected.

The CSAD and SMR coefficient equations for periods during Covid-19 were as follows:

$$CSAD = 0.066691 + 0.079305\ AMR + 0.281267\ SMR + \epsilon_t \quad (5)$$

Table 4 shows that the SMR variable has an insignificant relationship to the dependent variable. This can be seen through the probability value of the SMR variable, which is equal to 0.5554 (>0.05). Based on Table 4, it can be seen that the SMR coefficient value is 0.281267, which is positive and not significant. The data show no indication of herding behavior or non-linear relationship that occurred to Bitcoin during Covid-19. Thus, H1 and H1b are rejected.

Table 4
Results of the Regression Test

Before Covid-19				
Variables	Coefficient	Std. Error	t-Statistics	Prob.
C	0.065532	0.008423	7.780216***	0.0000
$AMR_{Bitcoin}$	0.133760	0.039997	3.344239 ***	0.0013
$SMR_{Bitcoin}$	0.003173	0.010893	0.291341	0.7716
C	0.096466	0.012692	7.600613***	0.0000
AMR_{Tether}	-0.004865	0.069030	-0.070478	0.9443
SMR_{Tether}	1.312317	0.135387	9.693076 ***	0.0000
C	0.195942	0.046550	4.209241***	0.0001
$AMR_{Ethereum}$	0.450066	0.277978	1.619071	0.1127
$SMR_{Ethereum}$	-0.160654	0.487065	-0.329841	0.7431
C	0.167336	0.038099	4.392102***	0.0002
$AMR_{Binance\ Coin}$	0.033270	0.191079	0.174115	0.8633
$SMR_{Binance\ Coin}$	0.186626	0.697609	0.267523	0.7915
C	0.121437	0.035851	3.387323***	0.0027
$AMR_{Cardano}$	0.308914	0.175694	1.758254	0.0926
$SMR_{Cardano}$	1.823882	0.644820	2.828515 ***	0.0098
During Covid-19				
Variables	Coefficient	Std. Error	t-Statistics	Prob.
C	0.066691	0.016287	4.094793***	0.0003
$AMR_{Bitcoin}$	0.079305	0.089776	0.883360	0.3838
$SMR_{Bitcoin}$	0.281267	0.471800	0.596157	0.5554
C	0.064935	0.006378	10.18149***	0.0000
AMR_{Tether}	-0.051471	0.035155	-1.464088	0.1532
SMR_{Tether}	2.863281	0.184752	15.49799 ***	0.0000
C	0.070708	0.024499	2.886153***	0.0070
$AMR_{Ethereum}$	0.110876	0.135045	0.821029	0.4179
$SMR_{Ethereum}$	1.979017	0.709700	2.788526 ***	0.0090
C	-0.055572	0.128415	-0.432754	0.6682
$AMR_{Binance\ Coin}$	-0.060349	0.707857	-0.085255	0.9326
$SMR_{Binance\ Coin}$	9.603862	3.719988	2.581692 **	0.0148
C	0.018012	0.077542	0.232280	0.8178
$AMR_{Cardano}$	0.351024	0.427431	0.821241	0.4178
$SMR_{Cardano}$	8.065078	2.246271	3.590430 ***	0.0011

Source: Various sources, processed
Note: * significant at 10 percent significance level; ** significant at 5 percent significance level; *** significant at 1 percent significance level
AMR refers to Absolute Market Return
SMR refers to Squared Market Return

Tethers

$$CSAD = 0.096466 - 0.004865\ AMR + 1.312317\ SMR + \epsilon_t \quad (6)$$

Table 4 shows that the SMR variable has a positive and significant relationship to the dependent variable at the 1 percent level. This can be seen through the probability value of the SMR variable, which is equal to 0.0000 (<0.05). Based on Table 4., it can be seen that the SMR coefficient value is 1.312317, which is positive and significant. The data show no indication of herding behavior, and there is no non-linear relationship that occurred to Tether before Covid-19. Thus, H1 and H1a are rejected.

The CSAD and SMR coefficient equations for periods during Covid-19 were as follows:

$$CSAD = 0.064935 - 0.051471\ AMR + 2.863281\ SMR + \epsilon_t \quad (7)$$

Table 4 shows that the SMR variable has a positive and significant relationship to the dependent variable at the 1 percent level. This can be seen through the probability value of the SMR variable, which is equal to 0.0000 (<0.05). Based on Table 4, it can be seen that the SMR coefficient value is 2.863281, which is positive and significant. The data show no indication of herding behavior, and there is no non-linear relationship that occurred to Tether during Covid-19. Thus, H1 and H1b are rejected.

Ethereum

$$CSAD = 0.195942 + 0.450066\ AMR - 0.160654\ SMR + \epsilon_t \quad (8)$$

Table 4 shows that the SMR variable has an insignificant relationship to the dependent variable. This can be seen through the probability value of the SMR variable, which is equal to 0.7431 (>0.05). Based on Table 4., it can be seen that the SMR coefficient value is -0.160654, which is negative and not significant. The data show no indication of herding behavior or non-linear relationship that existed for Ethereum before Covid-19. Thus, H1 and H1a are rejected.

The CSAD and SMR coefficient equations for periods during Covid-19 were as follows:

$$CSAD = 0.070708 + 0.110876\ AMR + 1.979017\ SMR + \epsilon_t \quad (9)$$

Table 4 shows that the SMR variable has a significant relationship to the dependent variable at the 1 percent level. This can be seen through the probability value of the SMR variable, which is equal to 0.0090 (< 0.05). Based on Table 4, it can be seen that the SMR coefficient value is 1.979017, which is positive and significant. The data show no indication of herding behavior or non-linear relationship that occurred to Ethereum during Covid-19. Thus, H1 and H1b are rejected.

Binance coins

$$CSAD = 0.167336 + 0.033270\ AMR + 0.186626\ SMR + \epsilon_t \quad (10)$$

Table 4 shows that the SMR variable has an insignificant relationship to the dependent variable. This can be seen through the probability value of the SMR variable, which is equal to 0.7915 (> 0.05). Based on Table 4, it can be seen that the SMR coefficient value is 0.186626, which is positive and not significant. The data show no indication of herding behavior or non-linear relationship that occurred to Binance Coin before Covid-19. Thus H1 and H1a are rejected.

During Covid-19, the CSAD and SMR coefficient equations were obtained as follows:

$$CSAD = -0.055572 - 0.060349\ AMR + 9.603862\ SMR + \epsilon_t \quad (11)$$

Table 4 shows that the SMR variable has a significant relationship to the dependent variable at the 5 percent level. This can be seen through the probability value of the SMR variable, which is equal to 0.0148 (<0.05). Based on Table 4, it can be seen that the SMR coefficient value is 9.603862, which is positive and significant. The data show no indication of herding behavior or non-linear relationship that occurred to Binance Coin during Covid-19. Thus, H1 and H1b are rejected.

Cardano

$$CSAD = 0.121437 + 0.308914\ AMR + 1.823882\ SMR + \epsilon_t \quad (12)$$

Table 4 shows that the SMR variable has a significant relationship to the dependent variable at the 1 percent level. This can be seen through the probability value of the SMR variable, which is equal to 0.0098 (<0.05). Based on Table 4, it can be seen that the SMR coefficient value is 1.823882, which is positive and significant. The data show no indication of herding behavior or non-linear relationship that occurred to Cardano before Covid-19. Thus, H1 and H1a are rejected.

The CSAD and SMR coefficient equations for periods during Covid-19 were as follows:

$$CSAD = 0.018012 + 0.351024\ AMR + 8.065078\ SMR + \epsilon_t \quad (13)$$

Table 4 shows that the SMR variable has a significant relationship to the dependent variable at the 1 percent level. This can be seen through the probability value of the SMR variable, which is equal to 0.0011 (<0.05). Based on Table 4, it can be seen that the SMR coefficient value is 8.065078, which is positive and significant. This statement shows no indication of herding behavior or non-linear relationship that occurred to Binance Coin during Covid-19. Thus, H1 and H1b are rejected.

The compilation of these results is presented in Table 5.

Table 3
Hypothesis Testing Results

Name	H_1	H_{1a}	H_{1b}
Bitcoins	Rejected	Rejected	Rejected
Tethers	Rejected	Rejected	Rejected
Ethereum	Rejected	Rejected	Rejected
Binance Coins	Rejected	Rejected	Rejected
Cardano	Rejected	Rejected	Rejected

Source: Various sources, processed

The conclusion that can be drawn in Table 5 is that the hypothesis is rejected, which means there was no herding behavior in cryptocurrencies before and during Covid-19. This means that investors act objectively in selecting and analyzing their investment instruments.

These findings do not support some previous studies such as Bouri et al. (2019); Haryanto et al. (2020); Haykir and Yagli (2022); Ballis and Drakos (2020); Coskun et al. (2020). Those studies found that herding in the cryptocurrency market does exist. Bouri et al. (2019) stated herding behavior occurs when investors follow the actions of other investors in making investment actions, which will be more apparent during uncertain times (the research used weighted average of 14 cryptocurrencies as market representative). Coskun et al. (2020) used the same method to support this finding. The periods used in this study were before and during the Covid-19 pandemic, with different levels of uncertainty than in 2013-2018.. However, lockdowns during the pandemic also gave investors more time to act carefully.

The finding of this study is consistent with research conducted by Kyriazis (2020); Amirat & Alwafi (2020), as they found that herding behavior did not occur in cryptocurrency market. Even though the cryptocurrency market has high risk of volatility and uncertainty, these do not lead to reckless decisions from investors (Coskun et al., 2020).

Conclusions

This study aims to determine whether herding behavior occurred in 5 cryptocurrency markets before and during Covid-19. Herding behavior occurs when the SMR calculation result is negative and significant. The study found no indication of herding behavior in Bitcoin, Tether, Ethereum, Binance Coin and Cardano markets before and during Covid-19. Investors tend to be rational in making investment decisions because they do not look at the actions of other investors and do not follow trends in the cryptocurrency market. It can be seen that investors are more likely to analyze and pay attention to fundamental and technical information before making investment decisions in the cryptocurrency market.

This study suggests investors to sharpen their analysis both fundamentally and technically. Even though they are rational and not affected by the actions of other investors, investors can still maintain their rationality in making investment decisions. Investors do not need to follow any actions taken by other investors publicized through social media. Investors can formulate their investment strategies by using any time frame that is suitable for them, rather than follow the market action. Various strategies, such as contrarian, can be used for investing. For investors who apply technical analysis during investing, other strategies such as stop loss can be imposed.

When this study was conducted, several geopolitical events, such as the Fed rate uncertainty, Russia-Ukraine war and Israel-Hamas conflict, exploded. These geopolitical events may affect t investors' behavior, including their tendency to 'herd'. Future studies can include the periods of the geopolitical events and analyze them separately by employing more sophisticated methods. Also, in this study, the cryptocurrency market indicator used is a cryptocurrency hedge fund, which still has limitations in detecting herding behavior. Future studies can be carried out using other market indicators that are more suitable, like Bitwise's decentralized finance crypto index fund and Dash 2 Trade.

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