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The influence of Indonesia's macroeconomic factors: Inflation and interest rate on large-cap cryptocurrency herding behavior

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Abstract

Research aims: This study aims to investigate herding behavior in the large-capitalization cryptocurrency market and analyze the role/influence of Indonesia's macroeconomic factors, namely inflation and interest rates, on herding behavior in the large-cap cryptocurrency market.

Design/Methodology/Approach: This study used secondary data from the daily closing prices of five large-cap cryptocurrencies and Indonesia's macroeconomic data (inflation and interest rates) from April 2019 to December 2022 by using the Cross-Sectional Absolute Deviation (CSAD) model and Newey-West estimator regression approach to detect herding behavior with a modified independent variable model involving factors influencing herding behavior.

Research findings: Based on the results using the Newey-West estimator, three main results were obtained. First, large-cap cryptocurrency investors tend to be irrational in their decisions and follow the decisions of others without reference to their beliefs or herding during the sample period. Second of the two macroeconomic factors studied, i.e., inflation and interest rates, only changes in inflation rates influence investor herding behavior. Third, the market is inefficient with the proven tendency of herding behavior in large-cap cryptocurrencies.

Practical and Theoretical contribution/Originality: This study narrows down the research of previous studies by using cryptocurrency research objects with a large market capitalization (large cap). In addition, this research extends the research of previous studies by considering external factors related to macroeconomic conditions in Indonesia in general, such as the inflation rate and the interest rate. This study can provide information about financial behavior in the cryptocurrency market, especially herding behavior, so that investors and policymakers can be assisted in formulating investment strategies and regulating cryptocurrencies.

Research limitation: This research was limited to using only cryptocurrency assets by not using crypto-tokens, non-fungible tokens (NFT), and other crypto-assets.

Keywords: Behavioral Finance; Cryptocurrencies; Herding Behavior; Inflation Rate; Interest Rate

Introduction

In the current technological and information development era, people seem to be increasingly aware of the importance of investing. In line with these developments, the types of investments offered are currently increasingly diverse, such as gold, stocks, bonds, deposits, mutual funds, peer-to-peer lending, and what is currently hot is cryptocurrency.

The crypto market has experienced rapid growth in the last decade (Liu, Tsyvinski, & Wu, 2019; Yi, Xu, & Wang, 2018).

In Indonesia, cryptocurrency has been officially regulated as an investment instrument with the type of commodity traded on futures exchanges following the letter of the Coordinating Minister for the Economy Number S-302/M.EKON/09/2018 (Perayunda & Mahyuni, 2022) with the crypto asset trading market regulated by CoFTRA (Bappebti RI) Regulations No. 8 of 2021 concerning Guidelines for Organizing Crypto Asset Physical Market Trading on Futures Exchanges.

The cryptocurrency trading market in Indonesia is experiencing an exceedingly high trend of public interest. Even the latest data reveals the number of cryptocurrency investors beating capital market investors. Reporting to data from Indonesia's Ministry of Finance (Kemenkeu) (CNBC Indonesia, 2022), the number of cryptocurrency investors is more than capital market investors; from the initial 4 million investors in 2020, it increased rapidly by 180% to 11.2 million investors in 2021, and this number continues to increase until the latest data in June 2022 recorded 15.1 million investors. The value of cryptocurrency transactions in Indonesia was reported from CoFTRA data in 2021; in a year, it experienced a substantial increase at 1.222% from the original in 2020 of only IDR 64.9 trillion, increasing to IDR 859.4 trillion (Katadata, 2022).

The International Institute Gemini survey also demonstrates that Indonesia is the largest crypto adopter in the world, along with Brazil, with an adoption rate of 41% in 2021 (Gemini Trust Company LLC, 2022). In addition, a report from Toluna as of August 2022 projects that Indonesia, in the next six months, can enter the ranks of one of the countries with the top crypto markets globally because Indonesia has positive sentiment towards crypto assets compared to developed countries (Toluna, 2022).

According to the latest data from the CoFTRA in 2021 (CNN Indonesia, 2021), five main types of cryptocurrencies that are very popular or widely traded in Indonesia include Bitcoin (BTC), Ethereum (ETH), Binance Coin (BNB), Ripple (XRP), and Cardano (ADA). Besides being popular, these cryptocurrencies are a type of cryptocurrency with a high market capitalization (large-cap) of over 10 billion USD. According to Danial, Laurence, Kent, Bain, and Solomon (2022), looking at market capitalization value is highly recommended for investing in cryptocurrency, especially for unsophisticated investors; regardless of the fundamentals of the crypto assets origin (Liu et al., 2019), the popularity of cryptocurrencies can be seen from the large market capitalization. Despite the popularity, it cannot describe the full potential of cryptocurrency, but its level of popularity or high market cap value may indicate the risk of losing the entire value (vanishing risk), fraud risk, and other non-systematic risks are less likely.

On the other side, the classical paradigm of financial theory, or the efficient market hypothesis theory by Fama (1970), assumes that investors make rational decisions. This theory assumes that investors must base their financial decisions on knowledge, expectations, and experience in the capital market. However, further research by Tversky

and Kahneman (1973) shows that investors' rationality is imperfect. In other words, investors often behave irrationally.

As with the capital market, research by Delfabbro, King, and Williams (2021) mentioned that several factors of irrational investor behavior seem to influence the amount of cryptocurrency trading or investment, especially for ordinary investors, including fear of being left behind by something happening or fear of missing out (FOMO) and being easily influenced by pseudo or misleading social media influencers; it indicates that sometimes, cryptocurrency investors, especially ordinary investors, act not based on their information or ignore their beliefs because of the nature of FOMO or the influence of pseudo-information from social media influencers. In other words, there are indications that investors tend to follow market consensus and rely heavily on other investment actions, not making decisions in selling or buying investment assets. That behavior is called herding behavior. According to Jabeen et al. (2022), herding behavior causes investors to set aside their personal information to follow the crowd, even though their personal information is thought to be accurate.

The consequences of herding behavior include mispricing of assets because investors do not act according to the information available in the market correctly due to their irrational behavior (Vidal-Tomás, Ibáñez, and Farinós, 2019). In addition, it is feared that herding behavior can exacerbate volatility, disrupt the market, and increase the fragility of the financial system in that market (Bikhchandani & Sharma, 2000), especially considering the high volatility and fragility of the financial system in the cryptocurrency market due to inadequate fundamentals and the large number of cryptocurrencies that its origins are unclear (Danial, Laurence, Kent, Bain, & Solomon, 2022; Liu et al., 2019; Setiawan, 2020). Therefore, analyzing the existence of herding behavior in the cryptocurrency market is essential, particularly for investors, since the herding phenomenon will result in an inefficient market in which an asset price model based on rational valuation cannot be appropriately applied, mainly when herding behavior causes extremely high cryptocurrency volatility.

A cross-sectional asset and market returns approach can reveal herding behavior in financial markets. Christie and Huang's (1995) Cross-Sectional Standard Deviation (CSSD) research with a modified model by Chang, Cheng, and Khorana (2000) using the Cross-Sectional Absolute Deviation (CSAD) model was the first proposed cross-sectional approach. In this regard, if herding behavior occurs, the spread of asset returns will increase less than the increase in market returns, or the spread of asset returns will decrease even if market returns increase (Chang et al., 2000).

Many previous studies have used an empirical approach to identify herding behavior in the context of the stock market using the CSAD model approach. Bogdan et al. (2022) examined herding behavior on the stock market in European countries, Bouri et al. (2021) researched the international stock market as a whole by limiting the research period to COVID-19 conditions, and Chang et al. (2020) investigated the stock market with restrictions on the energy sector globally.

In Indonesia's capital market (Anggara & Mustafa, 2020; Rizal & Damayanti, 2019; Sadewo & Cahyaningdyah, 2022), herding behavior in Indonesia's Islamic capital market is identified, sectoral stocks and IDX80 shares. These three studies showed that herding behavior occurs only when investor sentiment in the capital market is bearish (down market).

Furthermore, recent research tries to analyze the factors that influence herding behavior in the capital market, including macroeconomic or monetary policy in a country, such as interest and inflation rates. Several studies, such as Gong and Dai (2017), tried to analyze the relationship between macroeconomic factors in China at the Shanghai Stock Exchange and the Shenzhen Stock Exchange, Wibowo et al. (2021) used macroeconomic factors in 12 countries in the emerging market and developed country categories, and Wicaksono and Falianty (2022) employed Indonesia's macroeconomic factors in analyzing their relationship with herding behavior in the capital market. These three studies demonstrated that monetary policy as a macroeconomic indicator in a country, such as interest rates, inflation, and exchange rates, positively affected investor herding behavior in the capital market.

Nevertheless, the factors influencing herding behavior in the cryptocurrency market have not been appropriately explored and require additional analysis. Also, only a few studies have recently emerged to identify investors' herding behavior in the cryptocurrency market. For example, Vidal-Tomás et al. (2019) researched the cryptocurrency market's behavior from 2015-2017. Their study results indicate that market capitalization contributes to herding behavior in cryptocurrencies so that investors base their decisions on the performance of major cryptocurrencies (large market capitalization). In addition, Ballis and Drakos (2020) studied herding behavior toward cryptocurrencies in 2015-2018. This study's results suggest that herding behavior is significant when the cryptocurrency market is rising. From the previous research, the previous research results that examined herding behavior in cryptocurrencies were still limited to identifying the presence/absence of herding behavior on the market. Besides, few scrutinized further what factors influenced this herding behavior.

Amidst the current global uncertainty, there are fears that a global recession will cause the *cryptocurrency market* to fall, especially as a high-risk investment asset (Liu et al., 2019), which is very vulnerable to monetary policy. Not only on a global level like *The Fed, but the large-cap cryptocurrency* market is also indicated to respond in an identical way to Indonesia's macroeconomic policies, i.e., when the benchmark interest rate in Indonesia (BI7DRR) and the inflation rate fall, *cryptocurrency prices* tend to rise, and vice versa. The following graph of Indonesia's macroeconomic and the *large-cap cryptocurrency index* (CRIX) trend for 2020-2022 is in Figure 1.

Based on Figure 1, it can also be seen that the value of the CRIX market index experienced a very rapid upward trend as interest rates and inflation in Indonesia experienced a downward trend throughout 2020. Furthermore, the turning point occurred when the trend for the value of the CRIX market index experienced a very rapid decline from mid-2021 to the end of 2022 as interest rates and inflation experienced an upward trend. With

the drastic increase and decrease in the CRIX market index, besides having indications of herding behavior in the large-cap cryptocurrency market, movements of the CRIX market index in the opposite direction to Indonesia's macroeconomic conditions give rise to indications of influence between Indonesia's macroeconomic factors and herding behavior in the large-cap cryptocurrency market.
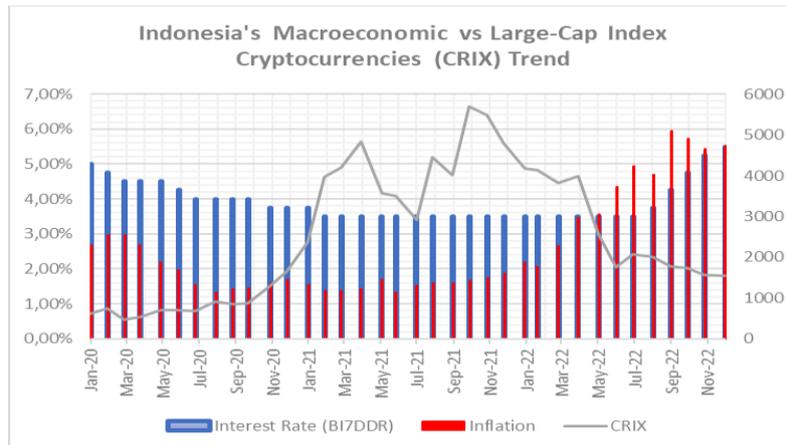

Figure 1 Indonesia's Macroeconomic vs. Large-Cap Index Cryptocurrencies (CRIX) in 2020-2022

In this case, Indonesia is one of the countries with the largest cryptocurrency adopters in the world, especially for the cryptocurrency market with a large market capitalization (large-cap); macroeconomic factors in that country on the cryptocurrency market are believed to have an essential role in the movement of the cryptocurrency market. Moreover, most investors in Indonesia consider cryptocurrency as a hedge against inflationary conditions (Gemini Trust Company LLC, 2022).

Additionally, a study by Wang, Ma, Bouri, and Guo (2022) stated that there is strong evidence that macroeconomic indicators influence volatility in the Bitcoin market. However, their research only focused on Bitcoin as the most dominant cryptocurrency and its influence on returns and volatility. In addition, what needs to be underlined is that investors in the capital market, especially in Indonesia, have been identified in several studies as tending to have herd behavior and macroeconomic indicators have been proven to influence herd behavior in the capital market. Therefore, this current study aims to analyze herding behavior in the large-cap cryptocurrency market and the influence of Indonesia's macroeconomic factors, namely inflation and interest rates, on herding behavior in the large-cap cryptocurrency market.

To fill the gap in previous research, this research will further contribute theoretically in at least two ways. First, this research narrows down the research of previous studies (Ballis & Drakos, 2020; Vidal-Tomás et al., 2019) by using cryptocurrency research objects with a large market capitalization (large-cap). Second, this research attempts to develop external factors that might influence investor herding behavior in cryptocurrencies, which

is still little done through general macroeconomic conditions in Indonesia, such as the inflation rate and the reference interest rate (BI-7 Day Reverse Repo Rate).

To see the effect of herding behavior on the large-cap market cryptocurrency, processing methods and data analysis in this study used the Cross-Sectional Absolute Deviation (CSAD) model, which was then regressed with the exogenous variables of Indonesia's macroeconomic conditions.

Literature Review and Hypotheses Development

Due to the popularity of the efficient markets hypothesis (EMH) theory, many studies have tried to develop and even refute it. One of the recent developments that serve as a counterpart to EMH theory is the emergence of behavioral finance theory, namely the science of finance from the perspective of social sciences, including psychology and sociology. According to Pompian (2021), "normal" people are very likely to behave irrationally in making decisions; in fact, almost no people behave perfectly rationally, especially financially.

An irrational behavior toward investing has been proven by many studies. In cryptocurrency research, Delfabbro et al. (2021) state that cryptocurrency investors tend to be overconfident, afraid of being left behind by something happening or fear of missing out (FOMO), and are easily influenced by pseudo or misleading social media influencers. In addition, this argument is confirmed by Hu, Valera, and Oxley (2019), which revealed that the top-ranked/market-cap cryptocurrencies proved to be inefficient, indicating investors' irrational behavior in that market. One of the irrational attitudes that may occur to investors is herding behavior.

Herding behavior, according to Jabeen, Rizavi, and Farhan (2022), leads investors to put aside their personal information to follow the crowd, even the realization that their personal information is believed to be accurate. Bikhchandani and Sharma (2000) define "intentional" herding as a clear intention to imitate the behavior of other investors, which can destabilize markets and increase volatility. The consequences of herding behavior include mispricing asset prices because investors do not correctly act according to the information available in the market due to their irrational behavior (Vidal-Tomás et al., 2019).

In behavioral finance research, herding behavior produces more empirical studies than theoretical studies since it is difficult to measure the extent of herding behavior with certainty in real financial markets (Choi & Yoon, 2020). Most empirical studies on herding behavior have uncovered that investors who follow others can generate important information and get maximum profit (Devenow & Welch, 1996). Furthermore, Bikhchandani and Sharma (2000) revealed that there are at least three reasons why herding behavior can occur in financial markets: information-based and cascades, reputation-based, and compensation-based.

The previous research also tried to identify herding behavior, especially in cryptocurrency. Vidal-Tomás et al. (2019), using the CSSD and CSAD models, corroborated that the existence of herding behavior in 65 digital currencies only occurred during market downturns with the contribution of market capitalization to herding behavior in cryptocurrencies so that investors based their decisions on the large market capitalization performance. Moreover, using the same model, Ballis and Drakos (2020) found that investors in the "top" sector of the cryptocurrency market acted irrationally and imitated the decisions of others without referring to their beliefs.

Further, while Lobão (2022) employed a more specific type of cryptocurrency, namely green or eco-friendly cryptocurrencies, Ren and Lucey (2022) compared investor herding behavior between green and black/dirty cryptocurrencies; both studies disclosed that green cryptocurrency investors were not proven to have herding behavior. Meanwhile, Ren and Lucey (2022) showed that black/dirty cryptocurrency investors tended to herd.

Based on the previous studies, herding behavior in financial markets, especially the cryptocurrency market, can be well proven by the CSAD model. In addition, there are indications that each type of cryptocurrency can have different investor tendencies; particularly, in previous research, it was revealed that there is a tendency for investors to act irrationally and base their decisions on the performance of large-cap cryptocurrencies, indicating that there is herding behavior in large-cap cryptocurrencies, which has not been explicitly answered in previous studies. Therefore, based on the above concepts, theories, and empirical results, the following hypotheses can be put forward:

H_1: Investors in the large-cap cryptocurrency market tend to herd.

Previous research (Blau, Griffith, & Whitby, 2021; Phochanachan, Pirabun, Leurcharusmee, & Yamaka, 2022; Smales, 2021) revealed that cryptocurrencies could be used as a hedge against inflation, especially in the short-term (short-run), and it is not recommended to be a long-term inflation hedge. On the other hand, Wardoyo et al. (2020) stated that cryptocurrency can be used as a hedge against monetary conditions in Indonesia. This study also proves that cryptocurrencies and inflation values are negatively correlated because, according to Bouri, Molnár, Azzi, Roubaud, and Hagfors (2017), an asset can be categorized as a hedge if the average asset is negatively correlated with other assets.

Other studies (Galariotis, Rong, & Spyrou, 2015; Gong & Dai, 2017; Wibowo, 2021; Wicaksono & Falianty, 2022) also succeeded in showing that monetary policy as a macroeconomic indicator in a country, such as interest rates, inflation, and exchange rates, have a significant effect in reducing the *return dispersion value* (CSAD), which has implications for the influence of macroeconomic factors on *herding behavior*.

Even though research on the direct influence of Indonesia's macroeconomic factors on the *cryptocurrency market* has not been well explored, research by Wang et al. (2022) has proven strong evidence that macroeconomic indicators globally influence the fluctuations or volatility of the Bitcoin market. According to Hougan and Lawant (2021),

cryptocurrencies, as part of a new investment asset class, can be influenced by various factors, including evolving regulations. Based on the above concepts, theories, and empirical results, the following hypotheses can be proposed:

H$_{2a}$: *Indonesia's inflation rate affects herding behavior in the large-cap cryptocurrency market.*

H$_{2b}$: *Indonesia's interest rate affects herding behavior in the large-cap cryptocurrency market.*

Research Method

The types and sources of data used in this study were secondary data. Sources of data in this study included closing prices of cryptocurrencies, which are a type of crypto assets in the coin/non-token category according to the definition of Burniske and Tatar (2018) based on daily price reports of large-cap cryptocurrencies obtained from CoinGecko (coingecko.com) and Indonesia's macroeconomic data (inflation and interest rates) from the Bank Indonesia website (bi.go.id). The other supporting data related to this research topic were obtained from books, articles, and electronic media.

Sampling was carried out by purposive sampling with the criteria of cryptocurrency with the largest capitalization (large-cap) based on the constituent criteria of the Royalton CRIX index as one of the references in cryptocurrency studies by Lee, Guo, and Wang (2018) as of January 2023. The sample period range was from April 2019 to December 2022. As a result, this study used a sample of five cryptocurrencies with the largest market capitalization as of January 2023 listed as a Royalton CRIX constituent and listed on the CoinMarketCap website (coinmarketcap.com) as a reference in the study (D. K. C. Lee et al., 2018; Liu et al., 2019). The cryptocurrencies chosen to be the object of research were Bitcoin (BTC), Ethereum (ETH), Binance Coins (BNB), Ripple (XRP), and Cardano (ADA).

Data processing was done quantitatively by identifying cryptocurrency price reports and independent variable proxy data in 2019-2022. After that, it continued to analyze herding behavior using a Cross-Sectional Absolute Deviation (CSAD) as referred to by Chang et al. (2000) with a modified independent variable model involving explanations of factors influencing herding behavior according to referrals (Choi & Yoon, 2020; Haykir & Yagli, 2022; Lobão, 2022; Yousaf & Yarovaya, 2022; Youssef, 2022). The steps in further data analysis are as follows.

Calculating Realized Return Each Cryptocurrency

Finding out the realized return of each crypto asset can be calculated using appropriate logarithmic return reference (Ballis & Drakos, 2020; Rizal & Damayanti, 2019) with the formula:

$$R_{i,t} = \ln \frac{P_t}{P_{t-1}} \dots (1)$$

Where $R_{i,t}$ describe for the actual rate of return of cryptocurrency-*i* in period-*t*; P_t for cryptocurrency price period-*t*; and P_{t-1} for cryptocurrency price period-*t*-1.

Calculating Markets Return

To find out the return on the large-cap cryptocurrency market, the equally-weighted method used market returns of the five returns sample cryptocurrency according to the reference (Ballis & Drakos, 2020; Lobão, 2022) with the formula:

$$R_{m,t} = \frac{1}{N} \sum_{i=1}^{N} R_{i,t} \dots (2)$$

Where $R_{m,t}$ describe for the rate of return on the cryptocurrency market in the period-*t*; $R_{i,t}$ for the actual rate of return of cryptocurrency-*i* in period-*t*; and N for number of samples of cryptocurrencies.

Calculating Cross-Sectional Absolute Deviation (CSAD)

To find out herding behavior, Chang et al. (2000) proposed the CSAD measure as a proxy for herding behavior inspired by the capital asset pricing model (CAPM) with the formula:

$$CSAD_t = \frac{1}{N} \sum_{i=1}^{N} |R_{i,t} - R_{m,t}| \dots (3)$$

Where $CSAD_t$ describe for the value of Cross-Sectional Absolute Deviation in the period-*t*; $R_{m,t}$ for the rate of return on the cryptocurrency market in the period-*t*; $R_{i,t}$ for the actual rate of return of cryptocurrency-*i* in period-*t*; and N for number of samples *of cryptocurrencies.*

Investigating Herding Behavior Cryptocurrency Market

In the next step, CSAD was regressed as the dependent variable with the absolute value of the return market and the squared value of the return market as an independent variable to investigate herding behavior on the market, with the following formula:

$$CSAD_t = \alpha_0 + \gamma_1 |R_{m,t}| + \gamma_2 R_{m,t}^2 + \varepsilon \dots (4)$$

The identification of herding behavior was tested through hypotheses while answering the first hypothesis (H$_1$) in this study according to the reference (Bouri et al., 2021): a) Null Hypothesis (H$_0$), means H$_{0a}$: Herding behavior cannot be identified (when $\gamma_1 > 0$ and $\gamma_2 = 0$), and H$_{0b}$: There is anti-herding behavior (when $\gamma_2 > 0$); b) Hypothesis 1 (H$_1$): There is a tendency for herding behavior (when $\gamma_2 < 0$).

Analyzing the Influence of Indonesia's Macroeconomic Factors on Behavior Herding Cryptocurrency Market

Similar to the previous equation, the effect factor of Indonesia's macroeconomy on cryptocurrency market herding behavior was analyzed by linear regression analysis with a modification of the previous CSAD model by adding the independent variables, which are adaptation study of Gong and Dai (2017) as following:

$$CSAD_t = \alpha_0 + \gamma_1 |R_{m,t}| + \gamma_2 R_{m,t}^2 + \gamma_3 \Delta Inflation_t R_{m,t}^2 + \gamma_4 \Delta Interest_t R_{m,t}^2 + \varepsilon \dots (5)$$

Where $CSAD_t$ describe for the value of Cross-Sectional Absolute Deviation in the period-t; α_0 for regression intercept value; γ_i for the value of the regression coefficient on the independent variable-i; $|R_{m,t}|$ for the absolute/absolute value of the return market in the period-t; $R_{m,t}^2$ for the squared value of the return market in the period-t; $\Delta Inflation_t$ for change level inflation in Indonesia in the period-t; $\Delta Interest_t$ for change level interest rates in Indonesia (BI7DRR) in the period-t; and ε for regression error.

The hypothesis from the above equation is similar to the previous hypothesis in the regression equation (4). If the regression coefficient value of each factor, γ_3 and γ_4, is negative (positive) and significant, it implies the influence of Indonesia's macroeconomic factors on investor herding (anti-herding) behavior.

Result and Discussion

Descriptive Statistics Analysis

Table 1 provides descriptive statistics for the market/sample mean daily returns ($R_{m,t}$) and cross-sectional absolute standard deviation (CSAD) throughout the sample period. The market return fluctuated between -47.96% and 18.87% over the entire sample period, with an average of 0.12%. The cryptocurrency market was highly volatile, with a standard deviation of 4.39%. In addition, the daily average of CSAD was 1.64%, indicating that cryptocurrency returns deviated significantly from market expectations.

Table 1 Descriptive Statistics Analysis of $CSAD_t$ and $R_{m,t}$

	Market Return ($R_{m,t}$)	$CSAD_t$
Mean	0.12%	1.64%
Median	0.30%	1.25%
Minimum	-47.96%	0.06%
Maximum	18.87%	16.21%
Standard Deviation	4.39%	1.46%
Skewness	-1.35	3.72
Kurtosis	16.43	25.70
Jarque-Bera	10713.46	32593.16
Prob.	0.00%	0.00%

Table 2 presents descriptive statistics for inflation and interest rates and changes over the sample period. The maximum and minimum values of change in interest rates ($\Delta Interest_t$) during the sample period were 0.500% and 0.2500%, respectively. In addition, the maximum and minimum values of the change in the inflation rate ($\Delta Inflation_t$) were 0.3500% and 0.0323%, respectively. According to these findings, interest rates and inflation fluctuated. Changes in inflation and interest rates were small (below 1%) due to monthly changes in interest rates and inflation values.

Table 2 Descriptive Statistics Analysis of Inflation and Interest Rates

	Inflation Rate	$\Delta Inflation_t$	Interest Rate	$\Delta Interest_t$
Mean	2.72%	0.0004%	4.25%	-0.0004%
Median	2.64%	0.0000%	4.00%	0.0000%
Minimum	1.32%	-0.0323%	3.50%	-0.2500%
Maximum	5.95%	0.3500%	6.00%	0.5000%
Standard Deviation	1.31%	0.0107%	0.84%	0.0331%
Skewness	0.96	27.20	0.81	5.07
Kurtosis	2.99	853.08	2.30	143.07
Jarque-Bera	211.43	41450006.00	177.62	1126654.00
Prob. (p-value)	0.00%	0.00%	0.00%	0.00%

Meanwhile, based on Tables 1 and 2, the skewness value in the average daily return's distribution was negative, indicating that the distribution of market returns tended to produce negative values or losses, relatively greater than the positive return achieved with the *left-tailed* distribution. On the other hand, the skewness value in the cross-sectional absolute standard deviation (CSAD) distribution, inflation and interest rates, and their changes were positive, denoting that the distribution produced dispersion of returns, changes in interest rates and inflation with relatively more positive values than the average with the *right-tailed* distribution. Besides, the kurtosis value of the entire distribution had a positive value, suggesting that the two distributions decayed (turning point) more quickly while implying a greater likelihood of large values with a leptokurtic or fat-tailed distribution.

Furthermore, based on the normality test results using the Jarque Bera approach, it produced a probability value (p-value) under normality conditions, implying that the market or sample average daily returns ($R_{m,t}$) and cross-sectional absolute standard deviation (CSAD) were generally not distributed. Thus, the hypothesis could not be tested using the ordinary least square (OLS) regression econometric estimator approach, which requires symmetries/normal distributions of variables. Alternatively, this study used Newey and West's (1987) approach according to reference (Ballis & Drakos, 2020; Gong & Dai, 2017; Rahman & Ermawati, 2020)

Testing Herding Tendencies in Large-Cap Cryptocurrency Markets

Table 3 describes the regression results without using Indonesia's macroeconomic factor variables (inflation and interest rates) based on equation (4). The regression results used aggregate sample data of five large-cap cryptocurrencies with 1371 observations. The empirical test results of the regression showed that the coefficient γ_2 was negative and

significant at the 95% confidence level (α=5%). Therefore, based on empirical results, it can be concluded that investors in the large-cap cryptocurrency market tended to herd, where hypothesis 1 (H_1) could be accepted during the sample period.

Table 3 Regression Results Based on Equation (4)

Variable	Coefficient	Standard Error	t-Statistic
α_0	0.0098***	0.0006	16.5550
γ_1	0.2322***	0.0318	7.3005
γ_2	-0.1944**	0.0797	-2.4381

Note: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

These results align with research (Ballis & Drakos, 2020; Vidal-Tomás et al., 2019), which showed that investors in the "top" (large-cap) sector of the cryptocurrency market acted irrationally and imitated the decisions of others without referring to their beliefs. However, the results of this study are contrary to research (Amirat & Alwafi, 2020; Lobão, 2022; Yousaf & Yarovaya, 2022) stating that herding behavior in cryptocurrencies could not be proven. In addition, these results indicate that the linear relationship between $CSAD_t$ and market returns did not apply, and there was a non-linear correlation between $CSAD_t$ and market returns while confirming that the model of Chang et al. (2000) is suitable for this study. Figure 2 illustrates the non-linear relationship between $CSAD_t$ and market returns.

Explanations regarding the evidence of herding behavior occurring in cryptocurrencies include the cryptocurrency market, which tends to be new and rapidly developing with high price volatility/risk (Makarov & Schoar, 2020; Setiawan, 2020), lack of quality and information disclosure (Corbet, Lucey, Urquhart, & Yarovaya, 2019), and the tendency of crypto investors/traders to expect high positive returns (Amirat & Alwafi, 2020; Setiawan, 2020). Thus, investors/traders ignore individual characteristics regarding their investment decisions and behave in herds according to the performance of the cryptocurrency market (Amirat & Alwafi, 2020).

Figure 2 Relationship between Daily $CSAD_t$ and Market Return

The Influence of Indonesia's Macroeconomic Factors on Herding Behavior of the Large-Cap Cryptocurrency Market

Table 4 displays the regression results using Indonesia's macroeconomic factor variables (inflation and interest rates) based on equation (5). The regression results used aggregate sample data of five large-cap cryptocurrencies and two of Indonesia's macroeconomic factors (inflation rate and BI7DRR as an interest rate) with 1371 observations. The empirical test results of the regression revealed that the coefficient γ_3 was negative and significant at the 99% confidence level ($\alpha=1\%$), while the coefficient γ_4 was negative but not significant. Therefore, based on empirical results, the inflation rate in Indonesia influenced herding behavior in the large-cap cryptocurrency market, where hypothesis 2a (H_{2a}) could be accepted. Nevertheless, hypothesis 2b (H_{2b}), the interest rate in Indonesia, failed to be empirically proven to affect herding behavior in the large-cap cryptocurrency market. Based on these results, it can be concluded that of the two Indonesia's macroeconomic factors tested, only movements/changes in the inflation rate in Indonesia affected the herding behavior of large-cap cryptocurrency investors in the sample period.

Table 4 Regression Results Based on Equation (5)

Variable	Coefficient	Standard Error	t-Statistic
α_0	0.0098***	0.0006	16.6135
γ_1	0.2327***	0.0313	7.4313
γ_2	-0.1951**	0.0793	-2.4615
γ_3	-4628.1050***	1570.3790	-2.9471
γ_4	-155.6918	871.4861	-0.1787

Note: ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

The results of this study support the research of Galariotis, Rong, and Spyrou (2015) by showing that changes in the inflation rate affect investors' herding behavior. As known in previous research (Blau et al., 2021; Phochanachan et al., 2022; Smales, 2021), cryptocurrencies, including Bitcoin and other large-cap cryptocurrencies, are hedged or negatively correlated with inflation in the short term (short-run), especially according to the Gemini Trust Company LLC (2022), which states that most investors in Indonesia perceive cryptocurrencies as a hedge against inflationary conditions in Indonesia. Therefore, this research can explain the phenomenon of financial behavior that occurs when cryptocurrency prices change rapidly when the inflation rate, especially in Indonesia, changes.

Nonetheless, these results contradict studies (Gong & Dai, 2017; Wibowo, 2021; Wicaksono & Falianty, 2022), which showed that interest rate movements failed to prove to affect investors' herding behavior. Unlike the inflation rate, when the Bank Indonesia (BI) Board of Governors Meeting announced that the interest rate in Indonesia (BI7DRR) experienced a change in value (increase/decrease), similar to the response to the Fed Funds Rate interest rate (Vidal-Tomás & Ibañez, 2018), cryptocurrency investors did not perceive changes in interest rates as bad news that can trigger herding behavior like capital market investors (Y. H. Lee, Liao, & Hsu, 2015).

According to research results, given that herding behavior exists in the large-cap cryptocurrency market, this market is proven inefficient (Urquhart, 2016; Vidal-Tomás et al., 2019). In addition, because herding behavior can cause a "tsunami effect," namely massive inflows and outflows, which eventually often result in bubbles and crashes in the large-cap cryptocurrency market (Pompian, 2021), global and local policymakers must establish adequate regulations to increase the efficiency of the cryptocurrency market.

It should be remembered that cryptocurrency is a high-risk asset (Liu et al., 2019; Setiawan, 2020), which has the potential to be dominated by types of investors with a tendency towards emotional type bias: self-control bias where investors' decisions with these conditions are very sensitive to changes in asset prices because this investment decisions tend to "consume today at the expense of saving for tomorrow" (Pompian, 2021). Especially unlike the stock market, which has an auto-rejection rule when the stock price is too high/low, the cryptocurrency market, according to Sapuric and Kokkinaki (2014), moves freely according to the movement of investor demand and supply. As a result, the price of cryptocurrencies can rise as high as possible and allow it to fall as low as possible.

Furthermore, Indonesia is one of the countries with the largest percentage of cryptocurrency adopters in the world for the large-cap cryptocurrency market; inflation in Indonesia can be proven to have contributed to investor herding behavior in large-cap cryptocurrency. Therefore, investors in Indonesia need to be careful in making rational investment decisions, especially when there is an announcement or news about the inflation rate movement in Indonesia. Finally, investors need to diversify their investment portfolios with assets that negatively correlate with cryptocurrencies and are resistant to inflation because, according to Choi and Shin (2022), cryptocurrencies are proven not to be resilient/safe-haven to inflation. It is also proven in this study that the herding behavior of the large-cap cryptocurrency market can be affected by movements in inflation. It can help minimize losses when cryptocurrency prices drop during a bearish/crash market.

Conclusion

The cryptocurrency market has experienced rapid growth and has become a type of currency and an important investment instrument. The main problem arises when investors carry out cryptocurrency investment activities recklessly with bias and decide to invest without regard to the high risk and rate of return on cryptocurrency. This behavior indicates investors' herding behavior in the large-cap cryptocurrency market. The CSAD approach was used with the Newey-West estimator approach to analyze this phenomenon, considering that the distribution was not symmetrical, and three main results were obtained. First, large-cap cryptocurrency investors tend to be irrational in their decisions and follow the decisions of others without reference to their beliefs or herding during the sample period. Second of the two macroeconomic factors studied, i.e., inflation and interest rates, only changes in inflation rates influenced investor herding behavior. Third, the market is inefficient with the proven tendency of herding behavior in large-cap cryptocurrencies.

The results of this study provide theoretical and practical implications. Theoretically, this study extends previous findings regarding herding behavior and the external factors influencing it, particularly in the cryptocurrency context, thereby contributing to future research by supporting the theory and results of previous studies. In practical implication, global and local policymakers must establish adequate regulations to improve the efficiency of the cryptocurrency market. In addition, large-cap cryptocurrency investors in Indonesia need to be careful in making rational investment decisions, especially when there is an announcement/news about the inflation rate movement in Indonesia. Finally, investors need to diversify their investment portfolios with assets that negatively correlate with cryptocurrencies and are resistant to inflation.

This research was limited to using only cryptocurrency assets by not using crypto-tokens, non-fungible tokens (NFT), and other crypto-assets. In addition, this research was still limited to only looking at the influence of macroeconomic factors in Indonesia on herding behavior in the aggregate large-cap cryptocurrency market. Therefore, further research can conduct research on herding behavior or other financial behavior by using other crypto assets or cryptocurrencies separately to determine the characteristics of each cryptocurrency and the influence on investor herding behavior by using other factors.

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