Applied Mathematics, Modeling and Computer Simulation
C. Chen (Ed.)

doi:10.3233/ATDE220018

Cryptocurrency and the Herd Behavior

Zhuocheng WANG[a,1], Zhiwei HUANG[b], Rongkuan HE[c], and Yixin FENG[b]
[a] *SEM, Tsinghua University, Beijing, 100084, China*
[b] *Computer Science, Durham University, Durham, DH1 3LE, UK*
[c] *Information Science and Engineering College, Hunan Normal University, Changsha, 410006, China*

Abstract. In the financial market, investors often do not consider the market environment, but only invest based on the investment behavior of others. This is commonly known as Herd behavior. The herd behavior not only takes part in traditional financial markets but also in cryptocurrency markets. This paper aims to build a model which is applicable in cryptocurrency markets. To research the herd behavior in cryptocurrency markets and the dynamic relationship between the investors and the value of cryptocurrency with the model.

Keywords. Cryptocurrency, Herd Behavior, CSAD.

1. Introduction

At the end of 2017, the price of cryptocurrency had been above 20,000 dollars. Since it's released in 2008, the cryptocurrency had received attention in some areas, but it was this drastic price increase that had pushed it to a wider audience and caused a lot of discussions.

Even though cryptocurrency had something to do with the illegal purchase in the darknet, the advocate of it usually regarded it as a measure to enhance personal freedom by providing a transaction method without any other third-party supervision. After the peak in 2017, the value of cryptocurrency had experienced a sharp drop at the beginning of 2018, which exacerbated the risk of cryptocurrency [1].

Because of some group factors, the market of cryptocurrency is unstable. There is some kind of special mechanism in these factors. Especially in the situation that it seems that there is no other information in the market, it needs a form of event catalyst to cause mass incidents. The catalyst is herd behavior.

Herd behavior in the cryptocurrency market is different from that in the traditional financial market. It has its own features. Because the number of cryptocurrencies is limited by government policy, it can not be a strong cryptocurrency financial market institution. This determines that the mainstream group participating in the cryptocurrency market is retail investors. When the number of retail investors growing up, herd behavior in the cryptocurrency market can be more obvious than that in the traditional financial market.

There are roughly three types of interpretation methods for herd behavior. The first is the reputation theory model [2]; the second is the flow theory model [3]; the last one

[1] Corresponding Author, Zhuocheng WANG, SEM, Tsinghua University, Beijing, 100084, China; E-mail: nus_hzw@163.com

is the wage structure theory model [4]. Based on the three interpretation methods, there are also three types of systematic research on herd behavior in the market. The first type is the LALSV model based on a specific market transaction method and its correlation with a trader recommended by Lakonishoketal [5]; the second type is an inter-departmental model established by Hutchison et al. That is, the standard deviation model of the yield rate; the third category is the CSDA model based on horizontal absolute deviation proposed by Chang et al after improving the CSSD method.

This passage aims to analyze the phenomenon in the cryptocurrency market by constructing the herding detection model based on the theory above.

2. The Herd Behavior Theory

Keynes first put forward herding in the concept of economics. This project was formally put forward in his famous paper General Theory of Employment, Interest, and Currency.

In a beauty contest, only the referee's choice is consistent with the final result (that is, the real winner), in order to win the contest. In this case, participants usually choose the most likely person, not the most beautiful person. In order to win and get rewards, players need to predict the most likely choices of other participants and treat the most likely choices as their own. The choices of the participants gradually became consistent.

That is the same in the financial market. The most important thing is not to invest in the most valuable stocks, but to predict the possible changes of public investors and choose the stocks that are most likely to invest. Keynes believes that herding behavior in the stock market is a phenomenon in which investors disclose personal information and make the same investment decisions as others. Therefore, he believes that the herding effect refers to the phenomenon that investors give up their own personal information and the investment decision information of others, and make the same investment decisions as others.

Nowadays, more and more scholars are trying to study behavioral problems in socialist economics from the perspective of experimental psychology. In this environment, the theory of behavioral finance has been developed, and herd behavior is one of the important research contents of behavioral economics. Since the 1980s, scholars have begun various in-depth scientific studies on the effects of herd movement, and have also begun to work hard to explore and research to collect more basic interpretations of various relevant scientific theories on the effect of herd movement and other empirical theoretical evidence.

3. The Herd Behavior in Cryptocurrency

The herding phenomenon has been extensively studied in the stock market [6], using a large number of definitions and methods [5,7-8]. In particular, the project of Christie and Huang (1995) studied the flock that tends to market consensus and believed that "the characteristic of the flock is that they suppress their own autonomous judgment and make investment decisions based only on collective actions in the market. Even if they disagree with the market’s predictions, this feature is very obvious in the cryptocurrency market.

Studies have proved that the price fluctuations of cryptocurrencies are caused by a large number of websites and social media, which are full of potentially biased information. Users obtain information from different channels and make corresponding investment behaviors because of profit-seeking. This kind of volatility in the cryptocurrency market is most likely caused by Herd behavior. There is also some empirical work, applying behavioral economics to the cryptocurrency market, trying to prove the influence of investor personality effects on the herding effect of the cryptocurrency market [9].

Most of the existing discussions on the cryptocurrency market still adhere to the efficient market hypothesis, believing that people obtain the same set of information as the basis for their decision-making. However, as mentioned above, investors can ignore their beliefs and imitate the behavior of other investors. Because of the irrational behavior of traders, they don't properly get all the information available in the market, so that the assets can not be accurately priced. Therefore, it is very essential to analyze the existence of herd behavior in the cryptocurrency market, because the existence of this phenomenon will lead to market inefficiency. In this kind of market, asset pricing models based on reasonable economic behavior cannot be applied correctly. This required the new herd model should resolve the problem in the cryptocurrency market.

4. Cryptocurrency and the Herd Model

The quantitative method of herding effect was first established by William, Sharpe, etc., based on modern investment portfolio theory and capital asset valuation model, which is called the CAPM model. The model assumes that investors in the asset market are rational, the market combination is effective, and the capital market is completely effective. When the return market (including the risk-free premium and risky return when the market) reaches equilibrium, it is expected that there will be a linear relationship between return and risk:

$$\mathrm{E_{ri}} = \mathrm{r_f} + (\mathrm{E_{rm}} - \mathrm{r_f})\,\beta_\mathrm{i}$$

It can be seen from the above formula that the expected return on stocks E_{ri}, has a linear relationship with the Market expected return E_{rm}, where the coefficient is the risk-reward coefficient β_i.

However, in the real capital model, both the investor rationality assumption and the efficient market assumption are unreliable. The linear relationship between the stock expected yield curve and the market expected yield is unreliable. In order to quantify the herd effect, we can first focus on whether the investment behavior in the rational asset pricing model has a nonlinear relationship in the time series, and then judge whether there is a herd effect.

4.1. LSV

A work in 1992 by Lakneck, Shriver, and Vishnu provides us with basic help in constructing an empirical model of the herd phenomenon. It can be said that their work is the basis for the empirical test of the herding effect. In this work, they created an index to measure the strength of herd behavior by studying the behavior of traders who bought and sold stocks at the same time. This method is called the LSV model. By comparing the data of 789 pension funds in the United States and analyzing the frequency of fund

purchases under different circumstances, they proposed an LSV model to verify whether there is a herd effect.

As mentioned above, the judgment basis of the LSV model is based on the transaction data of financial products in a specific time period and time series. By analyzing the transaction data under this time series, we can judge the average investment trend. And through time series analysis of this average trend, we can judge whether the herd effect exists. The mathematical expression of the model is:

$$\boldsymbol{H(i,t) = |P(i,t) - P(t)| - A\,F(i,t)}$$

$\boldsymbol{H(i,t)}$ describes the herd effect that buys $\boldsymbol{i}$ at $\boldsymbol{t}$. This is a description of the herd effect. $\boldsymbol{P(i,t)}$ is some kind of proportion. It means that the proportion of entities (or companies) that purchase $\boldsymbol{i}$ shares at time $\boldsymbol{t}$ among all purchase entities. Specifically, it can be expressed as:

$$\mathbf{P(i,t) = B(i,t)/(B(i,t) + S(i,t))}$$

$\boldsymbol{B(i,\ t)}$ means the number of buying $\boldsymbol{i}$ in $\boldsymbol{t}$, and the $\boldsymbol{S(i,\ t)}$ means the number of selling $\boldsymbol{i}$ in $\boldsymbol{t}$.

$\boldsymbol{P(t)}$ refers to the initial expectation of all the stocks will be bought by some entity at time $\boldsymbol{t}$. $\boldsymbol{AF(i,\ t)}$ is an instrumental variable to make $\boldsymbol{H(i,\ t)}$ can be zero theoretically. The specific expression is:

$$\mathbf{A\,F(i,\ t) = E[\,P(i,\ t) - P(t)]}$$

When the number of company buying $\boldsymbol{i}$ stock is big enough at time $\boldsymbol{t}$, the instrumental variable tends to be zero, otherwise it will be a postive number.

In conclusion, when $\boldsymbol{H(i,t)}$ is not significantly zero, the herd effect exists in the market.

The data required by the LSV analysis method is relatively easy to obtain and easy to operate. However, this analysis method also has some shortcomings. It ignores the difference in investment cycles. This makes the method unable to accurately judge whether there is a herd effect when institutional investors make short-term and long-term stock investments.

4.2. CSSD

Based on the LSV model, some scholars have made a series of improvements. Among them, the most significant result is the cross-sectional standard deviation ratio model proposed by Christie and Huang in 1995, which is the CSSD evaluation method we often call [10]. This method is also the most commonly used method in evaluating the existence of a herd model, or in doing an empirical study of the herd effect. The main idea of the CSSD method is to evaluate the overall trend of the trading market by evaluating the absolute rate of return, index return and other factors in the transaction data. This is similar to the assessment of the overall trading situation in LSV, but using different indicators.

When the herd effect appears in the studied market, it indicates that the market has experienced large volatility, and the investment strategy of investors in the market seems to be inclined to the overall market strategy. Therefore, in the earnings market, the

earnings of individual stocks might be closely distributed. In this case, the convergence of returns and individual stocks in the income market can be tested with the following formula:

$$\boldsymbol{CSSD = 1N - 1\,i = 1N\left(R_{i,\ t} - R_{m,\ t}\right)^2}$$

Among these, $\boldsymbol{N}$ is the number of shares, $\mathbf{R_{i,\ t}}$ is the rewords of $\boldsymbol{i}$ stock at t, $\mathbf{R_{m,\ t}}$ is the rewords of $\boldsymbol{i}$ portfolio at t.

So, if CSSD = 0, the herd effect is existent. At the time, the R of a single transaction object is similar to market expectations, and the index deviation will be smaller.

4.3. CSAD

In connection to the shortcomings of the CSSD model, ChangerI, Joseph and Khoranaa-Jay improved the CSSD model, and then proposed the CSAD model [11].

The CSAD model is based on the absolute difference in the cross-section of individual stocks' daily returns, which improves the sensitivity problem in LSV to a certain extent, allowing some non-significant herd effects to be tested. The model measures the herd effect from the daily average market return index. The calculation process is as follows:

$$\boldsymbol{CSAD = \frac{1}{N}\sum_{i=1}^{N}\left|R_{i,\ t} - R_{m,\ t}\right|}$$

Among these, $\boldsymbol{N}$ is the number of shares, $\mathbf{R_{i,\ t}}$ is the rewords of $\boldsymbol{i}$ stock at t, $\mathbf{R_{m,\ t}}$ is the rewords of $\boldsymbol{i}$ portfolio at t.

5. The Improved Inspection Method

Based on the above-mentioned detection methods, this article proposes an improved herd effect detection method for the cryptocurrency market.

Since the herding effect cannot be measured directly from the financial market, the previous literature has proposed different research methods to solve this problem. For example, based on the return test to detect herd behavior. This paper adopts one of the works [12]. This work is an improvement on the original method provided by Christie and Huang [13]. They suggested the use of the cross-departmental standard rate of return deviation (CSSD) to identify herding behavior in financial markets, which is defined as:

$$\mathbf{CSSD_t} = \sqrt{\frac{\sum_{i=1}^{n}\left(R_{i,\ t} - \overline{R_{m,\ t}}\right)^2}{N - 1}}$$

$\boldsymbol{R_{i,\ t}}$ is a rate of stock return that is observed by a certain company at some time. And $\mathbf{CSSD_t}$ is the cross-sectional average of the return on the portfolio aggregated at that point at the same time. CSSD expresses the average closeness of personal income to

the mean. In other words, CSSD will always be equal to or greater than zero, where the value linked to the lowest limit indicates that all benefits flow harmoniously when they fade, starting from the zero marks.

According to Christie and Huang, it is possible to test the herding effect under market pressure by exploiting the tendency of investors to overthrow their personal will to support the market consensus. This conclusion stems from the rational capital asset pricing model (CAPM). The forecast distribution will increase with the absolute value of market returns because each asset has a different sensitivity to market returns. On the other hand, if there is a herd, personal gains and market results will not be very different. The empirical test estimated by Christie and Huang is as follows:

$$CSSD_t = \alpha + \beta^L D_t^L + \beta^U D_t^U + \varepsilon_t$$

When DLT=1, it means that the income is in the long tail position. On the contrary, DLT=0. This indicator has an extreme increase or decrease compared to the expected "normal", expressed as 90% or 98% of the distribution. we can be used to detect the existence of the herd effect through this standard.

However, this method has two main disadvantages: firstly, it is too sensitive to outliers; secondly, it is arbitrary to be regarded as "extreme". Because the 1% and 5% rules may not apply to all distributions. Therefore, we have made certain improvements on this basis, and the improved model is:

$$CSAD_t = \frac{1}{N}\left|R_{i,\ t} - \overline{R_{m,\ t}}\right|$$

The key to the improved model is divergence, which uses the absolute difference between individual returns and average market returns, which makes it far less sensitive to return outliers than secondary returns.

This model refers to Arjoon and Shekhar studying the herd effect in the context of frontier markets, and Chiang and Zheng [15-16], Demirer, Lee, and Lien found the model of the herd effect in advanced stock markets [17].

6. Conclusion

This paper examines the herd effect that may occur in the cryptocurrency market and conducts empirical analysis, including establishing a herd behavior model suitable for the cryptocurrency market, studying the relationship between investor groups and cryptocurrency prices, and systematic analysis of The dynamic relationship between them.

In the process of constructing the model, this paper refers to three different basic discrimination methods about the herd effect of LSV, CSSD, and CSAD. Based on these models, and according to the general definition of cryptocurrency and the characteristics of cryptocurrency, it constructs a new verification model for the cryptocurrency financial market.

References

[1] Bohr, Jeremiah, and Masooda Bashir. "Who uses bitcoin? an exploration of the bitcoin community." 2014 Twelfth Annual International Conference on Privacy, Security and Trust. IEEE, 2014.
[2] Scharfstein, David S., and Jeremy C. Stein. "Herd behavior and investment." The American economic review (1990): 465-479.
[3] Banerjee, Abhijit V. "A simple model of herd behavior." The quarterly journal of economics 107.3 (1992): 797-817.
[4] Mauget, René, and Francis Declerck. "Structures, strategies, and performance of EC agricultural cooperatives." Agribusiness: An International Journal 12.3 (1996): 265-275.
[5] Lakonishok, Josef, Andrei Shleifer, and Robert W. Vishny. "The impact of institutional trading on stock prices." Journal of financial economics 32.1 (1992): 23-43.
[6] Chiang, Thomas C., and Dazhi Zheng. "An empirical analysis of herd behavior in global stock markets." Journal of Banking & Finance 34.8 (2010): 1911-1921.
[7] Christie, William G., and Roger D. Huang. "Following the pied piper: Do individual returns herd around the market?." Financial Analysts Journal 51.4 (1995): 31-37.
[8] Makris, Nicos, and Shih‐Po Chang. "Effect of viscous, viscoplastic and friction damping on the response of seismic isolated structures." Earthquake engineering & structural dynamics 29.1 (2000): 85-107.
[9] Faisal, Faisal, et al. "The content and determinants of greenhouse gas emission disclosure: Evidence from Indonesian companies." Corporate Social Responsibility and Environmental Management 25.6 (2018): 1397-1406.
[10] Christie, William G., and Roger D. Huang. "Following the pied piper: Do individual returns herd around the market?." Financial Analysts Journal 51.4 (1995): 31-37.
[11] Chang, Eric C., Joseph W. Cheng, and Ajay Khorana. "An examination of herd behavior in equity markets: An international perspective." Journal of Banking & Finance 24.10 (2000): 1651-1679.
[12] Chang, Eric C., Joseph W. Cheng, and Ajay Khorana. "An examination of herd behavior in equity markets: An international perspective." Journal of Banking & Finance 24.10 (2000): 1651-1679.
[13] Christie, William G., and Roger D. Huang. "Following the pied piper: Do individual returns herd around the market?." Financial Analysts Journal 51.4 (1995): 31-37.
[14] Arjoon, Vaalmikki, and Chandra Shekhar Bhatnagar. "Dynamic herding analysis in a frontier market." Research in International Business and Finance 42 (2017): 496-508.
[15] Chiang, Thomas C., and Dazhi Zheng. "An empirical analysis of herd behavior in global stock markets." Journal of Banking & Finance 34.8 (2010): 1911-1921.
[16] Demirer, Rıza, Hsiang-Tai Lee, and Donald Lien. "Does the stock market drive herd behavior in commodity futures markets?." International Review of Financial Analysis 39 (2015): 32-44.