Skewness in the Cryptocurrency Market

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Abstract. The cryptocurrency market is generally accepted in the world, and its price has soared and plummeted sharply. Meanwhile, skewness is an index reflecting the rapid rise and fall of asset prices in a short period. Studying the relationship between the skewness of cryptocurrency and its returns can help risk evaders expect bad news and provide a reference for risk enthusiasts to make investment decisions. Therefore, through univariate combination analysis, this paper groups cryptocurrency according to the skewness of the previous month before buying and holding it in the next week. Moreover, the excess return series are calculated to make statistical tests on it. Then we construct a three-factor model of cryptocurrency and adjust the return series. To enhance the robustness of the conclusion, we also use other measures of skewness such as idiosyncratic skewness to conduct a univariate combination analysis. The results show that a positive correlation between cryptocurrency skewness and its returns exists, which can be used as a reference index of the returns.

Keywords: cryptocurrency, skewness, market.

1. Introduction

Since Bitcoin was created by Satoshi Nakamoto in 2009, the private cryptocurrency based on Bitcoin has brought about profound changes in information technology, currency payment, accounting and auditing, financial investment, etc. The core concepts such as consensus mechanism, distributed bookkeeping, and decentralization contained in cryptocurrency exchanges are unprecedentedly innovative. Therefore, with the participation of many investors, the price of Bitcoin has risen sharply with the huge transaction volume and many investors. However, due to the lack of government credit endorsement, isolation from the financial supervision system, and excessive speculation in the market, its returns fluctuate greatly. The COVID-19 pandemic critically undercut the global economy, but the bitcoin price rose sharply with violent fluctuations. As Bitcoin-based private cryptocurrency will exist in the world for a long time with its price soaring and plummeting, its returns can respond to market information in time, which can not only be used as a tool for risk evaders to expect bad news but also influence the investment decisions of risk enthusiasts and assist them in portfolio management, risk analysis, and market sentiment analysis. Therefore, how to predict the change of bitcoin returns has been attractive in the financial industry.

Cryptocurrency belongs to new financial technology. Thus, there is a large space for exploring the research contents and methods of its returns in the financial field. Some scholars found that Bitcoin returns can predict the stock returns in the lag period when the Bitcoin price fluctuated at a high level (Zhou, 2021). Therefore, the introduction of traditional stock trading research methods may effectively help the study of cryptocurrency turns. At present, there have been a large number of studies in the research of cryptocurrency. Some people apply the max effect to predict cryptocurrency (Shahzad, 2021); Others found that there is a momentum effect when studying the rate of cryptocurrency returns (Li, 2021); Some researchers use the Granger model to find that a causal relationship exists between the fluctuation of cryptocurrency returns (Ma, 2021); Some people also use ARIMA-EGARCH dynamic forecasting model to analyze the inherent law of forecasting cryptocurrency returns series (Hou, 2021). In addition, scholars use wavelet coherence to study the common movement between cryptocurrency price and its related factors. It is found that under the bubble-like regimes of price series, the medium-term positive correlations between online factors and

prices are significantly enhanced, thus explaining why these relationships appeared and disappeared over time (Philips, 2018).

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There are also many important references in the study of cryptocurrency by using factor models. For example, after constructing a three-factor model of the cryptocurrency market including market factor, scale factor, and momentum factor, some people have made cryptocurrency produce statistically significant excess returns through long-short equity strategy, which proves that these strategies can be applied to cryptocurrency three-factor model (Liu, 2022); Some people also estimated the contagion measures of large-scale left-tail risk events in the special interference of cryptocurrency and then incorporated them into the three-factor pricing model. By using cryptocurrency data, it is proved that the performance of the four-factor pricing model is better than cryptocurrency CAPM and the three-factor model (Shahzad, 2021).

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This paper studies the correlation between skewness and cryptocurrency returns in the cryptocurrency market. Statistically speaking, the asymmetry of stock market return distribution is mainly described by the third-order moment, that is, skewness. High-frequency skewness depicts the characteristics of stock price rising or falling rapidly in a day and investors' decreasing risk aversion. In other words, investors have skewness preferences. Therefore, skewness is often used in the capital asset pricing model (CAPM). There has been much research literature on skewness in the study of stock market returns. After calculating the realized skewness of China's stock market, Zhang Yifan (2018) tested the ability of the realized skewness to predict the excess return rate of the stock market in the coming month through the predictive regression model and finally proved that the skewness as a systematic risk factor can predict the return rate of China's stock market. After constructing a three-factor model, Chen Jian and Zhang Yifan (2018) divided all stocks in China's stock market, including Shanghai and Shenzhen markets, into different portfolios according to company size, BM effect, and momentum, thus testing the prediction ability of realized skewness for different portfolios. Xia Shilong (2019) compared the ability of robust total skewness, robust systematic skewness, robust idiosyncratic skewness, and sample moment total skewness to predict individual stock returns in cross-section and time series dimensions, which found that skewness is an important factor in A-share pricing.

This paper studies the skewness effect of cryptocurrency returns and proves that the skewness effect is widespread in cryptocurrency to provide investors regarding the skewness effect when investing in cryptocurrency. Specifically, we selected 1,000 samples of large tradable cryptocurrency from May 5, 2013, to December 26, 2021. The skewness value of each sample data is calculated respectively, which is also divided into ten groups according to the skewness value. After each group averages the market value every month, it is invested with equal and weighted weight respectively. After buying and holding for one week, their return rate is observed and regression analysis is carried out to judge whether skewness can be used as the analysis standard of cryptocurrency returns.

The marginal contributions of this paper are as follows:

1). This paper selects a total of 1,000 cryptocurrency samples with the largest market value. Compared with other literature in this field, this paper contains abundant samples, so the coverage rate is wider and can better reflect the characteristics of the cryptocurrency market.

2). This paper studies the relationship between skewness and the cryptocurrency return. Because of the unstable cryptocurrency market, the price often fluctuates greatly and skewness can reflect the large fluctuation of cryptocurrency returns. Therefore, choosing skewness as an index to study the return of cryptocurrency provides a great reference for investors and scholars.

3). In addition, this paper refers to the three-factor model of the stock market to construct that of cryptocurrency based on the existing literature. Because momentum effect exists in the

cryptocurrency market, we add the momentum factor to the model, which has more significance for adjusting the returns series of cryptocurrency.

The rest of this paper is arranged as follows. In the second part, we introduce the data sources and show their descriptive statistical results. The third part introduces the calculation methods of skewness, idiosyncratic skewness, and the factor calculation method in the three-factor model. In addition to demonstrating the empirical content in detail, including the univariate analysis of cryptocurrency returns and skewness in the fourth part, idiosyncratic skewness and the adjustment of cryptocurrency's three factors to its returns series are also shown. In the fifth part, we describe the conclusion of the empirical analysis in detail.

2. Data

Following Yukun Liu (2021), we selected 1,000 cryptocurrency samples with the largest market value from http://coinmarketcap.com/for analysis. Coinmarketcap.com is the main source of cryptocurrency price and quantity data. It aggregates information from more than 200 major exchanges and provides daily data on the opening, closing, high, and low prices of most cryptocurrencies, as well as trading volume and market value (in US dollars). For each cryptocurrency on the site, Coinmarketcap.com assures concerns about survival bias from calculating its price by taking a quantity-weighted average of all prices reported in each market and listing active and invalid cryptocurrencies. https://coinmarketcap.com/The sample started on May 5, 2013, and ended on December 26, 2021. We decided to start sample analysis in May 2013, which includes the transaction date of the earliest cryptocurrency Bitcoin, so as to ensure sufficient reference of samples.

Table 1. Descriptive Statistics of Variables**1**

	mean	std	skewness	kurtosis	min	25%	0.50	0.75	Max
daily_ret	0.02	0.24	2.97	45.45	-0.31	-0.03	0.00	0.03	3.52
weekly_ret	8.02	64.66	3.93	52.24	-0.46	-0.07	0.00	0.11	534.61
monthly_ret4	16.83	136.98	5.30	72.78	-0.60	-0.10	0.09	0.35	1169.38
ln SIZE	16.67	2.33	0.58	1.15	11.30	15.11	16.56	17.90	24.33
volome	107669808.32	1074116990.90	9.85	136.93	347.76	224751.72	1248259.15	6809216.67	20690881755.25
Skew	0.60	1.04	0.87	2.11	-1.97	-0.06	0.46	1.11	4.13
Iskew	0.86	1.07	0.52	1.81	-2.12	0.22	0.75	1.40	4.23

In addition, we have carried out descriptive statistical tests on the main variables used in this paper. After excluding outliers, we can see that the average daily returns of cryptocurrency have reached 2%, the average weekly returns 8%, the average monthly returns 16.83%, and we have calculated the logarithmic value of returns to be 16.67. In addition, the daily variance of cryptocurrency returns is up to 0.24, skewness 2.97, kurtosis 45.45, with almost all remaining variables increasing with time.

3. Model

Because investors in the cryptocurrency market have obvious lottery preferences, prominent speculation, and a preference for pursuing extreme returns, the cryptocurrency market has repeatedly experienced a sharp rise and fall. At the same time, the overall returns of cryptocurrency market are not normally distributed but have the biased characteristics of leptokurtic. Therefore, in this paper, we study whether skewness can affect the return of cryptocurrency. First, we calculated the skewness of cryptocurrency in the last month. The calculation method is shown in the following formula:

$$\frac{1}{D_t}\sum_{d=1}^{Dt}\left(\frac{R_{i,d}-\mu_i}{\sigma_i}\right)^3$$

Among them, D_t is the number of trading days in a month, $R_{i,d}$ is the daily excess rate of cryptocurrency returns, μ_i is the average value of the returns of cryptocurrency i, and σ_i is the standard deviation of the return of cryptocurrency i.

To enhance the robustness of the conclusion, we also use other measures of skewness such as idiosyncratic skewness, referring to the skewness of the distribution of cryptocurrency idiosyncratic

returns manifested in the phenomenon of soaring or plummeting cryptocurrency returns. Therefore, it is of practical significance to study the phenomenon of soaring or plummeting returns for its market stability.

Calculation method of idiosyncratic skewness:

According to the research of Siddique and Harvey (2000) and Bali, Cakici, and Whitelaw (2001), we use the residual term $\epsilon_{i,d}$ in the regression function to calculate the characteristic skewness of cryptocurrency i, with the specific regression form as follows:

$$R_{i,d} = \alpha_i + \beta_i \cdot R_{m,d} + \gamma_i \cdot {R_{m,d}}^2 + \epsilon_{i,d}$$

Among them, $R_{i,d}$ is the excess return of cryptocurrency i in d day; $R_{m,d}$ is the excess return of market in d day and $\epsilon_{i,d}$ is the residual of the regression equation. The regression residual term was used to calculate the idiosyncratic skewness in the last month.

In this paper, the three-factor model (Shen, 2020) is used to adjust the excess return of cryptocurrency. The three factors include market, momentum, and market value. The specific construction methods of the factors are as follows:

$$MKT_t = \sum_{i=1}^{n} ret_{i,t} * \frac{Cap_{i,t}}{TotalCap_t}$$

MKT_t is the weekly return of the market portfolio, $ret_{i,t}$ is the return of the cryptocurrency i in one month, $Cap_{i,t}$ is the market value of the cryptocurrency, and $TotalCap_t = \sum_{i=1}^{n} Cap_{i,t}$

We use the earnings performance of six value-weighted portfolios based on market value in the previous month to construct the scale and reversal factor, that is, the intersection of the scale of two portfolios and the previous returns of three portfolios. Previously, the weekly breakpoints of earnings were the 30th and 70th percentiles, while we defined cryptocurrency with a market value higher than 50% as large and cryptocurrency with a market value lower than 50% as small (consistent with Fama and French 2012). The six independently formed portfolios are denoted as BU, BM, BD, SU, SM, and SD, where B and S represent large and small market value, U, M, and D represent high, medium, and low returns. In order to ensure that each portfolio has enough cryptocurrency, we will start sorting after June 2017.

The following formula presents the SMB market value factor:

$$\text{SMB} = \frac{1}{3}(\text{Small Up} + \text{Small Medium} + \text{Small Down}) - \frac{1}{3}(\text{Big Up} + \text{Big Medium} + \text{Big Down})$$

Therefore, the SMB-market value factor is the equal weight average of three small cryptocurrency portfolios minus the average of three large portfolios.

In addition, we also construct the momentum MoM factor, that is, the UMD factor. The average return of two high-return portfolios minus the average return of two low-return portfolios. The specific formula is as follows:

$$\text{UMD} = \frac{1}{2}(\text{Big Up} + \text{Small Up}) - \frac{1}{2}(\text{Big Down} + \text{Small Down})$$

4. Empirical Results

From May 5, 2013, to December 26, 2021, cryptocurrencies were grouped according to the skewness value of the last month, and each group of cryptocurrencies was bought and held for one week. This table reports the excess return and significance of each group of cryptocurrencies in these groups, that is, the return of each group of cryptocurrencies after holding for one week and the t value after significance regression analysis.

Table 2. Regression of Cryptocurrency Return on Skewness

	Low	G2	G3	G4	High	High-Low
Excess Return	0.039***	0.041***	0.041***	0.063***	0.147***	0.108**
t-value	(3.902)	(3.529)	(3.611)	(4.016)	(2.920)	(2.230)

Table 2 adopts the univariate combination analysis method, and obtains the excess return of cryptocurrency bought and held for one week with equal rights and the t value of its statistical test after being grouped into five groups according to the skewness of the previous month. According to the skewness value of all cryptocurrency samples every month, we divide them into five groups from small to large to ensure that there are enough trading day samples in each group for analysis. Then, we calculate its returns after holding cryptocurrency in each group for one week. At the same time, we construct a long-short combination to buy a group of cryptocurrencies with the highest skewness and sell that with the lowest skewness and calculate the returns of this strategy. We repeat this work every week, thus obtaining the time series of excess returns in five groups. Finally, we test the time series of excess returns statistically and get its t value.

From the table, after holding equal rights buy for one week, the cryptocurrency return of the group with the smallest skewness is also the smallest, which is 3.9% with its corresponding t value as 3.90, while the cryptocurrency return of the group with the highest skewness is as high as 14.7%, which corresponds to 2.92. With the increase of skewness, the excess return of cryptocurrencies from the first group to the fifth group also gradually increases, which is also confirmed by the return performance of the long-short strategy. By making a group of cryptocurrencies with the highest long skewness and shorting that with the lowest skewness every week, 10.8% excess return can be obtained with its corresponding t value as 2.23, which is statistically significant. Therefore, the univariate grouping results show that cryptocurrencies with higher skewness in the past will get higher returns in the future.

From May 5, 2013, to December 26, 2021, 261 cryptocurrencies were grouped from small to large according to the idiosyncratic skewness value of the past month, and each group of cryptocurrencies was bought and held for one week. This table reports the excess return and significance of each group of cryptocurrencies in these groups, that is, the return of each group of cryptocurrencies after holding for one week and the t value after significance regression analysis.

Table 3. Regression of Cryptocurrency Returns on Idiosyncratic Skewness

	Low	G2	G3	G4	High	High-Low
Excess Return	0.050***	0.041***	0.048***	0.050***	0.144***	0.094*
t-value	(3.869)	(3.510)	(3.811)	(4.099)	(2.866)	(1.921)

Table 3 also uses the univariate combination analysis method. First, we use the residual term obtained from the regression of market and cryptocurrency returns to calculate the idiosyncratic skewness of cryptocurrency in the previous month. Then, cryptocurrency is divided into five groups from small to large by this skewness. Through regression analysis, the excess returns of each group after buying and holding with equal rights for one week and the corresponding t value of its statistical test are obtained. Meanwhile, we continue to construct a long-short combination to buy a group of cryptocurrencies with the highest idiosyncratic skewness and sell that with the lowest idiosyncratic skewness and calculate the returns of this strategy. We continue to repeat this work every week and also get a time series of excess returns divided into five groups. Finally, we test the time series of excess returns statistically and get its t value.

It can be known from Table 3 that after each group of cryptocurrencies is bought and held with equal rights for one week, the cryptocurrency returns of the group with the smallest idiosyncratic skewness are 5.1% with its corresponding t value at 3.869, while the cryptocurrency returns of the group with the highest idiosyncratic skewness are as high as 14.4% with its corresponding t value as 2.866, which are statistically significant. It shows that the returns of cryptocurrency still reach their peak in the group with the largest idiosyncratic skewness. The returns performance of the long-short strategy also confirms it every week by making a group of cryptocurrencies with the highest idiosyncratic skewness and shorting that with the lowest idiosyncratic skewness. We can get 9.4% excess returns with its corresponding t value of 1.921, which is statistically significant.

After grouping the skewness and idiosyncratic skewness as well as constructing the long-short strategy, we further use the three-factor model to adjust the returns sequence of the strategy.

Specifically, we use market, market value, and momentum to regress the return series of long-short strategy in turn and report its Alpha. The results are shown in Tables 4 and 5.

Table 4. According to the market value, market, and momentum calculated in the past month, they are regressed separately, pairwise, and triply with the excess return series of cryptocurrency bought and held for one week after grouping based on skewness, and the α values in seven groups of regression equations and their corresponding significant t values are obtained.

	MKT	SMB	MOM	MKT + SMB	MKT + MOM	SMB + MOM	MKT + SMB + MOM
G1	0.023***	0.036***	0.038***	0.023***	0.024***	0.037***	0.023***
	(3.105)	(3.595)	(3.791)	(3.105)	(3.237)	(3.661)	(3.159)
G2	0.020***	0.033***	0.035***	0.019***	0.021***	0.033***	0.02***
	(2.657)	(3.212)	(3.427)	(2.577)	(2.736)	(3.271)	(2.624)
G3	0.021***	0.034***	0.036***	0.020**	0.022***	0.035***	0.021**
	(2.585)	(3.166)	(3.414)	(2.501)	(2.704)	(3.242)	(2.570)
G4	0.041***	0.055***	0.057***	0.041***	0.042***	0.055***	0.041***
	(3.193)	(3.694)	(3.854)	(3.128)	(3.232)	(3.731)	(3.152)
G5	0.119**	0.136***	0.134***	0.113**	0.109**	0.133***	0.110**
	(2.376)	(2.640)	(2.638)	(2.243)	(2.193)	(2.602)	(2.183)
G5-G1	0.096*	0.099**	0.096**	0.090*	0.086*	0.096**	0.086*
	(1.950)	(2.005)	(1.970)	(1.817)	(1.748)	(1.960)	(1.750)

Table 4 uses a three-factor model including market value, market, and momentum to analyze the excess return series obtained after buying cryptocurrency and holding it for one week. Using the three factors calculated in the previous paper, we regress the excess return series with three factors alone, pairwise, and triply to get seven groups of Alpha values and t values corresponding to the Alpha values after regression.

According to Table 4, we can know that the excess return series is still statistically greater than zero after being adjusted by the three-factor model. This is also proved in the return regression analysis of the long-short strategy, that is, the Alpha value is between 8.6% and 9.9%, and the t value is between 1.748 and 2.005, which are both statistically significant. It shows that the three-factor model can not fully explain the excess returns of the long-short strategy according to skewness.

Table 5 still uses the above-mentioned three-factor model to analyze the excess return series obtained by grouping according to idiosyncratic skewness and holding for one week. Using the market, market value, and momentum calculated above, we regress the excess return series with three factors alone, pairwise, and triply to get seven groups of Alpha values and t values corresponding to Alpha values after regression.

Table 5. The market value, market, and momentum are regressed separately, pairwise, and triply in the past month with the excess return series of cryptocurrency bought and held for one week after being grouped based on idiosyncratic skewness. The α values in seven groups of regression equations and their corresponding significant t values are obtained.

	MKT	SMB	MOM	MKT + SMB	MKT + MOM	SMB + MOM	MKT + SMB + MOM
G1	0.034***	0.046***	0.048	0.034***	0.035***	0.047***	0.034***
	(3.047)	(3.560)	(0.004)	(2.973)	(3.097)	(3.604)	(3.003)
G2	0.020***	0.033***	0.035***	0.020**	0.020***	0.033***	0.020**
	(2.571)	(3.171)	(3.375)	(2.514)	(2.659)	(3.231)	(2.562)
G3	0.026***	0.040***	0.042***	0.026***	0.027***	0.041***	0.026***
	(2.938)	(3.451)	(3.660)	(2.865)	(3.016)	(3.510)	(2.911)
G4	0.030***	0.044***	0.046***	0.030***	0.031***	0.044***	0.030***
	(3.380)	(3.821)	(4.033)	(3.329)	(3.483)	(3.889)	(3.384)
G5	0.115**	0.132**	0.130**	0.110**	0.106**	0.130**	0.106**
	(2.313)	(2.575)	(2.576)	(2.178)	(2.130)	(2.538)	(2.118)
G5-G1	0.081	0.086*	0.082*	0.076	0.071	0.083*	0.072
	(1.626)	(1.707)	(1.663)	(1.507)	(1.429)	(1.662)	(1.439)

According to Table 5, we can know that the excess return series adjusted by the three-factor model is significantly greater than zero statistically. This is also proved in the return regression analysis of long-short strategy, that is, the Alpha value is between 8.2% and 8.3%, and the t value is between 1.662 and 1.707 in significant groups, which are both statistically significant. It shows that the three-factor model cannot fully explain the excess returns of the long-short strategy according to idiosyncratic skewness.

5. Conclusion

Using 1000 cryptocurrency samples with the largest market value, this paper analyzes the cryptocurrency samples by univariate combination and divides them into five groups according to the skewness of cryptocurrency in the past month before buying and holding them for one week in the future to calculate the excess return and construct a long-short strategy. The grouping results show that there is a positive correlation between the return of cryptocurrency and the skewness. In addition, in order to enhance the robustness of the conclusion, we calculated other measures of skewness such as idiosyncratic skewness to test the same based on idiosyncratic skewness with the same method. Finally, we got the same conclusion, which further proved the robustness of the conclusion. This paper also uses the three-factor model in cryptocurrency, and a three-factor model about the market, market value, and momentum factor is constructed. Seven groups of regression are carried out between these three factors and the cryptocurrency returns series about skewness and idiosyncratic skewness obtained above. The results show that the adjusted returns Alpha is still statistically significant, which proves that the anomaly of skewness cannot be completely explained by the three-factor model.

The research enriches the research literature on lottery preference in the cryptocurrency market with guiding significance for investors in this market. At the same time, for skewness depicts the characteristics of the sharp rise and fall of cryptocurrency prices, this article can provide a theoretical reference for supervision.

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