**Abstract**

The cryptocurrency market has gradually attracted the attention of investors in recent years. With the increase in trading volume and traders, many investors have entered this market to try to obtain excess returns. For such a market mainly driven by volume and price information, testing the market’s "weak-form efficiency" is not only of great significance to investment, but also provides a basis for evaluating market information efficiency. This article selects daily transaction data represented by the top ten mainstream cryptocurrencies on the Coinmarketcap trading platform, and uses the gold futures market as a benchmark, understanding whether the cryptocurrency market is efficient and whether liquidity affects market efficiency, which can help them view market prices correctly and help them make better decisions and strategies. This empirical study can provide marketers and investors with valuable analysis and knowledge.

1. **Introduction**

The development of information technology and the emergence of problems in the current currency system, such as currency spam, have caused a series of decentralized virtual currencies represented by Bitcoin to flood the market. The birth of Bitcoin in 2009 marked the emergence of cryptocurrency, an emerging currency that fully utilizes network technology. Some conservatives initially believed that cryptocurrency was worthless and completely a bubble, but now the application of cryptocurrency has become more widespread, and the blockchain technology used by cryptocurrency has also been adopted by various industries. Cryptocurrency is a kind of currency that uses the principles of cryptography, is based on a distributed network of blockchain technology, and is then transmitted via the Internet. Compared with traditional currencies, cryptocurrency transactions are faster, with lower fees and higher safety factors. The emergence of cryptocurrency has attracted retail investors and some private equity institutional investors to enter the market in the hope of obtain excess returns. The increase in market participants has made transactions active and accelerated the response speed of market information.

Since 2017, the price of Bitcoin has been rising and then started to fall. The price of Ethereum has changed even more dramatically. It is well known that the cryptocurrency market is highly volatile, so there are opportunities for both profit and loss. If market participants want to obtain excess returns, the first basic issue they need to consider is whether the price trend of cryptocurrency market is predictable. In other words, investors or other stakeholders need to know whether historical information can be used to predict future prices. Since fundamental information in the cryptocurrency market is stable, people will pay priority attention to the ability of technical information such as volume and price to predict future returns. The corresponding theory here corresponds to testing the "weak-form market efficiency". The first purpose of this paper is to study the market efficiency of the current mainstream cryptocurrency and compare it with the traditional gold futures market as a convincing benchmark.

Although most of the current research on the cryptocurrency market can test whether the market is efficient, there are few studies on whether the micro-characteristics of the market promote market efficiency. Previous studies focused on testing the efficiency of the Bitcoin market, ignoring the reasons behind the efficiency or inefficiency of the market, or neglect to study the unidirectional impact of a certain micro-feature on market efficiency. Chunwei (2018) concluded by studying a variety of different cryptocurrencies that liquidity plays an important role in the market efficiency as well as return predictability of new altcoins. Additionally, with the emergence of market makers, investors' trading volume and market liquidity have increased significantly. However, the cryptocurrency market has many retail investors, and there is a lot of arbitrage or speculation. Therefore, the second purpose of this article is to study whether there is a positive correlation between market liquidity and the efficiency of the cryptocurrency market. We hope to extend this analysis to the altcoins that have been developed in recent years based on blockchain technology.

1. **Literature review**
   1. Market efficiency

Bachelier (1900) studied the trend of stock prices in the French stock market and found that the trend of stock prices did not present a certain rule but followed the process of random walk. Therefore, he inferred that it might be related to the market efficiency. Cowles and Jones (1937) analyzed and predicted the stock price sequence of the American stock market and found that its trend fluctuated randomly. Fama (1965) first put forward the research concept of "efficient market hypothesis"(EMH), which states that information cannot be used to make profits in the market. Then in 1970, Fama systematically summarized the past research on EMH as well as proposed a complete theoretical framework. According to EMH, we believe that all valuable information has been fully and timely reflected in the stock price trend. Related information can be divided into three categories, including internal information, public information, and historical information. And the efficient market is also divided into three levels by Fama, namely, “strong-form”, “semi-strong-form” and “weak-form” market efficiency.

Since the types of information are difficult to clearly define and quantify, it is difficult to empirically test the semi-strong effective market and the strong effective market. Therefore, most of the current research are mostly the test of the “weak-form” efficient market. The efficiency test methods are also different. From the basic definition of market efficiency, a more intuitive test of market efficiency can be done by testing whether the price trend satisfies the random walk. The principle is whether the information can be quickly obtained by the market. Praetz (1975) used the run test to test the effectiveness of the Sydney wool futures market from 1966 to 1972 and concluded that the market was weak-form efficient. Weston (1983) also conducted a run test on the futures markets of different exchanges and concluded that the market is inefficient. Hoque and Kim (2007) conducted market efficiency tests on emerging stock markets in several Asian countries and found that the price movements of eight markets did not satisfy the random walk process.

The main methods of research and testing of efficiency in the futures market include VAR, Granger causality test, cointegration test, correlation coefficient, "GS" model, etc. For example, Rausser and Carter (1983) used the mutual guiding ability of the futures and spot goods in the soybean futures market as the basis for judging market efficiency. Garbade and Silber (1983) developed the "Garbade-Silber" model on the basis of the VAR model, and used this model to test the relationship between the futures and the spot of various commodities such as gold and silver. The results showed that the price discovery function of the futures market depended on the ability of futures prices to guide spot prices. Sabuhoro and Larue (1997) used the co-integration test to test the efficiency of the coffee and cocoa futures markets in the United States and concluded that there was no mutual guiding relationship between coffees, cocoa’s futures and spot, that is, the market was inefficient. Because different scholars have different understandings of market efficiency, the judgment standards and test methods used are also different. Kenourgios and Samitas (2005) used an error correction model to test the short-term efficiency of the copper futures market of the London Metal Exchange. Milunovich and Joyeux (2007) conducted a co-integration and GRACH test on the efficiency of the EU carbon futures market and found that the futures market was inefficient for a long time, but they did not test the short-term efficiency of the market. Kumar and Pandey (2017) used the absolute deviation of the futures contract variance ratio to compare and analyze the relative information efficiency of the Indian futures market before and after the implementation of automated trading. Similarly, many scholars have made a lot of contributions to the detection of stock market efficiency. For example, Coronel-Brizio (2007) uses the Dow Jones Industrial Average Price Index and the Mexican Stock Market Index as research samples, and then selects relevant data from 1978 to 2006 as the empirical sample data. Their final research results found that the efficiency of the Mexican stock market has improved compared with the past through the comparison and analysis of return autocorrelation function and non-trend volatility. Kim and Shamsuddin (2008) conducted multiple variance ratios and Monte Carlo tests on multiple stock markets in Asia, and the results showed that the stock markets in Hong Kong, Taiwan, Japan, and South Korea are all in line with weak-form efficient stock markets.

In terms of weak form efficiency of cryptocurrency market, empirical research has not yet reached a consistent conclusion. Urquhart (2016) found through empirical research on the data of Bitcoin from 2010 to 2016 that the market efficiency was low at this stage, but it gradually increased over time. Subsequent studies by Nadaraja and Chu (2017) have shown the same thing. From the perspective of whether the market has long-term memory, Bariviera (2017) used the range of beyond standard deviation or rescaling range (R/S) and de-trend test (DFA) to test that the market efficiency of Bitcoin market was inefficient from 2011 to 2014. Some studies believe that the market is not completely inefficient. For example, Tiwari et al. (2017) used a series of long-term dependence estimators and considered the time variation to test the information efficiency of Bitcoin and concluded that the market efficiency was time-varying. Sashikanta and Pattanyak (2018) have verified that AMH was correct in the Bitcoin market and that the efficiency of the Bitcoin market changed over time. David and Ann (2018) observed that the market efficiency of Bitcoin increased over time, and that Bitcoin was not affected by monetary policy news. Alaoui et al. (2019) used multi-fractal detrended cross-correlation analysis to study the nonlinear correlation between the changes of price and trading volume in the Bitcoin market, and believed that Bitcoin seemed to lack efficiency.

* 1. Market efficiency and liquidity

An efficient market requires a moderate level of market liquidity, but whether the market efficiency will gradually improve with the increase of the level of liquidity, so far there is no conclusive conclusion. Therefore, the research on the relationship between market efficiency and liquidity is also an important topic.

Yakov(2002) pointed out that market liquidity was difficult to be directly observed. Amihud and Mendelson (1986) proposed that stock market liquidity is the cost of time and money spent by traders to reach an ideal exchange. Harris (1990) believed that the liquidity of the stock market can be measured in four dimensions, including Immediacy, Breadth, Depth and Resiliency. Massimb and Phelps (1994) proposed a view similar to that of Harris (1990), which took the immediate transaction capacity provided by the market for trading orders and the ability to execute the maximum number of orders to control stock price fluctuations as two criteria for measuring market liquidity. Houweling et al. (2005) divided liquidity measurement into two categories. One is a direct measurement method based on trading volume data, such as directly using trading volume to reflect depth and breadth dimensions. The other is an indirect measurement method based on asset characteristics, such as the price impact measure proposed by Yakov (2002). Liquidity itself has multi-level and multi-dimensional characteristics. Although scholars have proposed many indicators to measure the level of liquidity so far, there has never been a consensus point of view.

Chordia et al. (2008) and Hrazdil et al. (2010) found that the reduction of minimum quotation units improved market liquidity and reduced the predictability of short-term returns and variance ratio, thus improved market efficiency and confirming that the improvement of liquidity contributes to the improvement of market efficiency. Huang et al. (2012) also took the predictability of short-term stock returns as the reverse indicator of market efficiency measurement. Based on the data of listed companies in Taiwan Stock Exchange, they confirmed that market efficiency would gradually improve with the increase of liquidity level. However, the research of Baker and Stein (2004) obtained the opposite result, that was, liquidity may also be a proxy variable of investor sentiment, and when liquidity was too high, whether investor sentiment at the individual stock level or the market level was high, liquidity had a predictive effect on the rate of return, which was a phenomenon that did not conform to the efficient market hypothesis. Trading volume has been regarded as the carrier of market information for a long time because the effects of the actions of informed traders and unaffected traders will be revealed by order flow and reflected by market revenue, which has caused many scholars to investigate market efficiency from the perspective of market liquidity. Ibikunle et al. (2016) empirically found that increasing market liquidity will reduce the historical component of expected returns. Investors use historical prices to estimate future price trends. The accuracy of technical means is reduced, and market efficiency is improved.

At present, there is not a lot of literature on the relationship between market efficiency and liquidity of cryptocurrencies, but we can still find a few viewpoints that describe the impact of trading volume on market efficiency in the studies of some scholars. Brauneis and Mestel(2018) studied several cryptocurrencies and found that Bitcoin had the best liquidity and the highest market efficiency, and with the improvement of liquidity, the market efficiency of other currencies was also gradually increasing. According to Tran and Leirvik (2019), their research results were that the market efficiency of the top five cryptocurrencies was highly time-varying, while also analyzing how the increase in transaction volume affects the efficiency of the cryptocurrency market. Chunwei (2018) concluded that return predictability diminishes as liquidity increases in cryptocurrency market.

This article simply defines liquidity metrics as indicators at the level of trading volume.