

# Exploring Arbitrage Opportunities between the BTC Spot and Futures Market based on Funding Rates Mechanism

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## ABSTRACT

Crypto-currency, in nowadays occupies a very important position in the global financial market. Due to the importance of Crypto-currency, research on it has positive and significant meanings for financial purpose. This research examined how investors arbitrage between the BTC spot and futures market based on funding rates mechanism (Binance exchange). Secondary data was collected and testified in order to examine if there is an arbitrage opportunity between BTC spot and future markets. The data analysis tested the existences of arbitrage opportunities, and arbitrage profits were much larger during BTC market crashes than normal period. On the other hand, the risk of this investing is relatively smaller.

**Keywords:** Bitcoin, arbitrage, spot market, futures market.

## 1. INTRODUCTION

Crypto-currency nowadays occupies a very important position in the global financial market. On the date 30th of August 2021, the 24-hours trading volume of BTC was 320,216.94, which equals about 146,130,922,829 USD. 83.65% of the trades were in USD, and 6.71% in Korean Won. The Crypto-currency market is massive in nowadays, trades happen every second and there is no closing hour for the Crypto-currency market. Investors can trade 7\*24 and also everywhere in the world. China, as the world second largest economy, and its stock market trade volume reaches 1.9 trillion RMB (about 0.29 trillion USD) on the date 30th of August 2021. BTC is the most high-volume trade crypto-currency, the 24-hour trading volume equals almost half of the Chinese stock market onat the same day.

Mainstream crypto-currency exchange platforms launched Bitcoin futures contracts in order to provide an additional instrument for investors. OKEx as an exchange, first launched BTC futures contracts back in the year 2013, which was 4-year earlier than the Chicago Board Options Exchange (CBOE) and the Chicago Mercantile Exchange (CME). In the year 2014, Bitmex launched the BTC Perpetual futures contract, which was a futures contract but without a settlement date (no

delivery needed), the BTC futures daily trade volume for Bitmex in July 2019 was 4.4 billion USD, 3.0 billion USD for CME and 4.5 billion USD for OKEx.

Arbitrage opportunities between the spot and futures market are widely used in the modern global financial market, but at the same time, the arbitrage between the BTC spot and futures market seems not to be examined. Since financial derivatives are widely used within the crypto-currency market, examining the arbitrage between the BTC spot and futures is supposed to be positive and worthwhile. Makarov and Schoar (2019) claimed that price deviations in the crypto-currency markets to be much smaller within than across countries, which showed arbitrage opportunities between the BTC spot and futures market seemed to be rare [1]. Furthermore, Hattori and Ishida's (2020) research further shows few arbitrage opportunities especially in the normal period, while market crashes lead to arbitrage opportunities [2].

The aim of this research is to explore the arbitrage opportunities between the BTC spot and futures market, and historical intraday data from Binance (one of ta leading exchanges) and cryptodatadownload site are used in order to provide data support. Furthermore, in order to better testify if there are arbitrage opportunities under both normal market conditions and shock market

conditions, data are collected from both bullish market and bearish markets. So far, although plenty of researchers attempted to examine there are arbitrage opportunities between the BTC spot and futures market, they focused on arbitrage opportunities between different exchanges or different countries. This research focuses on using funding rates mechanism of exchanges to explore arbitrage opportunities.

## 2. LITERATURE REVIEW

This research is highly related to board literature on market efficiency in the crypto-currency market. Fama (1970;1998) suggested the theory of market efficiency, he believed that capital markets are efficient, all information directly reflecting the prices, and therefore trends in capital markets cannot be identified in advance [16 & 17]. The hypothesis of capital markets is efficient was purposed marker under the perfect competitive market circumstance, all participants are price takers, and any investments based on information cannot gain an abnormal return. According to Hattori and Ishida's (2020) study of BTC arbitrage, market efficiency provides fundamental theoretical support to discovering arbitrage opportunities between BTC spot and futures market [2]. There is a scholarly consensus that Urquhart (2016) was the first to study the efficiency of BTC prices, and he argued that BTC markets have matured but still were inefficient [20]. Jiang et al (2018) investigated changes in the long-term memory process on the BTC market, it showed a negative result on the market efficiency of BTC, and the property that the market does not become more efficient over time [5]. Furthermore, Lee et al (2020) claimed that they believed deviations from futures-spot arbitrage are not consistent with market efficiency, and they also believed that the futures basis does provide some information on future changes in the spot price and the risk premium [4]. On the other hand, several scholars such as Nadarajah and Chu (2017); Tiwari et al (2018); Vidal-Tomás and Ibaez (2018); argued that BTC markets were efficient [6, 7 & 9 ], but to sum up that the belief of BTC markets is inefficient nowadays have prevailed after all that. Furthermore, based on Urquhart and Manahov's (2021) latest study, they applied the STGP technique to historical data of Bitcoin at the one-minute and five-minute frequencies to investigate the formation of Bitcoin market dynamics and market efficiency [8]. Through the testing procedures, they found that both Bitcoin markets populated by high-frequency traders are efficient at the one-minute frequency but inefficient at the five-minute frequency.

Secondly, this research is also related to theories of arbitrage between Forwards, Futures, and Swaps. Mackinlay (1988, 2011) stated that it is difficult to specify the deviations of futures prices from "fair values", because deviations are affected by the flow of orders and as well as by the differences of opinions

among participants [12 & 15]. Furthermore, it was Aydogan's (1998) belief that the futures contracts in any market aimed to provide the investors in spot markets with means of hedging risk, and also the futures markets should be the vehicle for price discovery in the spot market for underlying assets [11]. Whaley (2012) believed there are three factors drive the valuation of a financial asset which are risk, return, and timing of cash flows, and if two investments have exactly the same three factors, the prices must be the same, otherwise market participants can make free money by simultaneously selling the more expensive one in the other hand buying the cheaper one [10]. Songyoo (2012) claimed that the discovery of the lead-lag relationship within markets was strong evidence of market inefficiency, and any mispricing led to arbitrage opportunities [13]. Bistarelli et al (2019) argued that the arbitrage opportunities within BTC markets are large, but seemed these opportunities exiting across exchange platforms (by using prices differences between platforms); furthermore, trading Bitcoin in different currencies more likely occurring huge arbitrage opportunities [14]. Makarov and Schoar (2019) suggested that there are arbitrage opportunities across counties within BTC markets, but it seemed rare chances between BTC spot and futures markets [1 & 3]. Hattori and Ishida (2020) attempted to examine the arbitrage between the BTC spot and futures market, according to their research, there are more arbitrage opportunities during crashes than normal market circumstances, since the arbitrage opportunities during normal time are few [2].

There are prices differences between BTC's current-month futures contract and the next-month futures contract, furthermore, there are also prices differences between the BTC spot market and the futures market. Under this circumstance, arbitrage opportunities seemed possible within BTC markets. Figure 1 under shows the Bitcoin-USDT perpetual premium index from 1st June 2021 to 1st September 2021, it shows there are always differences between BTC spot prices and futures prices. The premium index is mostly under 0.4%, but it shows under extreme circumstances the index skyrocketed to almost 1.06%.



**Figure 1** Bitcoin-USDT perpetual premium index 1st June 2021-1st September 2021. Source: Binance Exchange.

**2.1. Research aims and objectives**

Overall aim:

The research aims to explore the arbitrage opportunities between the BTC spot and futures market, since the arbitrage between BTC spot and futures market has not been examined. It is meaningful to testify if there are chances for investors to use futures and forward contracts as effective and efficient arbitrage instruments among BTC spot and futures markets.

Specific objectives:

To analyze previous intraday futures and spot prices of BTC, focusing on investigating the price premium and BTC-USDT futures contracts historical founding rates.

To examine there are arbitrage opportunities among BTC spot and futures markets by using historical data and impute to arbitrage model.

Hypothesis:

In this case, the hypothesis of this research is that: there are arbitrage opportunities by spot purchasing BTC from exchange and at the meantime short the same amounts of BTC /UDST perpetual contracts.

**3. METHODOLOGY**

This part aims at stating the research methodology of this study, which includes research philosophy; research design; data collection; data sampling and data analysis. The research philosophy of this study was Positivism. This research used intraday and hourly data from both exchange and cryptodatadownload.com to explore if there are arbitrage opportunities between the BTC spot and futures markets, therefore the research approach was deductive approach and quantitative research as well. In order to achieve research objectives, this research is based on secondary data from both exchanges and cryptodatadownload.com. Furthermore, how data are collected and analyzed is also presented in this section.

**3.1. Data & Research design**

This study adopts the quantitative research method to explore arbitrage opportunities between the BTC spot and futures markets through secondary data analysis. Furthermore, Statistics and Modeling were used in order to explore that if the hypothesis is tested. This section demonstrated data collection methods and techniques as well as how data are processed and analyzed. Last but not least, the research subject and data scopes are also presented. According to the hypothesis, numerical data such as BTC spot prices; BTC index; BTC futures market funding rates at various time are needed. Under this condition, quantitative research enables this study to be statistically rigorous analyzed. Brassington and Pettitt (2002) argued that the success of quantitative research depends on a large extent to establishing a representative sample that is large enough to ensure that the data are collected reliable and objective [19]. Furthermore, this research collected secondary data in order to test the hypothesis. In this study, 8-hour-data are collected in order to ensure the data amount is big enough to stay objective and reliable. Meanwhile, the sample selected was data from 11th September 2019 to 30th August 2021, because this time period contained normal market conditions; bullish market and bearish market. The advantages of secondary data collecting are mainly based on efficiency and accuracy.

The data population, in this case, was all-time BTC spot market prices and futures index as well as all-time historical funding rates. Nevertheless, in order to focus on the more recent BTC performances, the data from 11th September 2019 to 30th August 2021 were selected as an analysis sample. The sample period contains data from both bullish market and bearish market. Additionally, all the data were based on Binance, data were collected via

two different methods. Historical BTC spot prices were collected both from Binance exchange and cryptodatadownload.com for cross contrasting, therefore the accuracy of data was guaranteed. Goertz and Mahoney (2013) proposed that researchers should collect more data to increase the region covered by the data [18]; in this case, in order to test all-time markets arbitrage conditions, 8-hour data from 11th September 2019 to 30th August 2021 were analyzed. The data collected were: BTC spot and futures (BTC index) market prices on Binance from 11th September 2019 to 30th August 2021; BTC futures market funding rates on Binance from 11th September 2019 to 30th August 2021. According to the introduction to BTC perpetual contract posted on Binance, the funding fee occurs three times per day, 8:00; 16:00 and 00:00 GMT+8, therefore data of BTC spot prices at specific 8:00; 16:00 and 24:00 GMT+8 was extracted.

According to Binance, the funding rate is calculated based on the difference between the perpetual contract prices (BTC index) and spot prices. When funding price is positive, traders who are long on a perpetual contract will pay a funding fee to traders on the opposing side. Conversely, when the funding rate became negative, traders who are short on a perpetual contract will pay a funding fee to long traders. Funding payments occur every 8 hours at 00:00 UTC; 08:00 UTC and 16:00 UTC for all Binance Futures perpetual contracts (Binance, 2020).

In order to test the hypothesis, the formula related to Net present value theory is used. According to the hypothesis, holding BTC while short the same amount of BTC in futures market, provides arbitrage opportunities. Therefore, the formula shows as below:

$$NPV^t = V^t + V_f^t \tag{1}$$

Where  $V^t$  shows the values of spot BTC holding at time t.  $V_f^t$  shows the values of BTC futures account. Furthermore, the values of BTC futures account equal to  $S^1 + S^2 + \dots + S^t + E^t$  Where S means the funding rate amount gained or paid, E shows the current value of the BTC /UDST perpetual contract at time t. In this case, when BTC index doubles up, the value of BTC futures account drops down to 0, and the BTC spot price roughly doubles up as well. The spot price of BTC skyrocketed from 9880 Usdt to 48563.48 Usdt from 11th September 2019 to 30th August 2021, therefore in order to better explore the arbitrage condition, the hypotheses are tested in every 3-month-time. Assuming both spot and futures initial investment was X Usdt.

In order to better examining return rates of different time periods, the time were set into 3-month, where period 1 was from 11th Sep 2019 to 11th Dec 2020; period 2 was from 11th Dec 2020 to 11th Mar 2020; period 3 was from 11th Mar 2020 to 11th Jun 2020; period 4 was from 11th Jun 2020 to 11th Sep 2020; period

5 was from 11th Sep 2020 to 11th Dec 2020; period 6 was from 11th Dec 2020 to 11th Mar 2021; period 7 was from 11th Mar 2021 to 11th Jun 2021; period 8 was from 11th Jun 2021 to 30th Aug 2021.

**Table 1.** 3-month-period NPV and Return rates

Time period	$V^t$	S sum	$E^t$	[ NPV ] $V^t$	Return rate
Period 1	$X+(9851.74-7224.15)*X/9851.74$	2 $(X/10172.13)207.72$	$X+(9872.10-7232.96)(X/9872.10)$	2.021X	1.01%
Period 2	$X+(7894.57-7224.15)*X/7224.15$	$(X/7232.96)660.30$	$X+(7232.96-7773.39)(X/7232.96)$	2.110X	5.50%
Period 3	$X+(9885.22-7894.57)*X/7894.57$	$(X/7773.39)70.23$	$X+(7773.39-9757.58)(X/7773.39)$	2.006X	0.29%
Period 4	$X+(10336.86-9885.22)*X/9885.22$	$(X/9757.58)569.09$	$X+(9757.58-10414.51)(X/9757.58)$	2.037X	1.83%
Period 5	$X+(18254.81-10336.86)*X/10336.86$	$(X/10414.51)502.86$	$X+(10414.51-18131.28)(X/10414.51)$	2.073X	3.67%
Period 6	$X+(55851.59-18254.81)*X/18254.81$	$(X/18131.28)1045.30$	0 (at 16:00 7th Jan 2021, the BTC index was 36909.86, the value of BTC /UDST perpetual contracts drop to 0)	2.117X	5.87%
Period 7	$X+(36677.83-55851.59)*X/55851.59$	$(X/56374.82)5500.54$	$X+(56374.82-36893.51)(X/56374.82)$	2.099X	4.99%
Period 8	$X+(48767.84-36677.83)*X/36677.83$	$(X/36893.51)443.83$	$X+(36893.51-48489.96)(X/36893.51)$	$X+(36893.51-48489.96)(X/36893.51)$	1.35%

**3.2. Data analysis**

All-time BTC index and funding rates data from 0:00 GMT+8 of 11th September 2019 to 0:00 GMT+8 of 30th August 2021 was gathered and only selected data at time 0:00; 16:00 and 8:00 GMT+8 were kept. The hypothesis was tested every three months and assumed all the trades happened at 0:00 GMT+8, therefore spot prices of BTC only collected at 0:00 daily. Funding rate amounts were calculated by using BTC index times funding rates. Values of spot BTC were calculated by using current prices minus purchasing prices and then time purchasing amount. The values of BTC /UDST perpetual contracts were calculated by current BTC index minus BTC index purchasing price and then times amounts. Due to the BTC /UDST perpetual contracts (short), when the BTC index doubles up, the value of contract drops to 0 (Margin call), and in this case no leverage was used. When the margin call happens, no further action will be made until next time period.

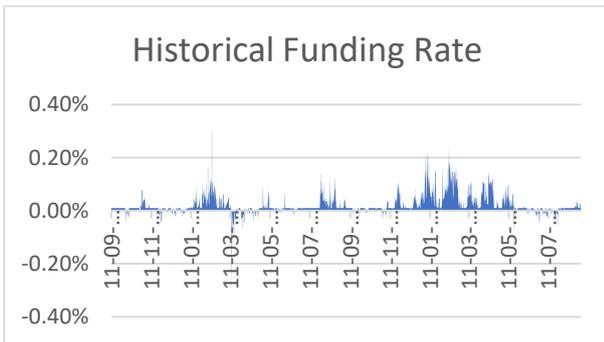
**3.3. Reliability & Validity**

All the data collected and analyzed are based on BTC historical data, therefore the hypothesis is only tested by

BTC historical performances, although it provides a potential effective investment portfolio, since the future BTC market is not predictable, the effectiveness and efficiency of the investment are not guaranteed. Secondly, the hypothesis was assumed based on perfect world conditions, assuming that there is no transaction fee or tax. Furthermore, the systemic risks could not be predicted, such as future policies and regulations on crypto currencies; bankrupts of exchanges or any accidental network conditions.

**3.4. Results & Discussion**

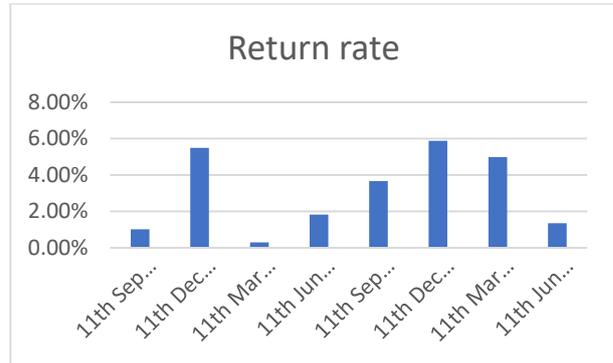
Based on the results of hypothesis testing, Table 1 above shows that 8 tested 3-month-investment occurred positive return rates. The highest return rate occurred during 11th Dec 2020 and 11th Mar 2021 which was 5.87%, but during this time period margin call happened on BTC/USDT shorts perpetual contracts, the value dropped to 0. On the other hand, the historical funding rates collected shows that most of time the funding rates were positive which means traders who are long on a perpetual contract mostly paid a funding fee to traders who are short on a perpetual contract (see Figure 2).



**Figure 2** Binance historical BTC/USDT perpetual contract funding rate from 11th Sep 2019 to 30th Aug 2021



**Figure 3** Binance historical BTC spot prices from 11th Sep 2019 to 30th Aug 2021



**Figure 4** Return rates based on hypothesis investment portfolios

Furthermore, the shape historical BTC spot price curve is highly similar to the shape of the historical BTC/USDT perpetual contract funding rate. Comparing Figure 3 and Figure 4 it shows that the return rate does not highly concern with the BTC spot prices, but by comparing Figure 2 and Figure 4 it can tell that the return rates are highly related to the funding rates.

**4. CONCLUSION**

The hypothesis: there are arbitrage opportunities, by spot purchasing BTC from exchange and at the meantime short the same amounts of BTC /UDST perpetual contracts; was empirically tested. The results showed a positive return rate on 3-month-peroid investments. Although the hypothesis was tested based on historical BTC performances, and transaction fees or tax were ignored, the arbitrage opportunities between BTC spot and futures market exist as long as the funding rates stay mostly positive. Hattori & Ishida’s (2020) conclusion on arbitrage opportunities between BTC spot and futures market argued market crashes lead to arbitrage opportunities, but arbitrage opportunities are few during normal period [2]. The results of this research examined similar outcomes.

The positive results of hypothesis-testing show BTC, as a kind of financial assets, provides potential better investment portfolios compare to traditional financial assets. Under same level of risks, spot purchasing BTC from exchange and at the meantime short the same amounts of BTC /UDST perpetual contracts provides better returns compare to government loan or fixed-time deposit.

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