Arbitrage in Cryptocurrency: A Survey

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Abstract — **Throughout numerous cryptocurrency exchanges, markets exhibit recurrent opportunities for arbitrage. There are various types of arbitrage strategies that can be carried out. Taking consideration of the pricing data from three famous exchanges (Binance, Kucoin and Coinbase) for bitcoin, the data analysis on spot prices for each timeframe helps in determining the buy market and sell market. Apart from the analysis, the profits generated by performing arbitrage using one of the discussed strategies are quantified. The implemented algorithm can be modified to suit the trading strategy. Finally, the future scope, as well as the issues and potential risks involved in these strategies, are discussed.**

Index Terms — Data Analysis, Python, Arbitrage, Cryptocurrency Exchanges

I. INTRODUCTION

Cryptocurrencies have been growing exponentially for the past few years. These currencies are digital and are built on blockchain - a distributed ledger in a decentralized network of nodes which are basically computers on the blockchain [1]. The reason why cryptocurrencies have gained so much traction is because of their decentralized and immutable nature which means that they are not issued by any central authority, hence granting them immunity from government interference. These cryptocurrencies are also heavily encrypted through private-public key pairs, elliptical curve encryption and other hashing algorithms which makes them less susceptible to security breach and enables anonymity to all the nodes.

As of 2021, it is estimated that there are more than 6000 cryptocurrencies in existence which marks a severe increase from a handful of tokens in 2013 [2]. It should be noted that a large chunk of these currencies holds minor significance in the market. As a matter of fact, the top 20 cryptos make up about 90 percent of the total market. It is estimated that the total number of cryptocurrency traders' range between 51.2 to 52.4 million [3]. These traders trade across about 500 exchanges worldwide [4]. A lot of these exchanges are independently owned and exist in parallels across various countries. Enough trends have been observed in the value of these cryptocurrencies but analysis on the trading strategies of these assets is still in inchoate stages. Individually, these exchanges behave like traditional equity markets where traders submit their buy and sell orders and the exchange validates these transactions [5]. Although these transactions are validated, unlike traditional regulated markets, cryptocurrency exchanges lack provisions for ensuring the best price. This lack of provisions or discrepancy opens gates for arbitrage opportunities where investors can trade the same token across different platforms and gain tremendous profits. Due to the volatile nature of the cryptocurrencies, the prices keep on changing in matter of seconds as. However, trends like decrease in value of cryptocurrencies leading to arbitrage opportunities have been observed [6]. There are multiple factors like number of transactions, bid-ask spread that affect these discrepancies in a positive or negative way [7]. Hence by making a model which can calculate maximum profits by surfing through the data gathered by various exchanges in real-time can be very beneficial for investors to perform successful arbitrages. This review paper intends to shed a light on the profits that can be yielded with the help of such models, the future scope of such trading and discusses the potential risks involved in such arbitrages.

II. Types of Cryptocurrency Arbitrage

A. Deterministic Arbitrage

This is the simplest type of arbitrage and similar to the traditional form of arbitrage. In this type of arbitrage, traders exploit market inefficiencies and concomitantly buy and sell a digital asset on two exchanges which results in a potential profit. The trader identifies arbitraging opportunities on two different exchanges, buys the asset on the exchange with the lower prices, and sells it on the exchange with the higher price for a profit.

B. Triangular Arbitrage

This type of arbitrage involves an opportunity to make profit from uncorrelated pricing of three cryptocurrency pairs on a single exchange, especially when one of the three cryptocurrencies is transitorily underpriced on the exchange. For instance, one could trade Bitcoin (BTC) for Ethereum (ETH), convert the ETH to Ripple (XRP) and then convert the XRP back to BTC. The goal of these transactions and this process is to end up with more BTC.

It can be described as the cross-exchange rate between two currencies calculated from their exchange rates against a third currency [8]. Triangular Arbitrage can also take place using two Fiat Currencies and a cryptocurrency [9].

C. Decentralized Arbitrage

With this strategy, arbitrageurs are looking to execute arbitrage trades on decentralized exchanges (DEXs) such as Uniswap, PancakeSwap or MDEX. Arbitrageurs can make transactions in pooled digital assets that maybe under or overvalued on these different platforms. Just as with centralized cryptocurrency exchanges (CEX), these activities

eventually result in price uniformity across DEXs. Arbitrage on DEX is comparatively less risky than on CEX [10][11].

D. Statistical Arbitrage

This type of arbitrage involves the use of quantitative data models and bots to capitalize from arbitrage opportunities at a bigger scale. By the power of automation, an arbitrageur can execute multiple trades in a short amount of time to boose their profitability potential. One of the first works was by Shah and Zang in their paper "Bayesian Regression and Bitcoin [12]." The authors aimed for predicting price changes of Bitcoin during a six-month period in 2014 using a Bayesian Regression Model and got an accuracy of 89 percent.

III. EXPERIMENTATION

A. Dataset Description

The dataset comprises of 3 exchanges where Bitcoins can be traded, i.e., Binance, Kucoin and Coinbase. It contains 98, minute wise spot prices of a single Bitcoin in USD starting at 11:06 on 8th August till 12:45 on 9th August obtained using the APIs provided by the exchanges [13] [14] [15].
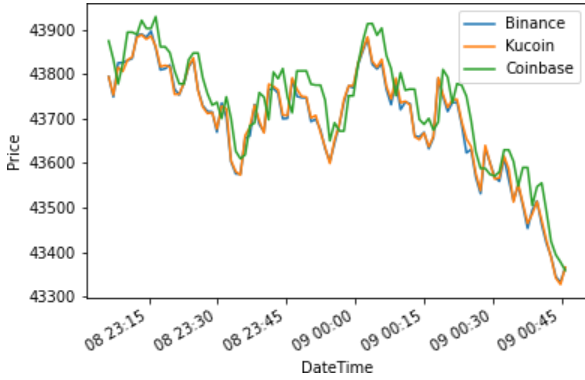
B. Implementation

Fig. 1. Bitcoin Prices in different Exchanges

As observed in Fig1, Coinbase appears to offer slightly higher spot prices than the others, while Binance and Kucoin have very similar prices.

For each timeframe the exchange offering the lowest spot price is recognized as the Buy Market and the exchange offering the highest spot price is recognized as the Sell Market results

This module implements a simple deterministic arbitrage algorithm between the 3 exchanges. A profit is generated by simultaneously buying and selling a bitcoin using the derived Buy and Sell markets as the medium to carry out the transactions. The algorithm assumes 0 transaction costs and time lag between the transactions due to this being a high-volume trading strategy.

Table 1 shows the first 5 transactions from the transaction logs generated by the algorithm. The algorithm generates 98 such logs through which the program booked a profit of 5168.93 USD. This comes out to show that there was an approximate profit of 52.74 USD per transaction. The program also recorded the highest price difference as 136.56 USD with Binance and Coinbase as the Buy and Sell markets respectively and the lowest price difference as 2.13 USD with

Coinbase and Binance as the Buy and Sell markets respectively.

Table 1. Transaction Log generated by the algorithm

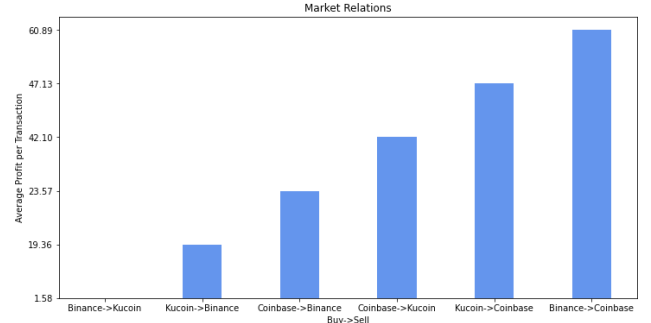| Binance	Kucoin	Coinbase	Buy	Sell	Profit
43793.97	43793.5	43874.1	Kucoin	Coinbase	80.6
43748.35	43752.9	43832.62	Binance	Coinbase	84.27
43824.78	43814.7	43777.33	Coinbase	Binance	47.45
43825.26	43805.9	43823.93	Kucoin	Binance	19.36
43830.32	43831.2	43893.67	Binance	Coinbase	63.35

C. Results

Fig. 2. Profit Analysis of Exchange pairs

As visible in Fig2. there are certain Buy, Sell pairs that offer a higher profit per transaction than the others. Buying Bitcoins from Binance and selling them on Coinbase resulted in the highest average profit, while buying coins from Binance and selling them on Kucoin generated the lowest average profit.
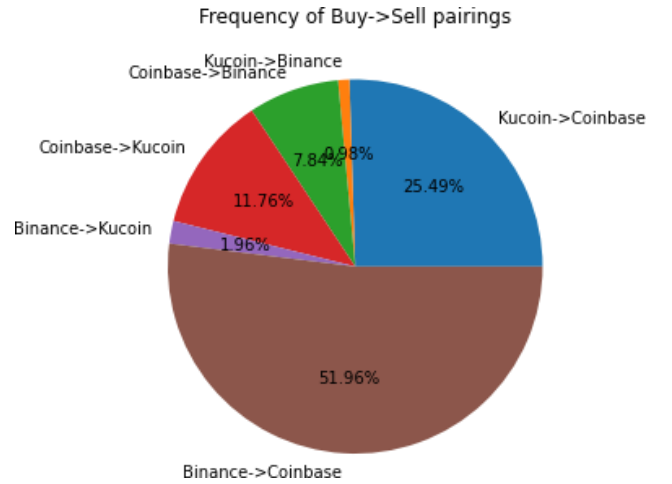

Fig. 3. Frequency of Exchange pairs

As observed in Fig3. Certain Buy, Sell pairings had a higher frequency than others. Buying in Binance and selling in Coinbase was the most frequent transaction and buying in Kucoin and selling in Binance was the least frequent transaction.

Fig 4, 5 depicts the percentage distribution of the frequency in which the different exchanges are recognized as either buy or sell markets.
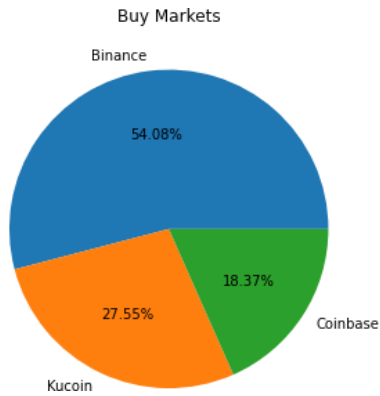
Fig. 4. Buy Markets

As observed in Fig4, Binance offers the most frequent lowest spot prices and Coinbase offers the least frequent lowest spot prices.
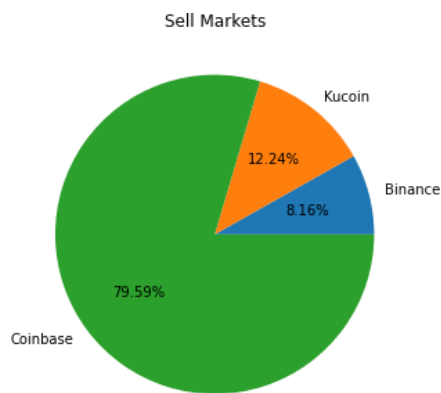

Fig. 5. Sell Markets

As observed in Fig5, Coinbase offers the most frequent highest spot prices and Binance offers the least frequent highest spot prices.

IV. ISSUES OF CRYPTOCURRENCY ARBITRAGE

There are various cryptocurrency tokens out there that have similar—or in some cases identical—ticker symbols. For avoiding this, just look carefully about the price and volume of both options. If the price is alarmingly low on one exchange, then it might be the wrong symbol. Just to be sure that arbitrage is done with the correct symbols is by simply looking at the symbols of each project - if they have different logos then it's not the same project.[16]

A coin wallet between two exchanges maybe disabled, inactive or offline. Even major exchanges frequently block all deposit and withdrawal options for specific currencies, if not all coins. To avoid this, check to see whether the wallets are online and if they are using the same blockchain. Many exchanges provide a feature that allows the user to check if the wallet is online or offline. This information maybe accessible on the deposit and withdrawal sites, through their application program interface (API), or on a dedicated page dedicated to the platform and wallets [17].

Many traders are aware of the fees charged by exchanges for withdrawals. However, some exchanges impose deposit fees, which is rare. These costs might add up quickly. While a swing trader may not notice transaction costs, an arbitrage trader may suffer as a result, reducing his profit to the bare minimum [18]. Before performing an arbitrage, check each exchange's deposit/withdrawal charge and determine the overall expenses.

While there are numerous possibilities on various exchanges, it is still a limited timed opportunity per transaction, and the arbitrageur must act quickly to guarantee that the deal can be committed on time and generate a profit, since market conditions in the cryptocurrency world may alter in seconds. To guarantee that the user can complete their checks and commit their transaction, they will need tools and a detailed plan for scanning for opportunities, checking profit, and committing the transaction.

Cryptocurrency exchanges are unregulated, which is beneficial in certain ways but detrimental in others. There have also been instances where exchanges have simply shut down, resulting in the loss of all investor funds. Sending a modest transaction before committing to a bigger one might help reduce risk. Also, many exchanges start to comply with KYC and AML or limit the account's transaction when the user is not complying with requests for more information.

Before starting arbitrage, be sure the currency that is to be traded has enough volume. Many currencies have been delisted owing to a lack of volume; if a coin has no volume, the arbitrageur will be unable to sell it and maybe stuck with it for a long period or lose the majority of their money. To avoid this pitfall, ensure that a transaction's depth volume is correct. Keep an eye on the exchange order book to observe if transactions are progressing or if they are at a halt. Also, keep in mind that exchanges may inflate the order book to make it appear active. Examine the coin's daily volume as well as the transaction to be completed. If neither has any volume, it is an indicator that the trade should be avoided.

V. CONCLUSION AND FUTURE SCOPE

This algorithm aims to analyze cryptocurrency exchanges' transactions, providing many insights into the market.

It builds an optimal portfolio of assets to do arbitrage in multiple exchanges. Odds can be increased to profit from arbitrage opportunities in the cryptocurrency market by applying this algorithm which has resulted in 5000 dollars profit in 98 transactions involving 3 exchanges- Kucoin, Binance and Coinbase onto other exchanges and cryptocurrencies.

These algorithms can be tailored to constantly monitor the intraday fluctuations in the price of one or more tokens to identify temporary and meaningful asymmetries that provide an opportunity for the arbitrageur. The algorithm can be programmed to carry out trades in case of an arbitrage opportunity or notify the user about it. It's important to note that the speed of execution and other relevant factors, such as trading fees and market depth, are crucial to perform a profitable arbitrage.

The program caters to deterministic arbitrage, i.e., it identifies arbitraging opportunities on three specific

exchanges, finds the pair with highest profit potential, buy the coin on the platform with the lowest price, and sell it at the exchange with the highest price.

The algorithm can be modified to identify three different cryptocurrencies and trading the difference between them on one exchange, thus carrying out triangular arbitrage.

Similarly, the algorithm can be quantified to trade hundreds of different cryptocurrencies at once, carefully working out the chance that a bot might profit from a trade based on the mathematical model made to optimize statistical arbitrage. Since this process is automated, the arbitrageur will be able to execute hundreds of trades in a matter of minutes and boost their profitability potential.

While cryptocurrency arbitrage offers the ability to earn great returns by leveraging inefficiencies in the market, it does not mean that there are no risks involved. It is important to understand and consider these factors before adopting this strategy.

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