Summary of Case Study: Crypto Arbitrage Opportunity Between Poloniex and Binance

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1 Abstract

This case study explores arbitrage opportunities between cryptocurrency exchanges Poloniex and Binance. We focus on the analysis of trade-level data from the given dataset (Aug 2022). The goal is to identify price differentials and evaluate the potential profitability of arbitrage strategies. The study analyzes various indicators including value and duration of significant differentials, driving factors, alternative exchanges, illiquidity, and limitations of the data. Findings reveal that significant arbitrage opportunities are sporadic and short-lived, meaning smart, low-latency programs must be used for profitable execution.

2 Problem

2.1 Intro

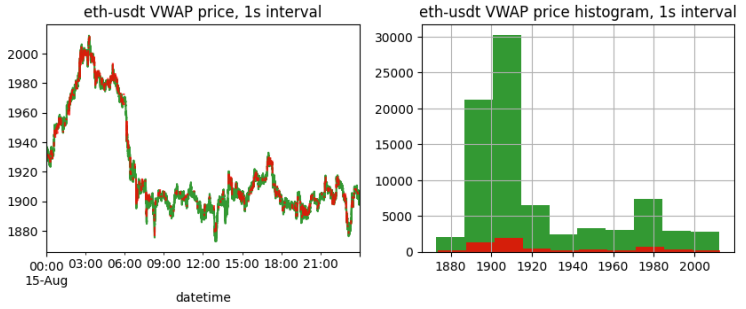
This case study focuses on identifying and capitalizing on a crypto arbitrage opportunity between two exchanges, Poloniex and Binance. We will examine various currency pairs, involving ETH, DOGE, and AAVE. The objective is to analyze indicators that signify arbitrage opportunities, determine their duration, and understand the primary driving factors behind them. Additionally, we will explore how to leverage illiquidity and strategically build positions on Poloniex for subsequent transfer to Binance. Finally, we will consider the required inventory amount to break even on withdrawals.

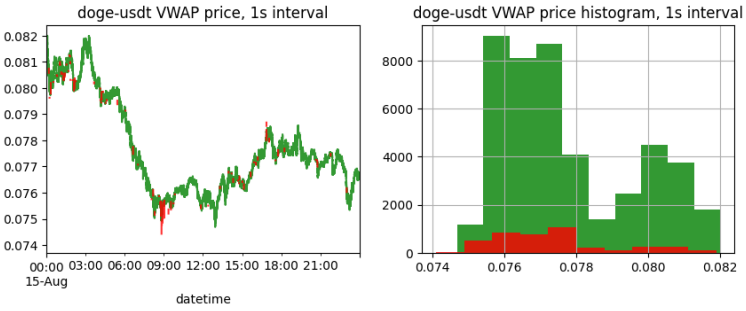
2.2 Data

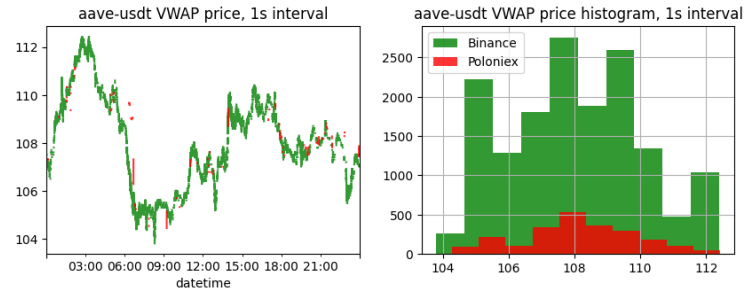
Our data consists of trade-level data from August 15, 2022 for all pairs on Poloniex and Binance sourced from data vendor Kaiko. Poloniex trade data is recorded in one second intervals, and Binance trade data is recorded in millisecond intervals. We will mainly look at the following pairs: ETH-USDT, DOGE-USDT, AAVE-USDT.

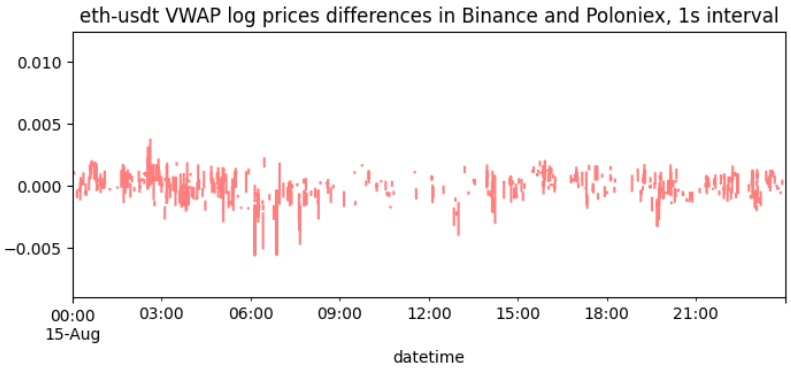
3 Analysis

3.1 Indicators





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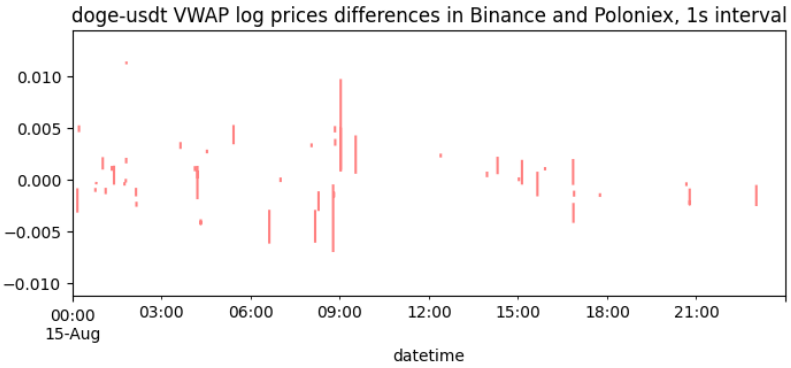
doge-usdt VWAP log prices differences in Binance and Poloniex, 1s interval
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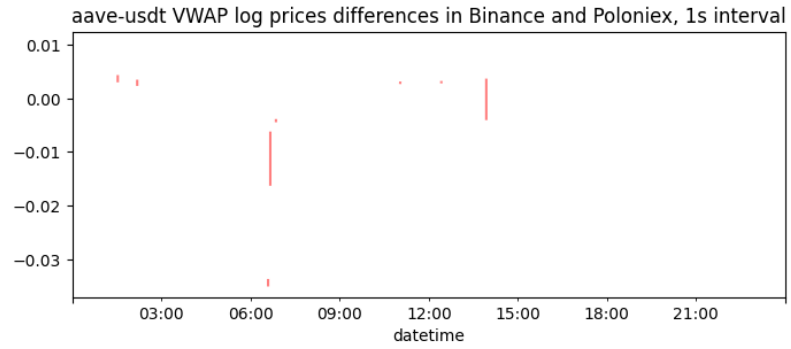
aave-usdt VWAP log prices differences in Binance and Poloniex, 1s interval
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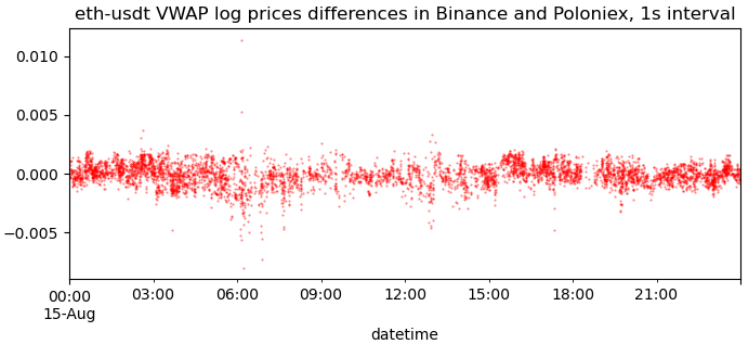
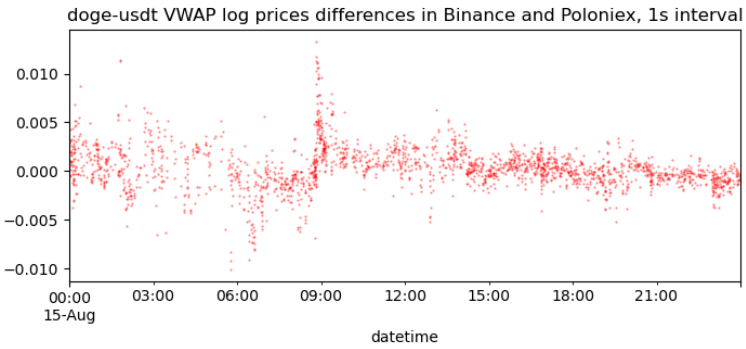
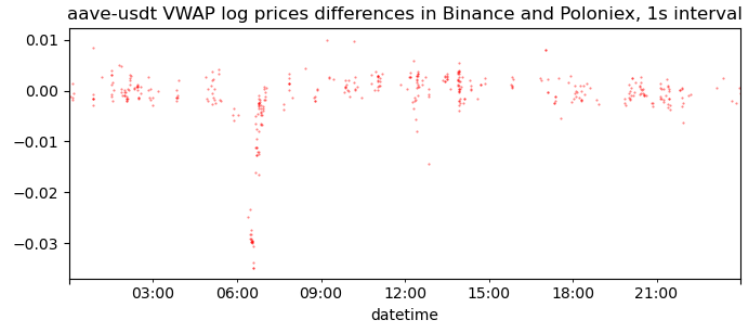






To determine the existence of arbitrage, we try to visualize the price and price differentials for ETH, DOGE and AAVE. It can be noticed that there are more arbitrage opportunities with ETH when compared to DOGE and AAVE. This is reasonable because ETH is one of the most traded cryptocurrencies around the world.

Based on the first figure, the prices of these three cryptocurrencies overlap a lot between the two exchanges; however, there are some points demonstrating clear price differentials and arbitrage existence (e.g. doge-usdt @9a.m.).

In addition, the histograms demonstrate a significant gap on the transaction frequencies in Binance and Poloniex among all cryptocurrencies that we investigated. This implies that the price of an asset in Poloniex could be more prone to high amounts of volatility, which implies more arbitrage opportunities.

From the second plot, despite many fluctuations of price differentials, there are some price differentials, some even more than 0.5%, which seem profitable.

3.2 Duration

We want to determine how long a given 'significant' price differential exists for. A 'significant' price differential, as it is defined here, is one which is above a minimum price differential.

It should be noted that the limitation of Poloniex providing only second-by-second data causes our analysis to be slightly inaccurate in the context of considering arbitrage opportunities. Many of these opportunities are sub-second, and may not be visible in the second-by-second time-series aggregation of the data.

For this reason, we have set the minimum differential to 0.1%, and the target differential (the differential at which our code flags an opportunity) to 0.25%. For more accurate time-series data, the minimum can be set higher. In the 'real world', the arbitrage must at the least still be profitable after exchange fees (usually ~0.1 percent for each the buy and the sell) for it to be worthwhile.

We use a minimum not only to show when a price differential disappears / dissipates, but also as a signifier of a ‘stop-loss’ of sorts. If we can at least gross 0.1% (e.g with a slower strategy, completing after the target differential shrinks), we will at least not be losing ‘that much’ (after exchange fees, though we will still be at a loss on the trade).

The method used involves creating an aggregated Pandas DataFrame which includes the percent price differential between the asset across the exchanges. We also create a subset of that DataFrame for points at which the price differential is above our 'target differential'. We then gather some statistics based on this information for analysis. Namely, the number of significant price differential instances above our target, the number and percentage of those differentials which last longer than our resample time (one second), and the average length of a significant price differential.

A significant price differential ‘instance’ is a second of trading data for which there exists a significant price differential (since the data is second-by second). Below, ‘# above target’ simply means the number of seconds throughout the day's worth of trading data that there existed a significant price differential (i.e. how many instances). We treat every instance as a separate instance, even if two instances overlap for the same arbitrage opportunity.

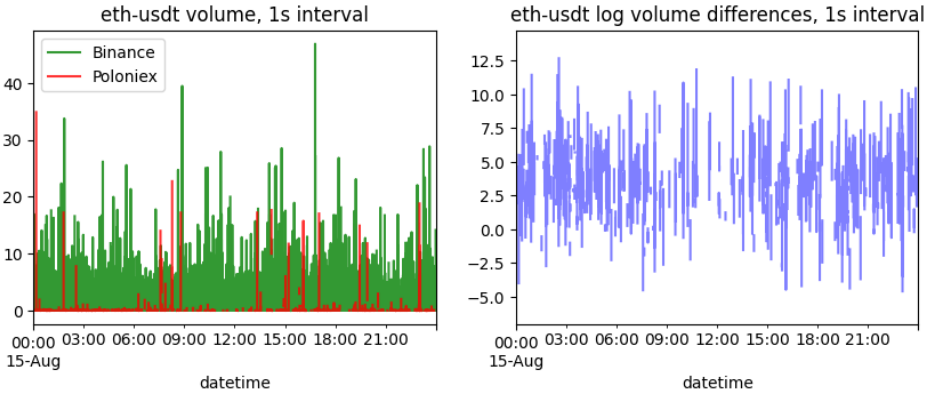
The results for each asset can be found on the next page.

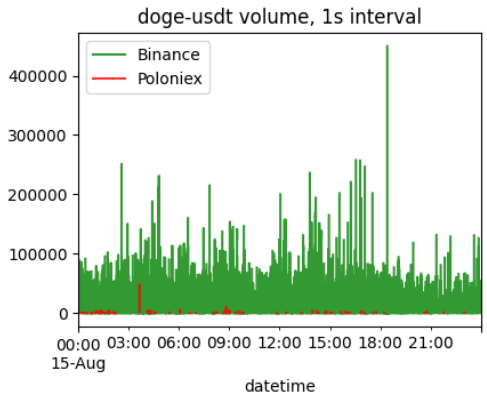
Pair	# Above Target	# That Don't Drop Below Min. After 1s	Avg. Time of Sig Diff.	Avg. Occurrence Of >= 0.25% Diff. (s)	Avg. Occurrence Of >= 0.25% Diff. (m)
BTC-USDT	14	3 (21.4%)	1.43	6171.43	102.86
ETH-USDT	79	12 (15.2%)	1.2	1086.1	18.1
XRP-USDT	0	0 (0%)	0	N/A	N/A
DOGE-USDT	394	17 (4.3%)	1.05	217.68	3.63
BCH-USDT	0	0 (0%)	0	N/A	N/A
TRU-USDT	137	1 (0.73%)	1.01	628.1	10.47
AAVE-USDT	141	7 (5%)	1.05	608.51	10.14

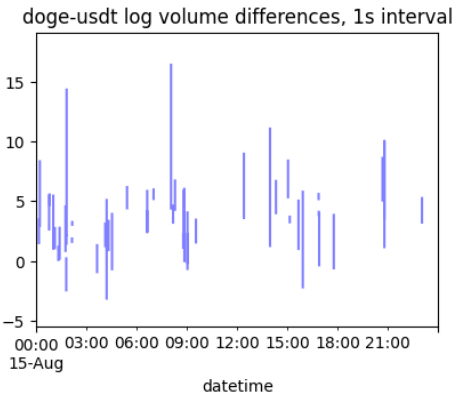
With 86 400 seconds in a day, the data shows that significant cross-exchange arbitrage opportunities in cryptocurrency do not occur often. Of these sparse opportunities, even less persist for longer than one second. This reinforces the need for high-frequency, low-latency programs to create profitable arbitrage strategies.

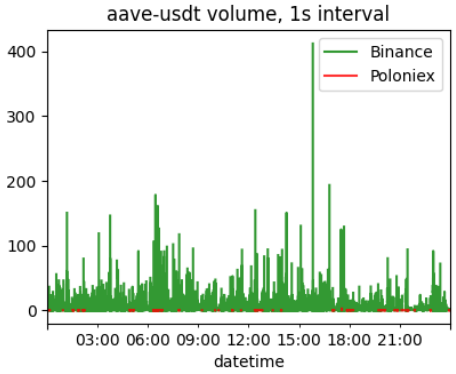
A 'worthwhile' arbitrage strategy does not only need to outperform exchange fees, but overtime must also outperform the risk-free rate. For this to occur, any given arbitrage strategy must be fast, precise, and well-thought-out.

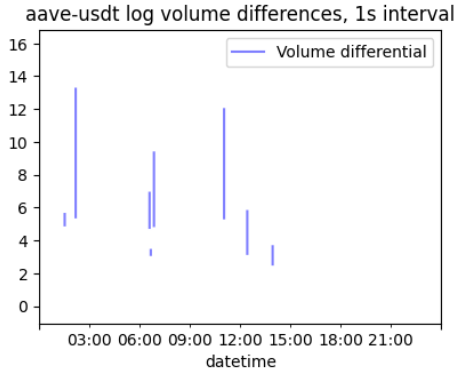
3.3 Driving Factors





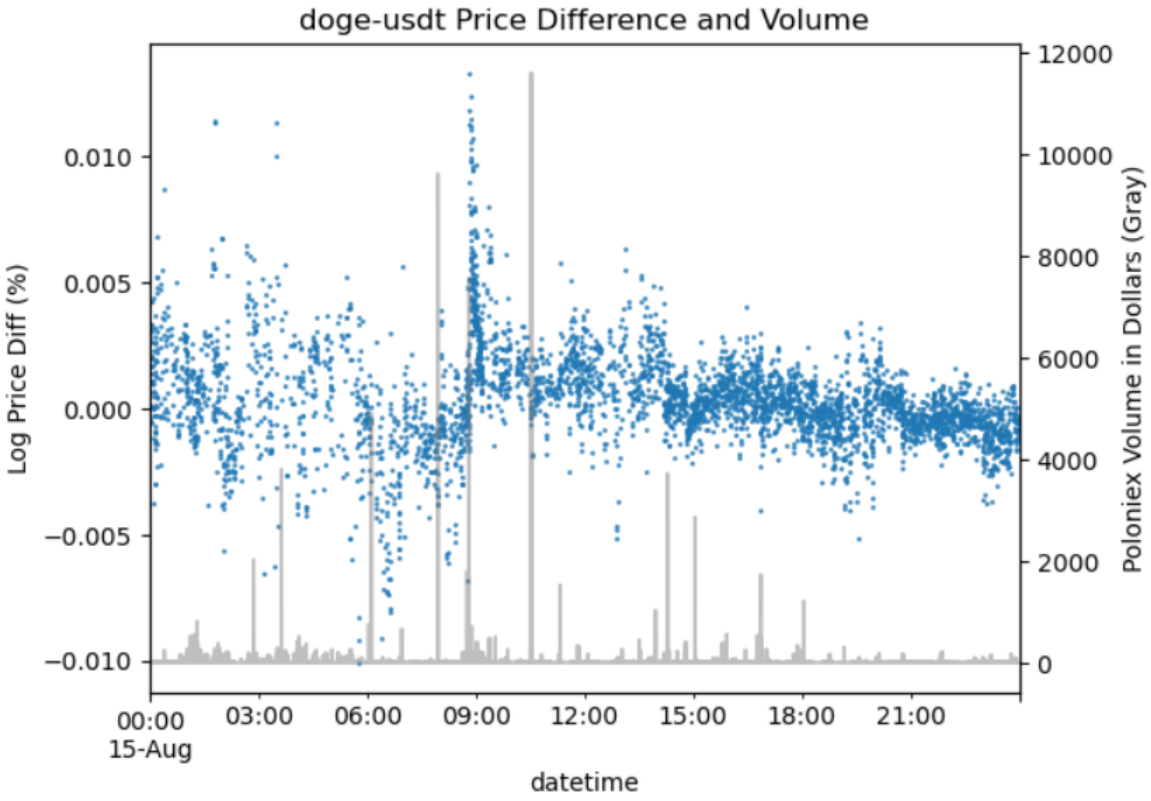






The above figures show the volume and price differentials among the three chosen cryptocurrencies. They demonstrate very similar patterns as VWAP price and price differentials. Let's take DOGE as an example again (see graph below). It can be noticed that the volume differential also peaks at 9am, which strongly proves the availability of arbitrage. Therefore, volume seems to be a driving factor of arbitrage. This also makes

sense conceptually, since illiquidity on Poloniex means that large-volume orders may temporarily move local prices on Poloniex without affecting the general market.



Below are some correlation coefficients calculated for data from DOGE-USDT. The left table shows Pearson Correlation, and the right table shows Spearman Correlation (correlation between rank of variables).

	Log Price Diff (%)	abs(Log Price Diff (%))
Log Price Diff (%)	1.000000	0.398381
abs(Log Price Diff (%))	0.398381	1.000000
Poloniex Volume	0.067206	0.072211
Binance Volume	-0.059664	0.036026
Log(Poloniex Volume)	0.186982	0.201089
Log(Binance Volume)	-0.081775	0.096890
Volume Percent	-0.154668	-0.022092
Binance Flow	0.051293	-0.010934
abs(Binance Flow)	-0.051022	0.034755

	Log Price Diff (%)	abs(Log Price Diff (%))
Log Price Diff (%)	1.000000	0.245507
abs(Log Price Diff (%))	0.245507	1.000000
Poloniex Volume	0.189315	0.193021
Binance Volume	-0.064992	0.111856
Log(Poloniex Volume)	0.189315	0.193021
Log(Binance Volume)	-0.064992	0.111856
Volume Percent	-0.149323	-0.017051
Binance Flow	0.094623	0.048460
abs(Binance Flow)	-0.050340	0.102886

Log price difference is calculated by the difference in Binance - Poloniex log prices, and absolute difference is an approximation of the size of arbitrage opportunity in percent.

Notice how the log of Poloniex Volume has a 0.2 correlation with the absolute price difference and a rank correlation of about 0.19, showing that higher volumes on Poloniex correspond to higher arbitrage opportunities. This probably occurs when large orders on Poloniex eat up liquidity and move prices temporarily.

Interestingly, Binance volume also has a 0.11 rank correlation with the size of arbitrage, possibly indicating arbitrage occurs when markets become volatile or with abnormally large trades.

Order flow on Binance does not seem to matter, but unfortunately Poloniex order flow data does not exist to test (which would likely be a good indicator of arbitrage).

3.4 Limitations

- We only looked at VWAP prices and not trade direction
- Poloniex data is in 1 second intervals, and does not include trade direction data
- We only have 1 day's worth of trade data, and no order book level data
- A lot of our analysis is qualitative from graphs, but mostly backs what we expect
- This data is from August 2022 when crypto was in a bear market and also much less traded market than it is today - so arbitrage conditions could have changed a lot

4 Proposed Strategy

4.1 Building Positions

Since it takes time to transfer and execute trades, one possible strategy is to pre-hold assets in both exchanges at equal values. Then, upon getting a price alert, we can buy on one exchange and proceed to sell on the other one to execute arbitrage. Or, we can continuously place and modify limit orders at profitable prices to capture arbitrage opportunities from illiquidity. When prices converge, we can proceed to sell back and buy back, balancing our inventory. Depending on the pattern of prices, we might have to hold more of either assets on either exchanges for a possibility of a larger buy/sell.

4.2 Transferring to Binance

We don't need to transfer to Binance as long as the price differential returns to a low enough percentage quickly, as we can just rebalance inventory by buying/selling at the same price. In the case the price differential persists for a long period of time, we can transfer inventory to Binance to maintain a 50/50 inventory level on each exchange, or

modify our profit spreads accordingly to mitigate inventory skew (i.e. if we are holding too much DOGE on Poloniex, we favor selling DOGE on Poloniex even if done at less profit than desired).

4.3 Profitability

The max possible profitability (all in dollars) is derived from the formula,

Price differential * Volume - Fee ($) (on both exchanges)

** The amount of profit is dependent on the total volume of the trade. For example, if there existed a large price differential, but little volume to take advantage of, the opportunity would not result in a high profit.

Realistically, assuming a fee tier of 0.1% per trade on both Binance and Poloniex, we would need at least a ~0.2% price differential to consider an arbitrage trade.

4.4 Risks

There are risks associated with implementing this arbitrage strategy. Some key ones are discussed below:

Risk	Explanation	Strategies to Mitigate
Latency (Adverse Selection)	Cryptocurrency is one of the most volatile securities. Prices can change fast in the middle of an arbitrage, which could make the trade unprofitable.	Latency must be measured to evaluate how long the securities are able to be transacted from one platform to another. The key to successfully implement this arbitrage opportunity will be minimizing latency. This can often be done with better written code, and good hardware / internet connection.
Directional Risk (for securities held overnight)	Inventory we hold can change in value. Holding a significant amount at any time leaves you open to directional risk, i.e the chance that the price of the currency moves against you.	Hedge with futures/options or derivatives, which comes with extra cost.

Counterparty Risk	Cryptocurrencies have benefited in the past from a vague regulatory environment. There is now an increased risk of them going bankrupt as regulators seek to crack down on them. The exchanges you trade on may go bankrupt, losing you your deposits (like FTX).	Difficult to mitigate for our purpose. In practice, you would look to an insurer to insure against this risk.
Limited Strategy Capacity	If the size and frequency of arbitrage opportunities is too small, it won't be worth it. i.e. making 10% a day, but only being able to trade $1 of arbitrage is only $0.10/day.	Monitor market conditions to see if they change from your assumptions. Sufficient backtesting could paint a clearer picture of your expected P & L and the risks associated.

5 Conclusion

Despite our lack of data, we can still notice arbitrage opportunities between Binance and Poloniex, showing that the crypto market is still relatively inefficient with many noticeably large price discrepancies. However, capturing these arbitrage opportunities comes with some risk and challenges which require fast systems and careful risk management. Furthermore, it remains to be seen whether these opportunities still exist today in a market that is likely more liquid and efficient than in 2022.