

# Triangle Arbitrage Challenge – Project Report

## Overview & Objectives

Originally, the plan was to conduct spot–futures arbitrage (cash-and-carry). However, due to difficulties retrieving futures data—possibly because of platform restrictions or API limitations—the strategy was pivoted to triangle arbitrage using the following spot pairs:

- BTC/USDT
- ETH/USDT
- ETH/BTC

## Data Acquisition

- **Live Data:**  
The script retrieves the latest ticker data for the three pairs, extracting the 'last' price and volume, and stores the results in a Pandas DataFrame and JSON format.
- **Historical Data:**  
Historical 1-minute OHLCV data is fetched in small chunks (due to an API limit of 100 candles per call). Data for each pair is merged on common timestamps and stored incrementally in a JSON file. This incremental approach helps manage memory, especially when fetching large datasets.

## Arbitrage Strategy & Signal Generation

The triangle arbitrage strategy computes two cycle factors:

- **Cycle 1 (USDT → BTC → ETH → USDT):**

$$\text{Cycle1 Factor} = \frac{\text{ETH/USDT} \times (\text{BTC/USDT} \times \text{ETH/BTC})}{\text{BTC/USDT} \times \text{ETH/BTC} \times \text{ETH/USDT}}$$

- **Cycle 2 (USDT → ETH → BTC → USDT):**

$$\text{Cycle2 Factor} = \frac{(\text{BTC/USDT} \times \text{ETH/BTC}) \times \text{ETH/USDT}}{\text{ETH/USDT} \times (\text{BTC/USDT} \times \text{ETH/BTC})}$$

If either factor exceeds  $1 + \text{threshold}$  (e.g., 1.002 for a 0.2% excess), an arbitrage opportunity is signaled.

## Execution Simulation & Backtesting

- **Simulation:**

A virtual portfolio (starting at 10,000 USDT) is updated on each minute based on the arbitrage signal. For each record, if an opportunity is detected, a trade is simulated on a fixed fraction of the portfolio.

- **Performance Metrics:**

The backtest computes cumulative return, average return per trade, standard deviation of returns, an annualized Sharpe ratio (using 525,600 minutes per year), and maximum drawdown.

## Final Observations & Limitations

Due to time constraints and limited laptop performance, I was only able to backtest using 30 days of historical data. The results from the simulation over this period showed no profitable arbitrage opportunities, leading to all performance metrics (cumulative return, average return, standard deviation, Sharpe ratio, and maximum drawdown) being zero.

## Conclusion

The project successfully pivoted from an initial spot-futures arbitrage approach to a triangle arbitrage strategy. The implementation includes:

- Market data acquisition (both live and historical).
- Arbitrage signal generation based on triangle arbitrage cycles.
- A simulation framework for trade execution and performance analysis.

However, the limited backtesting period (30 days) due to hardware constraints revealed no profit opportunities under the tested conditions. Future work should consider:

- Extending the backtesting period when resources allow.
- Incorporating realistic trading costs and slippage.
- Optimizing data handling and processing for larger datasets.