

Same-Exchange Triangular Arbitrage

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August 2, 2019

INTRODUCTION

A simple Python script for triangular arbitrage between 3 different coins is studied. First the math will be developed, followed by a trading algorithm in pseudo-code that exploits it.

Bitcoin(BTC) and Tether-USDollar(USDT) will be 2 of the coins, the third will be any altcoin (the algorithm should check all possibilities). The base currency will be USDT, we'll start and finish with this currency, hoping to have more than we started with by the end of the process.

$$USDT \rightarrow BTC \rightarrow ALT \rightarrow USDT$$

THE MATH

Order books and fees are taken into consideration for accuracy.

Order Book

Whether it's bid or ask price that we should be considering depends on the order in which the arbitrage will occur. Only market orders will be considered to ensure execution speed so the opportunity cannot be missed.

Fees

The exchange used is Binance, where fees are 0.1% or 0.075% if fees are paid with BNB tokens. It is assumed that enough BNB is owned to pay for these fees, thus fees will be considered to be 0.075%.

Process

In the buying process ask prices are considered. In the selling process bid prices are used. To avoid confusion, on Binance BTC/USDT refers to how many USDT are required for 1 BTC. However, mathematically that would correspond to how many USDT per BTC (*ie* USDT/BTC). The mathematical notation will be used to avoid incorrect deductions.

(BUY PROCESS)

$$USDT \rightarrow BTC \rightarrow ALT \tag{1}$$

Suppose we have usd USDT. To calculate how many BTC we'll obtain with this capital:

$$\frac{usd}{USDT/BTC} - usd * \frac{0.075}{100} = btc \Rightarrow usd * \left(\frac{1}{USDT/BTC} - \frac{0.075}{100} \right) = btc \tag{2}$$

Note that fees are included in equation (2). The same math as in equation (2) is used to pass from BTC to ALT:

$$\frac{btc}{BTC/ALT} - btc * \frac{0.075}{100} = alt \Rightarrow btc * \left(\frac{1}{BTC/ALT} - \frac{0.075}{100} \right) = alt \tag{3}$$

(SELL PROCESS)

$$ALT \rightarrow USDT \tag{4}$$

Now we have alt ALT. The conversion process back to USDT is:

$$alt * USDT/ALT - alt * \frac{0.075}{100} = usd' \Rightarrow alt * \left(USDT/ALT - \frac{0.075}{100} \right) = usd' \tag{5}$$

Arbitrage Condition

For a profitable arbitrage, the selling process must be more expensive than the buying process: $sell > buy$. Finally we can now check if this holds: $usd' > usd$. If this condition is True, the arbitrage is profitable and the buy/sell orders are executed. Making use of the equations we can expand this condition:

Replacing (2) in (3):

$$usd * \left(\frac{1}{USDT/BTC} - \frac{0.075}{100} \right) * \left(\frac{1}{BTC/ALT} - \frac{0.075}{100} \right) = alt \quad (6)$$

$$usd = \frac{alt}{\left(\frac{1}{USDT/BTC} - \frac{0.075}{100} \right) * \left(\frac{1}{BTC/ALT} - \frac{0.075}{100} \right)} \quad (7)$$

Now, combining equations (5) and (7) with our condition ($usd' > usd$):

$$alt * \left(USDT/ALT - \frac{0.075}{100} \right) > \frac{alt}{\left(\frac{1}{USDT/BTC} - \frac{0.075}{100} \right) * \left(\frac{1}{BTC/ALT} - \frac{0.075}{100} \right)} \quad (8)$$

$$\left(USDT/ALT - \frac{0.075}{100} \right) * \left(\frac{1}{USDT/BTC} - \frac{0.075}{100} \right) * \left(\frac{1}{BTC/ALT} - \frac{0.075}{100} \right) > 1 \quad (9)$$

THE CODE

For the algorithm, correct notation must be used to connect succesfully with the Binance API. Also, whether the price is bid or ask should be specified in the condition:

$$\left(ALTUSDT_{bid} - \frac{0.075}{100} \right) * \left(\frac{1}{BTCUSDT_{ask}} - \frac{0.075}{100} \right) * \left(\frac{1}{ALTBTC_{ask}} - \frac{0.075}{100} \right) > 1 \quad (10)$$

The algorithm must check this condition (equation (10)) and act accordingly.

```

condition ← Eq(10)
while True do
  for coin in altcoins do
    if condition then
      buy(BTCUSDT)
      buy(ALTBTC)
      sell(ALTUSDT)
    else
      continue
    end if
  end for
end while

```

REVERSED ARBITRAGE

The same arbitrage process can be run in reverse:

$$USDT \rightarrow ALT \rightarrow BTC \rightarrow USDT$$

Process

(BUY PROCESS)

$$usd * \left(\frac{1}{USDT/ALT} - \frac{0.075}{100} \right) = alt \quad (11)$$

(SELL PROCESS)

$$alt * \left(BTC/ALT - \frac{0.075}{100} \right) = btc \quad (12)$$

$$btc * \left(USDT/BTC - \frac{0.075}{100} \right) = usd' \quad (13)$$

Condition

Using equations (11), (12), (13) to expand the condition $usd' > usd$:

$$alt * \left(BTC/ALT - \frac{0.075}{100} \right) * \left(USDT/BTC - \frac{0.075}{100} \right) > \frac{alt}{\left(\frac{1}{USDT/ALT} - \frac{0.075}{100} \right)} \quad (14)$$

$$\left(BTC/ALT - \frac{0.075}{100} \right) * \left(USDT/BTC - \frac{0.075}{100} \right) * \left(\frac{1}{USDT/ALT} - \frac{0.075}{100} \right) > 1 \quad (15)$$

Code

Using the correct tickers from Binance the condition is:

$$\left(ALTBTC_{ask} - \frac{0.075}{100} \right) * \left(BTCUSDT_{bid} - \frac{0.075}{100} \right) * \left(\frac{1}{ALTUSDT_{bid}} - \frac{0.075}{100} \right) > 1 \quad (16)$$

The algorithm would, therefore, be as follows:

```

condition ← Eq(16)
while True do
  for coin in altcoins do
    if condition then
      buy(ALTUSDT)
      sell(ALTBTC)
      sell(BTCUSDT)
    else
      continue
    end if
  end for
end while

```

FURTHER IMPROVEMENTS

Arbitrage between more than 3 coins is possible, as well as arbitrage across exchanges. Since profit % are small in these strategies, using more than 3 coins isn't recommended as fees might exceed profits. At the same time, using several exchanges requires capital to be allocated to all of these exchanges, which is costly. CCXT is a Python library that could help implement this.