

Crypto Arbitrage

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Goal: Create a Cryptocurrency Arbitrage Strategy

Steps:

- Compare prices of Ethereum between two exchanges
- Incorporate fees
- Spread/Slippage
- Identify various volatility environments
- Calculate arb spread in different environments
- Incorporate strategy into algo
- Calculate PNL scenario
- Calculate and display rolling volatility

Data Preparation: Collection and Cleanup

- Ethereum prices were imported from
 - Binance (Fastquant/get_crypto_data)
 - Coinmarketcap (csv file)
- The prices were then cleaned and formatted
- All of the prices were then combined through DataFrame concatenation

```
import pandas as pd
import numpy as np
from coinmarketcap import Market

from fastquant import get_crypto_data
from fastquant import backtest
from matplotlib import warnings
%matplotlib inline
```

```
eth_concat=pd.concat([coinmarketcap_close_df, binance_close_df], axis=1)
eth_df=eth_concat[['coinmarketcap_close', 'binance_close']]
eth_df.head()
```

	coinmarketcap_close	binance_close
2020-12-24	611.61	612.31
2020-12-25	626.41	626.82
2020-12-26	635.84	637.44
2020-12-27	682.64	685.11
2020-12-28	730.40	730.41



Crypto Fees:

- Maker/Taker Costs
 - Maker Cost is incurred when providing liquidity
 - Limit Order
 - Lower Cost
 - No Guarantee of Execution
 - Taker Cost is incurred when taking liquidity
 - Market Order
 - Higher Cost
 - Guarantee of Execution
- Since Arbitrage is exploited quickly, we utilize Taker Costs for our calculations

Binance Fee Schedule

Level	30d Trade Volume (BUSD)	and/or	BNB Balance	Maker / Taker
VIP 0	< 1,000,000 BUSD	or	≥ 0 BNB	0.1000% / 0.1000%
VIP 1	≥ 1,000,000 BUSD	and	≥ 25 BNB	0.0900% / 0.1000%
VIP 2	≥ 5,000,000 BUSD	and	≥ 100 BNB	0.0800% / 0.1000%
VIP 3	≥ 20,000,000 BUSD	and	≥ 250 BNB	0.0700% / 0.1000%
VIP 4	≥ 120,000,000 BUSD	and	≥ 500 BNB	0.0700% / 0.0900%
VIP 5	≥ 200,000,000 BUSD	and	≥ 1,000 BNB	0.0600% / 0.0800%
VIP 6	≥ 500,000,000 BUSD	and	≥ 1,750 BNB	0.0500% / 0.0700%
VIP 7	≥ 1,000,000,000 BUSD	and	≥ 3,000 BNB	0.0400% / 0.0600%
VIP 8	≥ 2,500,000,000 BUSD	and	≥ 4,500 BNB	0.0300% / 0.0500%
VIP 9	≥ 5,000,000,000 BUSD	and	≥ 5,500 BNB	0.0200% / 0.0400%

Total Arb Costs

- In addition to trading fees we have to incorporate:
 - Spread – The difference between the bid/ask price
 - Slippage – The difference between our order price and the execution price
 - We assume spread and slippage increase as volatility increases

<u>Assuming .10% Taker fee:</u>	<u>Taker Fee</u>	<u>Spread (incurred once each time a trade is reversed)</u>	<u>Slippage</u>	<u>Total Costs Per Trade</u>
.10% will be charged 4 times per arbitrage transaction. We can assume a .40% fee (the highest transaction cost) for binance				
Buying on one exchange	0.10%		X	
Shorting on the other exchange	0.10%		X	
Reversing (selling) the buy	0.10%	X	X	
Reversing (buying) the short position	0.10%	X	X	
Low Spread		0.05%		
Medium Spread		0.25%		
High Spread		1%		
Low Slippage			0.01%	
Medium Slippage			0.10%	
High Slippage			0.50%	
<u>TOTAL COSTS PER TRADE</u>				
Low Volatility				0.54%
Medium Volatility				1.30%
High Volatility				4.40%

Arbitrage Spread at varying volatility crypto fees

- We calculated the arbitrage spread between Binance & the aggregator: CoinMarketCap
- The arb spread we calculated was in terms of percent to allow for continuity between arb spread and the crypto fees (in percentage)
- We also calculated the arb spread in terms of dollars for the PNL calculations
- Taking into consideration the crypto fees for the varying volatility (Zero Fee, Low, Medium and High) we calculated the various arb spreads

	coinmarketcap_close	binance_close	arbitrage_spread	arbitrage_spread_dollars	Actual Returns Binance	lowvol_arb_spread	medvol_arb_spread	highvol_arb_spread
2020-12-25	626.41	626.82	0.000654	0.41	0.023697	-0.004746	-0.012346	-0.043346
2020-12-26	635.84	637.44	0.002513	1.60	0.016943	-0.002887	-0.010487	-0.041487
2020-12-27	682.64	685.11	0.003612	2.47	0.074784	-0.001788	-0.009388	-0.040388
2020-12-28	730.40	730.41	0.000014	0.01	0.066121	-0.005386	-0.012986	-0.043986
2020-12-29	731.52	732.00	0.000656	0.48	0.002177	-0.004744	-0.012344	-0.043344

Trading Algo Code

- Based on these arb spreads at differing crypto fees structures for different volatilities we created a Signal for the algo to know when to execute an arbitrage opportunity

```
# Zero fee scenario
arb_spread_df["Zerofee_Signal"] = np.where(arb_spread_df["arbitrage_spread"] > 0, 1.0, 0)

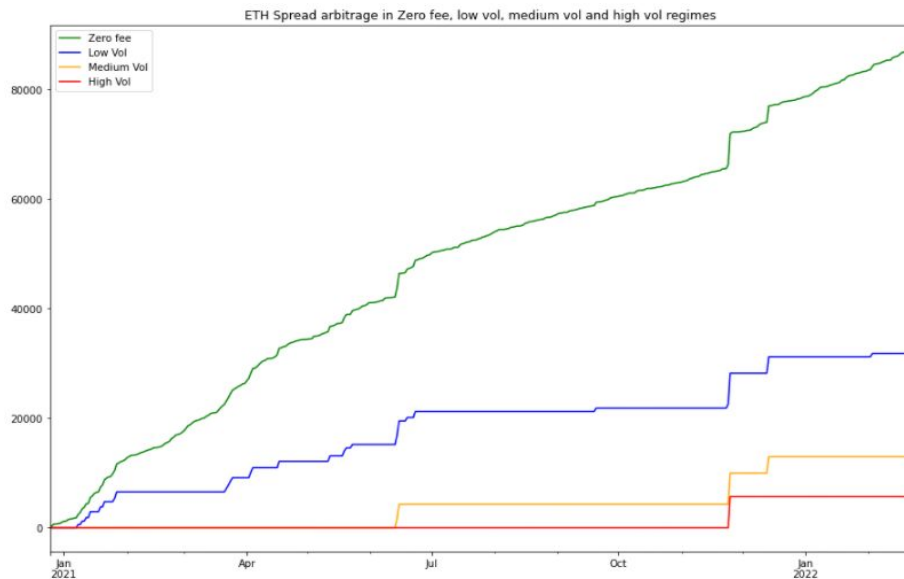
# Low vol scenario
arb_spread_df["LowVol_Signal"] = np.where(arb_spread_df["lowvol_arb_spread"] > 0, 1.0, 0)

# Mid vol scenario
arb_spread_df["MedVol_Signal"] = np.where(arb_spread_df["medvol_arb_spread"] > 0, 1.0, 0)

# High vol scenario
arb_spread_df["HighVol_Signal"] = np.where(arb_spread_df["highvol_arb_spread"] > 0, 1.0, 0)
```

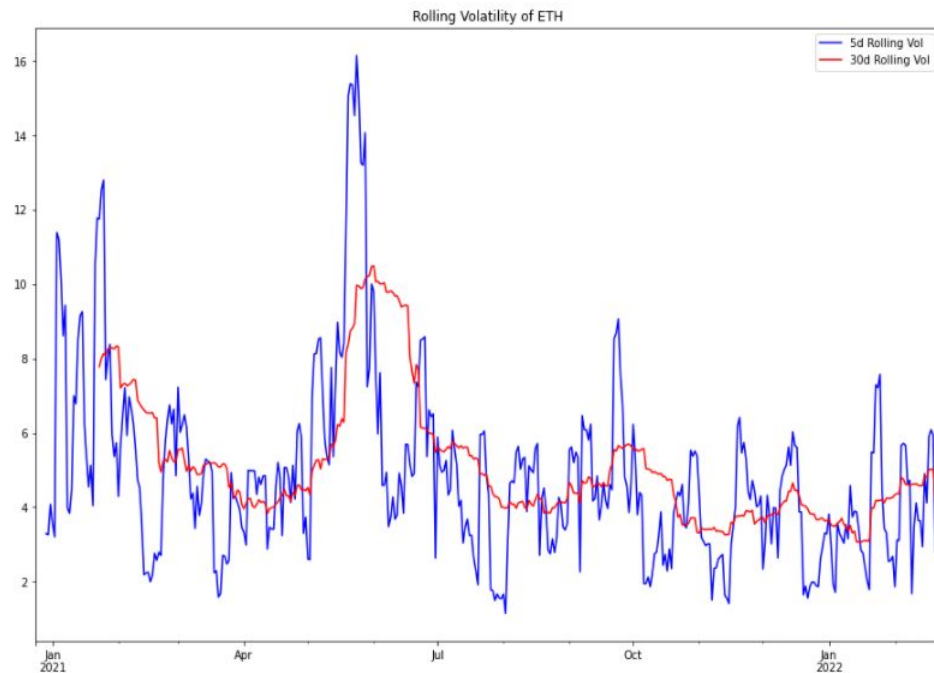
Profit and Loss (pnl) Analysis

- Profit and Loss (Pnl) analysis was conducted using the trading signals along with the different fee structures.
- Below are the pnl results under all 4 scenarios (zero fee, low vol fee, medium vol fee, and high vol fee)



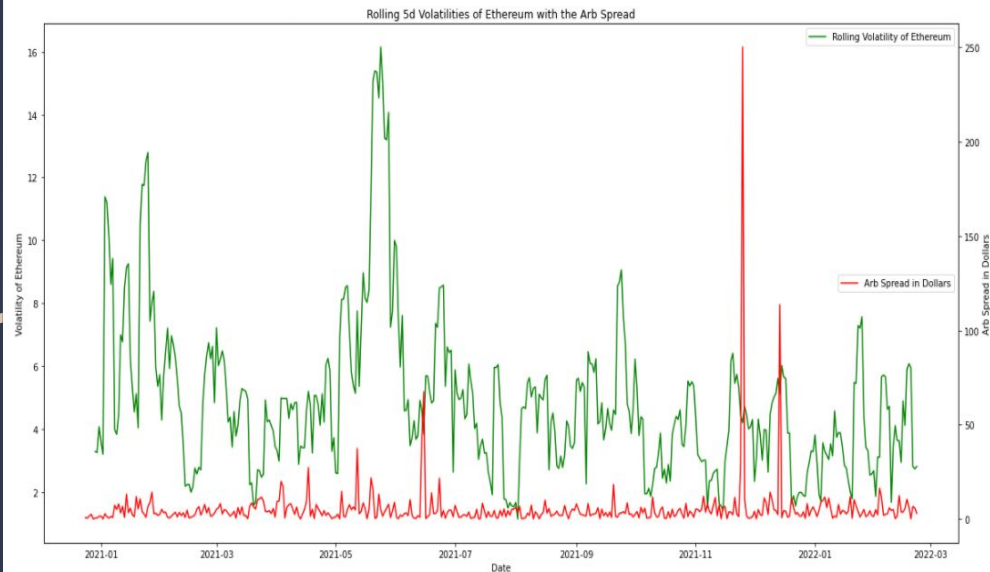
Rolling Volatility of Ethereum

- We analyzed different Volatility rolling windows to see if we could use the volatility as an additional signal



Rolling Volatility of Ethereum

- We plotted the volatility of Ethereum versus the Arbitrage Spread in dollars



Conclusion/Results

- Trade costs significantly impact the opportunity for arbitrage
- Low volatility environment showed the most arbitrage opportunities as well as the highest total arb PnL
- High volatility did not yield greater arbitrage opportunities

If we had more time we could:

- Access APIs that have higher frequency data and derive more precise results
- Attempt arb pairs between different coins
- Test arb using 3 different exchanges