Trading Bitcoin using On-Chain Data

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1. Introduction

Since the inception of Bitcoin in 2009, the blockchain and cryptocurrency industry/technology has evolved a lot. According to CoinMarketCap, there are 19,050 different cryptocurrencies and 510 exchanges at the time of writing (2022-04-22). Also, as of 2021, triple A, a blockchain solution company, estimated that there are 300 million crypto users worldwide. Although this number is still low relative to the global population, the trend is increasing and more businesses/banks are researching blockchain and cryptocurrencies. As a result, the amount of data generated from blockchain, on-chain data, is exploding. Therefore, this study investigated whether it is possible to generate a trading strategy that outperforms the market using on-chain indicators.

1.1 Data

1.1.1 Price Data

Price data used in this paper are from Binance. The data was retrieved from Crypto Quant's database and comparison between the actual data and retrieved data is shown below. The price data ranges from 2017-08-17 to 2022-02-08.

1.1.2 On-chain Data

On-chain data refers to data generated from a blockchain such as transaction count, transaction volume, etc. Among many different coins, Bitcoin was used because it has the longest history and is widely accepted as one of the asset classes now. Since there are numerous number of different types of on-chain data, there were several indicators that were recommended by Crypto Quant which seemed to have some predictive power over the price of Bitcoin. Therefore, this research focused on those recommended indicators.

1.2 Objective

The objective of this paper is to use on-chain indicators to predict Bitcoin's price direction and develop a trading strategy based on these indicators. The result will be compared with the benchmark performance (buy and hold for the testing period).

2. Backtest Methodology

2.1 Table of indicators

As mentioned in section 1.1.2, due to many different types of on-chain data, all of the on-chain indicators below are recommended by Crypto Quant and these indicators were used in this study.

Category	Indicator	Explanation
Coinbase Premium	Coinbase premium gap	Calculated as gap between Coinbase price (BTCUSD) and Binance price (BTCUSDT). The higher the premium, the stronger the spot buying pressure from Coinbase.
	Coinbase premium index	calculated as percent difference from Binance price (BTCUSDT) to Coinbase price (BTCUSD).
	According to Crypto Quant, Coinbase Pro is considered to be the gateway for institutional investors purchase to cryptocurrencies. Thus, Coinbase Premium is used to track institutional whale's movement. Also, 2020 bull run was driven by institutional investors and high net-worth individuals in the U.S. which makes investors check Coinbase Premium index/gap more than ever.	
BTC Fun Flow Ratio	Fund Flow Ratio	The total BTC amount of top 10 transactions (in terms of total BTC sent) divided by the total BTC amount flowing into a given exchange.

BTC Exchange Inflow	Inflow total	Sum of total number of BTC inflow to the exchange for a given time window.
	Inflow top10	Sum of top 10 transactions with the most number of BTC inflow to the exchange.
	Inflow mean	Inflow total divided by the total number of transactions.
	Inflow mean ma7 * Moving Average (7)	Moving average of inflow for 7 timeframe.
BTC Mining pool reserve	Reserve	Total number of BTC in mining pools
	Reserve USD	USD value of the reserve
BTC exchange reserve	Reserve	Total number of BTC in exchanges
	Reserve USD	USD value of the reserve
Capitalization	market cap	Market Capitalization
	realized cap	The stored value of BTC calculated by summing up each UTXOs multiplied by the price they last moved.
	average cap	The forever moving average, calculated by dividing the cumulated sum of daily market cap by the age of the market.
	delta cap	Calculated as the subtraction of Realized Cap to Average Cap. A capitalization model that helps to find market bottoms.
	thermo cap	Calculated as the weighted sum of mined coins by the creation price. This measures total capitalization flowed into the blockchain network, which in turn is to be called as Inflows Cap.

BTC Fund holdings	digital asset holdings	Total number of BTC held by funds(institutions) **List of fund tickers:** GBTC, QBTC.U, BTCQ.U, BTCC.U, BTCE, BTCG.U
MPI (Miner's Position Index)	Mpi	The total miner outflow USD divided by MA 365 total miner outflow USD. * Moving Average (365)
	MPI compares the USD value of BTC leaving the mining pool at time T with moving average of 365 days to determine whether current outflow is relatively large or small compared to the past 365 days.	
MVRV (Market Value to Realized Value)	MVRV	The MVRV is defined as a BTC market capitalization divided by realized capitalization, assessing fair BTC value. Values above 3.7 indicate BTC is overvalued, and values under 1 indicate BTC is undervalued.
Spent output profit ratio	SOPR	Ratio that is calculated as the USD value of spent outputs at the spent time divided by the USD value of spent outputs at the created time
	a-sopr (Recent)	Exclude UTXO aged less than an hour
	STH-sopr (Short term)	Only include UTXO where 1hr < age < 155 days
	LTH-sopr (long term)	Only include UTXO age > 155 days
Stablecoin supply ratio	stablecoin supply ratio	The ratio of BTC market cap relative to the aggregated market cap of all stablecoins. The number increase means an increase in selling pressure.

Exchange stablecoin ratio	stablecoins ratio	The BTC reserve divided by all stablecoins reserve held by an exchange.
	stablecoins ratio USD	The BTC reserve in USD divided by all stablecoins reserve held by an exchange.

2.2 Signal Generation & PnL calculation

To assess the predictive power of all the indicators selected by Crypto Quant, backtest was done. Backtest refers to the simulation of a trading environment using historical data. Using the historical price data and indicator data, 2 types of trading strategies were generated.

2.2.1 Mean Reversion

Mean reversion strategies assume that certain values will revert to mean when the values deviate from the mean by a certain degree. This degree is usually dynamically set by different methods.

2.2.2 Trend Following

Trend following strategies assumes that the trend will follow until the momentum is weakened. Therefore, when a certain condition is met, the trader will conclude that trend has been formed and deduce a conclusion from the trend.

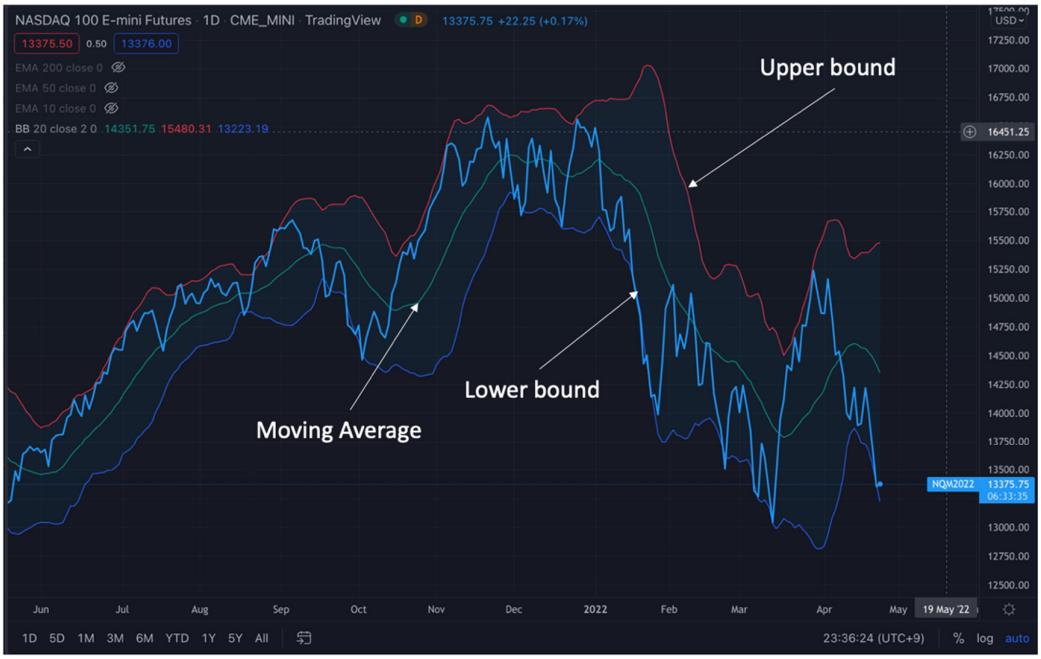
2.2.3 Bollinger Band

Mean reversion and trend following strategies were both implemented using the Bollinger band, which is a widely used method of measuring how much a certain value deviated from the mean. To generate a Bollinger band, 2 parameters are required, period and Standard deviation multiplier (k). The period is used to generate a moving average and the standard deviation multiplier is used to plot the upper and lower bound of the band.

How to plot a Bollinger Band

1. Choose the parameters: period (n) and standard deviation multiplier (k)
2. Calculate moving average and standard deviation of a given period (n)
3. Plot the average in the middle, and plot upper and lower bounds
    a. Upper bound = moving average (n) + standard deviation * k
    b. Lower bound = moving average (n) - standard deviation * k

Figure 1. Example of Bollinger Band



Source: Tradingview

Mean Reversion

1. Calculate Bollinger Band
2. If the indicator value at current time *t* is higher or lower than the previous upper or lower band, signal is generated.
    a. $Value > MA(n) + k \times SD \longrightarrow enter\ short$
    b. $Value < MA(n) - k \times SD \longrightarrow enter\ long$
    c. $MA(n) - k \times SD < Value < MA(n) + k \times SD \longrightarrow exit$

Trend Following

1. Calculate Bollinger Band
2. If the indicator value at current time *t* is higher or lower than the previous upper or lower band, signal is generated.
    a. $Value > MA(n) + k \times SD \longrightarrow enter\ long$
    b. $Value < MA(n) - k \times SD \longrightarrow enter\ short$
    c. $MA(n) - k \times SD\ < Value < MA(n) + k \times SD \longrightarrow exit$

2.3 Performance Evaluation Matrix

2.3.1 Compound Annual Growth Rate (CAGR)

$$CAGR\ =\ \left(\frac{V_{Final}}{V_{Initial}}\right)^{1/t}\ -\ 1$$

V_{Final} = Final value, $V_{Initial}$ = Initial Value, t = time in years

CAGR refers to the rate of return to reach from initial balance to final balance assuming all the profits are reinvested.

2.3.2 Maximum Draw Down (MDD)

$$MDD\ =\ \frac{V_{min}\ -\ V_{max}}{V_{max}}$$

V_{min} = lowest portfolio value, V_{max} = highest portfolio value

MDD refers to maximum loss in capital that the investor has to withstand. MDD is usually used as a reference for assessing investor's psychological risk limit. MDD can be calculated based on a certain time period or whole investment period. However, in this paper, MDD of the whole period was computed.

2.3.3 Sharpe Ratio

$$SR = \frac{E[R_a - R_f]}{\sigma_a}$$

E = expected value, R_a = asset/investment return, R_f = risk free return,

σ_a = standard deviation of the asset/investment return

Sharpe Ratio is an average excess return per unit of standard deviation or risk. Therefore, if the return on investment was very steady and kept growing, the Sharpe ratio would be very high. On the other hand, if the return volatility is very high, SR will be very low. Since Bitcoin does not have any risk-free return like fiat currencies, Rf is set to 0. SR is also a widely used indicator for evaluating the performance of an investment.

2.3.4 Time series cross-validation

Based on the above 3 evaluation matrix, cross-validation was done to finalize the performance evaluation. Conventional k-fold cross validation segments data into k fold and use one segment as a test set and use the remaining as a training set. Since the test set is left out of training/optimizing the parameter, the test results are considered reliable and free of look-ahead bias.

However, due to the nature of time-series data, this method is not plausible because the flow of time must be retained. Therefore, in this research, a cross-validation method for time series data was used. There are 2 main ways to achieve this. The first method is cumulatively testing as shown in figure 2. The second method is to divide the entire dataset into k sets and set train and test sets within each smaller dataset as shown in figure 3. In this paper, cross-validation was done as shown in figure 3. Therefore the final result consisted of CAGR and Sharpe Ratio where they were re-calculated based on k test results and MDD was averaged.

In this study, the total data (1637 days/rows) were divided into 3 sets (545 each), and each set was further divided into 80% for training set (436 days) and testing set (109 days) as shown in figure 3. The final performance was than evaluated as combination of 3 results.

Figure 2. Time series split

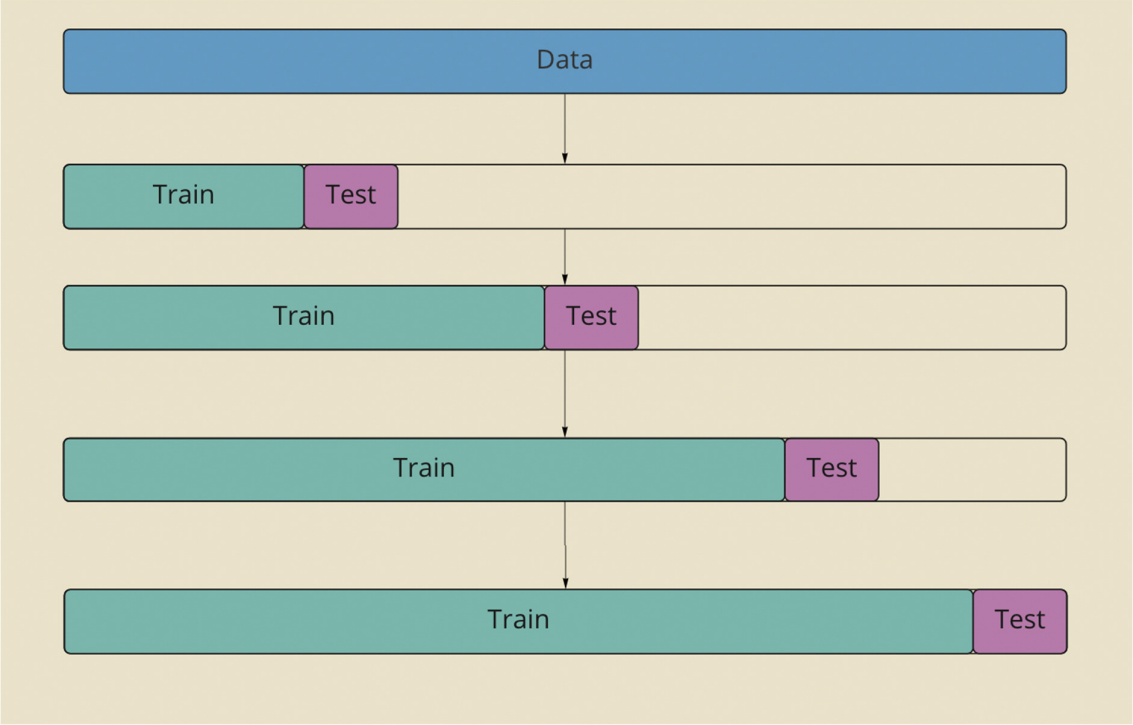
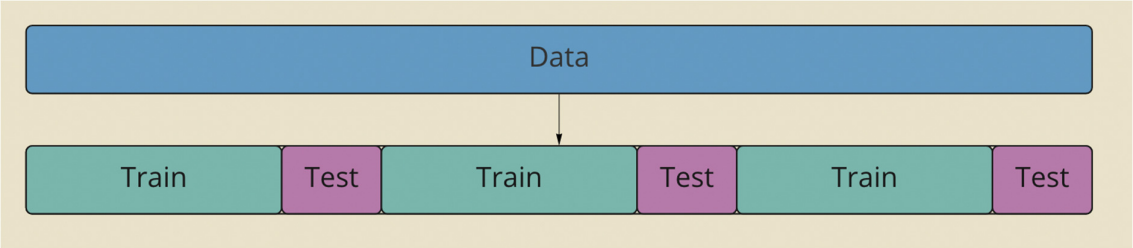


Figure 3. Block time series split



2.4 Parameter Optimization

Since Bollinger Band requires 2 parameters, window and threshold constant, these 2 parameters were optimized in the train set. The optimization algorithm utilized random searching because the model performance surface is not expected to be smooth. Therefore, I have set a heuristically reasonable space for each variable and iterated the optimization algorithm 1000 times. In addition, the target for optimization was Sharpe Ratio. After 1000 iterations, the best parameter was used to backtest on the test set.

3. Data Analysis

3.1 Result

3.1.1 Backtesting conditions

- Cumulative investment
- No partitioning in investment capital
- Each test case's initial fund = 10,000 USD
- The dataset was divided into 3 for cross validation
    - Total of 30,000 USD as initial balance
- Random number seed was set for reproducibility

All the tests had a duration of 330 days which could be considered short. The length of the Bitcoin price dataset contains around 4 years and 6 months of data (2017-08-17 ~ 2022-02-08), 1636 days(rows). To test the performance in the different market situations, the time series cross-validation method was performed as shown in figure 2. Therefore, 1636 rows were divided into 3 different sets, and 80% of each set is used to train the parameters and 20% to test. Therefore, the testing period is relatively short.

Benchmark Result (Buy and hold)

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-7.8%	-0.65	-45.4%	-7.11%

Indicator Results

BBMR: Bollinger Band Mean Reversion

BBTF: Bollinger Band Trend Following

Coinbase Premium

Indicator	Coinbase premium gap	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	3.02%	0.718	-5.97%	2.73%

Indicator	Coinbase premium index	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	3.71%	0.933	-6.84%	3.35%

Fund Flow Ratio

Indicator	Fund Flow Ratio	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	7.32%	1.20	-11.5%	6.60%

BTC Exchange Inflow

Indicator	Inflow total	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-6.23%	-1.37	-7.7%	-5.65%

Indicator	Inflow top10	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-5.98%	-1.05	-12.5%	-5.42%

Indicator	Inflow mean	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-1.94%	-0.35	-8.01%	-1.76%

Indicator	Inflow mean MA7	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-3.54%	-1.49	-3.99%	-3.21%

BTC Mining Pool Reserve

Indicator	Reserve	**Strategy**	BBTF

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	8.09%	1.33	-9.63%	7.29%

Indicator	Reserve USD	**Strategy**	BBTF

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-1.31%	-0.076	-11.86%	-1.19%

BTC Exchange Reserve

Indicator	Reserve	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-10.28%	-1.01	-17.55%	-9.34%

Indicator	Reserve USD	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-8.98%	-1.04	-11.38%	-8.15%

Capitalization

Indicator	Market cap	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-6.39%	-0.65	-14.13%	-5.80%

Indicator	Realized cap	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	13.07%	2.07	-10.38%	11.74%

Indicator	Average cap	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-2.70%	-1.09	-2.44%	-2.44%

Indicator	Delta cap	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-8.20%	-0.66	-17.78%	-7.44%

Indicator	Thermo cap	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-5.31%	-1.23	-4.82%	-4.82%

BTC Fund Holdings

Indicator	Digital asset holdings	**Strategy**	BBTF	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-7.30%	-1.17	-9.27%	-6.62%

Miner's Position Index

Indicator	MPI	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-5.40%	-1.02	-6.91%	4.87%

Market Value to Realized Value

Indicator	MVRV	**Strategy**	BBMR	
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-10.02%	-1.17	-13.43%	-9.11%

Spent output profit ratio

Indicator	SOPR	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-5.83%	-0.77	-11.69%	-5.29%

Indicator	a_SOPR	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	2.31%	0.43	-9.78%	2.08%

Indicator	STH_SOPR	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-7.89%	-1.38	-8.21%	-7.16%

Indicator	LTH_SOPR	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-0.086%	-0.036	-10.4%	-0.078%

Stablecoin supply ratio

Indicator	stablecoin supply ratio	**Strategy**	BBMR

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-6.81%	-0.88	-13.22%	-6.18%

Exchange stablecoin ratio

Indicator	stablecoins ratio	**Strategy**	BBTF

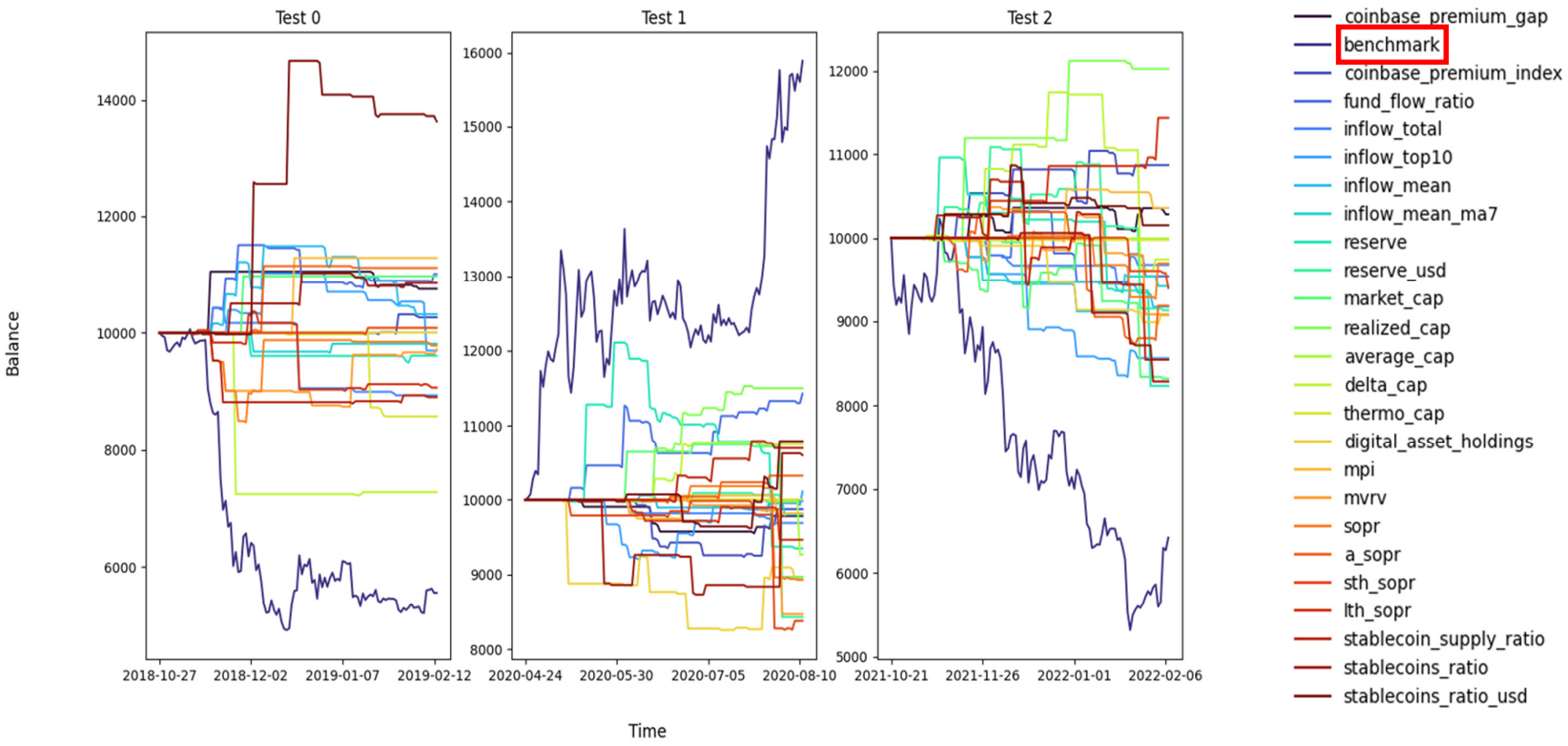
Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	-0.96%	-0.043	-14.98%	-0.87%

Indicator	stablecoins ratio USD	**Strategy**	BBTF

Duration	**CAGR**	**Sharpe Ratio**	**MDD**	**Total Profit**
330 days	16.93%	1.41	-17.00%	15.19%

Performance Summary

Figure 4. Balance chart for each indicator vs benchmark



4. Conclusion and Discussion

There were 3 criteria that were used to evaluate an indicator's performance - CAGR, MDD, and Sharpe Ratio, and the results were compared with the benchmark performance which is a buy and hold strategy for a given period. When the indicator's performance was compared with benchmark using CAGR, MDD, and Sharpe Ratio the indicators outperformed the benchmark as shown in the table below. However, it is clear that certain indicators are not suitable to be used alone to generate a trading signal such as MVRV (market value to realized value, CAGR: -10.02%, MDD: -13.43%, Sharpe Ratio: -1.17)

Average performance vs benchmark

	CAGR	MDD	Sharpe Ratio
Average of all the indicators	-1.95%	-10.44%	-0.32
Benchmark	-7.8%	-45.4%	-0.65

Based on the balance chart in performance summary section, it is enough to suggest that the maximum loss is definitely better than benchmark but the maximum gain is also less than benchmark. However, the results in this study could serve as a preliminary filtering indicator. For example, the performance of realized cap as an indicator was impressive (CAGR: 13.07%, MDD: -10.38%, Sharpe Ratio: 2.07). Therefore, more sophisticated analysis techniques could be applied to find more information embedded in this indicator.

There are many components in this research that could be improved and further investigated.

1. The result of all the backtest will completely differ when a different strategy is applied.
2. The parameter optimization algorithm could be refined as the current method is likely to be overfitted to the training data.
3. There are also numerous other indicators are not included in this study.
4. The timeframe used in this study was daily data. Therefore, the amount of training and test set was rather limited. Higher timeframes such as 1 hour could be investigated in the future, which will yield data.

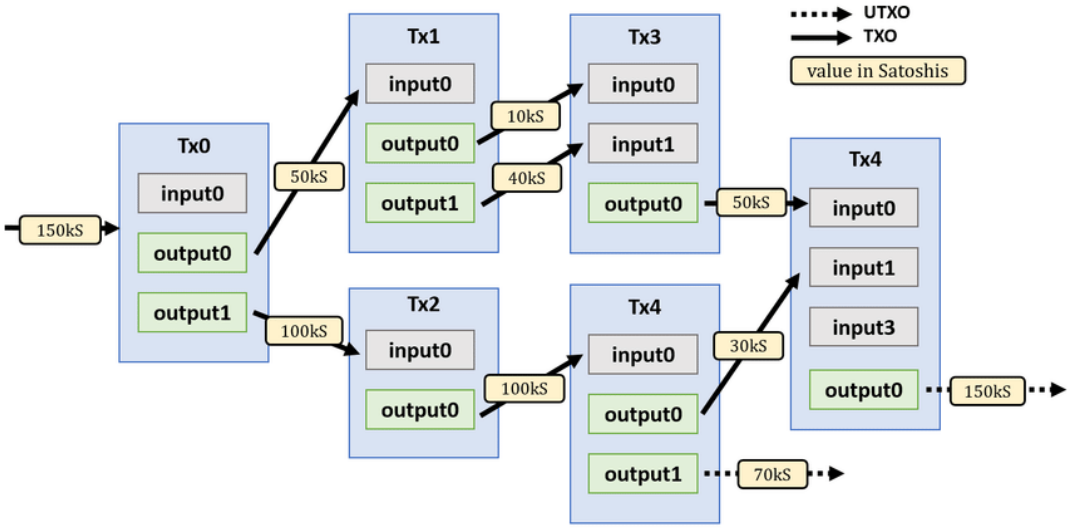
5. The strategies were made only based on one indicator. In the future, trading strategies to use multiple indicators could be studied.

To conclude, recent advances in blockchain technology led to a rise in the volume of on-chain data. In this study, a list of indicators were selected by data provider and used to generate a simple trading signal. Further research is required as the approaches are taken to generate a signal in this paper is very naïve and simple. However, the results were enough to conclude that on-chain data has some predictive power over Bitcoin's price.

5. Glossary

UTXO: Unspent Transaction Output

- Bitcoin network doesn't have any "wallet". Instead blockchain keeps record of inputs and outputs of every transaction.
- Therefore, in order to calculate the balance of a public key, you can add up all the inputs and outputs in the network for a certain public key.
- UTXO refers to coins that are not spent/sent to others.
    - Example
        - Alice receives 10BTC
        - Alice sends 3 BTC to Bob
            - Transaction: Alice sends 3 BTC to Bob and 7 BTC to herself
        - UTXO of Alice would be 7 BTC as she has the right to spend 7 BTC.
            - In other words, 7 BTC requires Alice's signature to be spent.
- Making a transaction would consume previous UTXO and create a new one.



Source: https://www.researchgate.net/figure/An-example-of-UTXO-based-transfers-in-Bitcoin_fig6_334434726