

Evolving Money charting a way through price prediction: Rules Based Trading Models - TA volume 1

James (at Evolving Money)

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1 Introduction

In this introductory basic concepts and terminology document, we look at key concepts and terms in Technical Analysis for stock price prediction, and introduce a simple rules based trading model that uses those concepts. The model is developed specifically for trading Ethereum (a crypto currency), performance of the model over different time frames is studied. Based on the observed performance, improvements are made to increase the trading yield.

1.1 Charting the basics

Charting techniques attempt to find patterns in historical price data that can be used to help make better trades in the future. The underlying philosophy of why it can work, is that even though the future is unwritten, people tend to behave in the same way and make similar decisions, when presented with the same kinds of price information. The technique aims to look at past price data, and establish patterns in the data which enable the trader to produce forecasts of where the stock price is more likely to go next, and this helps the trader to make more effective trades when the predictions from the technique are good.

1.2 Reverting to the mean

A key idea in Charting and Technical analysis is that prices will over time eventually revert to a mean price (average price). If the price is high compared to the mean, it is a good time to sell. If the price is low compared to the mean it is a good time to buy. People use different kinds of averages, the most basic form of average uses all the price data. Other techniques use recent price data for example the last 50 days or 100 days of data. In section 2 moving averages are looked at more detail, and examples of trading rules using moving averages are provided. In the examples the Simple Moving Average (SMA) is used. It is also possible to have different kinds of averages that make use of weightings such that more recent price data is given more importance.

1.3 Resistance and momentum

1.3.1 Resistance

Resistance is an important concept in technical analysis. Moving averages are often use to describe price floors and price ceilings. If the current price falls below a floor price, it can indicate that a large drop is likely as the floor is broken. Similarly if the price exceeds a ceiling price, it can indicate that a larger rise is possible, as the ceiling is broken. There are no guarantees of course but these concepts can be use to establish turning points in a market where it switches from bull to bear or vice versa. In section 2 resistance concepts are used in the trading rules example table 9 to identify the probable market bottom and top. Floors a ceilings can be psychological barriers, such as if a price has never gone that low before (at least recently) for a price floor, and high for a price ceiling. Until perception changes the barriers are not broken, at least that's the concept.

1.3.2 Momentum

Momentum is another important concept in technical analysis. In general terms momentum refers to the ability of prices to continue to trend. When the prices lose momentum downward or upward, the price direction can change. There are two commonly used and related indicators Momentum (MTM) and Rate Of Change (ROC). MTM is the difference in price today and the price a chosen number of days ago. ROC is the difference defined by MTM divided by the number of days. The origins of Momentum trading can be traced as far back as the 1700s, (a British economist named David Ricardo is known to have used the technique in the late 1700s). In section 2 momentum (or strictly speaking ROC is used to augment the SMA based trading rules example defined in table 9 to improve upon them. MTM and ROC are used to find an additional rule that allows the market peak to be identified, but with the sale taking place closer top than with the basic SMA rules. Momentum comes about because the majority of traders believe the rally will continue, (or the crash). Media attention and herd behaviour are a ideas linked to the concept.

1.4 Disclaimer

Technical analysis techniques seek to improve the probability of making good trades in the future based on using past data, and making the assumption that in the future behaviours from the past will be repeated. There are no guarantees, as the future is unwritten. Different circumstances

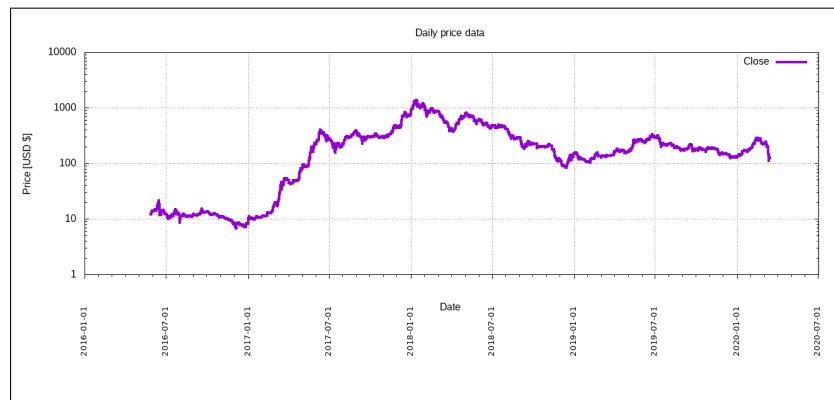
can come into effect that mean past behaviours are not repeated; behaviour also changes over time. The ideas presented in this document should not be construed as investment advice. This document seeks only to explain concepts in technical analysis using past data.

2 Applying the ideas to past data

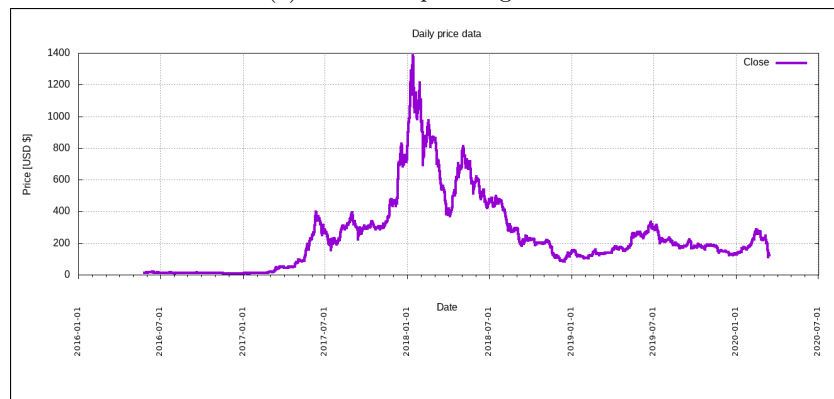
This section looks at how the ideas can be applied to past price data sets. In particular we look at where the techniques provided great insights into where the price would move next. Based on the observations some basic rules for trading are developed. These rules get embodied into a trading model, and performance of the model over different timeframes is studied.

2.1 Worked Example - Charting Ethereum

Crypto currency past data sets, like the Ethereum price data presented here, are interesting examples to look at because the price data is volatile, so there is a lot of rich information that allows us to look at different kinds of price movements.



(a) Ethereum price log scale



(b) Ethereum price standard scale

Figure 1: Ethereum price data 2016 to 2020

In this price data set there are several regions of strong price appreciation (or bull markets). The one that stands out on the standard graph is from August 2017 to Jan 2018. The price rose from roughly 260 USD to a peak at 1400 USD (a growth of 480 percent, and a multiple of 5.8).

There is also another bull run that happened earlier in 2017. It ran from March 2017 to June 2017. On the standard graph the rise visually does not look as significant as the 2017-2018 bull run, but on the log graph it looks more significant. A good question to focus on is in which situation would a given investment yield a bigger return?

If we look closely at the 2017 bull run, we can see the price rises from roughly 10 USD to 400 USD (that is a growth of 3900 percent, and a multiple of 40, and it happened in less time). It can be very useful to look at data using log scales as you can more easily see trends in percentage change. Percentage change trends is the lens through which you should view things, (the objective is to achieve high percentage increase in price, not high price).

2.1.1 Summer bull market Ethereum March 2017 to July 2017

The Ethereum bull market in 2017 was a fantastic opportunity to make large percentage returns on investments, if you had bought at the bottom, and sold at the top. A key question is how can technical analysis techniques help you identify a bull market and help you maximise your chances of selling at the top?

The graphs below in figure 2 show the 2017 bull run. We will make use of some of technical analysis techniques and begin to answer that key question.

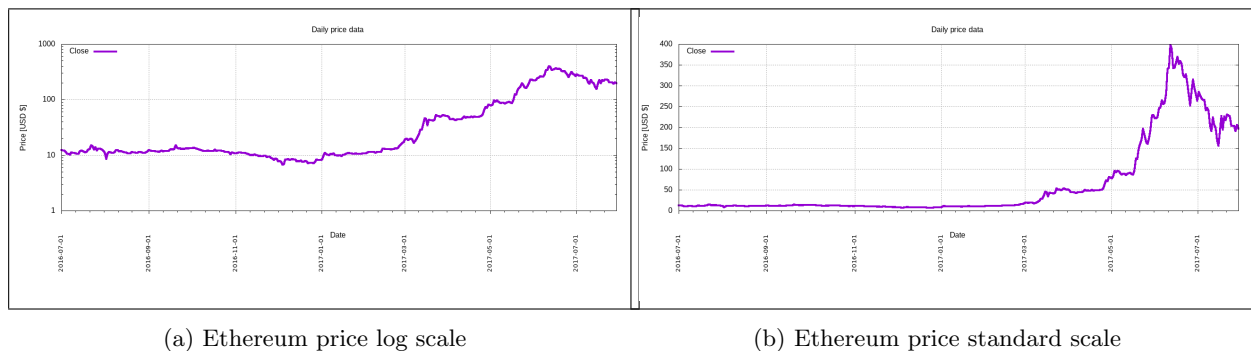


Figure 2: Ethereum bull market 2017

The first key thing to understand in the data in figure 2 is when the data confirmed a bull market. We will zoom in on the initial stages and look at how moving averages, momentum can help answer that question.

In figure 3 below, the 50 day and 100 day moving averages are plotted. Moving averages can help with decisions on good buy and sell times based on the idea of prices being likely to later revert to the mean. In the example below a good buy point would be to buy when the close price has fallen below and stayed below the 100 day Simple Moving Average (SMA); buying slightly later when it's started rising again and has risen back past the 100 day SMA can be better but it's hard to know how long the price will stay below the 100 day SMA (and time is as important as price). A good point to sell can be when the price subsequently falls back to the 100 day SMA, even better would be when it falls back to the 50 day SMA. It is hard to buy at the top, you only know where the top is after the price starts to fall again. Other metrics can also be used to try and sell closer to the top, for now we look only at the SMA by way of introduction of key concepts.

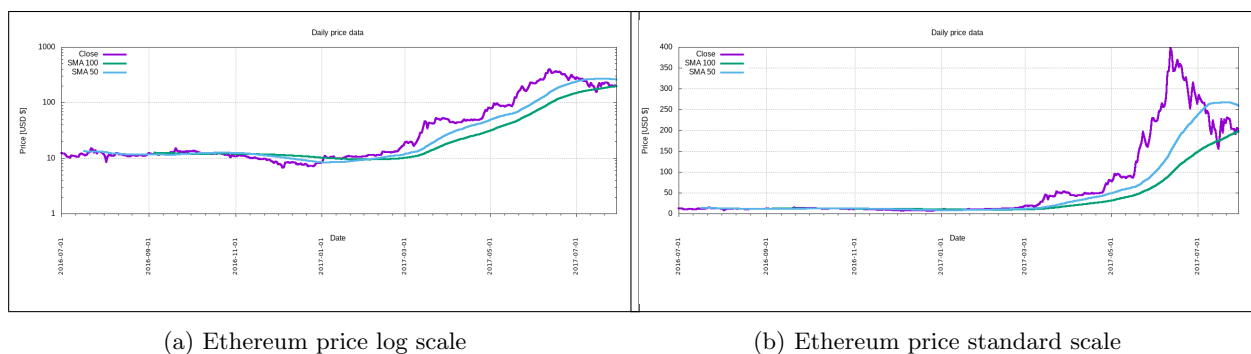


Figure 3: Ethereum summer bull market 2017 with 50 day and 100 day moving averages

If we want to make an algorithm we need to be a bit more formal about the rules that define the exact buy and sell points, an example of some more precisely defined decision criteria is presented in the table 9.

We can compare how much money would have been made trading with these rules compared with just buying and holding over the timescale in question.

Rule number	Rule	Rationale	Action and date
Rule 1	Buy only if price < 100 day SMA, and has remained below for > 5 days.	Identifies a probable market low	Condition achieved 01 Nov 2016
Rule 2	If rule 1 satisfied buy when price rises to > 100 day SMA and remains above for > 10 days. and only if the gradient of the 100 day SMA is greater than -0.5 USD/Day.	Identifies a probable rising market (bull market)	Buy 22 Jan 2017
Rule 3	Sell if price falls below 50 day SMA.	Identifies probable passing of a market peak and return to falling market (bear market)	Sell 10 July 2017

Table 1: Buy and sell example rules using moving averages

Date	Action	Balance \$	Balance ETH	ETH close price \$
01-07-2016	None	1000	0	12.3
22-01-2017	Buy Ethereum	0	91.84	10.78
10-07-2017	Sell Ethereum	18620	0	202.86

Table 2: Example trading with SMA rules summer bull Market Ethereum

In table 1 the dates of buy and sell actions are presented in column 4. It is interesting to understand how trading with these rules compares with just buying and holding. An example calculation is provided in table 2 to show how trading a starting amount of \$1000 would have progressed following these rules and assuming trading fees of \$10 per trade to make the maths easier

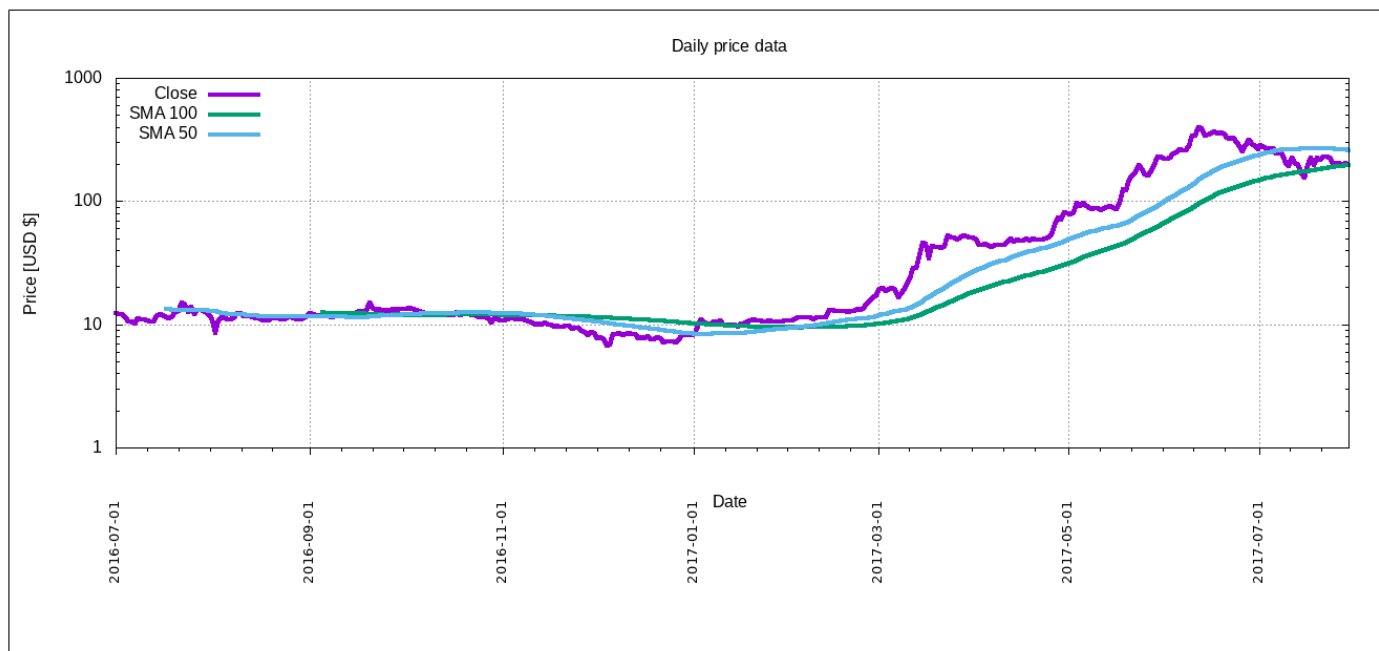


Figure 4: Ethereum price log scale (Summer 2017 bull market)

Trading with the rules in table 2, a starting balance of \$1000 is taken to \$18620. That is a growth of 1762%. Buying and holding over the same time frame would have also made good gains, but you would have been left buying and holding Ethereum in a rapidly falling market.

Date	Action	Balance \$	Balance ETH	ETH close price \$
01-07-2016	Buy	0	80.49	12.3
20-07-2017	None	0	80.49	226.0

Table 3: Buy and hold Ethereum summer bull market

Method	Starting balance \$	Final balance \$ equivalent	Growth %	Multiple
Buy and hold	1000	18190	1719	18.19
SMA rules trading	1000	18620	1762	18.62

Table 4: Trading strategy comparison Ethereum summer bull market 2017

Table 3 shows the prices for Ethereum at the beginning and end of the time scale in figure 2. Buying at the start would get you 8.49 ETH after fees. At the end of the timescale it would be worth \$18190.24, a growth of 1719 %. As mentioned before a good gain, but the risk is that you would be holding Ethereum in a bear market, and would need to decide to sell to realise the gains. If you held waiting for more growth it would have been disappointing (refer to figure 1).

Table 4 summarises the comparison of the rules based trading over a buy and hold strategy for the Ethereum 2017 summer bull market.

2.1.2 Winter bull market Ethereum Nov-2017 to Feb-2018

In table 1 example SMA based trading rules were introduced. These were derived by observation looking at the 2017 Ethereum summer bull market. It is interesting to see how they perform elsewhere in bull markets in the Ethereum price data set. The Winter bull market running from November 2017 to February 2018 is presented in figure 5. The trading rules are applied again here and the decisions and trading performance are tabulated.

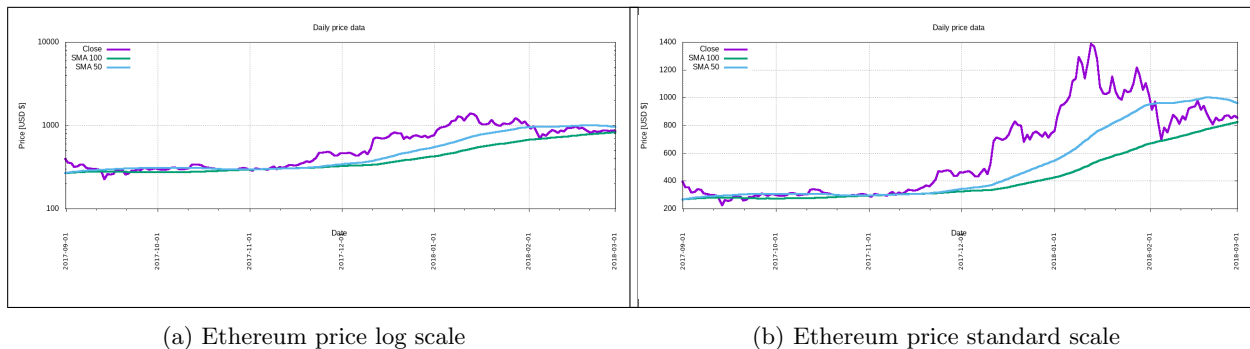


Figure 5: Ethereum winter bull market Nov 2017 to Feb 2018 with 50 day and 100 day moving averages

For convenience as in the previous example a starting balance of \$1000 and a \$10 trade fee are assumed to simplify the maths for the example. Trades determined using the SMA rules from table 9 are presented in table 5.

Date	Trading Action	Rationale	ETH Price \$	Balance \$	Balance ETH
01-09-2017	None	Start	392.87	1000	0
18-09-2017	None	Rule 1 achieved	298.0	1000	0
25-10-2017	Buy	Rules 1 and 2 achieved	296.76	0	3.34
30-01-2018	Sell	Rule 3 achieved	1054.39	3504.14	0

Table 5: Trading decisions using SMA rules Ethereum winter bull market

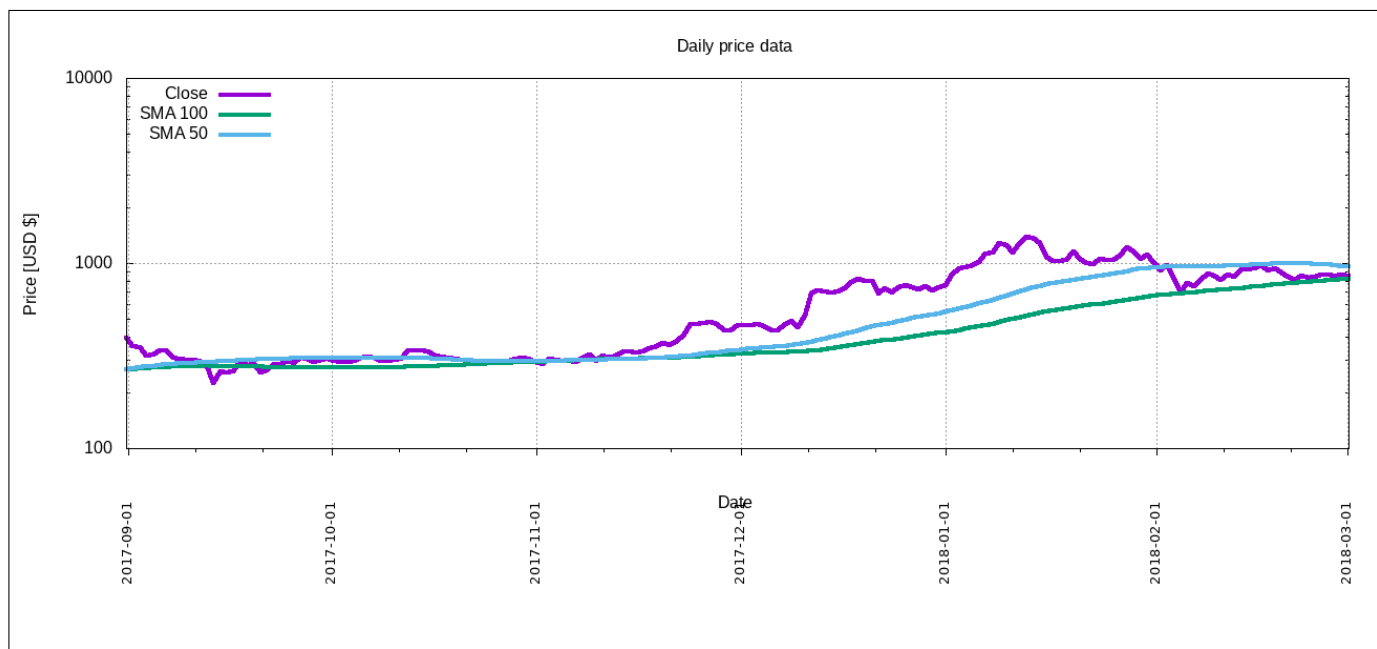


Figure 6: Ethereum price log scale (Winter bull market Nov 2017 to Feb 2018)

Date	Action	Balance \$	Balance ETH	ETH close price \$
01-09-2017	Buy	0	2.52	392.87
01-03-2018	None	2179.15	0	868.74

Table 6: Buy and hold Ethereum winter bull market

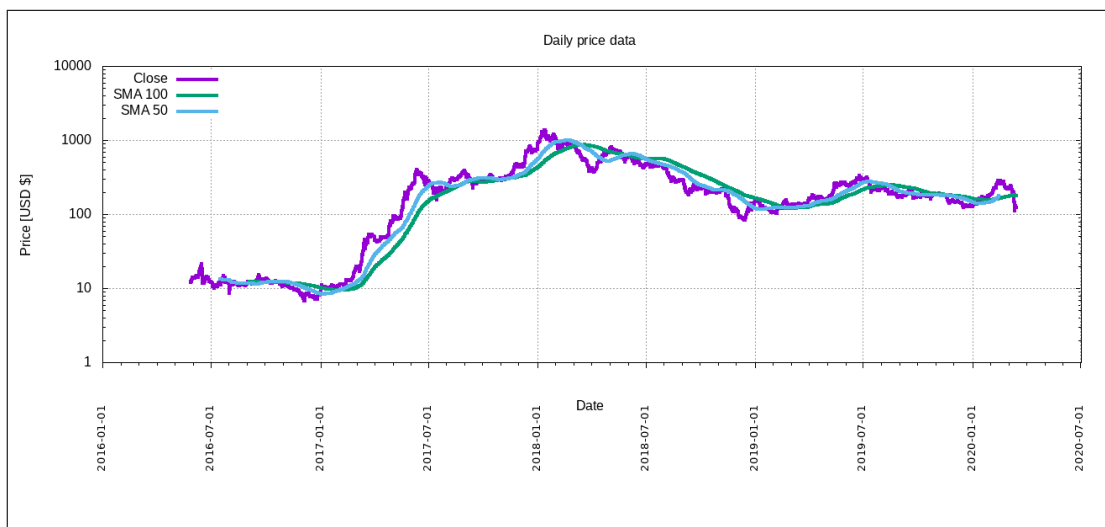
Method	Starting balance \$	Final balance \$ equivalent	Growth %	Multiple
Buy and hold	1000	2179.15	117.92	2.18
SMA rules trading	1000	3504.14	250.41	3.50

Table 7: Trading strategy comparison Ethereum winter bull market

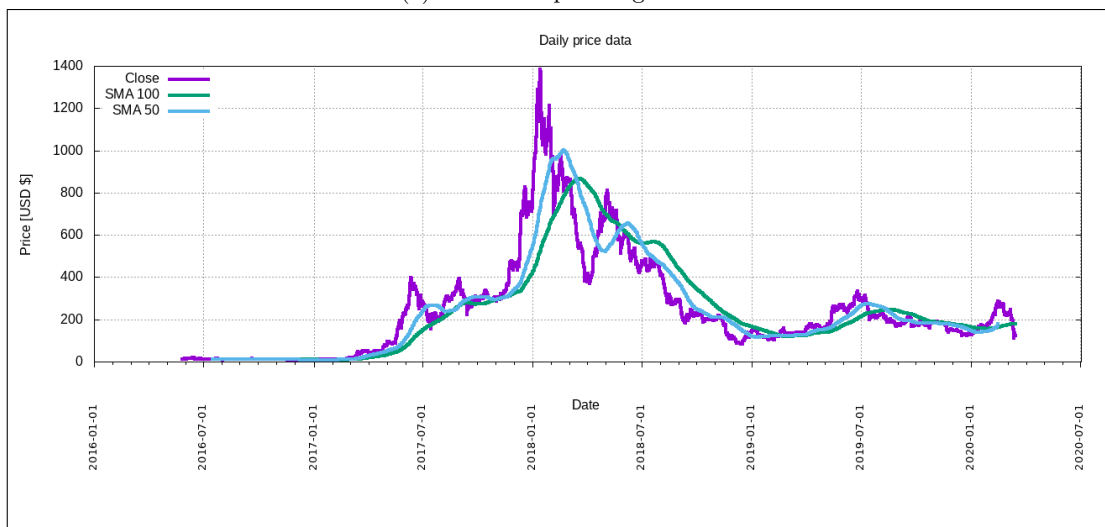
As with the previous example, the rules based trading outperforms simply buying and holding. In this example the differences between the two approaches are more substantial, although both approaches make money.

2.1.3 Performance of the rules based trading over the full maket 2016 - 2020

Rules based trading examples have been given for two periods of bull market (rising market) conditions from the Ethereum price data set. A remaining question is what would the rules based trading do in a bear market (falling market), would it lose money or not? What would the rules based trading do over the full price data set from 2016 to 2020? We look at the full market performance here, and tabulate the trades and performance. The price data for the full period from 2016 to 2020 is presented in figure 7.



(a) Ethereum price log scale



(b) Ethereum price standard scale

Figure 7: Ethereum price 2016 - 2020 with 50 day and 100 day moving averages

The rules base trading has been used over the whole period from 2016 through to 15 March 2020. The trades made from the decisions are tabulated in table 8. A starting balance of 5000 USD is assumed, per trade fees are assumed to be 10 USD to simplify the maths.

Date	Trading Action	Rationale	ETH Price \$	Balance \$	Balance ETH
27-05-2016	None	Start	11.25	5000	0
25-09-2016	Buy	Rules 1, 2 met	13.07	0	381.79
10-10-2016	Sell	Rule 3 met	11.78	4487.49	0
26-01-2017	Buy	Rules 1, 2 met	10.66	0	420.03
15-07-2017	Sell	Rule 3 met	167.72	70436.97	0
02-10-2017	Buy	Rules 1, 2 met	296.72	0	237.35
01-11-2017	Sell	Rule 3 met	290.82	69016.60	0
26-02-2019	Buy	Rules 1, 2 met	135.76	0	508.3
14-07-2019	Sell	Rule 3 met	225.76	114743.45	0
26-02-2019	Buy	Rules 1, 2 met	162.40	0	706.50
12-03-2020	Sell	Rule 3 met	110.30	77915.492	0

Table 8: Trading decisions using SMA rules Ethereum full market 2016 to 15 March 2020

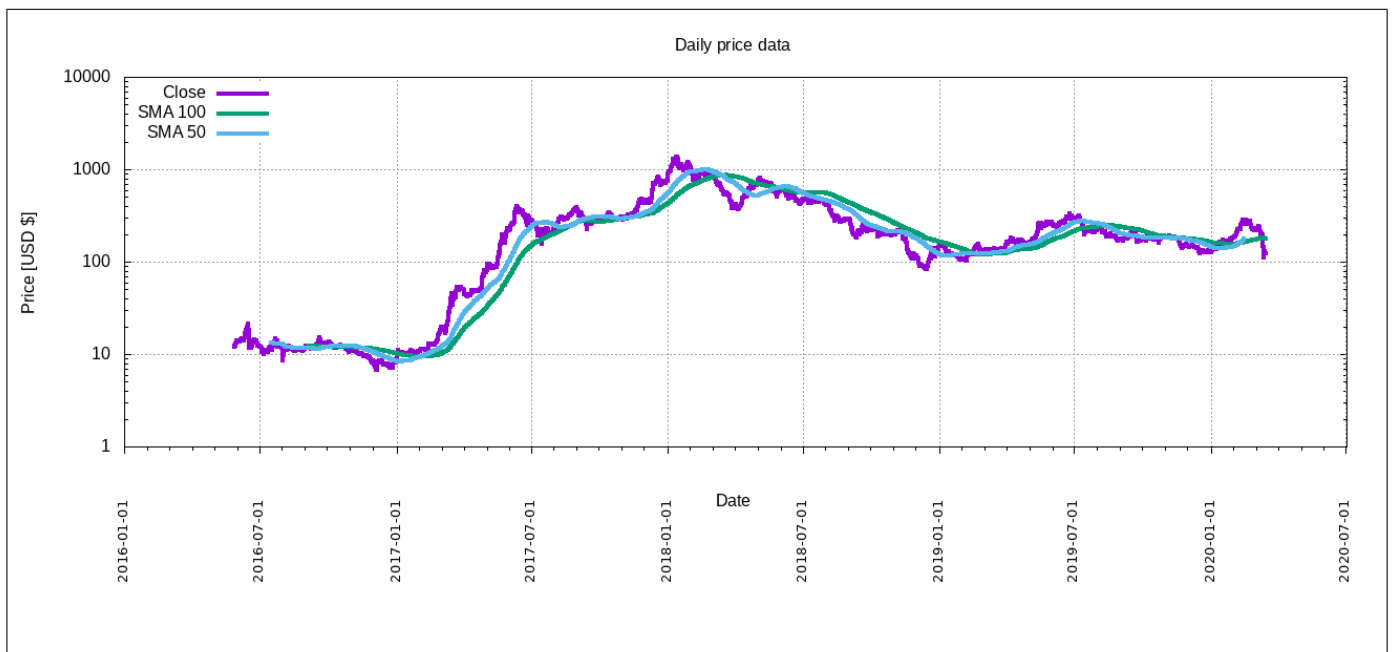


Figure 8: Ethereum price log scale (full market data from 2016 to 2020)

The rules based trading using the rules in table 9 has been on the whole reasonable successful, but not all trades have been good, there is room for improvement. The first trade makes a loss, gains could be higher if a way could be found to get it to sell closer to the top. More money could also be made by getting the buy trades to be placed closer to the bottom. Having said all of that it has performed better than buying and holding over the same time period. A big reason for that is selling out of the bear markets near the top and holding cash until a recovery (return to bull market is confirmed).

In figure 9 a zoom in on the bear market is provided, no trades are made in this time period (because the buy and sell rules are not satisfied). In figure 10 a zoom in on the year up to 15th of March is provided. This looks at an "interesting time" in the market, where there is the onset of a global pandemic and lock down. Potentially very different conditions to the previous time period where rules could break down. The rules sell out on the dip. Predicting a deep fall or a recovery because of unanticipated external influences is a hard game. The model rules will wait until the price data confirms a return to bull market. It will not buy the dip, there is an expression, "it's hard to catch a falling knife"; some people may be better at this than the algorithms. Alessio Rastani is a good place to go to get some more insights, he has a youtube channel, I'm a fan.

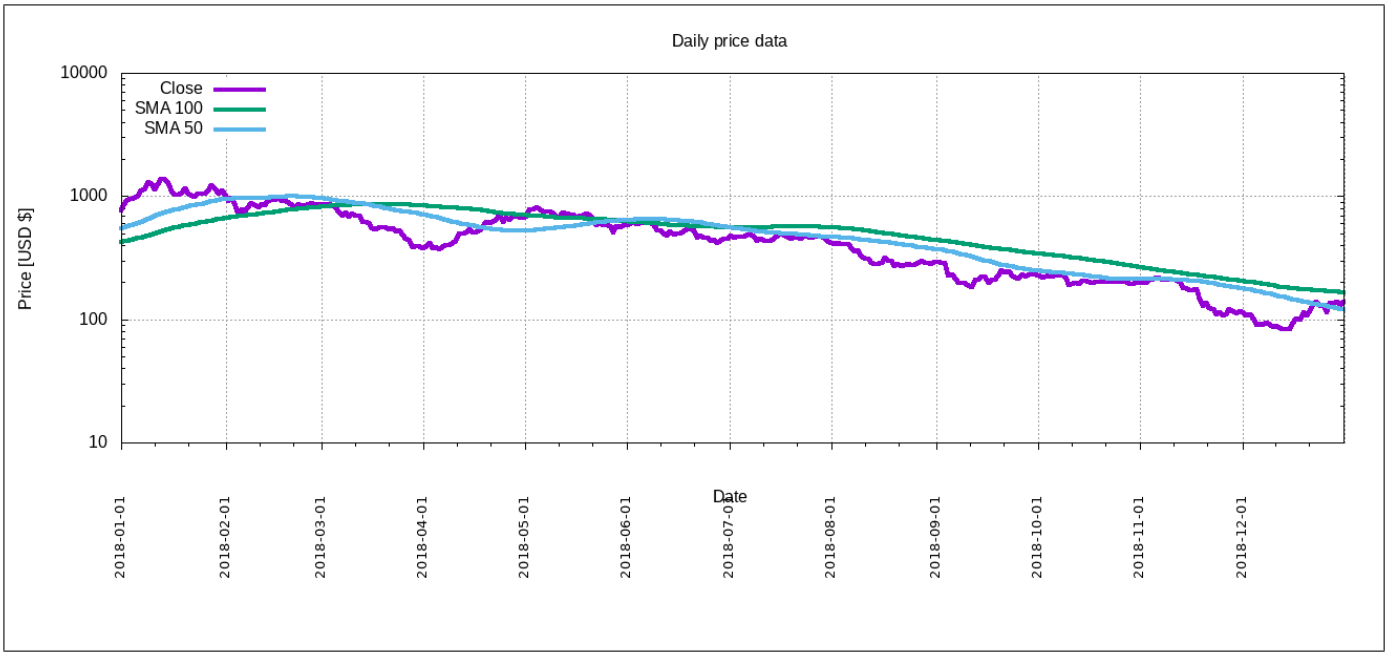


Figure 9: Ethereum price log scale (bear market zoom in)

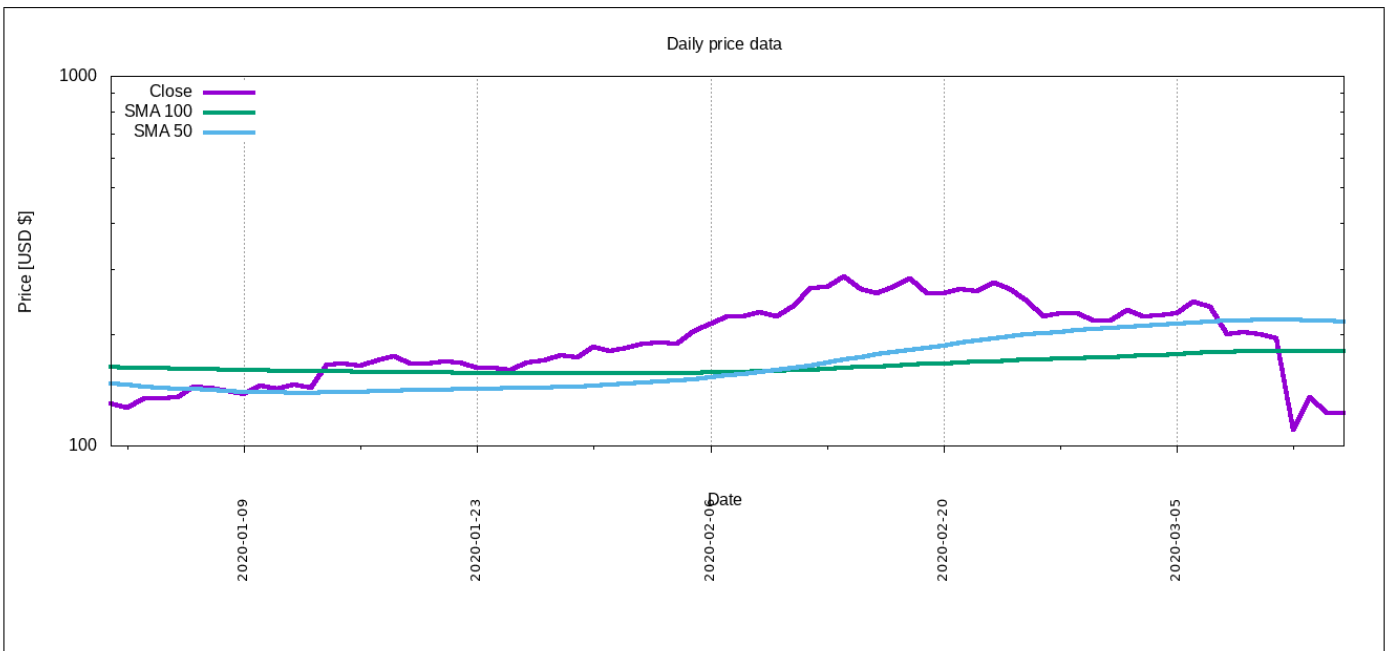
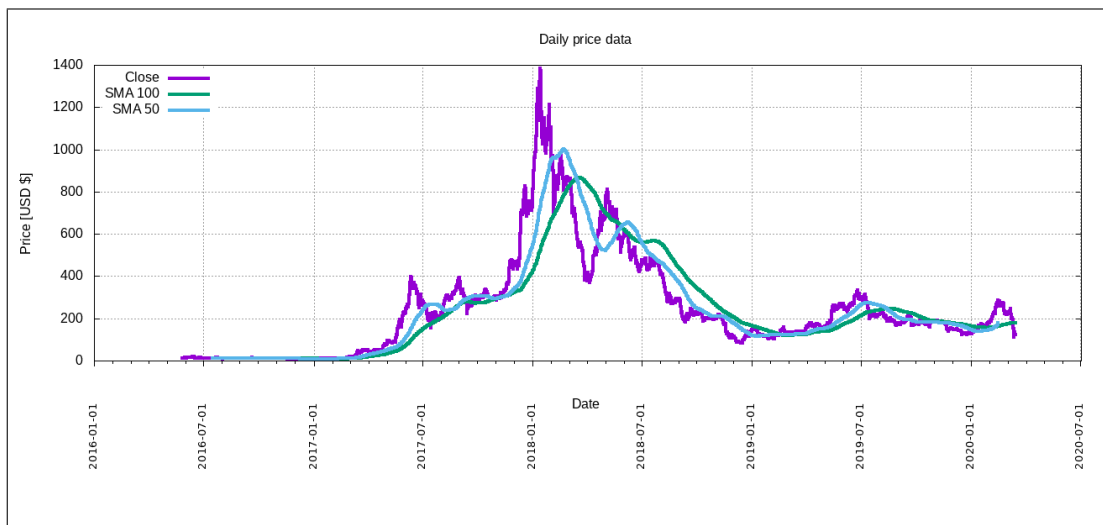


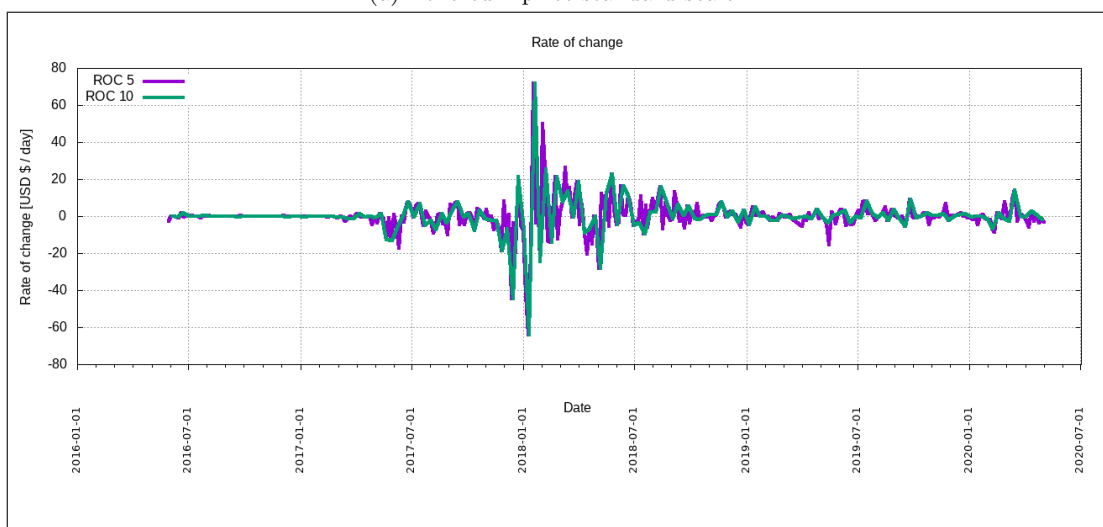
Figure 10: Ethereum price log scale (year to date zoom in)

2.1.4 Finding the top using momentum

A model improvement (an additional trading rule that could be made to enhance performance), would be something that would get it to sell closer to the top, but without selling to early and missing the peak. In this section, we look at improving on the 50 day SMA trigger with a momentum trigger.



(a) Ethereum price standard scale



(b) Ethereum price Rate of Change

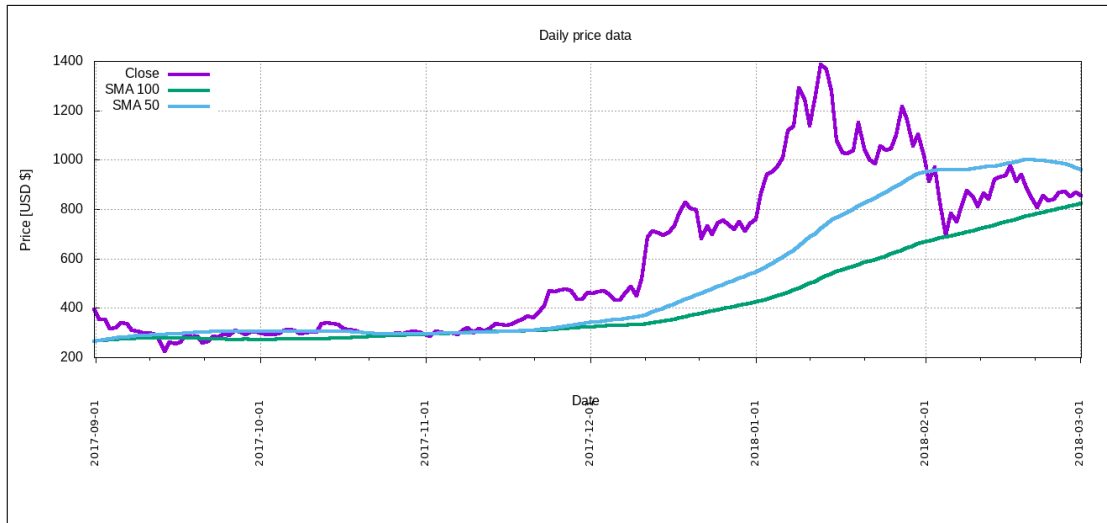
Figure 11: Ethereum price 2016 - 2020 with SMAs and Rate of change (ROC)

In figure 13b the rate of change in price over a 5 day and a day day time scale is plotted. Rate of change (ROC) and Momentum (MTM) were introduced at the beginning of this document in the introductory concepts. ROC can be used to help identify when a bull (rising) market has "run out of steam" and is likely to fall. ROC (on a sufficiently short timescale) can therefore be used as an advanced indicator of a market peak. SMA was used to identify peaks in the earlier model, but this is a lagging indicator. The peak is identified after it has happened. The challenge is with ROC you risk selling too early before the real peak in price, and with SMA you definitely sell to late because you sell post peak. However the right ROC timescale might get you closer to the actual peak.

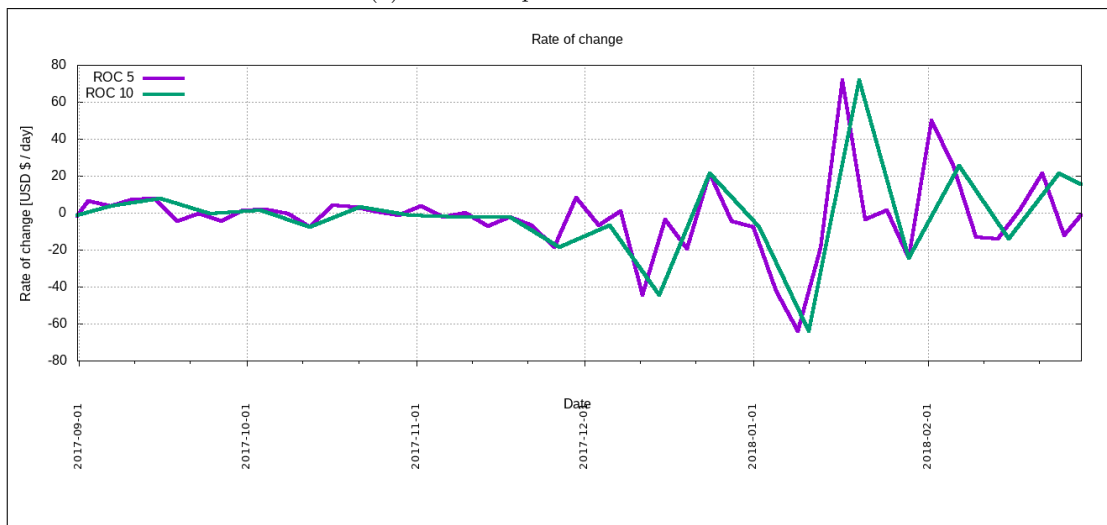
It can be seen from figure 11 that the ROC graph 5 day and 10 day variations follow very closely the price variations. A negative ROC means a falling market (at that point in time) and a positive ROC a rising market (at that point in time). The largest spikes in negative ROC occur at the point that the 2017-2018 Ethereum bear market begins. Using this observation, a trigger to sell can be set based on the idea that the ROC has become too negative. The 5 day ROC might be too volatile an indicator, the 10 day on the other hand might be better indicator. For example a rule

that a sell should be made if the 10 day ROC drops to -50 USD/day for Ethereum, could be an improvement on the previous rule to sell rule (to sell only when the close price falls below the 50 day moving average of close price). With ROC at 10 days, the ROC is lagging and sale will occur post peak, but it's more responsive than the 50 day SMA.

(Gradients of the 50 day SMA could also work for the current purpose, but by convention the terms ROC and MTM are more common, so the rules are for convenience derived based on MTM and ROC.)



(a) Ethereum price standard scale



(b) Ethereum price \$ Rate of Change

Figure 12: Ethereum price 2017 - 2018 bull market with SMAs and \$ Rate of change

Figure 12 presents a zoom in on the 2017-18 Ethereum bull market, plotting both ROCs, SMAs and the closing price. A sell trigger set at -50 USD/day would cause the sale to be enacted much closer to the true market peak than waiting for the close price to fall below the 50 day SMA. Additionally this threshold of ROC is only reached once in the timescale so a sale would not occur too early. A higher value or ROC would be too sensitive a trigger.

The problem with the ROC trigger as described is that only one trade would be made in the 2016 to 2018 period. Defining ROC in USD/day is not a relative measure. Really ROC needs to be defined as a percentage of previous average price to be useful.

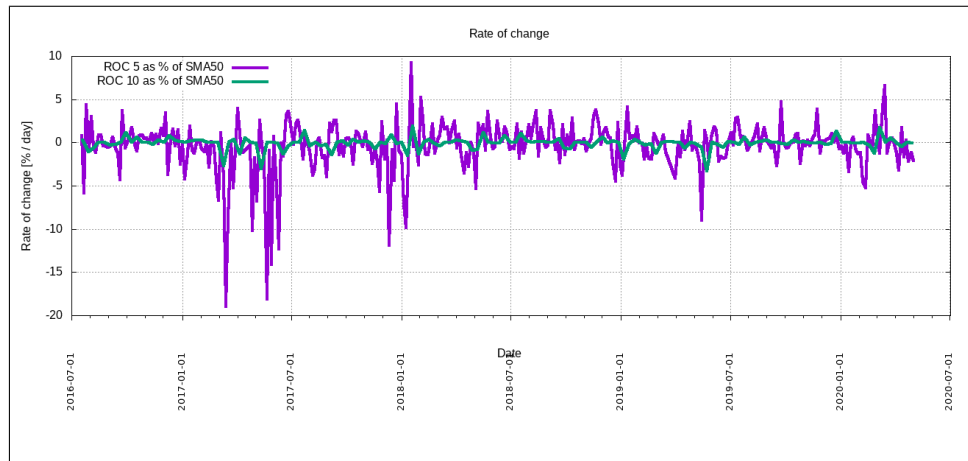
A revised version of the 5 day and 10 day ROC presented as a percentage of the 50 day SMA close price is presented in figure 13.

Rule number	Rule	Rationale
Rule 1	Buy only if price < 100 day SMA, and has remained below for > 5 days.	Identifies a probable market low
Rule 2	If rule 1 satisfied buy when price rises to > 100 day SMA and remains above for > 10 days. and only if the gradient of the 100 day SMA is greater than -0.5 USD/Day.	Identifies a probable rising market (bull market)
Rule 3b	Sell %ROC10 falls below -0.8%.	Identifies probable passing of a market peak and return to falling market (bear market)

Table 9: Upgraded buy and sell example rules using moving averages



(a) Ethereum price log scale



(b) Ethereum price % Rate of Change (5 day and 10 day)

Figure 13: Ethereum price 2016 - 15 March 2020 with SMAs and % Rate of change (ROC)

It can be seen in figure 13, that the percentage ROC is a better metric to use than the absolute ROC. Setting a sale trigger on the 10- day percentage rate of change at -0.8% would result in a similar number of trades to the 50 day SMA trigger, but with the sales occurring closer to the peaks.

Date	Trading Action	Rationale	ETH Price \$	Balance \$	Balance ETH
27-05-2016	None	Start	11.25	5000	0
25-09-2016	Buy	Rules 1, 2 met	13.07	0	381.79
12-03-2017	Sell	Rule 3b met	23.39	8920.08	0
26-07-2017	Buy	Rules 1, 2 met	203.23	0	43.84
12-01-2018	Sell	Rule 3b met	1260.00	55231.33	0
26-02-2019	Buy	Rules 1, 2 met	135.76	0	406.76
28-02-2020	Sell	Rule 3b met	227.37	92474.35	0

Table 10: Trading decisions using SMA upgraded rules Ethereum full market 2016 to 15 March 2020

With the improved rules \$5000 is traded up to \$92474, this is an improvement over the previous \$77915.5.

3 Conclusions

We have seen a rules based trading model using simple moving averages to make decisions on when to buy and sell. The model performs reasonably well, it makes money and outperforms a simple buy and hold strategy over the same time scales. It managed to take a starting investment of \$5000 in 2016 and trade up to a balance \$77915 in March 2020 (refer to table 8).

The model can be improved using momentum and rate of change to create an improved sale rule that causes the sales to occur closer to the peak prices, improving the returns from the trading model. With the improved model \$5000 was traded up to \$92474 in March 2020 (refer to table 10).

Rules based trading models are a first step on the journey. They are useful in helping to take emotion out of trading, and making decisions in a standardised way. The formal terminology for the current work would be that a basic moving average based trading model has been developed using back-testing on the Ethereum price data. An upgrade has been made on the basic model with a percentage rate of change sell rule.

3.1 Next steps...

The model presented in this document (TA volume 1) is basic, and it considers only a low frequency trading time-scale. It could be adapted to have buy and sell decisions on shorter time-scales (days to weeks) during the rising markets. It seeks to trade only the large market movements with timescales in weeks to months. The type of model presented here would in AI terminology be described as a rules based expert system. These types of model have been around a long time, even as far back as the 1970s. The problem with this kind of model is that it requires an expert to come up with the rules. In the next volume, we will start to look at improvement of the model using more sophisticated AI techniques (firstly with a Genetic Algorithm (GA)), and introduce additional trading on shorter time-scales to improve the gains made in the bull markets, by making trades that buy on low excursions from the rising mean and sell on the high excursions.

Technical analysis techniques seek to improve the probability of making good trades in the future based on using past data, and making the assumption that in the future behaviours from the past will be repeated. There are no guarantees, as the future is unwritten. Different circumstances can come into effect that mean past behaviours are not repeated; behaviour also changes over time. The ideas presented in this document should not be construed as investment advice. This document seeks only to explain concepts in technical analysis using past data.