2022 MCM Problem C: Trading Strategies

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Abstract

Our goal for this project is to develop the best investment strategy for gold and bitcoins. Using data collected from past streams of daily prices, the model has to determine when to hold, buy or sell to maximize the value in its portfolio of assets. By constructing and testing simple threshold, momentum trading, and simple moving average models, we find which model results in the greatest profit. We then conduct sensitivity analysis for our models to determine which is the most appropriate for an investor.

This paper will present our assumptions for each model, as well as an explanation of each of our models. We then run our models, finding the optimal profit for each trading method. Finally, we give our grand recommended model.

Table of Contents

Introduction 3

Assumptions 4

Models 5

Conclusion 10

References 11

Introduction

Our team was tasked with developing the best investment strategy for a trader based on the past values of gold, in troy ounces, and bitcoin, in bitcoins. The data consists of daily trading values from 9/11/2016 to 9/10/2021, pictured in the graphs below. There is a commission fee for each transaction, where we assume that $\alpha_{gold} = 1\%$ and $\alpha_{bitcoin} = 2\%$. Upon graphing our data, we can visualize overall trends.

Figure 1: Gold daily prices, U.S. dollars per troy ounce. Source: London Bullion Market Association, 9/11/2021

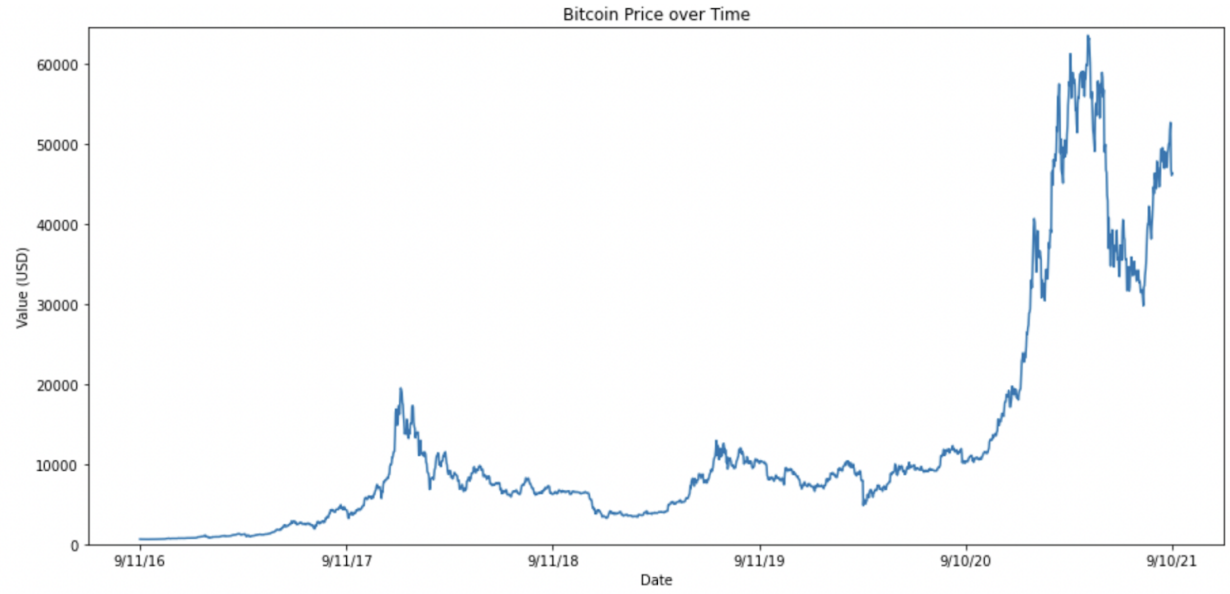


Figure 2: Bitcoin daily prices, U.S. dollars per bitcoin. Source: NASDAQ, 9/11/2021

Assumptions

The following assumptions are made in regards to our models:

1. There is only one fixed price for gold and bitcoins per day.
2. The gold market is either fully open or closed, i.e. it is never partially open or closed early. It is not open on weekends and various US holidays. Our models will reflect this schedule.[1]
3. The trader has no outside trading information and can only have their assets in either cash, gold, or bitcoin. While this is not realistic in actuality, it is needed to simplify our model and its applications.
4. The trader can only use the assets in their portfolio.
5. The trader cannot predict the future and thus cannot predict the decrease of value. They cannot sell before buying.
6. Bitcoin and gold are liquid assets. The trader can buy and sell any proportion of these stocks at any time.

[1] *Trading hours & holidays*. Holiday Market Hours | FOREX.com. (n.d.). Retrieved June 7, 2022, from https://www.forex.com/en-us/support/trading-hours/#:~:text=Spot%20Gold%20and%20Silver%20Market,5pm%20to%206pm%20ET%20daily.

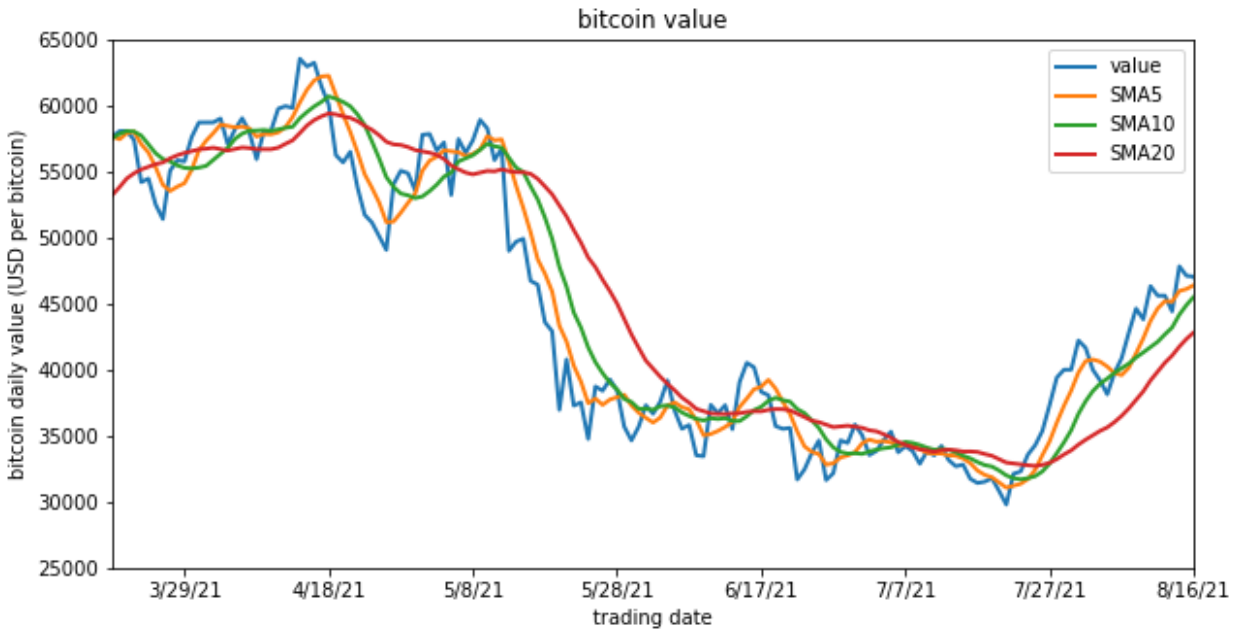
Models

Our first model uses thresholds to predict a stock's performance. Whenever a stock's percentage change is above the maximum threshold, the investor should sell their shares because their shares have already surpassed the initial purchase value. However, if a stock's percentage change drops below our minimum threshold, the investor should buy more shares in anticipation of rising value in future trading periods. Intuitively, stock values should be slowly rising over time, and any abnormal increase or decrease in price signals for the investor to wait until the next trading period. Nevertheless, one downside of this model is that the threshold has to be decided upon and set at the beginning. While this is beneficial in theory (due to the fact that it simplifies matters), it is unreasonable for the thresholds to be the same for over five years. On top of that, a small percent change in our thresholds can drastically change the total profit, so it is important to consider this sensitivity as well.

Our second model uses the principle of momentum trading. The concept is that market trends are more likely to follow their current trends than shift direction. This strategy is essentially the opposite of our first model. For momentum trading, the investor will buy shares no matter how high the stock value grows and sell when the stock's value enters a declining trend. The only threshold that this model considers is when to sell. However, momentum trading is risky. While theoretically market trends should be stable for trading periods, there can also be fluctuations as well. This all-or-nothing method is prone to large payouts or heavy losses.

Our third model uses a simple moving average (SMA) to predict the stock's trends.[2] The SMA is the arithmetic mean of a stock's value over a designated period, $SMA = \frac{A_1 + A_2 + \ldots + A_n}{n}$ where A_k is the price of an asset at day k and n is the total number of asset periods. Essentially, the SMA is a 'smoothed' trend line for a stock's value. We can plot the simple moving average for 5, 10, and 20-day intervals, and see the trend lines. An investor considers critical points in the simple moving average graph to be where there is a significant change in a stock's value compared to that period's average. A 'golden cross', for example, is whenever the short-term SMA crosses above the long-term SMA which indicates that the average stock value is increasing faster during that trading period compared to the more generalized average. A 'death cross' is the opposite and it occurs when the short-term SMA drops below the long-term SMA. Therefore an investor should buy more at golden crosses and sell at death crosses. As an example, the graph below is zoomed into the SMA graph for bitcoin for roughly the last 6 months of 2021. We notice that there is a death cross occurring around 5/8/21 and a golden cross around 7/27/21.

[2] Hayes, A. (2022, February 9). *Simple moving average (SMA)*. Investopedia. Retrieved June 9, 2022, from https://www.investopedia.com/terms/s/sma.asp



For our final model, we decided to combine the threshold and simple moving average models. This model, named the Bit MA Prioritization model, splits our initial cash amount into arbitrary divisions, and simultaneously invests those into a modified threshold model and a modified SMA model. That way, our model can act conservatively, because of the nature of the threshold model, but can also capitalize on any sudden changes, because it relies on the SMA model as well.

Sensitivity Analysis

After the initial model runs, we noticed a significant difference in the gross profit between gold and bitcoin assets. Therefore, we ran iterations partitioning our initial $1000 to gold and bitcoin shares, simultaneously running separate models, and then recording the total profit. For every model that we developed, bitcoin greatly outperformed gold, often tenfold or more. So, we decided to focus our models on the trading of bitcoin only.

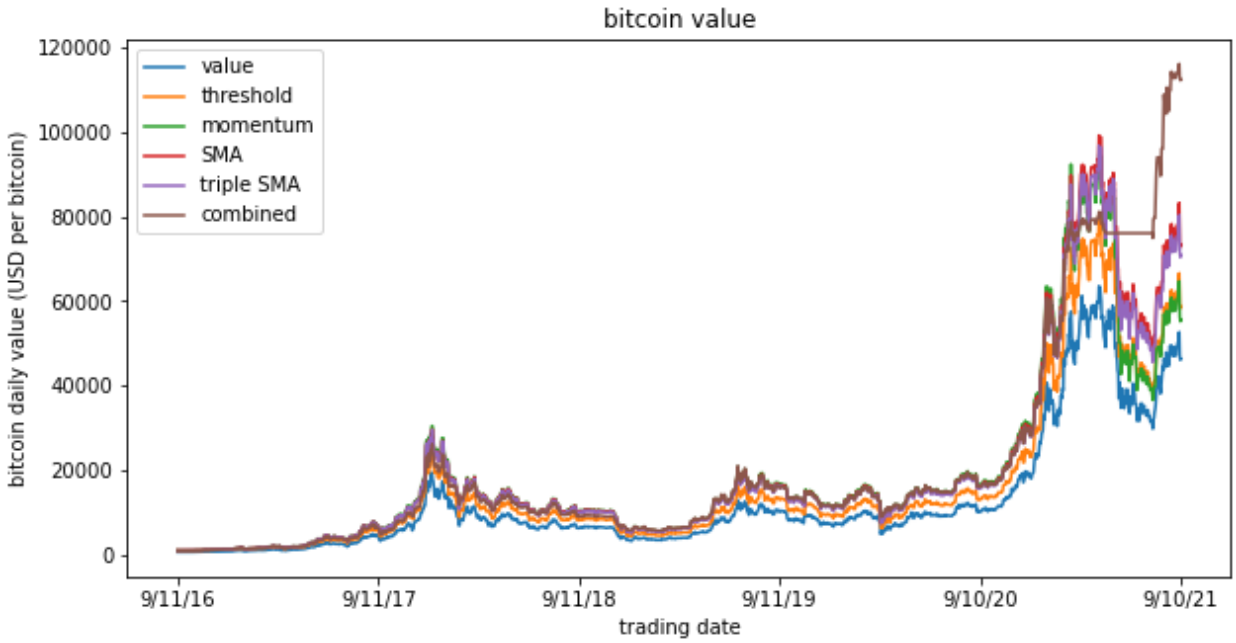
The threshold model results in the greatest profit when our maximum threshold is 60, our minimum threshold is -5, and we trade every 3 days. This version results in a **$63,56039** total of assets and a commission fee of **$436.46**. However, small changes to any of the parameters could drastically reduce our total profit.

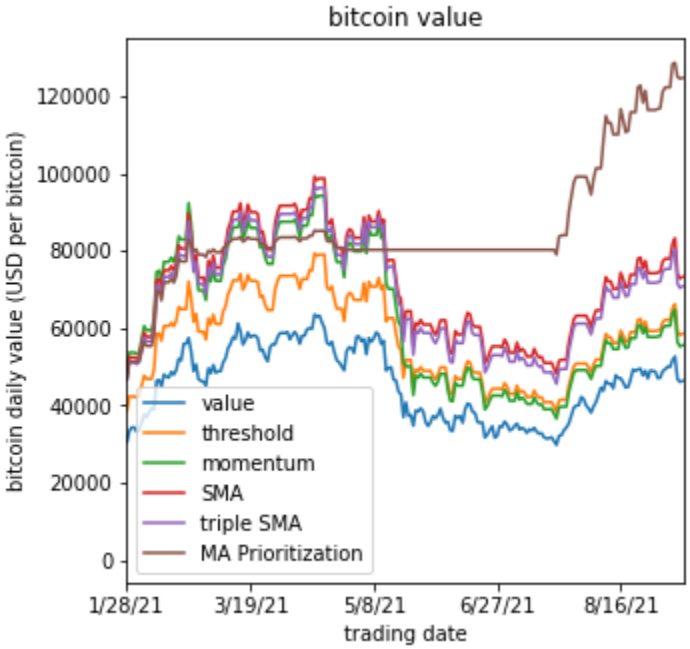
Our momentum trading model is optimal when we trade daily and sell 100% of our shares whenever the daily percent change significantly drops. This model gives **$55,582.92** in bitcoin shares. However, we incur **$10,367.84** in commission costs, which is a whopping 16% of our potential profit. This is because whenever our model sells, it sells our full share, so we incur large commissions.

On the other hand, our SMA model performs surprisingly well. We used a short-term average of 5 days compared to a long-term average of 20 days and found that if we traded daily, bought for 100% of our worth, and sold shares at 50% of their value, we maximized our profit, being **$73,296.51**. More importantly, we only incurred **$417.42** in commission fees, which is only 1% of our potential profit. This method was able to produce high profits while minimizing commission fees.

Next, we designed a model to compare 3 moving averages and make trades only if the two short-term averages cross the long one. This SMA is more conservative, as it only buys or sells if 2 averages are changing at once. Our best trial used a small-term average of 5 days, a medium-term average of 10 days, and a long-term average of 20 days. We bought at full price and sold shares at 5% of their value. This model profited **$70,844.23** and incurred **$343.31**. This is very close to our SMA model with only 2 moving averages. Because our profit is slightly less and our commission fees are slightly higher, we can conclude that using three moving averages, while safer, may have no evidence that it outperforms our original SMA model.

However, our combined model named the Bit MA Prioritization model, greatly outperformed our previous models. It predicted the drop in bitcoin price in 2021 the best and successfully held its assets in cash. Because of this, it profited **$124,763.57** and had a commission fee of only **$7,402.22**, which is roughly 6%. The graph below provides more information.





Here is a graph of the profits of our various models over time. We can zoom in on the last four months, and notice how our combined model successfully sold our bitcoin shares and bought back in when prices rose in September 2021. Our Bit MA Prioritization model performed the best when we used a maximum threshold of 420, a minimum threshold of -220, and 25% of our assets prioritized the modified SMA model, and 75% prioritized the modified Threshold model.

Conclusion

We developed a total of 5 models: threshold trading, momentum trading, simple moving average trading, triple simple moving average trading, and our combined model. After our initial runs, we noticed no matter how we partitioned our initial money into gold and bitcoin, bitcoin greatly outperformed gold. So, we focused our attention on solely trading with bitcoin. Next, for each model, we ran many trials to find the optimal thresholds, trading periods, and trading proportions. We conclude that the threshold trading strategy while profiting **$63,560.39**, may not be the best method on its own, because it is difficult for an investor to constantly adhere to these thresholds, and as we saw in our tests, small changes drastically reduce our profit. However, the final profit is impressive, and if used right, this model is helpful. The momentum model profited **$55,582.92**, but also incurred the most commission fees of any model, and is overall very risky for an investor, especially for such a volatile stock like bitcoin. Both of the simple moving average models performed similarly well, profiting around **$72,000** each, with very low commission fees. These models can easily be adapted if we choose to change our moving average trading lengths. However, it was our Bit MA Prioritization model that surpassed all of our previous models. By combining a threshold method with a simple moving average method, our final model could successfully tell when to sell shares and also took advantage of rising stock values and has a total of **$124,763.57.** Not only was this the most successful model, but it was also very helpful for an investor. It is flexible in its partitioning of funds and its thresholds. It also had very low commission fees, thus saving money for the investor. Overall, our bit MA Prioritization model is our grand recommendation.

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