2022 MCM Problem C: Trading Strategies

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Problem Statement and Background

1 Problem Statement and Background

- Create a model that maximizes a trader’s total profit based only on information from previous days’ prices
- Start with $1000 to invest and can only invest in either gold or bitcoin
- Start date: 9/11/2016
- End Date: 9/10/2021
- We will utilize concepts of moving averages to “buy low and sell high”

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Initial Assumptions

Initial Assumptions

- Our model's only knowledge is the previous value of an asset. We have no access to news, world events, economic developments, etc.
- Since gold is only traded on days the market is open (6 PM Sunday to 5 PM Friday and closed on holidays), we assumed that the value of gold on the days it was not traded is the same as the value of gold the previous day it was able to be traded.
- We make all trades trade exactly right after the market opens each day, since we only know the previous day's closing price.
- There are transaction costs for buying/selling which costs a set percentage of the asset traded.
    - The transaction costs for gold is 1%
    - The transaction cost for bitcoin is 2%
    - There is no cost to hold an asset
- We are starting with $1000 on 9/11/2016 and will be trying to increase the value of our portfolio as much as possible by 9/10/2021.

Price Prediction Model

3.1 Asset Predictions - Stochastic Baseline

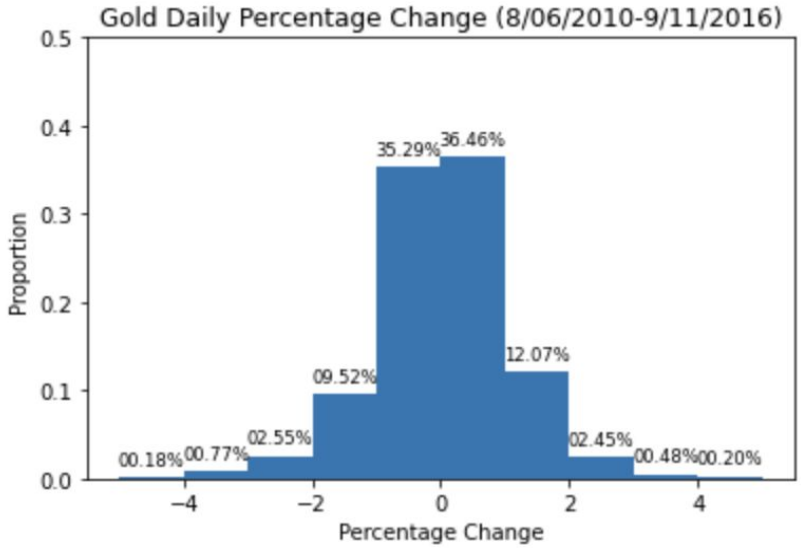
- Utilization of Stochastic Model for gold
  - Model predict future prices after a certain day using only prices up to that day. We plan to then use this model to base our buying/selling decisions on predicted future prices.
  - Model uses distribution of past gold and bitcoin’s daily percent change as the data we based our predictions on. This way, we can incorporate the randomness of each market into our predictions.

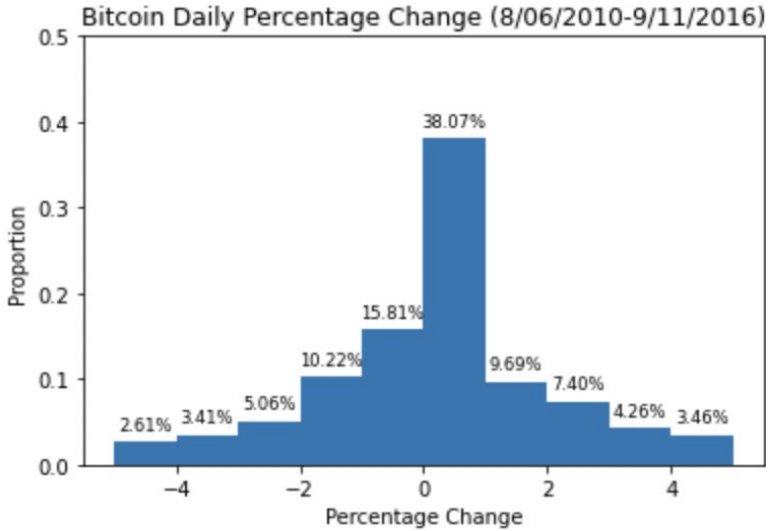
3.1 Asset Predictions - Stochastic Baseline

- Utilization of stochastic model for bitcoin
  - Uses distribution of daily percent change up to 9/11/2016 to simulate conditions of cryptocurrency market

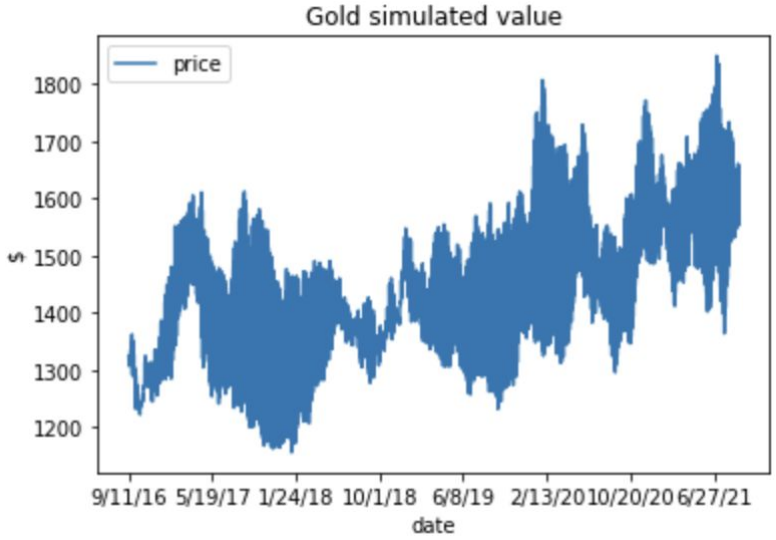
Date	Price	Open	High	Low	Vol.	Change %
Jun 10, 2022	1,842.60	1,849.80	1,850.95	1,841.75	-	-0.55%
Jun 09, 2022	1,852.80	1,855.10	1,857.80	1,841.90	131.29K	-0.20%
Jun 08, 2022	1,856.50	1,855.00	1,862.40	1,846.60	114.14K	0.24%
Jun 07, 2022	1,852.10	1,843.50	1,858.20	1,838.50	119.21K	0.46%
Jun 06, 2022	1,843.70	1,853.70	1,861.20	1,843.00	103.18K	-0.35%
Jun 03, 2022	1,850.20	1,872.60	1,878.60	1,849.70	115.34K	-1.13%

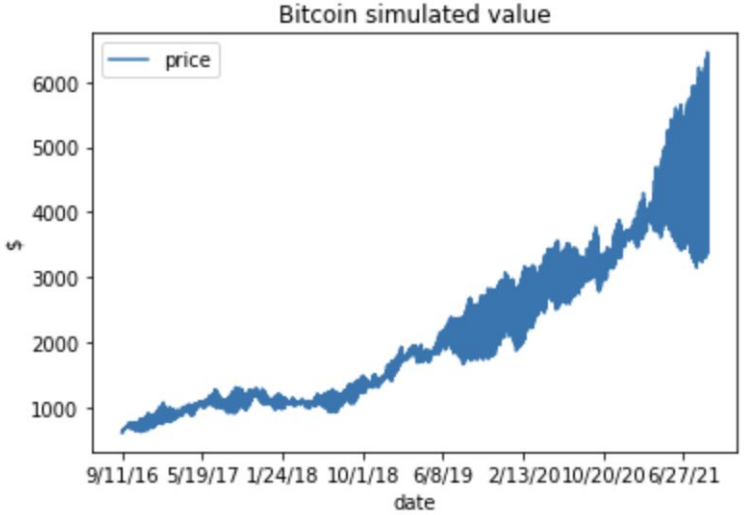
3.1 Asset Predictions - Stochastic Baseline





3.1 Asset Predictions - Stochastic Baseline





3.1 Asset Predictions - Stochastic Baseline

- Utilizing seemingly random change → inaccurate simulations of actual prices
  - Works better with stable markets with long history of % daily change
  - Does not work well with volatile/newer markets
- As a result, stochasticity is not a good approach
  - Random changes in price come from various causes
  - Does not update daily: the same prediction is used for the entire duration that we are trading over
  - Not enough information on bitcoin
- More deterministic approach
  - Good trading model should be able to update every day in order to account for the price information from the previous day
  - Moving averages

3.2 Moving Averages

- Only requires data from past asset prices
- Estimates the trend of the value of assets over a specified window of days
- Indicates the expected value of the stocks
    - Helps us predict whether to buy, sell, or hold
- Allows us to take advantage of variations in market

3.2 Moving Averages

$$MA_n = \frac{1}{14} \sum_{k=n-14}^{n} x_k$$

MA_n = Moving Average on day N

n = Number of days since 9/11/2016

x_k = The actual price of the asset on the *k*th day

3.2 Moving Averages

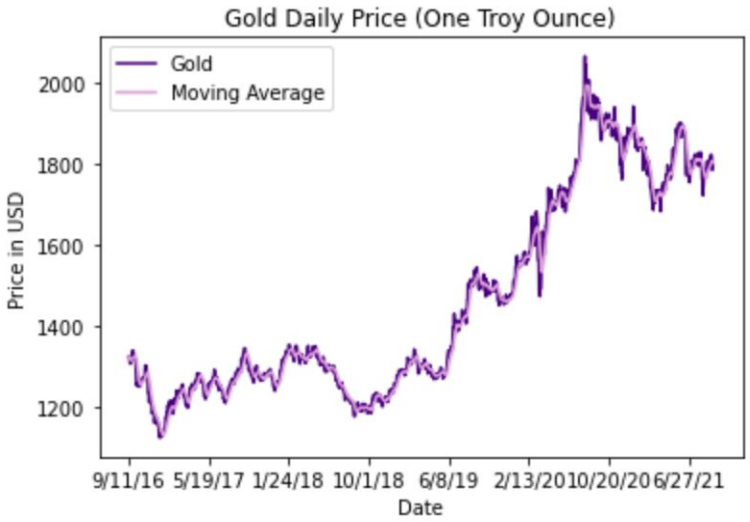


Figure 3.2.1: Gold daily price and moving average

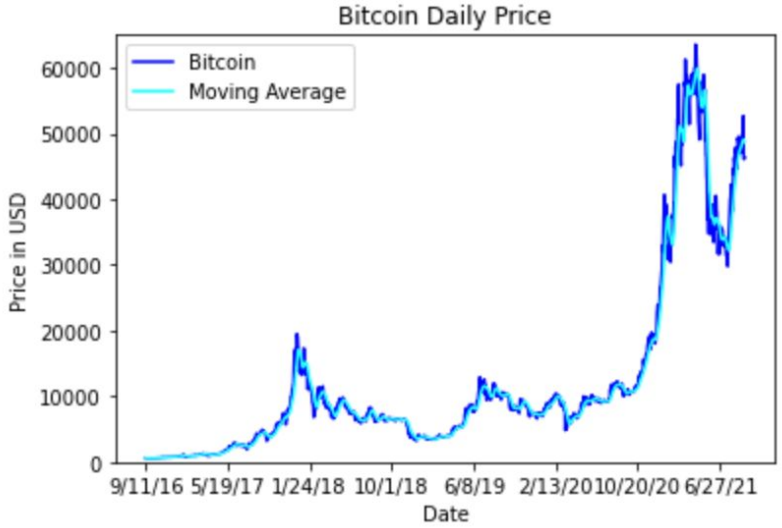
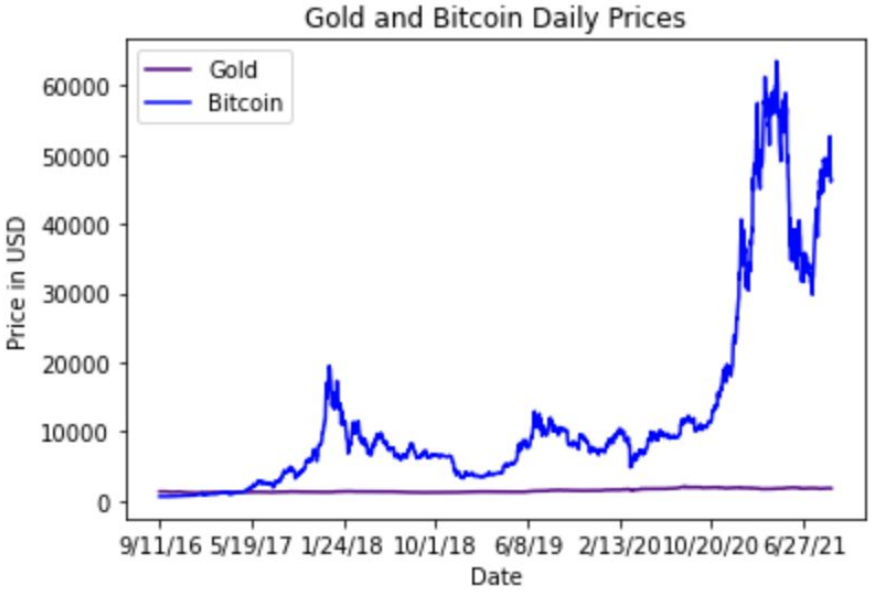


Figure 3.2.2: Bitcoin daily price and moving average

3.2 Moving Averages



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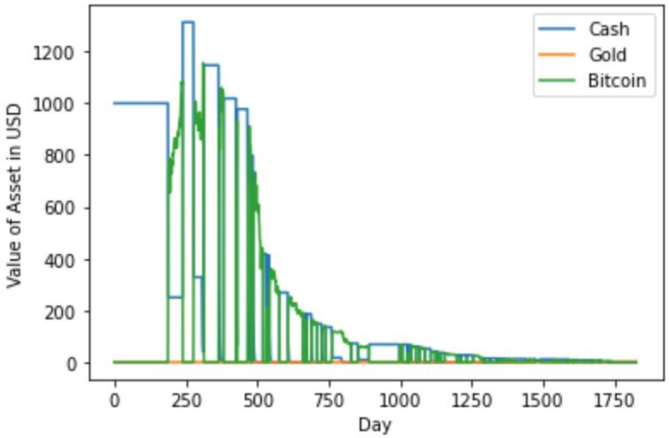
Update Assumptions

4 Trading Models - Moving Averages

- Update model's assumptions after previous revelation
- Our moving average uses $k = 14$ so that it examines the price of the previous 14 days in its calculations
- Now construct a model and continue to refine through iterations

Trading Model 1: Initial procedures

Trading Model 1: Initial buy/sell procedures



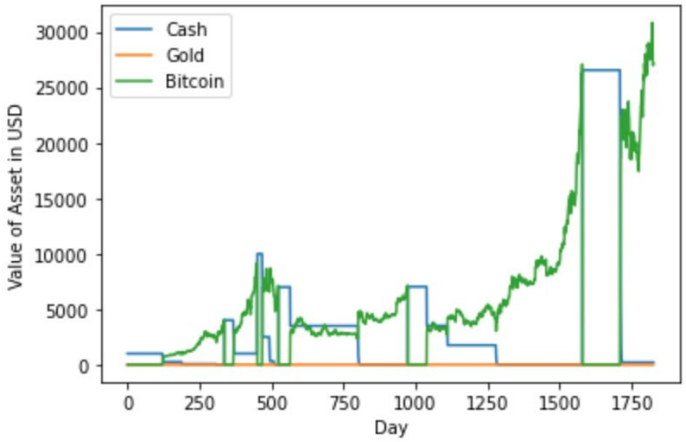
Trade Procedures:

- Gold price less than moving average by $75 or more
  - Buy gold with 50% of our cash
- Gold price more than moving average by $75 or more
  - Sell 100% of our gold
- Bitcoin price less than moving average by $200 or more
  - Buy bitcoin with 50% of our cash
- Bitcoin price more than moving average by $200 or more

- **Final Portfolio Value: $2.94**
- **Number of Transactions: 1,113**

Trading Model 2: Percent Differences for Thresholds

Trading Model 2: Use Percent Differences for Thresholds



- **Final Portfolio Value: $27,334.13**
- **Number of Transactions: 63**

Key Change: Look at Percentage Difference for thresholds

$$T_n = \frac{P_n - MA_n}{P_n}$$

T_n = Percentage Difference

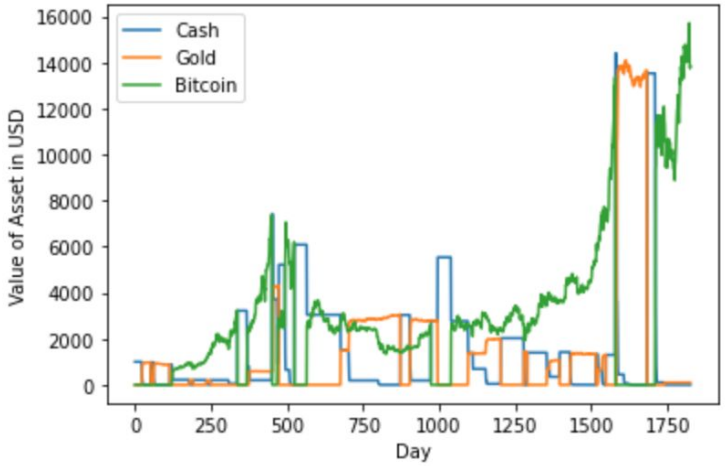
P_n = Actual Price of Asset on day *n*

MA_n = Moving Average on day *n*

	Gold	Bitcoin
Buy threshold	**-20%**	**-20%**
Sell threshold	**+20%**	**+20%**
Buy amount	50% of cash	50% of cash
Sell amount	100% of asset	100% of asset

Training Model 3: Changing Threshold for Gold

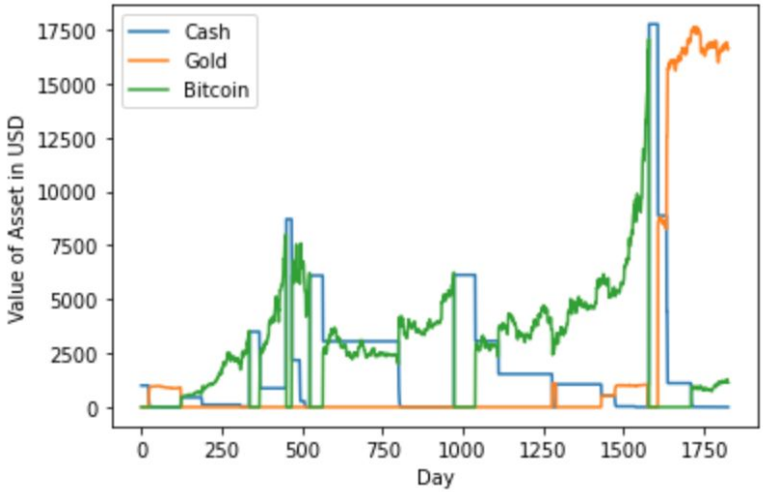
Trading Model 3.1: Changing Threshold for Gold



	Gold	Bitcoin
Buy threshold	**-2%**	-20%
Sell threshold	**+2%**	+20%
Buy amount	50% of cash	50% of cash
Sell amount	100% of asset	100% of asset

- **Final Portfolio Value: $13,931.00**
- **Number of Transactions: 311**

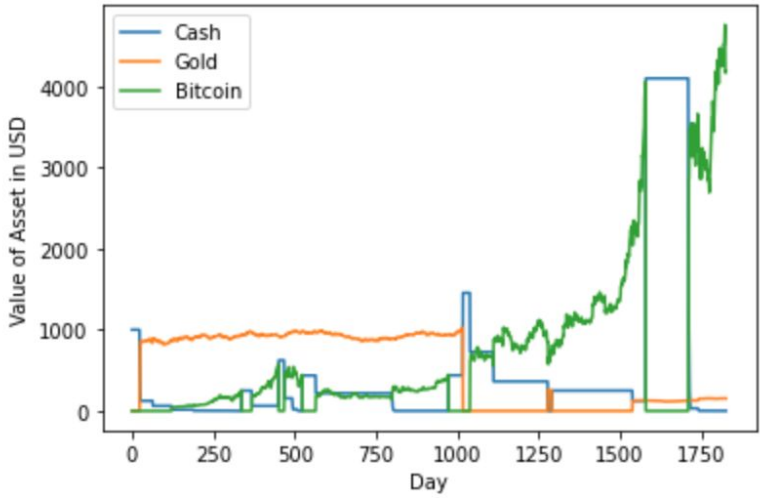
Trading Model 3.2: Changing Threshold for Gold



	Gold	Bitcoin
Buy threshold	**-3%**	-20%
Sell threshold	**+3%**	+20%
Buy amount	50% of cash	50% of cash
Sell amount	100% of asset	100% of asset

- **Final Portfolio Values: $17,770.20**
- **Number of Transactions: 152**

Trading Model 3.3: Changing Threshold for Gold

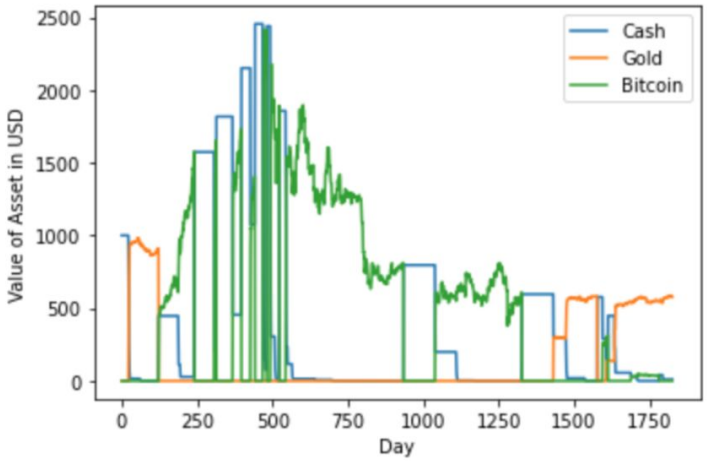


	Gold	Bitcoin
Buy threshold	**-4%**	-20%
Sell threshold	**+4%**	+20%
Buy amount	50% of cash	50% of cash
Sell amount	100% of asset	100% of asset

- **Final Portfolio Values: $4,321.69**
- **Number of Transactions: 100**

Training Model 4: Changing Threshold for Bitcoin

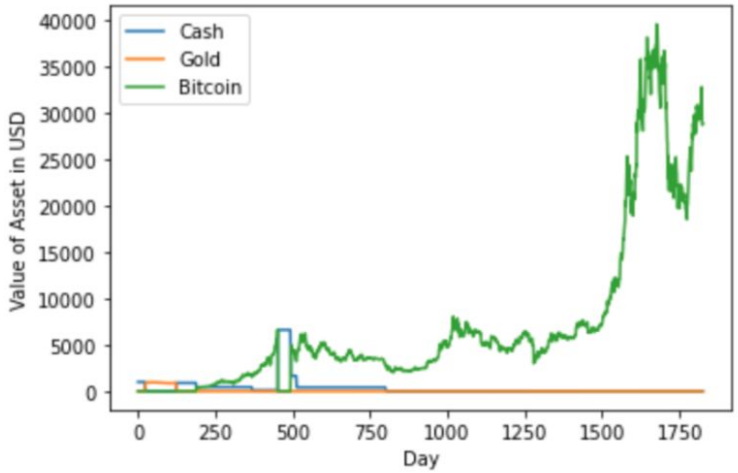
Trading Model 4.1: Changing the Threshold for Bitcoin



	Gold	Bitcoin
Buy threshold	-3%	**-15%**
Sell threshold	+3%	**+15%**
Buy amount	50% of cash	50% of cash
Sell amount	100% of asset	100% of asset

- **Final Portfolio Values: $586.57**
- **Number of Transactions: 242**

Trading Model 4.2: Changing the Threshold for Bitcoin

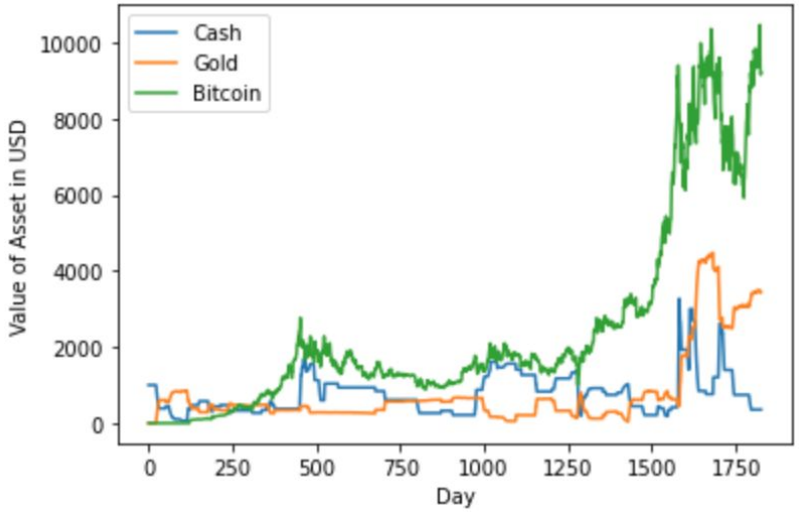


	Gold	Bitcoin
Buy threshold	-3%	**-25%**
Sell threshold	+3%	**+25%**
Buy amount	50% of cash	50% of cash
Sell amount	100% of asset	100% of asset

- **Final Portfolio Values: $28,847.89**
- **Number of Transactions: 115**

Training Model 5: Increasing Trading Frequency

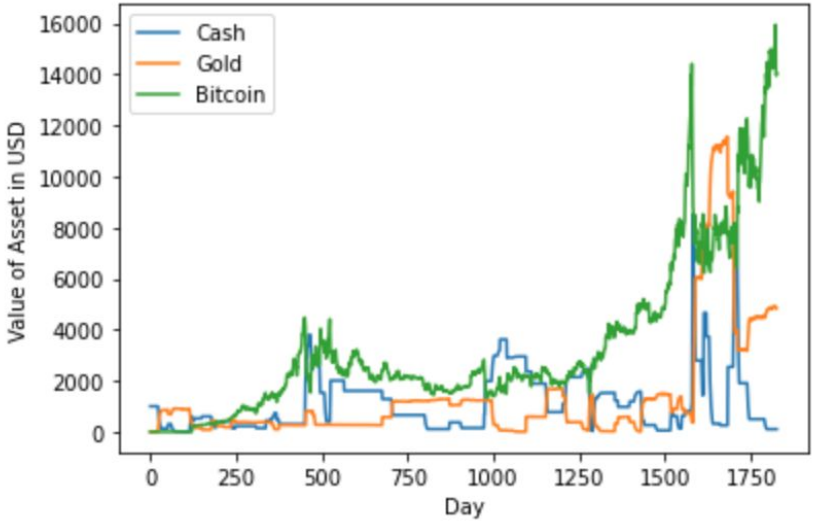
Trading Model 5.1: Increasing Trading Frequency



	Gold	Bitcoin
Buy threshold	-2%	-20%
Sell threshold	+2%	+20%
Buy amount	**10% of cash**	**10% of cash**
Sell amount	**10% of asset**	**10% of asset**

- **Final Portfolio Values: $13,005.39**
- **Number of Transactions: 311**

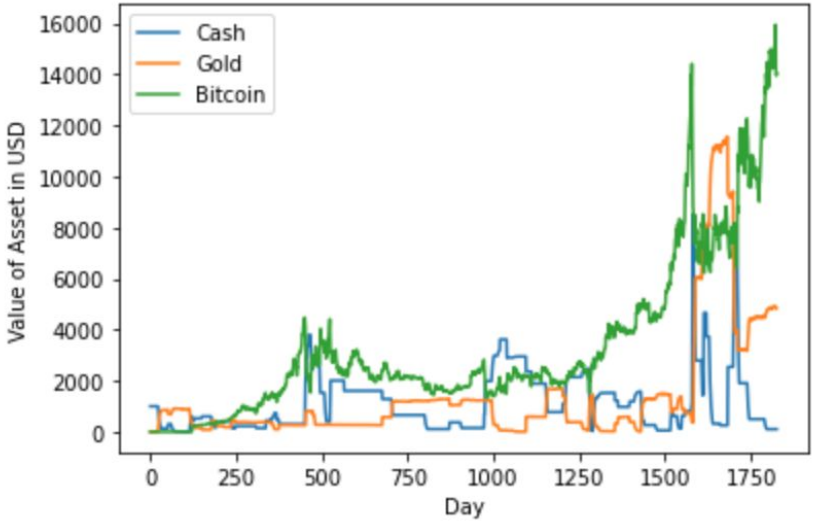
Trading Model 5.2: Increasing Trading Frequency



	Gold	Bitcoin
Buy threshold	-2%	-20%
Sell threshold	+2%	+20%
Buy amount	**20% of cash**	**20% of cash**
Sell amount	**20% of asset**	**20% of asset**

- **Final Portfolio Values: $18,988.26**
- **Number of Transactions: 311**

Trading Model 5.3: Increasing Trading Frequency

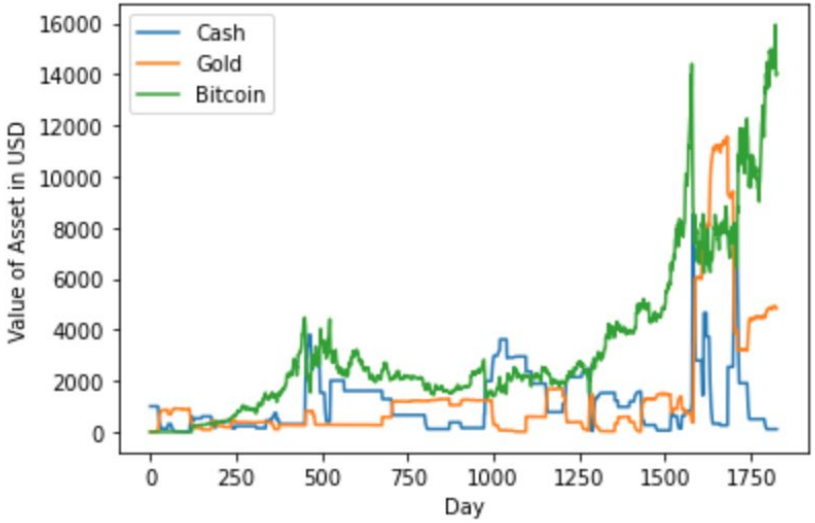


	Gold	Bitcoin
Buy threshold	-2%	-20%
Sell threshold	+2%	+20%
Buy amount	**50% of cash**	**50% of cash**
Sell amount	**50% of asset**	**50% of asset**

- **Final Portfolio Values: $18,793.73**
- **Number of Transactions: 311**

Training Model 6: Initial Diversification

Trading Model 6.1: Initial Diversification

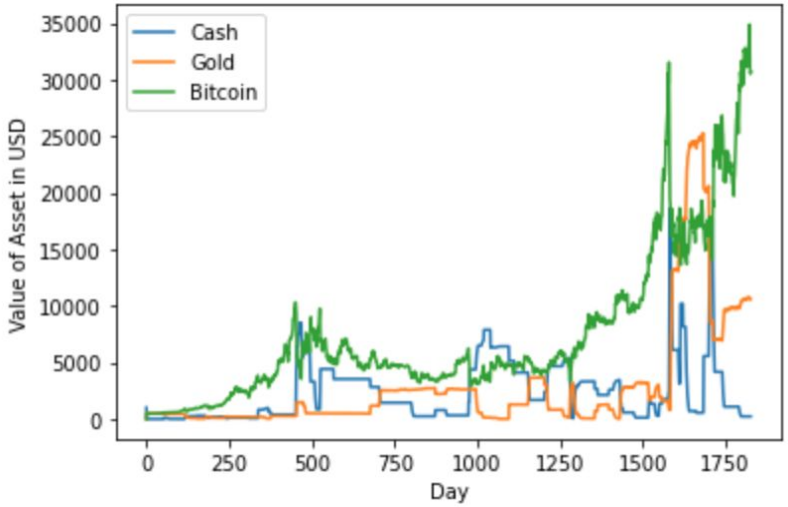


Key Change: We buy **$100** worth of gold and **$100** of bitcoin on the first day to diversify

*From Model 5.2	Gold	Bitcoin
Buy threshold	-2%	-20%
Sell threshold	+2%	+20%
Buy amount	20% of cash	20% of cash
Sell amount	20% of asset	20% of asset

- **Final Portfolio Values: $23,498.22**
- **Number of Transactions: 311**

Trading Model 6.2: Initial Diversification

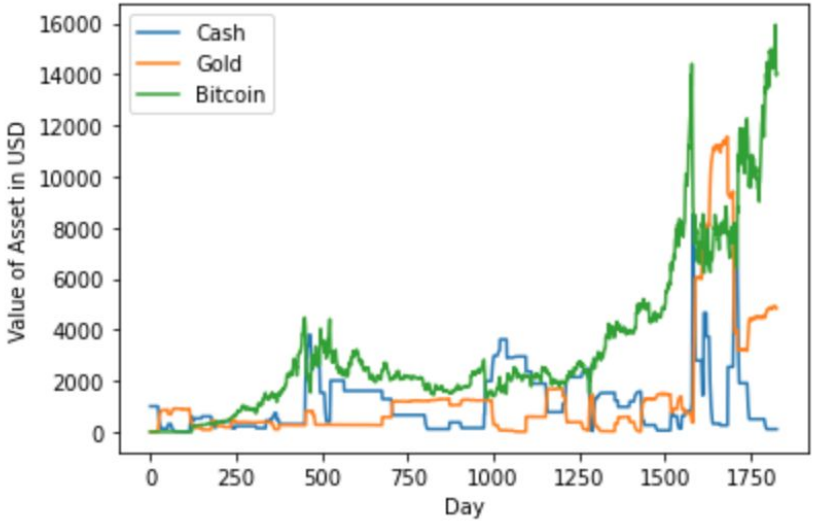


- **Final Portfolio Values: $39,283.12**
- **Number of Transactions: 311**

Key Change: We buy **$450** worth of gold and **$450** worth of bitcoin on the first day to diversify

*From Model 5.2	Gold	Bitcoin
Buy threshold	-2%	-20%
Sell threshold	+2%	+20%
Buy amount	20% of cash	20% of cash
Sell amount	20% of asset	20% of asset

Trading Model 6.3: Initial Diversification

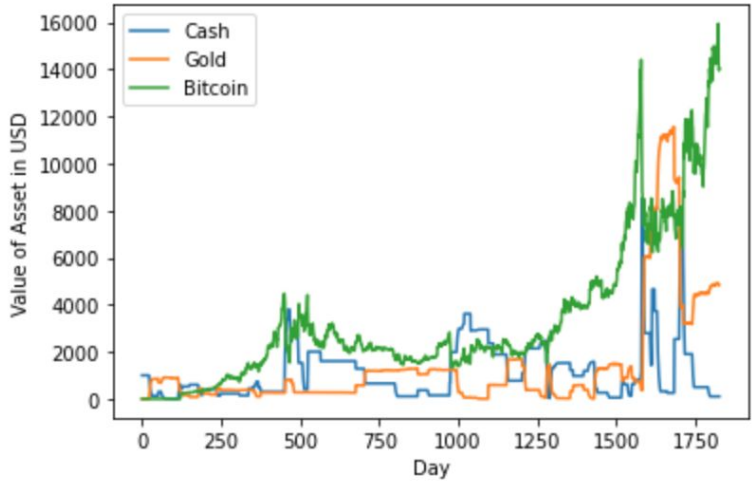


Key Change: We buy **$500** worth of gold and $**500** worth of bitcoin on the first day to diversify

*From Model 5.2	Gold	Bitcoin
Buy threshold	-2%	-20%
Sell threshold	+2%	+20%
Buy amount	20% of cash	20% of cash
Sell amount	20% of asset	20% of asset

- **Final Portfolio Values: $41,538.10**
- **Number of Transactions: 311**

Final Model



Initial Diversification: $500 gold, $500 bitcoin

	Gold	Bitcoin
Buy threshold	-2%	-20%
Sell threshold	+2%	+20%
Buy amount	20% of cash	20% of cash
Sell amount	20% of asset	20% of asset

- Trading Model 6.3 proved to be the most successful with a final portfolio value of $41,538 and 311 transactions
- Model 6.3 resulted in **gains of over 415%** from our initial $1000 investment

Analysis: Changes in Transaction Fees

- Gold Transaction Fee at 4% and Bitcoin Transaction Fee at 8%
  - Ending Value is $28,591.22, so we lost $12,946.88 due to elevated transaction fees.
- Gold and Bitcoin Transaction fees at 0%
  - Ending Value is $47,073.06, so we gain $5,534.96
- Since we are making a significant number of trades (311), adjusting the transaction fees has a significant impact on our ending values. But regardless, our model still turns a profit, even with larger transaction fees.

5

Conclusion

Conclusion & Summary:

- Price Prediction Model:
  - Stochastic model leads to inaccurate results
  - Deterministic model using moving averages is more accurate
- Trading Model:
  - Initial trading model
  - Used percentage difference thresholds for sell/buy conditions
  - Lower thresholds for gold since it's less volatile
  - Increased trading frequency
  - Initial diversification to make more money when not trading
  - Transaction fees affect profits proportionally
- 9/11/2016 Portfolio Value: **$1,000**
- 9/10/2021 Portfolio Value: **$41,538**