Problem Chosen	2021 MCM/ICM Summary Sheet	Team Control Number
C		2227113

Our approach to this problem includes simplifying the problem to determining a set of everyday investing operations that optimize long-term profits, where we introduce a mathematical model that calculates the most profitable and most practical daily trading strategy based only on prices up to that point in time and $1000 cash on 9/10/2021 as a starting point.

We first consider our assets allocation first hand to guarantee that it could avoid the situation where our operations are so risky that we lose large amounts of money in a very short period of time. Moreover, we want to maintain the flow of our assets so we can avoid the situation in which we run out of funds when we want to buy bitcoin or gold at their buying climates.

After making sure our distribution of our assets are in a safe range, we then create another sub model called Decision-Making Model in order to decide which operation we should use. In this sub Model, we could only get general command of operations, meaning that we could only make the qualitative command where we could simply buy or not buy, sell or not sell instead of making precise decisions about how many we should sell or how many we should buy.

As linked with the Decision-Making Model, the next sub-model called Rational-Decision Model, gives quantitative information of how many we should buy and how many we should sell. This model counters for three factors,

- How many times continuous increase or decrease
- The distribution of our assets
- Measure how many money we could profit from selling

Therefore, we decided to construct a sub Model called the **BGC Model**.

And for each of the three factors, we generalize the relationship of how those three factors could affect the quantitative decisions, and in the end, while combining those three factors, we could get an executable qualitative and quantitative decision.

The final decision is made using all 3 models combined. We use the **BGC Model** to decide the ideal assets distribution and hence the limit of our operation (i.e. for example, the percentage of bitcoin in our total asset cannot exceed the maximum percentage allowed, which is 58.823%.

After that, we use the **Decision-Making Model** to decide whether we should hold, buy, or sell for gold and bitcoin separately. If we decided to buy or sell, we would then use the **Rational-Decision Model** to determine how much we should buy/sell.

Contents

1 Model Structure

1.1 Restatement of the Problem

1. Develop a model that gives the best daily trading strategy based only on price data up to that day. e.g. Get a result when given an initial 1000 dollars investment worth on 9/10/2021 using the model and strategy.

2. Determine the impact of transaction costs on the trading strategy.

1.2 Introduction

In this project, we would like to analyze based on the ten days' situations, that is, we assume we do not do any manipulations in the very first ten days but start to apply our next models after the tenth day. For example, we would not buy or sell in the first ten days, but we would buy or sell starting from day 11, and our analysis would focus on the Day 1-10, and while we decide when to buy or sell on day 12, our analysis would focus on the Day 2-11. Also, note that the ten days interval of bit-coins and the ten days interval for gold is different since the gold could only be sold or bought in the specific times. Our goal is to make decisions based on various factors in order to maximize our profit up to the specific day. In order to satisfy this need, we intend to divide the large model into three small models, which come first is the **BGC Model**, **Decision-Making Model**, and last the **Rational-Decision Model**.

2 Model 1: the BGC Model

2.1 Goal

- Attain balance between the Bit-coin, Gold and Cash, meaning that we are intended to keep those three types of assets in the proper proportion of our total assets.

- Solve the dilemma while the price of bitcoin and the price of gold goes up at the same time, but we fail to buy the best-profit-amount of gold or bitcoins that we calculated from the Rational-Decision Model.

- We introduce two constants in order to help us compared the average buying value of Bit-coin and gold we have right now with the current day's value, which will further discussed in the Decision-Making Model.

2.2 Assumptions

- Based on the real life economic strategy, it is often wise to keep $15-20\%$ of total assets in cash to balance the entire portfolio since it would "give us a buffer to even invest when the market tanks." Therefore, in this case, we determine the cash as 15% of our total assets, and the Bits-coin, which is the more risky but more profitable one, would take up 50% percent of our total assets and our gold, which takes up 35% percent of our total assets.

- Since we could use cash to buy the bit-coins and gold, we are inclined to say that the cash would go down to 0 percent of our total assets in some extreme cases. Therefore, we assigned the cash, which is the 15% of the total assets to the bit-coin and the Gold one proportionally, meaning that

$$Bitcoin : 50\%/(50\% + 35\%) = 8.823\%$$
$$Gold : 35\%/(50\% + 35\%) = 6.1764\%$$

- Therefore the ranges of the Bit-coins, Gold, and Cash would be:

  Bit-Coin: $50\% \pm 8.823\%$

  Gold: $35\% \pm 6.1764\%$

  Cash: $0 - 30\%$

3 Model 2: Decision-Making Model

3.1 Goal

In this Model, we will focus on the decision making process, meaning that given at the specific time, whether we should buy or sell.

3.2 Symbols Terms

MAD: refers to the average distance between each data value and the mean in a data set.

Constant: refers to the price at which we will not lose nor profit from selling/buying

3.3 Principles

- We first decide whether the current day is value is at a lower/ higher position in the ten days interval.
  - When the current day's value > Max - MAD of the data set, We consider selling
  - When the current day's value >= Max + MAD of the data set, We consider buying
- Selling Case:
  - Compare the current day's value vs. constant + rate (Explanation 1)
    - If the the current day's value > constant + rate, we then run the **Rational-Decision Model**.
    - Otherwise, no decisions would be made. Hold.
- Buying Case:
  - Run **Rational-Decision Model** directly (Explanation 2)

3.4 Explanations

1. The reason that we are doing above comparison is because the current day's value must be larger than the constant+rate, otherwise we are losing money.

2. The reason that we do not consider the constant rate here is because it will not influence the profit in long term investment, and the same for transaction fees. However, it is the difference between the buying and selling price that determines the profits, instead of the primary buying price.

4 Model 3: Ration-Decision Model

4.1 Goal

The goal of the **Rational-Decision Model** is to make precise quantitative decisions of how many bit-coins or how much gold we should buy or sell.

4.2 Factors

- How many times continuous increase or decrease happens
- The distribution of our assets
- Measure how many money we could profit from selling

4.3 Factor 1: Number of Increases/Decreases

- If we record several continuous increases or decreases in a specific interval, we would be inclined to sell or buy based on how many times it continuously increases or decreases. This means that if we record 3 times continuous increase, we would sell more than the times where there are only two continuous increases.
- Another question arises while we use the word "more" above. Readers might ask how to define "more"—-readers might ask the specific quantity that we would buy or sell. And this part would address this problem.
  - We would assume this would be roughly an exponential relationship.
  - While looking through our interval, which is a ten days interval, we would only have 9 days to do the operations, and if we record n times continuously decrease in the nearest interval, we would assume it would reach the bottom in the near future. However, since we could not anticipate when it would reach the bottom, we would buy some amount immediately while detecting this trend.
  - Since we got the limit of each type of asset in the BGC Model, therefore, we denote the maximum change of one type of asset would be 100%. And since we only have 9 days to do the operations in the ten days interval, we denote the daily change as q, and we would have $q^9 = 100$, and thus we got $q = 2.0959$, which denotes the largest possible change in a day.

  - And the rate here is q because q represents the largest possible change in a day.
  - Therefore, our first function is

$$y = x^{2.0959} \tag{1}$$

4.3.1 Assumptions for Factor 1

- In the ten days interval, we only have 9 days to do the operations, and if we record n time continuously decreasing or increasing, the next day, meaning the n+1 day, if it is still decreasing or increasing, respectively, we are more likely to buy more or sell more respectively.
- Assume, it does not exist the possibility that the person buy and sell several times the same type of assets in the same day, meaning that it does not exist a possibility that the person first buy the gold in day N and sold the gold in day N and then buy it and then sold it still in the Day N that simply just want to use the transaction fee to ruin the total assets.
- If there's a scene that first continuously increases N days and then continuously decreases K days, we would only consider the continuous decrease K days interval instead of the previous one since the decrease K days interval is most near the current day.
- According to the data set , the minimum bitcoin we could buy is 0.00001, and thus we assume the minimum bitcoin and gold we could buy in our model is also 0.00001.
- We assume this would be roughly an exponential function between x-axis would be the number of counts of the continuous trend and y-axis is the maximum allowed change based on the **BGC Model**.
  - Justification: we would get a function that the y-axis is the maximum allowed change based on the **BGC Model**, and its x-axis would be the number of counts of the continuous trend. And its relation is that while the more counts of nearest continuous increase or decrease is, the more sell/buy we would operate based on the counts. And while more approaching the maximum of counts, meaning that while more approaching there's a ten days interval that is strictly continuous increase or decrease, we would be more inclined to sell or buy to reach the maximum point or the minimum point for each type of the assets in the **BGC Model**. (Based on the restriction of the range of each type, all in or all out). However, while more approaching there is strictly continuous increase or decrease only in two or three days, we would still sell or buy but the amount we buy or sell won't be large since we just have too little information about the trend.

4.4 Factor 2: Asset Distribution

- This factor is used to determine how much more investment we should make based on the current distribution of our assets.
- Essentially we can think of this factor as a score of whether we should invest more or less. This "score" is decided from the ratio of how much we can buy before reaching the limit we set and the range of maximum and minimum percentage allowed. The reason that we are inclined to

do this is because we would like to present how many proportions we should buy based on the relationship we presented above.

- While thinking about the relationship between those two, the maximum proportion should be 100. Also, as we approach the ceiling, the rate of change would become slow since if our assets right now match with the best distribution, we would do fewer operations. Therefore, we would like to think about this as a log function.

- While regarding this as an natural growth, we would like to assume the function is ln(x+b)+c, and since we got (0,0) and (1,1), while plug into the function, we then got the equation below begin equation

$$y = ln(x - 1/(1 - e)) - ln(-1/(1 - e)) \tag{2}$$

4.5 Factor 3: A Meter for Evaluating Profits from Selling

- Key phrase: constant average price refers to the weighted average purchasing price of the bit-coin or gold before.

- This factor is intended to show the proportion of the difference between the current day price and the constant average price, which is how many percentage of money we could earn if we sell them, and compare it with the highest proportion value that we derived similarly in previous selling process, which is an updating constant that we used to measure the profit that we can gain at today's selling point. In addition, we also consider the real-life scenario that the inflation happens every day, where the constant average price is supposed to changing, which we measure the proportion rather than actual value.

- As the current day price is approaching the historical maximum proportion value, we are more inclined to sell them because it represents that we can gain more profit by selling at today's price. In addition to this method, we scale the historical maximum value as one and compare today's proportional value with it to obtain a relation between today's price and how many units we should buy.

- In the extreme case where the current day price is larger than the history max price, we then replace the history max price with the current day price, which not only guarantees that the max proportion(the Y-axis) will always be 100% and the history maximum are constantly updating.

- Based on the consideration above, we are inclined to use the exponential function to portrait the relationship, where

$$y = x^{2*\ln 10/\ln(hismax)} \tag{3}$$

5 Validity of Model and Generality

1. This model is suitable for all scenarios while the global trend is going up or going down. It could also adjust the peak and bottom shown just in a ten-day interval, meaning that it could handle situations where very rapid change occurs during the ten days interval.

2. This model could be applied to the scenario while the first ten days won't affect the total results, meaning that the first ten days are relatively "common" compared to the other days. The reason for it could only be applied here is because if we have a very "uncommon" pattern in the first ten days, for example, we face a global maximum price or face a global minimum price that has an extremely large difference compared to the total mean price, the ability to maximize the profit would be discounted since we do not have any operations on the first ten days.

3. This model is modeling the general procedure of the customer, meaning that given at any point during this internal process, the person would always make the decisions based on our logic. However, it does not count the possibilities while the customers' decisions are non-steady. For example, if one person would like to do a one year investment but he is inclined to make big transactions and take more risks in the beginning but become less willing to take the risk at the end of the investment interval. Then, under this scenario, we do not account for this situation.

4. This model is modeling the situation where the factors in the Rational-Decision Model are equally important, meaning that each of them have the same impact towards the end result. However, while the customer is more inclined to choose based on any one of them instead of the others, the formula in the end won't not be applicable. Instead, we should use another formula or weigh each factor in the final procedure.

6 Advantages & Limitations

6.1 Advantages

1. It could maximize the profit where it contains several peaks and bottoms in a small amount of time.

2. It could maximize the profit in a relatively lower risk since we carefully design how many amounts of one type of asset we should buy.

3. It contains not only the flow of the different types of assets but also guarantees the distribution of our assets could give us a buffer to even invest when the market tanks.

6.2 Weaknesses

1. It fails to counter the scenario when there are more factors that would infect the results.

2. It fails to counter the scenario when the customers are more inclined to make risky decisions at first but change this habit in the end.

3. It fails to counter the scenario while the very first ten days of investment would dramatically infect the person's investment result.

7 Impact Determination of the transaction fee

- We assume the next situations based on the time interval from the initial day to the 10/20/2017
- The sensitivity of the Gold transaction fee:

  The Gold transaction fee is not very sensitive

  Justification: Our program shows that while we increase the buying transaction fee by 1 percentage, our max profit at the same time would only change 4657.34 - 4590.33 = 67.01
- The sensitivity of the Bit-Coin transaction fee:

  The Bit-Coin transaction fee is relatively sensitive

  Justification: Our program shows that while we increase the buying transaction fee by 1 percentage, our max profit at the same time would change 4657.34- 4561.79 = 95.55

  However, different from others, it is more sensitive while increasing 4799.62 - 4590.33 = 209.29
- The sensitivity of the Buying transaction fee combined with the sensitivity of the Selling transaction fee:

  While combined them together, it is much more sensitive than the respective ones.

  Justification: Justification: Our program shows that while we increase the buying transaction fee and the sale by 1 percentage, our max profit at the same time would change 4657.34 - 4496.63 = 160.71

8 The Final Answer

How much is the initial 1000 dollar investment worth on 9/10/2021 using your model and strategy?

The Answer is: Until 10/20/17 we could have 4657.34 dollars, which is extra 3657.34 dollars. Therefore, based on this one year interval, in the next five years, we could estimate that we would have at least 300% increment per year.

9 Communication to the memorandum

While applying this model in real life, you have to be patient and should avoid doing the large transaction in the first ten days since this model should learn the pattern from the first ten days and record them inside its memory so that it could be able to transaction in the future. However, when the first ten days have passed, you could do the transactions without worrying about it.

This model could allow you to maximize the profit where it contains several peaks and bottoms in a small amount of time, and even maximize the profit in a relatively lower risk since we carefully design how many amounts of one type of asset we should buy. Also, do not worry about the flow and exchange between each type of asset since it contains not only the flow of the different types of assets but also guarantees the distribution of our assets could give us a buffer to even invest when the market tanks.

Also, this model is suitable for all scenarios while the global trend is going up or going down. It could also adjust the peak and bottom shown just in a ten-day interval, meaning that it could handle situations where very rapid change occurs during the ten days interval.

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However, it does not count the possibilities while the customers' decisions are non-steady. For example, if one person would like to do a one-year investment but is inclined to make big transactions and take more risks in the beginning but become less willing to take the risk at the end of the investment interval. Then, under this scenario, we do not account for this situation, and this model is modeling the situation where the factors in the Rational-Decision Model are equally important, meaning that each of them has the same impact on the end result. However, while the customer is more inclined to choose based on any one of them instead of the others, the formula, in the end, won't be applicable. Instead, we should use another formula or weigh each factor in the final procedure.

10 Reference list

[1] “Building a cash buffer: How you can tackle a cash flow crunch”https://www.zoho.com/books/articles/how-to-build-a-cash-buffer.html: :text=At%20such%20 times%2C%20you%20can,when%20the%20 going%20gets%20tough.