Problem Chosen	**2022**	**Team Control Number**
C	**MCM/ICM**	2221952
	Summary Sheet	

The LaTeX Template for MCM Version v6.3.1

Summary

Here is the main abstract part.
Go to the next line.

Keywords: keyword1; keyword2

Contents

1 Introduction

1.1 Restating the Problem

1.2 Restatement of the problem

In the problem, traders buy and sell Gold and bitcoins frequently, with a goal of maximizing the total return. Start with $1000 on 9/11/2016 and build the model, to reach the best return on 9/10/2021. Bitcoin can be traded every day, but gold is only traded if market is open. The commission for each transaction (purchase or sale) costs α of the amount traded, including $\alpha\_gold = 1\%$ and $\alpha\_bitcoin = 2\%$. No cost are required to hold an asset.

1.3 Our Work

- Develop a model that gives the best daily trading strategy based only on price data up to that day. Explicate the return and the supremacy of the model
- Determine the sensitivity of the strategy to transaction costs. How do transaction costs affect the strategy and results?
- Communicate the strategy, model, and results to the trader in a memorandum.

2 Assumptions and Justifications

When discussing the optimal strategies of transactions based on the market situation, we usually need to adjust our actions with the ever-changing market situation. In this problem, the data is provided on daily basis and our models are expected to be focused on the official data. To simplify our analysis and facilitate the data-driven modeling, we raised several assumptions in this section.

- **The scenario follows the basic market assumptions.** To be specific, there is no arbitrage in the market, and we assume no external events with significant influence on the gold's or bitcoin's prices will occur within the time period of our discussion.
- **Traders only perform one action at most on each kind of asset per day.** That means, we choose to either buy in or sell a certain amount of asset in a single day, and the action must be finished in one go. No hedging or shorting are included in our discussion.
- **The change in asset prices is slight on days the market is closed**. Even if gold cannot be traded on the closed days, we can fit the existing data to complete the missing values, which corresponds to the closed dates. Interpolation, regression and cubic spline are applicable to help us evaluate the prices on these days.
- **The prediction error follows a normal distribution**. If the prediction value is $\hat{y}$, with standard variance σ, then the true value fits the distribution of $N(u, \sigma)$.

3 Notations

Symbols	Definitions
EMA_1	Short-term exponential moving average
EMA_2	Long-term exponential moving average
u_i	Daily return on day i
e_i	Residual of item i

4 Calculating and Simplifying the Model for Question 1

We used an integration of financial and machine learning model to predict the opportunity of transaction. Among several popular stock trading techniques, we chose Moving Average Convergence Divergence (MACD) as the financial signal, as it is both stable in value and sensitive in the market trend.

We also applied neural network model to predict the asset prices, as it provides the feedback from a technical perspective.

4.1 The MACD strategy

Moving Average Convergence Divergence (MACD) is used to detect the signal to trade in or trade out. It shows the best return and profit in a lot of trading scenario, as it combines the long-term and short-term moving trend [1]. The first stem is to compute the Exponential Moving Average curve, which is defined by

$$EMA(N, x_n) = \frac{2x_n + (N-1)EMA_N(x_{n-1})}{N+1}$$

We computed both short-term EMA where $N = 12$ and long-term EMA where $N = 26$. The Diff is calculated as $Diff = EMA_1 - EMA_2$ and DEA is the 12-day moving average $DEA = \frac{1}{12}\sum_{k=1}^{12} Diff_k$. Then, we can calculate the MACD from the equation

$$MACD = 3 \times (\text{Diff} - \text{DEA})$$

. The visualization shows that the two EMA lines are very close to the prices. The MACD, $Diff$ and DEA can be both negative and positive, as they provides a reflection on the transformation of market. If the MACD of one day is larger than zero, the MACD of the day before yesterday is smaller than zero. It's the indicator that the price of the gold has a tendency to rise up. When the MACD is smaller than zero, and the MACD was larger than zero the day before yesterday, then it's the signal to sell the gold.

We back-tested the MACD method on the training data to trade bitcoin and gold respectively, resulting in positive profit in both cases. Bitcoin, particularly, obtained a net profit of xxx by the end of xx period. The testing result shows that the MACD is feasible, but we need to take the budget and risk capability in the next step.

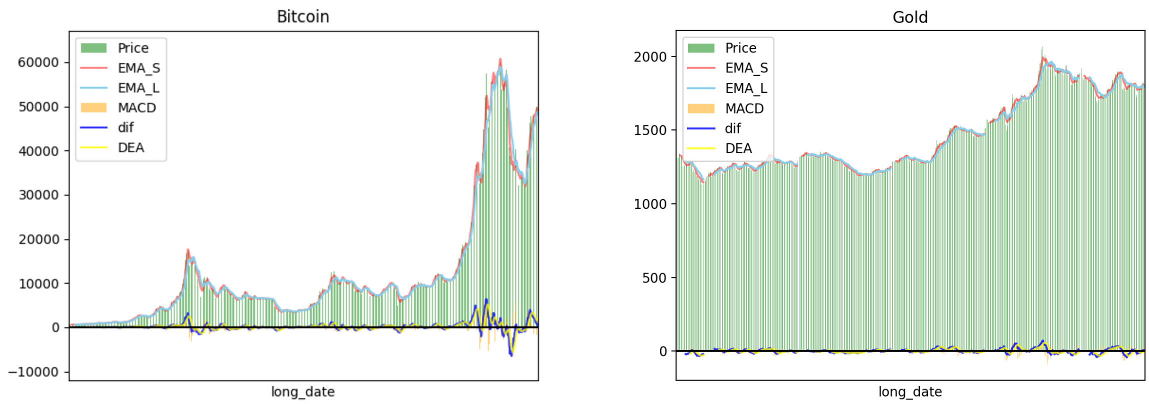

Figure 1: The MACD lines of bitcoin and gold

4.2 Signal of trade for the Bitcoin

4.2.1 The prediction model of Bitcoin

4.2.2 The strategy to trade

Assume there is a prediction of the price of one bitcoin the next day, noted by $\hat{y}$, with standard varience σ, the price of the day is y. Since when we by one Bitcoin, the cost is 1.01y, while if the Bitcoin is sold the next day, the profit of purchase follows the distribution of $N(0.99\hat{y} - 1.01y, (0.99\sigma)^2)$. If $0.99\hat{y} - 1.01y < 0.99\sigma$, nothing would be done. If $0.99\hat{y} - 1.01y \leq 0.99\sigma$, According to normal distribution, the probability to get the profit is 84.1%. If $0.99\hat{y} - 1.01y > 1.98\sigma$, the probability to get the profit is .

4.3 Risk measuring and prediction

Despite that an asset's price can be predicted to be attractively high, one may wish to take the risk into consideration, as high risk may coexist with high rewards. The risk can be measured by the volatility of daily return u_i, which can be simplified to u_i^2, as u_i is usually close to 0 [2]. The Augmented Dickey-Fuller (ADF) Test reveals that the u_i^2 is stationary, which mean it is suitable for Autoregressive Integrated Moving Average (ARIMA) model.

We found the best models of Bitcoin and gold are ARIMA(4,0,0) and ARIMA(4,1,1), with formula $\hat{\sigma}^2_{t,Bitcoin}$ is

$$\hat{\sigma}^2_{t,Bitcoin} = 0.0640\sigma^2_{t-1} + 0.041\sigma^2_{t-2} + 0.0376\sigma^2_{t-3} + 0.0557\sigma^2_{t-4}$$

$$\hat{\sigma}^2_{t,gold} = \hat{\sigma}^2_{t-1,gold} + 0.0158\sigma^2_{t-1} + 0.1584\sigma^2_{t-2} + 0.0327\sigma^2_{t-3} + 0.1043\sigma^2_{t-4} - 0.9844\epsilon_{t-1}$$

. Comparing the fitted prediction and the original u_i^2, the trend and peak of the predicted and true values basically corresponds each other. The Box-Ljung test, whose null hypothesis is that the residuals are white noises, has a p-value 0.9217 and 0.355 respectively, meaning that the residuals have no correlation. It means that our ARIMA model has a good fitting outcome, as it explained the periodical variations well.

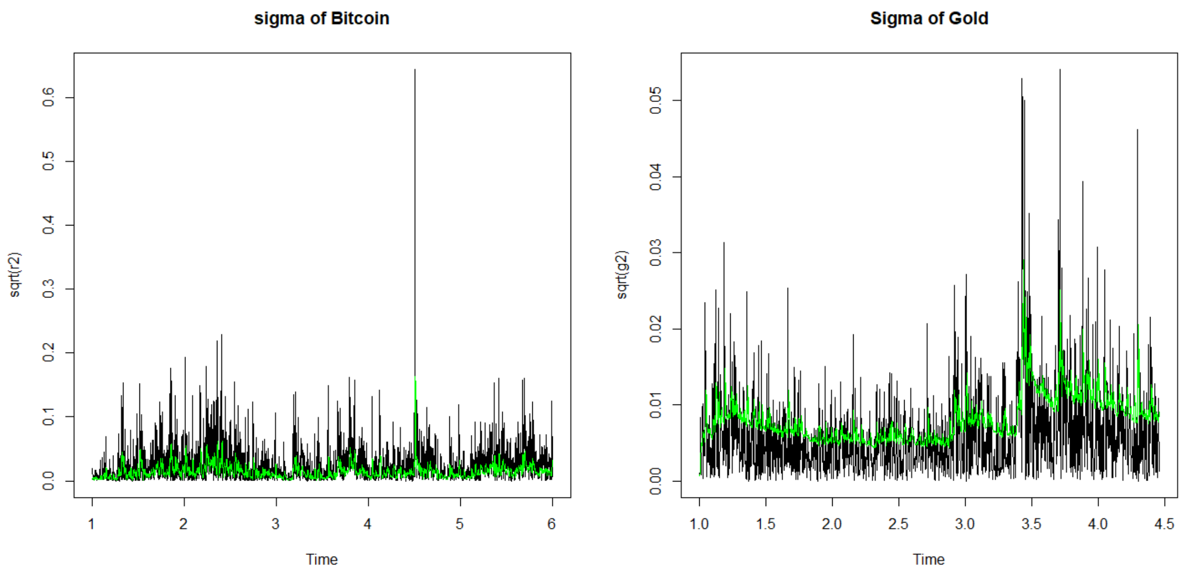

Figure 2: The ARIMA fitting of u_i^2

5 The Model Results

6 Validating the Model

7 Conclusions

[6]

8 A Summary

9 Evaluate of the Model

[7]

10 Strengths and weaknesses

10.1 Strengths

- **Applies widely**
  This system can be used for many types of airplanes, and it also solves the interference during the procedure of the boarding airplane,as described above we can get to the optimization boarding time.We also know that all the service is automate.

10.2 Weakness

- **MACD methods is efficient only if the market is stable.** The gold or death cross are indicators of trend, which assumes the trend is consistent over time. If the future trend does not inherit the historical character, the MACD signals may be incorrect.

References

[1] T. T.-L. Chong, W.-K. Ng, and V. K.-S. Liew, "Revisiting the performance of macd and rsi oscillators," *Journal of risk and financial management*, vol. 7, no. 1, pp. 1–12, 2014.

[2] D. G. Luenberger *et al.*, "Investment science," *OUP Catalogue*, 1997.

Appendices

Appendix A First appendix

[13] Here are simulation programmes we used in our model as follow.