Problem Chosen	2022 MCM/ICM Summary Sheet	Team Control Number
C		2207267

Real gold or virtual gold: prediction and decision-making integrated model to help

Summary

Bitcoin and gold up and down trends are embedded in market rules and international situations and are somewhat predictable. We want to capture market trends to the best of our ability and measure asset allocation for maximum profit. We have constructed a trading model that combines forecasting and economic indicators decisions for trading bitcoin and gold.

Question 1:A gray-Markov model and an LSTM neural network model are used to predict future price trends. In this case, the predicted value of the **future one day** price was obtained using the Gray-Markov model. The LSTM model was used for **medium and long term forecasting**, and the historical data was used to predict the bitcoin price trend for the next 15 days and the gold price trend for the next 20 days. In the decision-making scheme,the **MACD** indicators were selected to reflect the beginning and end of the rising and falling market, and the characteristics of MACD indicators and buying and selling rules were combined to determine the selection of **trading points** and the primary trading amounts. The LSTM prediction results, 15-day RSI values (reflecting the short- and medium-term strength and weakness of the market) and the grey-Markov model prediction results are **graded separately**, and **weighted votes** are conducted according to the graded results, and the trading amounts are adjusted up and down according to the voting results.Set the investment ratio of the two according to gold and bitcoin fluctuations (determined to be dominated by bitcoin), calculate the 15-day deviation value and the average value of returns for comprehensive risk assessment, while adjusting the bitcoin and gold ratios, and finally get the total assets of **2710225.99$**.

Question 2: A variable control approach is used to demonstrate model superiority: Firstly, while **keeping the trading timing strategy unchanged** the three actions of setting to **ignore weighted voting results**, increasing and decreasing the amount of each buy, all result in a decrease in total assets. Secondly, Holding the trading amount strategy constant, making the trading timing fluctuate randomly, results in a decrease in assets for both. Finally, we analyzed the accuracy of the two prediction models and obtained the final annualized rates.

Question3: The impact of bitcoin transaction costs on the final asset is **almost linear** (the buy and sell points are usually fixed) with a fitted slope of 371024.4. Gold transaction costs have little impact on the final asset. When the transaction cost is high, the number of transactions should be reduced and vice versa to increase the number of transactions.

Eventually, our model and strategy are communicated to the decision-makers in a memo.

Keywords: **MACD** **gray-Markov** **LSTM** **Risk**

Contents

1 Introduction

1.1 Problem Background and Restatement

The greater the return, the greater the risk, so market traders often buy assets with high market volatility, such as gold and bitcoin, in order to maximize returns.The market values for gold and bitcoin over a five-year period starting on 2016/09/11 are as follows:1 The trader asks us to create a model that

Figure 1: Gold and Bitcoin

uses only data up to the day to determine the trading strategy that will maximize the expected return five years from now. In order to establish the best investment strategy, we will:

- Use historical data to predict future price movements of gold and bitcoin on each trading day
- The decision model of the trade is set with an initial capital of $1000, and the total value of assets after five years is obtained by simulating the trade through the decision model guidance program.
- Prove that our model provides the best trading strategy from different perspectives
- Analyze the impact on trading strategies and results by applying small perturbations to trading rates to obtain the results and test the stability of the model
- Communicate our models, strategies, and results to traders in a memo

1.2 Our Work

Data processing:
In order to make more effective use of historical price data, the following processing is carried out:

1. Standardize and unify the date format
2. For the days when gold cannot be traded, we set its price to the previous day's value to complete the missing data and better predict the trend
3. Generate the increase and decline directly according to the existing data to get more information
4. Sort, compare, sum and average the data to mine the essential characteristics of the data

When building the model, we used a variety of factors to predict the future price trend of gold and bitcoin, analyzed the date of purchase and sale and the number of transactions so that we could buy at the low point and sell at the high point as much as possible, to maximize profits. In addition to the current very effective MACD, convergence and divergence ratio and other vital indicators, We also determine how to trade by predicting price movements. Our optimal model comprehensively utilizes historical data and future trends to ensure profit maximization through prediction and evaluation.

2 Reasonable Assumptions

1. It is assumed that there are no major changes and force majeure that would cause significant changes in the price of gold and bitcoin.
2. Assume that gold trading days are not affected by holidays.
3. Assume that the trading window is not closed at the time of each analysis to obtain a buying and selling strategy.
4. Assume that the number of bitcoins will not reach the maximum within five years.

3 Predicting the daily price of gold bitcoin by time series model

In order to ensure maximum returns, we need a certain amount of data at our disposal to decide what to invest in that day. Usually we can only refer to historical data when making decisions on trading days, which requires us to make predictions about and future gold and bitcoin prices. Gold and bitcoin rise and fall with a certain randomness, but also contains certain market operation laws, and gold and bitcoin trading strategies need short, medium and long-term characteristics. In view of the comprehensive performance of the model, we make both short-term and long-term forecasts. This is

done by using a gray-Markov forecasting model to predict future day price movements and LSTM to predict price movements over a slightly longer range.

3.1 Based on gray-Markov Model predicts the short-term price of gold and bitcoin

The gray forecasting model is highly accurate and easy to test. The characteristics of the model for short- and medium-term forecasting meet our needs. However, the gray forecasting GM(1, 1) model does not consider the distribution pattern and trend and is an exponential function with monotonicity. In order to remedy this deficiency, we perform Markov chain analysis on the forecast results to correct the forecast values and reduce the errors. Since the data provided only reported the occurrence of the sightings, according to the habits of the Vespa mandarinia, we believe that the correctly witnessed wasps came from a certain area around the incident site. This assumption makes the model better fit the distribution of data points.

3.1.1 Model Construction

GM(1,1) Model We first use the data of the first seven days of gold to determine the time series to predict the data of the eighth day,Original sequence

$$x^{(0)} = (1324.6, 1323.65, 1321.75, 1310.8, 1308.35, 1314.85, 1313.8)$$

Do a sum

$$x^{(1)} = (1324.6, 2648.25, 3970, 5280.8, 6589.15, 7904, 9217.8)$$

Construct the quantity matrix$B$ and data vector$Y$

$$\mathbf{B} = \begin{pmatrix} -0.5(x^{(1)}(1) + x^{(1)}(2)) & 1 \\ -0.5(x^{(1)}(2) + x^{(1)}(3)) & 1 \\ \vdots & \vdots \\ -0.5(x^{(1)}(6) + x^{(1)}(7)) & 1 \end{pmatrix} \quad \mathbf{Y} = \begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(4) \end{pmatrix}$$

Then

$$\hat{u} = \begin{pmatrix} \hat{a} \\ \hat{b} \end{pmatrix} = (B^T B)^{-1} B^T Y = \begin{pmatrix} 0.001575793 \\ 1323.84916 \end{pmatrix}$$

construct model

$$\frac{dx^{(1)}(t)}{dt} + \hat{a}x^{(1)}(t) = \hat{b}$$

Then

$$x(t) = 840116.0 - 838791.0 * exp(-0.00157579t)$$

Then performing cumulative subtraction, we obtain the predicted time series of the first seven days and the predicted value of the eighth day

$$\hat{x}^{(0)} = (1324.6, 1320.72, 1318.64, 1316.57, 1314.49, 1312.42, 1310.36)$$

$$x_{predict} = 1308.29$$

gray-Markov Model

The relative error of the GM(1,1) model is used as a simulation predictor, and the relative error is

Table 1: Variables

Day	Original value	Predicted value	Relative Error	Status
1	1324.6	1324.6	0	1
2	1323.65	1320.72	0.22%	2
3	1321.75	1318.64	0.24%	2
4	1310.8	1316.57	0.44%	3
5	1308.35	1314.49	0.47%	3
6	1314.85	1312.42	0.18%	1
7	1313.8	1310.36	0.26%	2
8		1308.29		

divided into 3 states, which are$Q_1 \in [0, 0.2\%], Q_2 \in [0.2\%, 0.4\%], Q_3 \in [0.4\%, 0.6\%]$Determine the state of day 8 to be predicted using the three-step transfer method.From the table, we can calculate the state transfer count matrix$M$the state transfer and probability matrixP^m

$$M = \begin{pmatrix} 0 & 2 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{pmatrix}$$

$$P^1 = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0.5 & 0.5 \\ 0.5 & 0 & 0.5 \end{pmatrix} P^2 = \begin{pmatrix} 0 & 0.5 & 0.5 \\ 0.25 & 0.25 & 0.5 \\ 0.25 & 0.5 & 0.25 \end{pmatrix} P^3 = \begin{pmatrix} 0.25 & 0.25 & 0.5 \\ 0.25 & 0.375 & 0.375 \\ 0.125 & 0.5 & 0.375 \end{pmatrix}$$

M_{ij}denotes the number of occurrences of the transformation from state i to the next state j,P^mThe superscript m indicates the number of transfer steps,P_{ij}^mdenotes the probability of transferring from state i to state j after m steps The state of the gold price on the 5th, 6th and 7th trading days determines the relative error of the gold forecast on the 8th trading day, and the probability of the state of the relative error of the gold price forecast on the 8th day is

$$P_1 = P_{31}^3 + P_{11}^2 + P_{21}^1 = 0.125$$

$$P_2 = P_{32}^3 + P_{12}^2 + P_{22}^1 = 1.500$$

$$P_3 = P_{33}^3 + P_{13}^2 + P_{23}^1 = 1.375$$

$$MaxP^1, P^2, P^3 = P_2$$

Therefore, the state in which the gold error is located on day 8 is most likely to be state 2, i.e., the relative error between the original value and the predicted value of the GM(1,1) model on day 8 is most likely to be in the interval$[0.2\%, 0.4\%]$,We use the midpoint of the interval 0.3%as the error,This value is used to correct the gray prediction value and to obtain the gray-Markov model prediction value. The calculation is as follows:

$$\frac{x - x_{predict}}{x_{predict}} = 0.3\%$$

$$x = 1312.25$$

Equidimensional update of gray-Markov model

The original series changes with time, and when we are at day n, we can construct the time series$(x_{n-6}, x_{n-5}, x_{n-4}, x_{n-3}, x_{n-2}, x_{n-1}, x_n)$ to substitute the original sequence of GM(1,1) modelof which$x_i$denotes the price of gold and bitcoin on day i.This allows us to predictx_{n+1},This result informs our decisions.

model test

We compared the original and predicted values of gold over a 5-year period. To distinguish the two

Figure 2: Gold predict

curves, we used different scales for the two y-axes, and we can see that our model predicts very well.

3.2 Prediction of long time series based on LSTM model

3.2.1 Model Introduction

We use the LSTM model (Long Short Term Memory) for a more extended time series to predict daily price trend changes of gold and bitcoin in the medium and long term. Compared to ordinary mathematical models, LSTM has superior performance in handling more extended time-series data, so we choose LSTM for future gold and bitcoin price prediction.LSTM is an excellent variant model of RNN and inherits most of the properties of RNN models (remembering information of long periods). They are both well suited to be used (and suitable) for problems that are highly correlated with time series. The advantages of such models are as follows:

- need to handle time-series data (with time dependence) and require global processing
- There may be a specific time span between the input and output elements (e.g.,historical and forecast data)

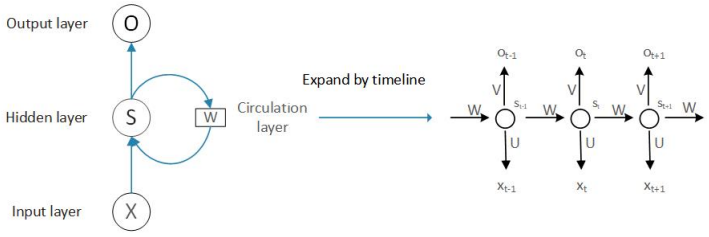


Figure 3: RNN Structure

$$S_t = f(W * S_t - 1 + U * X_t)$$

t denotes the time series. X denotes the input sample. W denotes the weight of the input, U denotes the weight of the input sample at this moment, and V denotes the weight of the output sample. As can be seen from the above figure, a sequence is passed through the neuron nodes in multiple cycles, recording the historical features in the weights and hidden layers, thus gaining the ability to process the sequence. The remaining details of the model are more complex and are not described here.

However, just using a simple RNN will have the problems of vanishing and exploding gradients, resulting in serious errors when making predictions on longer sequences, while LSTM adds three gating units to the RNN structure: forget gate, input gate and The output gate solves the above problems well. The LSTM model selectively stores information through the gating unit and effectively utilizes the sequence information. Compared with the RNN that memorizes all the information, the ability of the LSTM model is significantly improved. The following are three gated unit structures:

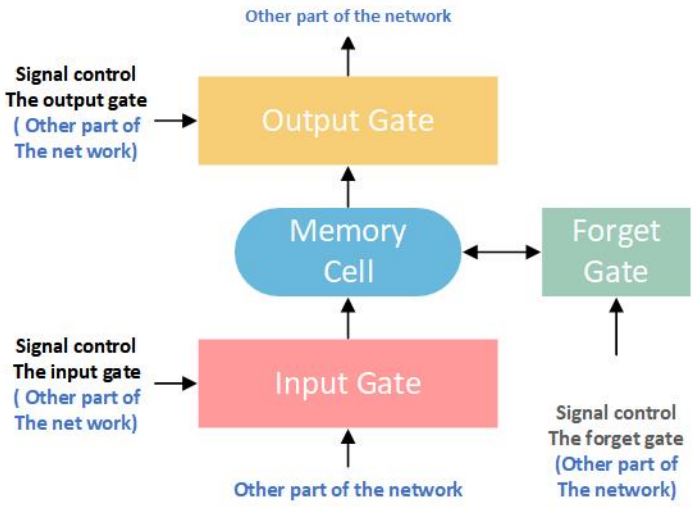


Figure 4: Door control unit diagram

3.2.2 Specific implementation of LSTM

Each time the LSTM is used, the daily price of gold or bitcoin in a continuous period of time before the current node is fed into the model as a training sample train_data,and the model learns the sequence information contained in the train_data and predicts its price trend for the subsequent period of time pred_data based on this information.(train_data should be much longer than pred_data)

Important parameter settings

Table 2: parameter

parameter	Explanation
train_num	Length of training samples
pred_num	Length of predict samples
train_windows	Length of training windows
epoch	Number of training iterations
hidden	Number of hidden layers
lr	Learning Rate

Explanation of parameters

Set a window of train_windows length (also known as time step), the window moves backward one day at a time to read data for training, the training samples are all the data in the window, the labels are the next data outside the window, and the cycle repeats until all the training samples are taken. (train_windows) must be much smaller than the total length of the training samples)

By first performing the maximum-small normalization at the input of each round of data for training,

we can speed up the LSTM to find the optimal solution and possibly improve the prediction accuracy.

$$x^* = \frac{x - x_{min}}{x_{max} - x_{min}}$$

Parameter adjustment

The historical data before each time node is divided into two parts, one part is the training sample train_data and the other part is the real sample true_data used for testing, using the training sample to input the model for training and testing the test sample, comparing the obtained data with the known data, continuously adjusting the parameters (train_windows, regularization coefficient lamda, number of hidden layers h, epoch and learning rate lr) to get a better prediction effect, and then putting these parameters into use.

After the parameters have been adjusted, we can input the training data into the model for training, and we can output the post prediction value. Whenever a MACD buy and sell point is encountered, an LSTM prediction is made, the historical price is input, and the predicted price is output. Since Bitcoin and gold are both volatile investments, the prediction accuracy will be reduced for a long time in the future, and we need to integrate other indicators (RSI, gray Markov prediction) for a comprehensive judgment.

3.2.3 Whenever a MACD buy and sell point is encountered

An LSTM prediction is made, train_num is input, and pre_num is output. Since Bitcoin and gold are both volatile investments, the prediction accuracy will be reduced for a long time in the future, and we need to integrate other indicators (RSI, grey Markov prediction) for a comprehensive judgment.

4 decision-making scheme

4.1 Buy and sell decisions based on MACD indicators

The MACD is a technical indicator proposed by Geral Appel that uses the convergence and separation between the short-term closing exponential average moving average and the long-term exponential average moving average to determine the timing of buying and selling, and is an optimally performing investment indicator that is often used to determine the beginning and end of an upward or downward trend in the medium to long term. MACD has the following advantages:

- It can determine whether the market is long or short, avoiding reverse operations and latent risks
- It can be used to determine the main trend of the market and avoid unnecessary market entries
- MACD uses an exponential moving average indicator, which eliminates lagging characteristics to a certain extent

4.1.1 Variable Declaration

Table 3: Variables

Variables	Meaning
$EMA(n)$	n-day moving average
$EMA_{pre}(n)$	n-day moving average of the previous day
$EMA_{cur}(n)$	The n-day moving average of the current day
DIF	Today's deviation value
DEA_{cur}	9-day EMA of DIF
DEA_{pre}	Previous day's DEA
$MACD$	exponential smoothed divergence moving average
$price$	Today's closing price

4.1.2 Calculation formula

1. Initial value setting

$$EMA = price, \quad DEA = 0$$

2. **Calculate moving average (EMA)**
   The formula for calculating the 12-day EMA

$$EMA_{cur}(12) = EMA_{pre}(12) * \frac{11}{13} + price * \frac{2}{13}$$

   The formula for calculating the 26-day EMA.

$$EMA_{cur}(26) = EMA_{pre}(26) * \frac{25}{27} + price * \frac{2}{27}$$

3. **Calculate the difference-in-difference (DIF)**

$$DIF = EMA_{cur}(12) - EMA_{cur}(26)$$

4. **Calculate DEA**

$$DEA_{cur} = DEA_{pre} * \frac{8}{10} + DIF * \frac{2}{10}$$

5. **Calculate MACD**

$$MACD = 2 * (DIF - DEA_{cur})$$

Buying and Selling Principles

- DIF,DEA are positive,DIF upward breakthrough DEA,buy signal reference.
- DIF, DEA are negative, DIF down below DEA, sell signal reference.
- If the DIF line diverges from the K line, a reversal signal may occur.

We hope to use MACD to guide the timing of buying and selling gold and bitcoin. In actual operation, we calculate the MACD indices every day and judge whether there is a golden cross or a dead cross. Once there is a golden cross or a dead cross, the buying and selling point, then immediately the next day to buy and sell operations.
The MACD chart is shown below5, which provides us with great help in determining the timing of buying and selling (for easier display, the chart below contains only 300 days):

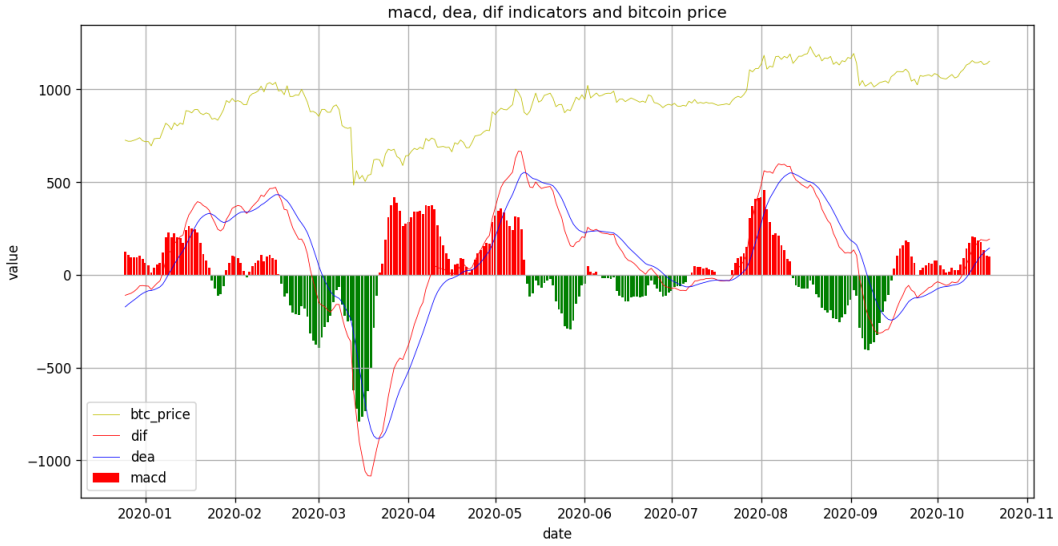


Figure 5: macd dea dif indicators and bitcoin price

4.2 Determine the amount of each purchase or sale based on the combined voting of the forecast model and RSI indicators

First of all, the RSI indicator, Relative Strength Index RSI is a technical curve made according to the extent of rise and fall in a certain period of time. It can reflect the strength or weakness of the

market over a certain period of time. The specific calculation formula is as follows:

$$Nday'sRSI = A/(A+B) * 100 \quad (0 \leq RSI \leq 100)$$

A=sum of closing gains in N days, B=sum of closing losses in N days (taking positive values)
From the above formula, RSI reflects the comparison of upward force and downward force, if the upward force is larger, the calculated indicator rises; if the downward force is larger, the indicator falls, thus measuring the strength of the market trend. RSI=50 is the dividing point between the strong market and the weak market. Strong markets are usually considered to buy, weak markets are usually considered to sell, usually set RSI>80 for overbought area, the market trend back to increase the chances, need to consider reducing positions; RSI <20 for oversold area, the market trend rebound chances increase, need to consider increasing positions.

We consider that the RSI indicator belongs to the short term oscillator, which is a kind of warning signal to judge the short term risk of the market mainly through overbought and oversold, but the RSI value swings quickly and there is no clear buying and selling point. Moreover, the blunting of the indicator after overbought and oversold may give wrong operation signals, so you cannot analyze the market strength and buying and selling signals based on RSI values alone, but need to integrate other indicators to achieve them.

According to the MACD fast and slow line rules described above, the golden cross point (DIF up through DEA) and the dead cross point (DIF down through DEA) are alternately generated, and there is no continuous buying or selling. Without changing the timing of buying and selling, we want as much money to flow as possible to create maximum value, so the ratio of each buy amount to available funds a should be set to a value closer to 1. On this basis, we need to integrate the long-term and short-term prediction results of the time series model and RSI indicators to determine the future market strength and weakness, and the amount of buying and selling to adjust accordingly. The formula is as follows:

$$y = x * a * (1 \pm b)$$

x:Dollar funds
a is a parameter (guiding the amount of each purchase or sale as a percentage of dollar funds)
b:Combined market outlook scoring results
We obtain a comprehensive index b for the future market through weighted voting. The detailed voting rules are as follows:

- Long-term forecast15 days: up 1, down 0
- RSI: 0.8 for 0-20, 0 for 20-50, 1 for 50-80 and 0.2 for 80-100
- Gray-Markov model (1 day) : 0-0.3, 0.3-0.7, 0.7-1

(Quantile calculation: Rank all gains and losses before the day, calculate the gains and losses of the 3rd and 7th quartiles, compare them with the predicted values, and score them.)

The combined results of the long term and short term forecasts and the market strength indicators give the expectations of the current buying and selling points for the future trend (within the [0,3] range). The higher the value, the more confident one is in the market. We cannot use this composite indicator directly. We need to map it to an interval centred on 0 [-a,+a], and the value obtained is b. It should be noted that at the point of buying, the higher the confidence level, the more buying, and the lower the confidence level, the less buying, so the weighting is 1+b, and the sign of b is negative in the opposite direction. Comprehensive indicators b from multiple perspectives to measure (reflect) the strength of future market trends, so we have to adjust the amount of buying and selling accordingly to maximize the benefits. Based on x*a, we adjust the amount of buying and selling by changing b value to reduce the risk of buying and selling transactions and increase the profit. Finally, we get the equation as above.

4.3 Gold and Bitcoin Matching and Risk Defense Strategies

According to the market rules, bitcoin is much more up or down than gold, so in order to maximize the return, we need to allocate as much as possible to bitcoin, but high return also means high risk, if only buy bitcoin may reap higher returns, but its risk resistance will also decline, so we need to establish the dominance of bitcoin trading at the same time, allocate a certain amount of gold share to hedge the risk to a certain extent, to enhance the risk defense ability of the model.

The initial gold/bitcoin ratio is set to G0/B0. To assess the risk, we introduce the 5-day deviation rate of bitcoin. BIAS is used to measure the deviation of the stock price from the mean size. When a stock price deviates from the market by a large amount, there is a regression. Whether the stock price is above or below the moving average, as long as the deviation is too far, it will converge towards the moving average, from which the percentage deviation of the stock price from the moving average is calculated to determine the timing of buying and selling.

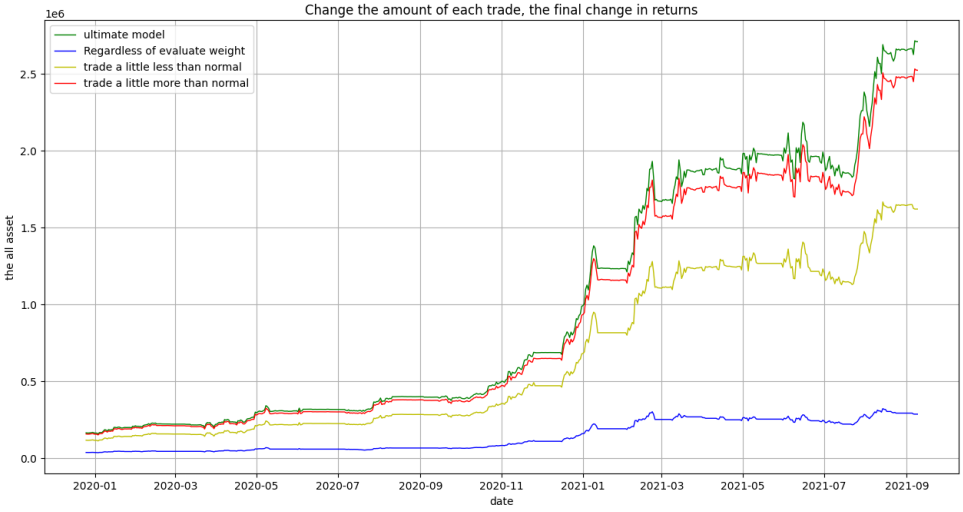
Deviation Formula: 5-Day Deviation = (Current Day Closing Price - 5-Day Moving Average)/5-Day Moving Average *100% Calculate the 5-day deviation rate of Bitcoin and use it as a risk assessment score. When the risk assessment score is greater than alpha, Bitcoin is in a high volatility, high risk zone and needs to move a% of its assets to gold to hedge the risk. When the risk score decreases, the asset will be reallocated from gold to bitcoin. Thus we have successfully reduced some of the value at risk.

5 Evidence of the best model

The model mentioned in the first part is the best strategy obtained by combining the metrics. To demonstrate this.

1.we start by varying the amount of each buy or sell by fixing the buy and sell points. There are two ways to vary the amount.

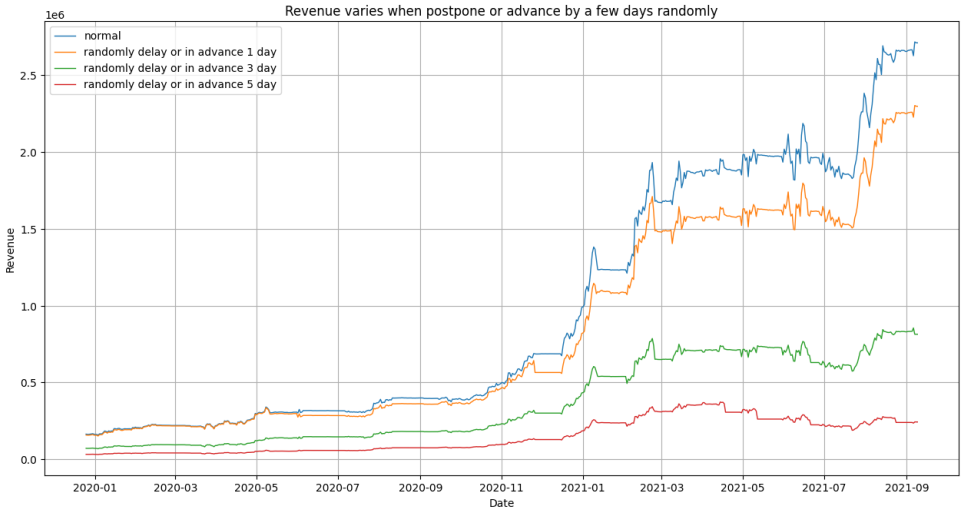
- Ignore the effect of the b-value, which is equivalent to abandoning the judgment of the future market boom and buying and selling directly according to a fixed ratio
- Increase and decrease the daily trading amount without changing the b-value
  The simulated values of total asset changes for different conditions are compared and the following graph is obtained: (To ensure the display effect, the data after 1200 days are taken for plotting)



The figure shows that the market sentiment values obtained through the combined voting of LSTM, gray-Markov model, and RSI are very significant in guiding the amount of buying and selling inputs. Figure 2 shows that increasing or decreasing a certain percentage of inputs will make the final total assets lower, so we set a very reasonable ratio of transaction amounts.

2.Similarly, keeping the amount of each trade constant while changing the timing of buying and selling, the specific operation is based on the optimal strategy with random changes before and after the trading point, with the intervals of [-1,1], [-3,3] and [-5,5], and the obtained total assets are compared as shown below.

In the chart , the strategy we chose is the blue fold (in the highest position), and the rest of the folds from top to bottom are perturbed +1, ±3, ±5days, indicating that the current strategy is the best strategy and has the greatest guidance value for the buy and sell points. The further the trading time is from

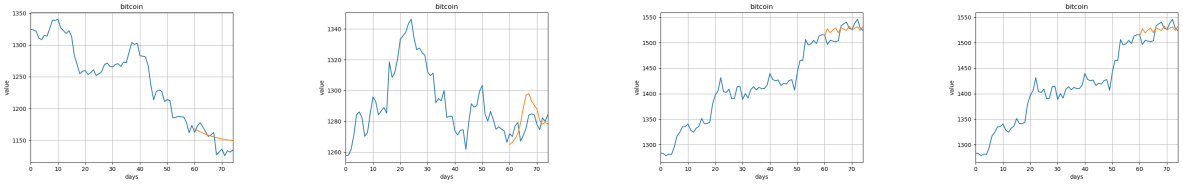


the current decision point, the lower the final total asset, fully reflecting the correctness of the current buying and selling timing decision.

3.Analysis of the accuracy of two prediction models

LSTM

Figure6 shows the results of the extracted LSTM



(a) (b) (c) (d)

Figure 6: LSTM prediction model

Because the longer the prediction time, the higher the uncertainty, the prediction accuracy will decline, the number of wrong prediction results is also increasing. Long-term prediction can not be used to calculate the average relative error, so we decided in the first part of the comprehensive voting, the LSTM prediction results processing do not consider the median specific value and its fluctuation size, only to determine whether up or down, the specific voting decision is: LSTM long-term prediction results, So we only need to calculate the ratio between the predicted interval up or down and the actual interval up or down to get an accurate value suitable for measuring long-term forecasts.

Normalize the interval up and down values obtained by LSTM prediction, regardless of up and down, as long as the trend is predicted correctly set to positive values, prediction error set to negative values, will be presented in the form of the following chart. As shown in the figure, focusing only on the up and

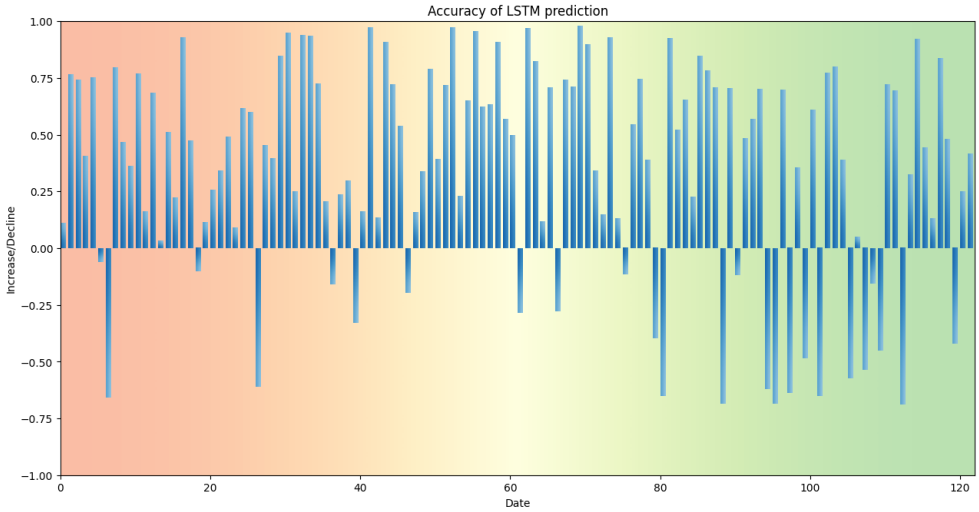


Figure 7

down trends, the LSTM model accuracy is above 80%. The LSTM model also has a higher prediction accuracy, although it cannot accurately predict the price for each day because the poll is based only on predicting the total rise and fall of the interval.

The final amount of total assets is $2783753.3, which translates into a five-year annualized interest rate of 556.4457724537228%, which is a very high value.

Gray-Markov

Gray-Markov only predicts the future day's price with fine granularity; we calculate the average relative error between the predicted and valid values for each gold price to get the result of 0.871% **Figure**8, for bitcoin the average relative error obtained is 0.941%

6 Impact of trading rates on strategies (sensitivity analysis)

We ermine the influence of the transaction cost of the two assets on the final total return, respectively. The transaction cost fluctuation interval of gold and Bitcoin is set as [0.005, 0.015] and [0.01, 0.03], respectively. Finally, it is found that the impact of bitcoin transaction cost on the final asset is almost linear (the buying and selling point is relatively fixed), and the fitting slope is -371024.4. Gold transaction cost has little impact on final assets, only -0.0279, which is negligible. Therefore, the gold transaction cost is insensitive, while the bitcoin transaction cost is sensitive. In this case, the higher the transaction cost, we should reduce the number of transactions and, conversely, increase the number of transactions. We analyze revenue change when the two factors change simultaneously in three dimensions as shown in the figure below: This result is in line with our expectations, as bitcoin is a highly volatile asset and is the main asset we trade, whereas gold is relatively stable, so in most cases,

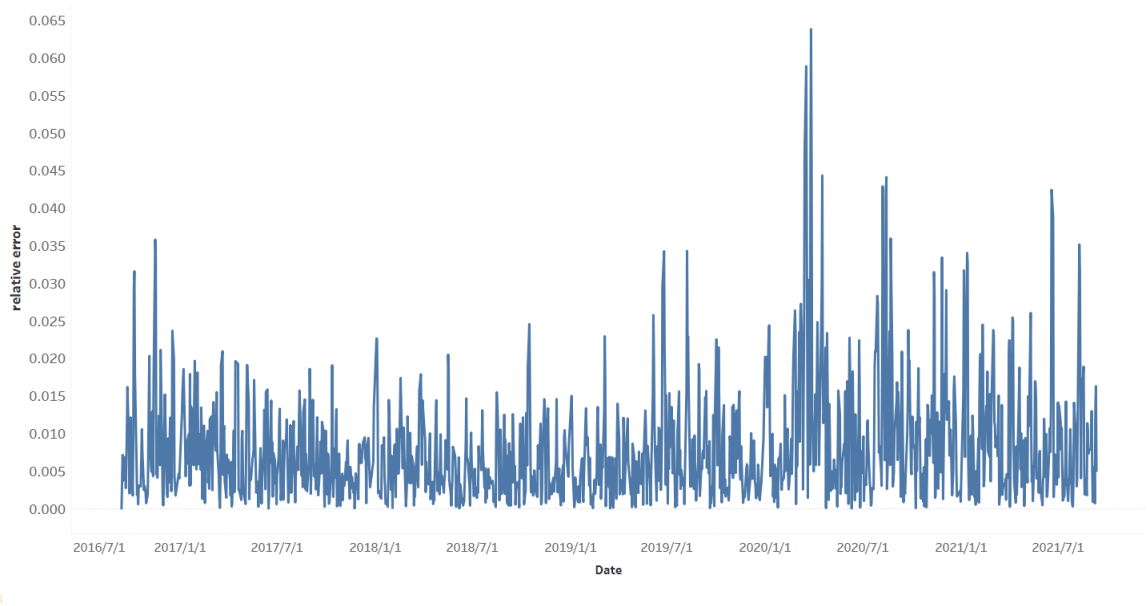


Figure 8: Gold relative error

we have chosen to buy and sell bitcoin for a profit, but at the same time there is some risk associated with our model's heavy use of bitcoin.

7 Model Analysis

7.1 Advantages and disadvantages of the model

Advantages

- Using the grey-Markov model and LSTM model to integrate and make full use of long-term and short-term historical data, making the model more credible.
- The MACD indicator is used to determine the trading nodes, which is very valuable as a guide, and the indicator is weighted by multiple variables, which is very comprehensive and reduces the probability of loopholes in the model due to poor consideration.
- Use MACD, RSI, BIAS and other economic indicators combined with neural networks and mathematical models, multidisciplinary crossover makes the model more extensive (not only for gold and bitcoin trading), scalable .
- Use of scoring mechanism mechanism risk comprehensive assessment system, exceed the threshold to escape from the high-risk area, so that the model has a specific risk-averse ability.

Disdvantages

- The model is sensitive to the transaction cost of bitcoin, and large changes in transaction cost may have some impact on the model
- The use of a single MACD indicator is more effective, but still has some room for improvement.

7.2 Model improvement scheme

There is a certain lopsidedness in using only one indicator of MACD when deciding trading points, we can combine KDJ indicator to optimize the decision-making scheme. KDJ is the representative of oscillating class indicator, characterized by sensitivity, and MACD is the representative of trend class indicator, characterized by stability. By overlaying the KDJ line with the MACD's bars, the advantages of each can be brought into play to achieve higher returns.

8 Conclusion

1. In order to get the best daily trade, we designed a trading strategy model with MACD indicator as the main body, and also used the deviation value as an auxiliary judgment indicator, and combined with gray-Markov model, LSTM model and RSI value for comprehensive evaluation, and finally got the result: ***the final asset is 2710225.9906$***
2. After controlling the trade timing and trade size respectively, and changing other indicators, the total return obtained will be somewhat higher, and ***our model and strategy are the best according to the accuracy of the prediction model and other indicators.***

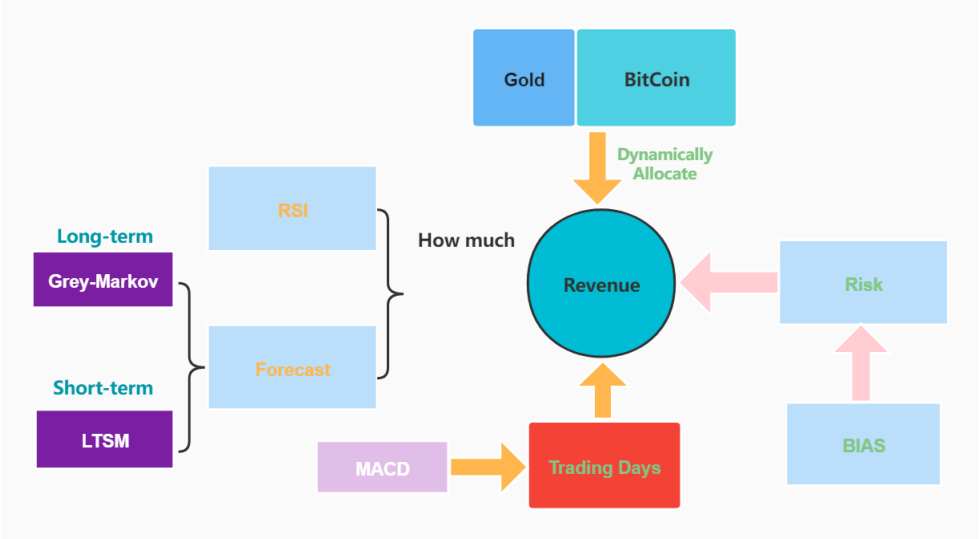
3. Our model mainly uses bitcoin as the profitability method, the transaction cost of bitcoin has a greater impact on the model, while the impact of gold is relatively small. When the transaction cost rises, we need to adjust the trading nodes to ***make the frequency of trading lower.***

9 memo

TO:the trader
FORM:MCM Team 2207267
DATE: February 21, 2022
SUBJECT:Gold and Bitcoin Investment Strategies

Dear Sir/Madam,

Hello, we were informed about your request for a strategy model for investing in gold and bitcoin. Bitcoin and gold are two assets with high price volatility, but market rules dictate that their prices are somewhat predictive, and we would like to capture this pattern to measure our asset allocation. Therefore, in accordance with your needs, we have created a trading model.



Simply but, the model works in three steps:

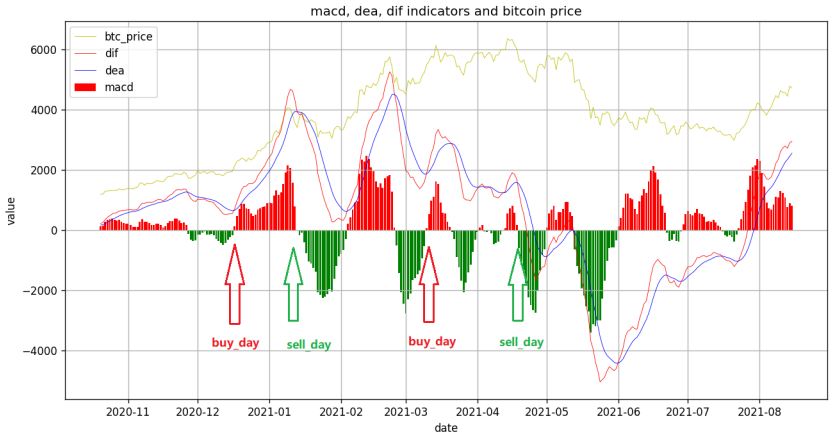
1. Short term forecasts for future gold and bitcoin prices on the current trading day, using existing data, and long term forecasts

2. Determine buy and sell points and buy and sell amounts based on MACD indicators and voting models

3. Calculate the risk value based on the deviation ratio and other indicators, and adjust the position according to the risk value.

Reliability:

Our predictive model has a high guarantee of accuracy, reliable and recognized economic indicators to guide the timing of buying and selling, and good performance of the decision model after several tests with different levels of perturbation. Combining economic indicators with neural networks and mathematical models, the multidisciplinary intersection allows for a broader coverage (not only for gold and bitcoin trading) and scalability of the model. And with five years of simulated values showing our trading model to be extremely profitable, please feel free to use our model.



Modeling strategies:

1. Please focus your attention on the MACD indicator chart, he is closely related to the timing of trading, if on a certain day, the green bar (red bar) in this chart changes to a red bar (green bar) then it indicates that a buying (selling) time has arisen, if you wish to gain maximum benefit, please refer to our recommended trading amount at this time

2. While buying and selling trades, do not forget to observe the risk indicators. When the risk indicators warn you, you should wake up and realize that you need to adjust your position. If you are overly greedy and forget about risk you may lose more than you gain.

References

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Appendices

A code

```
from MACD import Macd
from Trading import Trading
from icecream import ic

import numpy as np

ema12_btc = Macd.ema(12)
ema26_btc = Macd.ema(26)
dif_btc = Macd.dif()
dea_btc = Macd.dea()
macd_btc = Macd.macd()

ema12_gold = Macd.ema(12, False)
ema26_gold = Macd.ema(26, False)
dif_gold = Macd.dif(False)
dea_gold = Macd.dea(False)
macd_gold = Macd.macd(False)

capital_list = np.zeros((Trading.DAYS,))
trading = Trading()

gold_overall_grade = np.loadtxt("../data/gold.csv")
btc_overall_grade = np.loadtxt("../data/btc.csv")
bias_list = Macd.get_bias()

gold_day = 0
flow_capital = 0

for day in range(Trading.DAYS - 1):
trading.day = day
if Trading.GOLD_TRAN[day] == 1:
if (macd_gold[day] < 0) & (macd_gold[day] > 0):
money = trading.capital[0] * Trading.TRAN_SCALE *
```

```
 (1 + Trading.FACTOR_WEIGHT * gold_overall_grade[gold_day])
trading.tran(money, 2)
elif (macd_gold[day] > 0) & (macd_gold[day + 1] < 0):
money = -trading.capital[2] * Trading.GOLD_VALUE[day] *
 Trading.TRAN_SCALE * (1 - Trading.FACTOR_WEIGHT * gold_overall_grade[gold_day])
trading.tran(money, 2)
gold_day += 1

if (macd_btc[day] < 0) & (macd_btc[day + 1] > 0):
if bias_list[day] > Macd.MAX_BIAS:
money = 1 / 2 * trading.capital[1] * Trading.TRAN_SCALE *
(1 + Trading.FACTOR_WEIGHT * btc_overall_grade[day])
trading.tran(money)
if Trading.GOLD_TRAN[day] == 1:
trading.tran(money, 2)
else:
trading.capital[0] += money
trading.capital[1] -= money
flow_capital += money
else:
if flow_capital > 0:
temp = min(flow_capital, trading.capital[0])
trading.capital[0] -= temp
trading.capital[1] += temp
flow_capital -= temp
money = trading.capital[1] * Trading.TRAN_SCALE * \\
(1 + Trading.FACTOR_WEIGHT * btc_overall_grade[day])
trading.tran(money)
elif (macd_btc[day] > 0) & (macd_btc[day + 1] < 0):
money = -trading.capital[3] * Trading.BTC_VALUE[day] * \\
 Trading.TRAN_SCALE * (1 - Trading.FACTOR_WEIGHT * btc_overall_grade[day])
trading.tran(money)
capital_list[day] = trading.get_asset()

ic(np.sum(trading.tran_num))
ic(trading.capital)
ic(trading.get_asset())
```

```
np.savetxt("../data/capital.csv", capital_list)
x = np.arange(Trading.DAYS)
plt.plot(x[:900], capital_list[:900])
plt.show()
```