Problem Chosen C

2022 MCM/ICM Summary Sheet

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Trading strategy based on LSTM-RNN-CBAM model and Dynamic Programming model

For the first problem, above all, by the stock data has the characteristics of the large amount of data and non-smoothness, we introduced the recurrent neural network model, but found that using this model cannot solve the problem of long-time prediction; second, on this basis, we added the LSTM neural network model to solve the problem of too long time series. By adjusting the time step constantly, and finally setting the time step to 20. We use the data of the first 20 days as the neural unit input layer and the closing price of the 21st day as the label for training the model. Third, to extract the critical factors from the many factors affecting the price change, we introduce the attention model, which first uses the convolution module to generate the feature maps of each influencing factor. Then calculates the weight maps of the feature maps from the channel and space and finally multiplies the two to obtain the position of the critical information, increasing the weight of such information. The weight of such information in the prediction process. The predicted gold price error is 1.85% and the bitcoin price error is 3.08%. Then, based on the predicted prices, a yield function is constructed to quantify the buying and selling criteria to develop a buy, hold, and sell strategy. Then we introduce the relative intensity index (RSI) to determine the investment risk level to determine the amount of each asset to buy. With the above strategies, assets held and the RSI model to determine the constraints, the RSI dynamic programming model is constructed with the maximum net return as the objective function, and the final total value of assets owned is $25,316.85.

For the second problem: first, a rebuy strategy is built based on the local optimum using the greedy algorithm, which is a reallocation for the number of assets already purchased, and the increased return can compensate for the commission; then, an allocation strategy is built based on the global optimum using dynamic programming, with the capital of the purchased assets as the decision variable, the maximum holding principal as the objective function, and the amount invested cannot exceed the holding principal and the price Stability is the constraint to find the maximum return. The entire transaction obtains the best investment strategy through global and local optima.

For the third problem, above all, the commission rate fluctuation is quantified by introducing the perturbation parameter k and comparing the old and new trading strategies by plotting 3D histograms and calculating the mean squared deviation. The decision model is less sensitive to changes in the commission rate and can withstand market fluctuations within a specific range, and the decision model is more sensitive to changes in the bitcoin commission rate.

Keywords: **LSTM-RNN-CBAM model RSI Dynamic Programming**

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1 Introduction

1.1 Problem Background

Since the emergence of the international stock market, the huge international stock market has significantly impacted the global economy. Under economic globalization and financial liberalization, countries worldwide have developed extensive cooperation in the fields of economy, trade, and capital, which also means that the economic ties between countries are getting closer and closer. Since national stock markets are often considered macroeconomic barometers, stock market fluctuations in one country can propagate to another country's stock market through multiple channels, causing stock market resonance and generating stock market linkages. The correlation between international stock markets has received increasing attention from investors and scholars. 2020 saw a sudden outbreak of Newcastle pneumonia sweeping the world, with confirmed cases climbing worldwide. The epidemic has dramatically impacted people's lives and hit the global economy hard. Due to the uncertainty caused by the epidemic, the S&P 500 index fell by more than 7% on March 9, March 12, March 16, and March 18, causing global stock market shocks[1]. Bitcoin and gold are now popular worldwide, and investment in bitcoin and gold is actually the same as stocks, and the development of the stock market is inextricably linked to the global economy[2].

1.2 Ask Questions

The current questions give the daily bitcoin price from September 11, 2016, to September 10, 2020, the dollar closing price of troy ounces of gold on the specified date, and a reasonable daily allocation of the initial $1,000 in hand by analyzing the stock market quotes over a 4-year period, which requires us to consider both the bitcoin and gold quotes as a way to give a reasonable investment plan.

Based on the above background and the attached information, we need to build mathematical models to solve the following problems.

1）For the first question, the daily bitcoin price and gold dollar closing price for four years is shown in Annex I and Annex II. The two tables are integrated to see the daily price comparison between the two and the degree of increase and decrease.

2）For the second question, it is a verification of the first question, not a modeling problem, but actual proof of the rationality of the strategy of the first question. The proof method is to reason out the investment model strategy of the prediction treatment step by step through strict mathematical reasoning by the return maximization, i.e., to prove that the model built in the first question is the best strategy.

3）For the third problem, each transaction amount is allocated differently through yield comparison, which leads to different input costs of bitcoin and gold every time. Then each commission also changes accordingly. It is evident that the price of the commission is directly proportional to the invested capital, and the rate of return is closely related not only to the rise and fall of stocks but also to the commission. To

make a better investment, it is necessary to determine the impact of transaction costs on strategy.

4）All three of the above are very specialized disciplines of mathematical issues for the creation and validation of trading strategy models, including specific ideas, solution processes, code runs, etc., which is a very specialized language and too detailed. For investors, they only need to know how to invest to maximize their benefits, so we need to use simple, appropriate and easy to understand general language to accurately communicate trading strategies, models and results to investors.

2 Problem Analysis

2.1 Analysis of Problem 1

For problem 1, first, through the analysis of the meaning of the question, it can be determined that this is a forecasting and planning type of problem. We read the data in Annex I and Annex II, pre-process the data in the two tables, and after integrating them through the time difference of the data, we can see the different prices of both in the same period. Then, based on the recurrent neural network (RNN) model to predict asset prices, but the whole price fluctuation has four years, the time series is too long, at this time the recurrent neural network model produces the problem of gradient disappearance, and the herding effect of investors also affects the stock market changes, so the introduction of long short-term memory (LSTM) neural network model to predict future prices through historical prices, the model can reasonably deal with the time gradient and investor's perturbation to the stock market. Then, we found that there are many factors affecting price fluctuations, so we introduced the attention model on this basis and added screening conditions to smooth the prediction results; finally, the predicted prices are analyzed together with the invested capital to give the return function, and the daily investment strategy is planned through the comparative analysis of the return function values.

2.2 Analysis of Problem 2

For question two, which is a validation of the first question, the validation strategy is to prove that the strategy is optimal by explaining that each step performed according to our scheme will maximize the investor's rate of return and obtain the maximum holding principal. First, the first step is to determine whether to buy the asset based on the rate of return, then we need to consider how to purchase bitcoin and gold respectively, we clarify that this is a planning problem, as the market risk and commission, gold rate and daily asset prices are always changing, take these issues into account to build a dynamic planning model, and based on the favorable degree of market conditions to add a risk indicator The model takes the investor's maximum principal holding as the objective function, the investor determines the amount to be invested on that day according to the risk level of the market, and invests the amount according to the yield of bitcoin and gold, so as to obtain the

maximum return, which is the final investor's maximum holding principal, each time using this trading strategy will get the maximum return, and the dynamic planning includes the whole trading process The maximum return will be obtained every time this trading strategy is used, and the dynamic planning includes the entire trading process, so the principal obtained must be the highest, i.e. the strategy is optimal.

2.3 Analysis of Problem 3

For the third problem, the question is a sensitivity analysis of the forecasting model and decision model described above. In real markets, their transaction costs tend to be constantly fluctuating and are generally affected by many factors. In order to facilitate the quantitative calculation, a perturbation parameter is introduced and the commission rates of the other two assets fluctuate within a certain range to simulate the changing transaction costs, and the sensitivity of the model can be obtained by comparing the volatility of the results of the old and the new trading strategies and by using the changed commission rates to derive the results of the new trading strategy; fixing the commission rate of one asset and using the perturbation parameter to change the commission rate of the other asset The sensitivity of the model can be obtained by fixing one asset commission rate and varying the other asset commission rate using the perturbation parameters, and the degree of influence of the fluctuation of the two asset commission rates on the final trading result.

3.Model Assumptions

1.Regardless of the impact of the economic cycle and the country's financi al situation

2. The commission rate will not change for five years

3.Bitcoin and gold prices are not related to trading volume

4. Ignoring other factors, asset prices are influenced only by historical prices

5. Traders are able to execute daily trading strategies with precision

6. The gold and bitcoin markets are fully liquid and can be bought and sold at will

7. Gold and bitcoin can be traded in any way

4.Symbol Description

Symbol	Symbolic interpretation
Wi	Input gate weight matrix
W_f	Forget gate weight matrix
Wc	Update gate weight matrix
Wo	Output gate weight matrix
B_i	Input gate offset
B_f	forget gate Offset
B_c	Update door offset
B_o	Output gate offset
H_t	Output at the t_{th} time
C_t	State at the t_{th} time
P_i	Forecast price on the i_{th} day
Y_i	rate of return on the i_{th} day
M_i	Principal amount held on the i_{th} day
K	Disturbance parameters

5. Model Establishment and Solution

5.1 Question 1

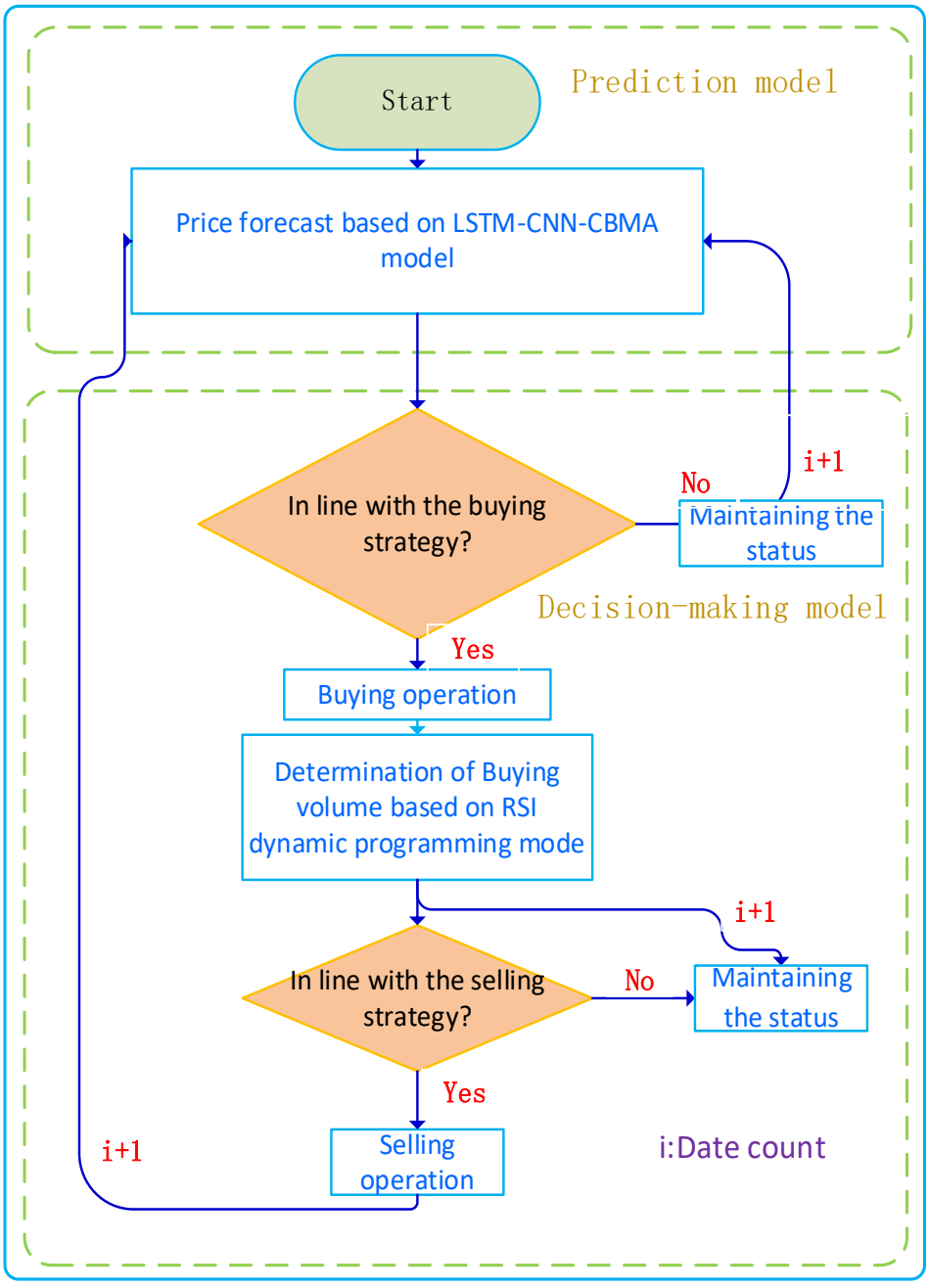

Figure 1 Problem 1 solving flow chart

5.1.1 Prediction Model

1. Model Establishment

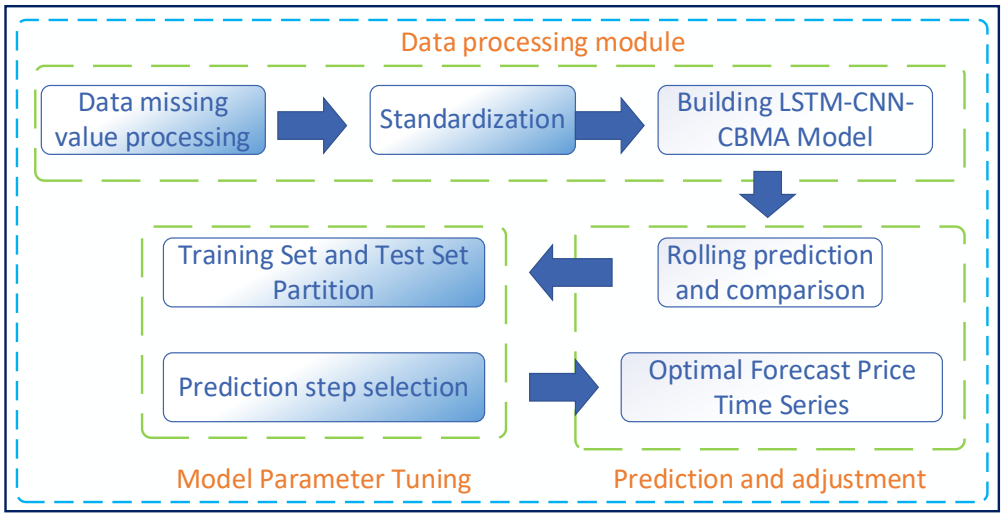

Figure 2 Prediction model mind map

In order to predict the price fluctuations of bitcoin and gold, it was determined that a recursive neural network model [3] (RNN) was used. However, the entire time-length of price fluctuations has four years, and the time series is too long, at which point the recursive neural network model will produce the problem of gradient disappearance [4], and most investors tend to be irrational. Vulnerable to subjective emotions, the herd mentality that accompanies the "herd effect" [5] indirectly affects the stock market's liquidity. When the stock market is bullish, investors' emotions may be contagious, attracting more new investors to actively invest in the market and increasing the stock market's liquidity. When the stock market is depressed, investors are pessimistic, willingness to invest is reduced, in a wait-and-see hovering state, limited attention to the stock market decline, reducing stock market trading activities, and thus stock market liquidity decreases, this sentiment of investors is the cause of stock market price fluctuations, so on this basis optimization using LSTM neural network, the method is mainly composed of storage units, input gates, output gates, forget gates The method not only solves the problem of long time series, but also takes into account the influence of investors' emotions on stock prices. The input gate is used to control the input information of the neural unit at the current moment, the forgetting gate is used to control the historical information stored in the neural unit at the previous moment, and the output gate is used to control the output information of the neural unit at the current moment [6].

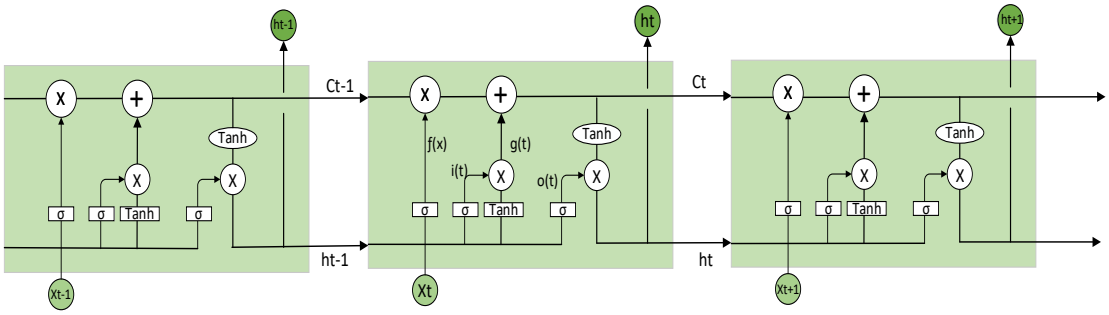

fig 3. LSTM network structure expansion diagram

LSTM calculation formula:

$$I_t=\sigma(W_i*[H_{t-1},X_t]+B_i) \quad (1)$$

$$F_t=\sigma(W_f*[H_{t-1},X_t]+B_f) \quad (2)$$

$$O_t=\sigma(W_o*[H_{t-1},X_t]+B_o) \quad (3)$$

$$C'_t=\tanh(W_c*[H_{t-1},X_t]+B_c) \quad (4)$$

$$C_t=F_t*C_{t-1}+I_t*C' \quad (5)$$

$$H_t=O_t*\tanh(C_t) \quad (6)$$

The model used above belongs to the machine in-depth learning series. Because the content of machine learning is very extensive, the factors affecting the price fluctuation of the stock market include the performance of similar stocks in the market, the performance of other financial investment products, trading factors, momentum [7], etc., and only some of these factors account for the main reason, In order to select more critical information from these factors affecting stock market prices, attention model is introduced. The model uses a convolution block attention module (CBAM) to realize the attention mechanism. CBAM represents the attention mechanism module of the convolution module. It is a simple and effective attention module designed for convolution neural networks. It combines spatial and channels attention modules. Compared with senet, CBAM has more spatial attention functions and can achieve better results. CBAM enables the model to extract key features and ignore useless features. CBAM is a lightweight general module that can be incorporated into various convolutional neural networks for end-to-end training.

The channel attention module focuses on the meaningful content of the input data. It is expressed as:

$$M_c(F)=\sigma(MLP(AvgPool(F))+MLP(MaxPool(F)))=$$

$$\sigma(W_1(W_0(F^c_{avg})))+W_1(W_0(F^c_{max})) \quad (7)$$

Where， $W_0 \in R^{c/r\times c}$， $W_1 \in r^{c/r\times c}$。

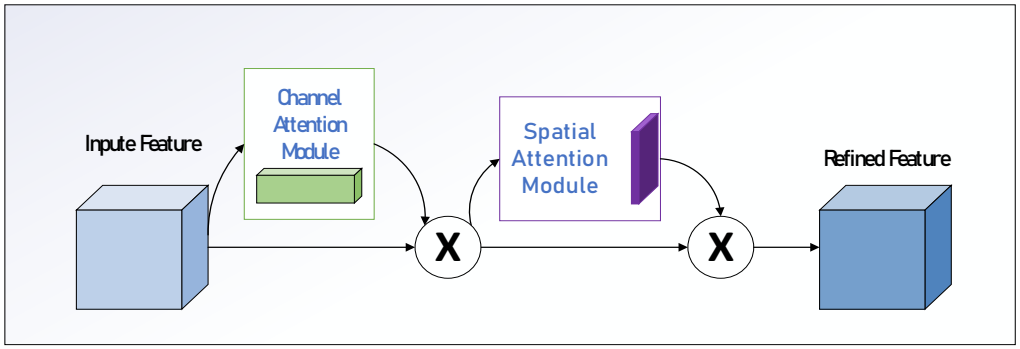

Fig 4. CBAM network structure diagram

The Spatial Attention Module focuses on which location information is meaningful and is complementary to the channel attention. Its expression is :

$$M_c(F)=\sigma(f^{7\times7}([AvgPool(F)])) \quad (8)$$

$$MLP(MaxPool(F))=\sigma(f^{7\times7}[F^s_{avg},F^s_{max}]) \quad (9)$$

The model automatically learns and extracts local and long-memory features in time series by adding a CBAM attention mechanism to a time series classification model that combines long and short-term memory neural networks and convolutional neural networks for long-memory analysis.

2. Model solving

In this prediction network model, different time steps were set for experimental comparison, and through the experiments, we found that setting different step lengths had a greater impact on the accuracy of the prediction results. After continuous optimization planning tests, we finally set the time step to 20 and used the data of the first 20 days as the input layer of the neural unit and the closing price of the 21st day as the label of the training model, and the prediction results obtained were as expected.

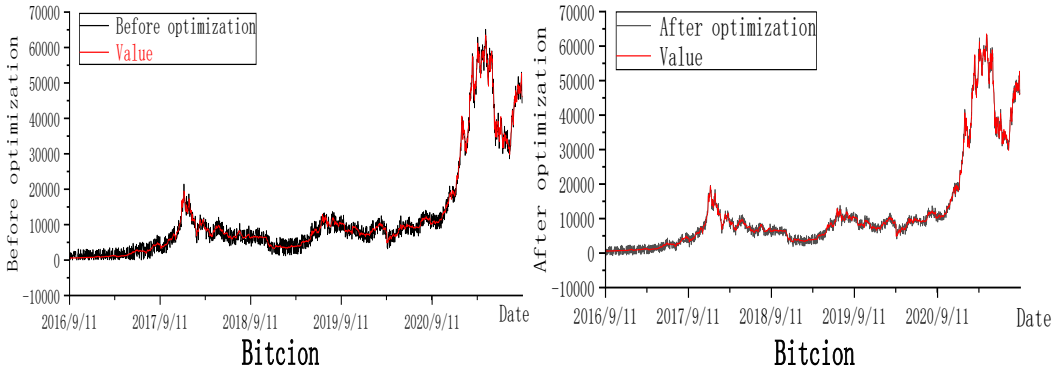

Fig 5. Bitcoin Forecast Price Chart

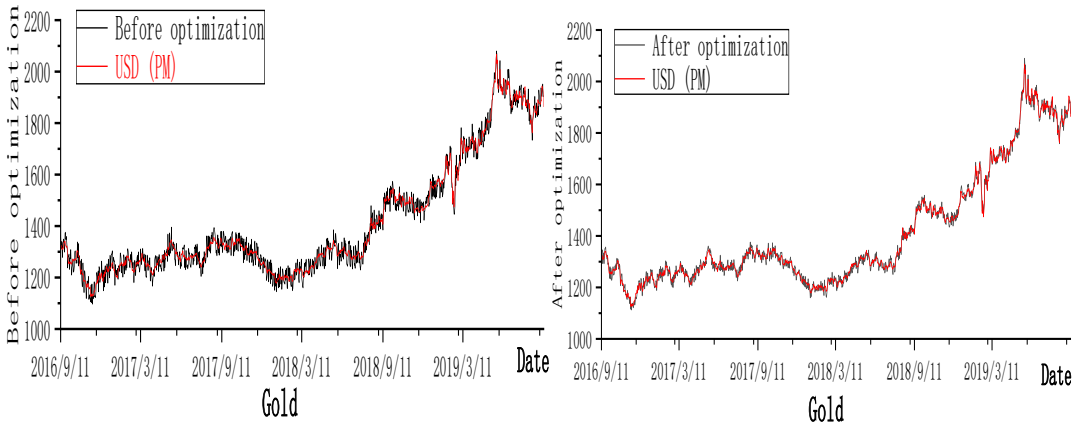

Fig 6 Gold Forecast Price Chart

The prediction results of the model are shown in Figures 3-4. The black dashed line is the price prediction value, the red curve is the real price value, the horizontal coordinate is the time, and the vertical coordinate is the price after the normalization process of the stock. By comparing the left and right graphs above, we can see that, as indicated in the left graph, when solved with only the LSTM neural network model, it does not accurately predict the price fluctuations of bitcoin and gold. The combined model of LSTM neural network and attention model in the right figure, on the other hand, has a high accuracy precisely because the CBAM module is able to use the attention model to select the feature maps that have an essential impact on the prediction results from the large number of feature maps generated by the convolutional neural network, and also to select the valuable feature information from the spatial information of these feature maps. In other words, the model has reasonable accuracy in predicting the price fluctuations of bitcoin and gold.

5.1.2 Decision-making model

Based on the prediction of the daily price trend of bitcoin and gold, we build a decision model, which determines the buying and selling method and allocation method of bitcoin and gold through the analysis of the rise and fall of both. To precisely quantify the buying and selling criteria, we introduce the ratio of Net revenue to invested capital

as the rate of return：

$$Y_{i+1} = \frac{P_{i+1}(1-\partial)-P_i(1+\partial)}{P_i(1+\partial)} \quad (10)$$

where ∂ is the commission and P_i is the forecast price on the i_{th} day .

Through a comprehensive analysis of predicted stock price fluctuations and invested capital, we give a yield function and plan daily investment strategies through a comparative analysis of yield function values.

✧ Buying strategy

From the above prediction model one can clearly derive from the historical gold and bitcoin prices the extent to which they will rise or fall in the coming period. When the predicted price on the i_{th} day, the predicted price on the $i+1_{th}$ day and the commission meet the following conditions, the investor uses the buy strategy:

$$\frac{P_{i+1}}{P_i} > \frac{1+\partial}{1-\partial} \quad (11)$$

Where ∂ is the commission, P_i is the forecast price on the i_{th} day. Assuming that the number of purchases is all one copy, $P_i(1+\partial)$ denotes the investor's total return after paying the commission on the $i+1_{th}$ day, and $P_i(1+\partial)$ is the investor's total asset purchase spend (including commission spend) on the i_{th} day.If $\frac{P_{i+1}}{P_i} > \frac{1+\partial}{1-\partial}$, It indicates that the Net revenue is greater than the commission expense, and the assets can be purchased. Then, when investors decide to use the buying strategy, the operation of how to buy bitcoin and gold is as follows:

1. Rebuy strategy

A rebuy is when an investor has bought an asset and, after a period of time, sells one asset and buys another. Since commissions are paid for buying and selling assets, a repurchase is made when the difference between the expected return on the other asset to be bought and the expected return on the purchased asset is greater than the commission paid for the selling operation. The net profit increases.

$$P_{2,i+1}(1-\partial) - P_{1,i+1} > \partial P_{2,i} \quad (12)$$

$P_{2,i+1}(1-\partial)$ denotes the total return after the commission paid by the investor on the $i+1_{th}$ day assuming the purchase of another asset, and $P_{2,i+1}(1-\partial)$ denotes the forecast price of the purchased asset on the $i+1_{th}$ day. When equation (12) is not satisfied, it means that the increased revenue from repurchase does not cover the commission expenses, then the repurchase operation is expected to lose money. To ensure that the income is maximized, the investor must execute a holding plan that keeps the original quantity of both constant.

2. Reliability evaluation model

Based on the investor's execution of the buying strategy, it is first necessary to consider the riskiness of the market, which is a crucial issue in the selling strategy, and there is a risk that occurs when buying and selling, which affects the amount of money invested by the investor, hence the introduction of the Relative Strength Index [8] model (RSI). The model can predict the future direction of prices based on price changes over a period of time and can determine the strength of the market according to the magnitude of price increases and decreases [9]. RSI is calculated as follows: RSl parameters commonly use the number of trading days, there are 5, 9, 14 days, according to the bitcoin and gold trading time table decided to choose the parameters selected 14 days, at this time, first obtain the previous 15 days of closing prices including the day, with each day's closing price minus the previous day's closing price, to obtain 14 days of closing prices. The closing price of these 14 days is greater than or equal to zero, that is, the asset price upward movement, there is less than zero, that is, the asset price downward movement, to determine the investment strength. The calculation formula is as follows.

Sum of upward price changes in 14 days:

$$N = \sum_{n=i-7}^{i+7} P_n(P_n \geq 0) \qquad (13)$$

The sum of the absolute values of downward price changes in 14 days:

$$L = -\sum_{n=i-7}^{i+7} P_n(P_n < 0) \qquad (14)$$

Average upward price movement as a percentage of asset price movement：

$$\mathrm{RSI}_{14} = \frac{N}{\mathrm{N+L}} \times 100\% \qquad (15)$$

3. Buy volume decision strategy

When an investor decides to use a buying strategy, the most critical question is how to use a buying scheme that allocates the purchase of bitcoin and gold in a way that maximizes the return, which is obviously a planning problem. Using the predicted bitcoin and gold prices and considering the risk of buying and selling, i.e. the reliability model described above, the planning objective function is given as the maximum net return:

$$Max\_\Delta M_i = \triangle B_i Y_{b,i} + \triangle G_i Y_{g,i} \qquad (16)$$

constraint condition：

$$st.\begin{cases} (1+\partial_b)\triangle B_i \le (RSI_b)M_i \\ (1+\partial_g)\triangle G_i \le (RSI_g)M_i \\ (1+\partial_b)\triangle B_i + (1+\partial_g)\triangle G_i \le M_i \\ \triangle B_i, \triangle G_i \ge 0 \end{cases} \quad (17)$$

✧ Direct selling strategy

This strategy is opposed to the buy strategy, when investors find that in the recent period of time asset prices are in a continuous decline, which is obviously contrary to the buy strategy, at this time, investors in order to maximize their own interests, the most intelligent approach is to sell all the assets in their hands, while investors such changes in sentiment also have a certain impact on asset prices, the price line after the wait and see, when the price is stable, again to determine whether to meet the buy strategy.

Direct sell-off conditions:

$$\frac{P_{i+1}}{P_i} < \frac{1+\partial}{1-\partial} \quad (18)$$

5.2 Question 2

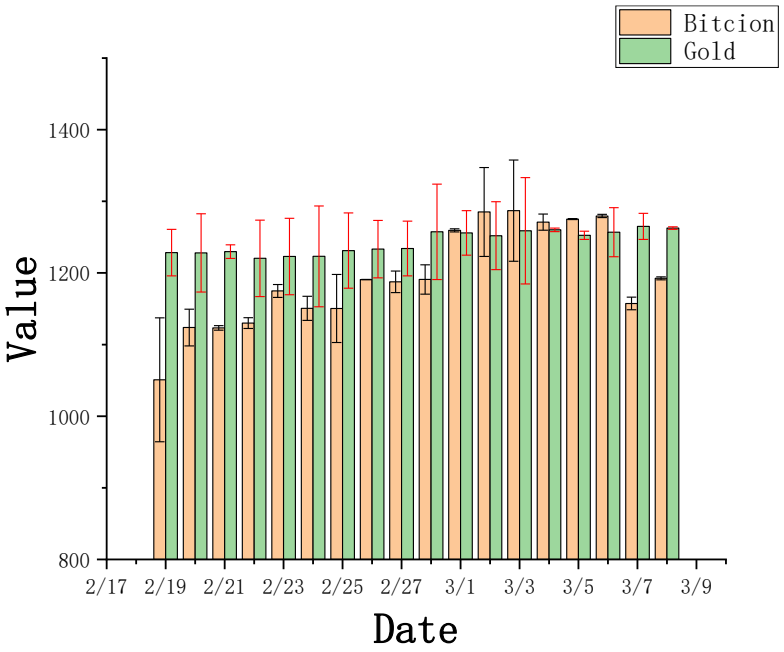

Fig 7. Error diagram of predicted prices and actual prices for some dates

As can be seen from the figure above, the predicted price of bitcoin and gold extracted from some dates is found to have little error with the actual price. The error

of gold price calculated from all predicted data is 1.85% and bitcoin price error is 3.08%.5.2.1 Decision model proof

5.2.1 Buying Strategy

The return Y_{i+1} on the i+1th day is calculated by first calculating the investor's total return on the i+1th day including the commission payment as $P_{i+1}(1-\partial)$, and then calculating the total amount spent by the investor on the ith day to buy the asset and pay the commission as $P_i(1+\partial)$, The two are subtracted as the net return, and the ratio of the net return to the original capital is the rate of return. Only when the predicted rate of return is greater than 0, the investor will buy the asset, so the buy strategy is implemented, which is in line with common sense and proven:

$$Y_{i+1} = \frac{P_{i+1}(1-\partial)-P_i(1+\partial)}{P_i(1+\partial)} > 0 \qquad (19)$$

When equation (20) is satisfied the investor buys the asset：

$$\frac{P_{i+1}}{P_i} > \frac{1+\partial}{1-\partial} \qquad (20)$$

5.2.2 Holding Strategy

Fig. 8. Indicative diagram of operation without holding assets (left) and holding assets (right)

It is clear from Figure 8 that holding and non-holding exist for at least three days before they occur, the main reason being a decision made by the investor when considering price changes, assuming that the assets purchased are all one copy, as can be seen from the graph on the left, the return on the $i+1_{th}$ day is first derived, and then the principal owned by the investor on the $i+1_{th}$ day is calculated, and similarly the amount held by the investor on the $i+2_{th}$ day is the sum of the return on the $i+1_{th}$ day

and the principal The sum of Since the execution of the switch buy operation on the i+1th day, although it can make the return higher, but also need to pay the commission again, at this time the holding amount of the i+2th day is $P_{i+2}(1-\partial)(\frac{1-\partial}{1+\partial})$, if the asset is held on the i+1th day, only one commission needs to be paid, as shown on the right side figure. At this time, the amount of holding on the i+2th day is $P_{i+2}(1-\partial)$ and the amount of holding is compared, if the total return of not holding the asset is less than the total return of holding the asset, indicating that the commission is more expenses, and the opposite is a good return, not only to make up for the commission but also to improve the return, then use the switch to buy, which is in line with the investor's consciousness and get the evidence.

Non-holding

$$Y_{i+1}=\frac{P_{i+1}(1-\partial)-P_i(1+\partial)}{P_i(1+\partial)}$$

$$M_{i+1}=M_iY_{i+1}+M_i=P_{i+1}(1-\partial)$$

$$Y_{i+2}=\frac{P_{i+2}(1-\partial)-P_{i+1}(1+\partial)}{P_{i+1}(1+\partial)}$$

$$M_{i+2}=M_{i+1}Y_{i+2}+M_{i+1}$$

$$=P_{i+2}(1-\partial)(\frac{1-\partial}{1+\partial})$$

Holding

$$Y_{i+2}=\frac{P_{i+2}(1-\partial)-P_i(1+\partial)}{P_i(1+\partial)}$$

$$M_{i+2}=M_iY_{i+2}+M_i=P_{i+2}(1-\partial)$$

$\boldsymbol{P_{i+2}(1-\partial)(\frac{1-\partial}{1+\partial})}$ is the principal amount on the i+2th day after the sell operation and $\boldsymbol{P_{i+2}(1-\partial)}$ is the principal amount on the i+2th day after the no sell operation. Since $\boldsymbol{\left(\frac{1-\partial}{1+\partial}\right)<1}$ is true, indicating that the sell-off requires excessive commission payments, all commission payments resulting from buying and selling assets should be avoided if the conditions of the buy-and-sell strategy are not met:

$$P_{i+2}(1-\partial)(\frac{1-\partial}{1+\partial})<P_{i+2}(1-\partial)$$

5.2.3 Selling Strategy

This strategy is based on the buy strategy. Only after the investor has bought do they need to consider how to redistribute the amount of bitcoin and gold they hold in order to make the most of their gains, when the increased gains from rebuy to buying are greater than the commission payments, the gains are greater after performing the resell operation. Assuming the number of purchases is one, the first consideration for bitcoin is that when bitcoin sells off and gold is bought resulting in an increased return greater than the commission expense, a rebuy strategy is executed. The formula proves that.:

Bitcoin's rate of return on the i+1th day：

$$Y_{1,i+1} = \frac{P_{1,i+1}(1-\partial)-P_{1,i}(1+\partial)}{P_{1,i}(1+\partial)} \quad (21)$$

Holding bitcoin on the $i+1_{th}$ day：

$$M_{1,i+1} = M_{1,i}Y_{i+1} + M_{1,i} = P_{1,i+1}(1-\partial) \quad (22)$$

Gold's rate of return on the i+1th day：

$$Y_{2,i+1} = \frac{P_{2,i+1}(1-\partial)-P_{2,i}(1+\partial)}{P_{2,i}(1+\partial)} \quad (23)$$

Holding gold on the $i+1_{th}$ day：

$$M_{2,i+1} = M_{2,i}Y_{2,i+1} + M_{2,i} = P_{2,i+1}(1-\partial) \quad (24)$$

$$P_{2,i+1}(1-\partial) - P_{1,i+1} > \partial P_{2,i} \quad (25)$$

By comparing the assets in the hands of the investor after a round of operations, when the formula (25) is satisfied indicates that the net benefit of the switch is greater than the commission expense, the investor should only consider making a rebuy between bitcoin and gold, otherwise keep, which is obviously in line with common sense, to get evidence.

5.3 Question 3

5.3.1 Sensitivity Test

Considering that in real life the market or policies are constantly changing, the commission rates of transactions tend to fluctuate to a certain extent. In order to simulate the real market situation, for this purpose, a perturbation parameter k is introduced to change the commission rates of both products. Verify the robustness of the model.

Bitcoin trading commission rate changes:

$$\partial_b = \partial_{bitcoin} \pm k(k = 0.1\% \sim 0.5\%) \quad (26)$$

Gold trading commission rate of change:

$$\partial_{gold} = \partial_{gold} \pm k(k = 0.1\% \sim 0.5\%) \quad (27)$$

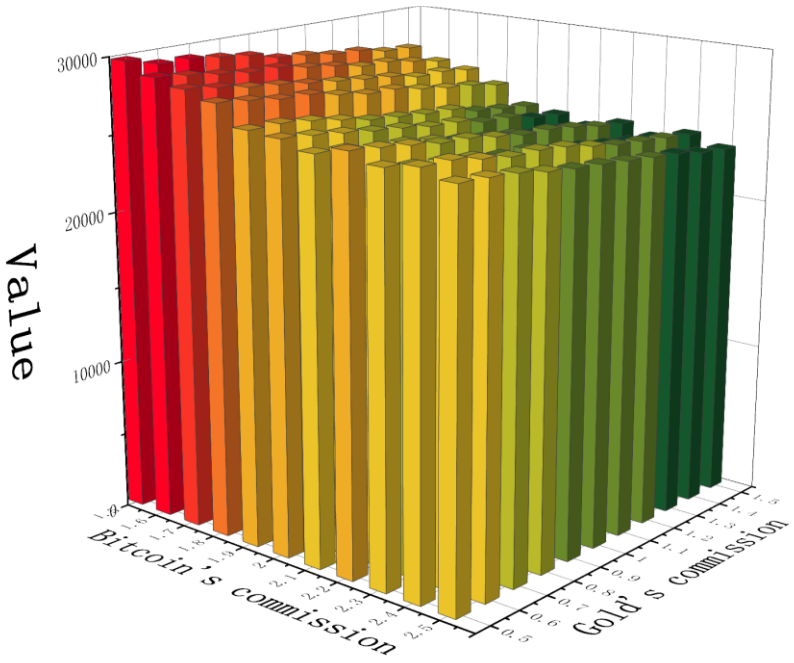

Fig 9. Graph of the impact of commission changes on final revenue

The new trading commission rate is brought into the above decision model to derive the total assets obtained after the change in commission rate, and the resulting data is used to construct an 11×11 matrix to draw the graph shown in Figure 9. It can be seen that when a certain increase or decrease in the trading commission rate occurs (±0.5%), there is no significant change in the magnitude of the final total assets, which shows that the model is resistant to certain disturbances, can withstand market fluctuations within a certain range, has the ability to be replicated, and has good robustness.

5.3.2 Sensitivity Analysis

When both assets' trading commission rates change at the same time, the impact of fluctuations in which asset's trading commission rate has on the final total assets is not obvious, although the overall trend can be seen. Therefore we fix the trading commission rate of one of the assets and let the trading commission rate of the other asset fluctuate, in this case comparing the mean and mean squared deviation of the final total assets, as in Figure 10.

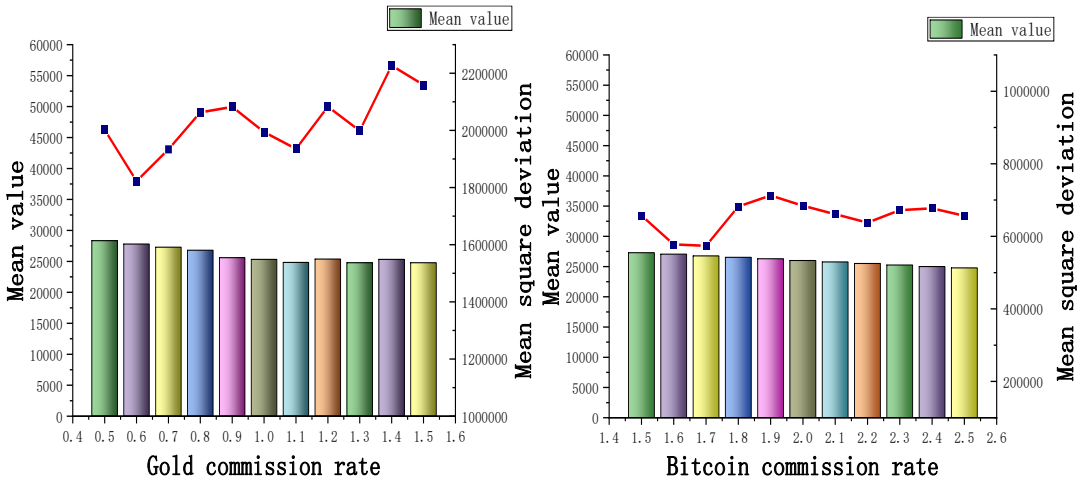

Fig 10. Degree of impact of single stock commission changes on final returns

It can be seen that when the gold trading commission rate is constant and the bitcoin commission rate is changed, the mean squared difference is much larger than when the bitcoin trading commission rate is constant and the gold trading commission rate is changed. This is because the trading decision pays more commissions due to the high volatility of bitcoin prices and frequent short-term trading, while gold prices are more stable and more long-term trading is chosen for the pursuit of greater returns, paying less commissions. So the fluctuation in the commission rate for bitcoin trading has a greater impact on the total final asset value.

6. Model Evaluation and Improvement

For the prediction model, this paper compares the Recurrent Neural Network model(RNN) with the LSTM neural network model and shows that the LSTM with the presence of memory cells can accurately remember the daily bitcoin and gold price changes over four years, and the prediction accuracy is improved. Meanwhile, the comparison experiments of LSTM and LSTM-CNN show that the price error predicted after filtering the key information affecting the market changes is only 1.85% and 3.06%. This shows that the model is feasible and effective in predicting market information, and the comparative analysis of the timeliness of the three prediction models proves that the model has good timeliness. Secondly, the peak prices of bitcoin and gold among this prediction still have large errors with the actual prices, and will be considered in future work to combine factors such as public opinion analysis and text mining [10], hoping to improve the accuracy of the model for stock price prediction and improve the application scope of the model. For the decision model, this paper not only uses to greedy algorithm to plan the local optimal solution, but also uses dynamic programming to solve the global optimal solution, so that investors get the maximum return in all investment steps and practically consider the investor sentiment, but the total daily trading volume of the market is ignored in this model, and in the actual market, the daily trading volume will have a profound impact on the market price, and

secondly, in verifying the decision Secondly, when verifying the sensitivity of the model to the transaction cost, the transaction cost is simplified to the change of commission rate, but in the actual market, the transaction cost is very extensive, including tax, principal, etc. Therefore, the method cannot avoid causing certain errors, and based on the time problem, the above problems cannot be solved for the time being, but we will still conduct research and learning

7.Reference

[1] Gong Jinguo, Shi Daimin. Financial liberalization, trade intensity and stock market linkages I-Evidence from the Chinese and US markets[J]. International Financial Studies,2015（06）：85-96

[2] Niu Wenxin. The Real Intention of the "Active Stock Market Policy" in the Global Economic New Deal Deserves Attention [D]. China Economic Weekly,2019.11.

[3] Li J, Lin YF. Time-series data prediction based on multi-timescale RNN[J],Computer Applications and Software, 2018, 35(7): 33-37.

[4] Ren Jun, Wang Jianhua, Wang Chuanmei, et al. Stock index prediction based on regularized LSTM model[J]. Computer Applications and Software, 2018, 35(4): 44-48.

[5] Yang, L.S., Yang, J.. Research on Monetary Policy, Investor Sentiment and Stock Market Liquidity [D]. Yunnan: Yunnan University of Economics, 2021.9.

[6] Liu Changkun. Research on stock prediction based on deep learning [D]. Beijing: Beijing University of Technology, 2018.

[7] Li Ling. Analysis of factors influencing the stock price of listed companies based on Eviews [D]. Computer Programming Skills and Maintenance, Changchun: Changchun College of Architecture, 2021.12.

[8] Lin J, Gong Z. A comparative study of futures program trading strategy models-an example of palm oil futures trading [D]. Shanghai: Tongji University, School of Economics and Management, 2019

[9] Wells Wilder. New ideas for technical trading systems [M]. Gao, H. R.. Shanxi:Shanxi People's Publishing House, 2018:102-306.

[10] Zheng Guojie Stock time series analysis and prediction based on Internet investor sentiment, Zhejiang [D] Hangzhou: Zhejiang University of technology, 2019

MEMORANDUM

To the traders:

Our team has analyzed the impact of historical prices of assets in the market on subsequent future prices and expects to construct a trading decision model that will generate good returns, and we are writing this letter to report our findings in the hope that they will inspire you.

We first analyze the historical prices of two common assets in the market (gold and bitcoin) to predict their future price movements, and through our tests, with a large enough data sample, we have a prediction error of no more than 5% for the price. We then construct a trading decision model that generates as much revenue as possible. In the specific model, we use the historical prices of gold and bitcoin to predict their prices in the next few days, and compare the specific returns of buying, holding and selling the assets, taking into account the fees, i.e. commissions, to calculate and choose the strategy with the highest possible return to trade. Of course, due to the uncontrollable nature of the market, we add a risk factor to determine the current market strength of the asset by judging its historical price increase or decrease over a certain period of time to determine the exact amount of our investment. Although this will reduce the return to a certain extent, the advantage is that it is more stable and has less loss in the event of an uncontrollable market crash：

These results were subjected to sensitivity analysis, i.e., the commission rates of each asset were continuously changed to calculate new trading strategies, and it was found that the final results did not fluctuate to a large extent, which can reflect that our model is more stable and has promotion value; and because the price of bitcoin is more volatile, the commission paid is more frequent for short-term trading; while the price of gold is more stable, and in order to pursue greater returns, more long-term trading and pay less commission, so the change of bitcoin commission rate has a greater impact on the final decision, indicating that the commission rate of assets that need to be traded frequently in the trading process is more worthy of attention. Based on the above analysis, we propose some recommendations to better select trading strategies during the trading process：

Before entering the market, you should first establish your own investment plan, but more importantly, you should clarify your own investment motives, how much investment risk you can bear, the source of your own funds, the use of proceeds and other issues.

The risk of betting on one stock is very high. It is impossible for an investor to accurately grasp the fluctuations of a stock, and a slightly larger fluctuation in the stock

price can affect the investor's mood and even make him/her make a wrong buying or selling decision. Therefore, it is recommended to use the diversification method of buying and selling, dividing the money into several shares and then investing in different stocks.

Using previous historical price data to predict future market prices and then constructing trading strategies in an appropriate manner to achieve larger returns, our model is reasonable and easily replicable in our tests.

Above, we hope our model can inspire you. Thanks!

Yours sincerely

Team #2204152