ISSN 2616-5775 Vol. 5, Issue 7: 47-54, DOI: 10.25236/AJCIS.2022.050708

Research on asset trading strategy based on forecasting model and decision-making trading model

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Abstract: *Quantitative investment is becoming more and more popular among traders. Market traders who seek to maximize returns by buying and selling volatile assets focus more on quantitative trading. They try to find the optimal trading strategy by quantitative investment. We developed a decision trading model to try to find the optimal trading strategy to obtain the optimal returns. Our model consists of four parts, data processing, Arima prediction model, risk prediction model and bull-bear market predicting model.*

Keywords: *Trading strategies; Arima prediction model; AHP*

1. Introduction

When market traders have accumulated enough capital, their nature tends to make them want to enter the financial market to accumulate more capital. In the past, market traders often adopted the traditional way of investment, which uses fundamental analysis or tech-nical analysis in the investment process, through human experience and judgment to deter-mine asset allocation, stock selection and timing[1,2].

With the continuous development of computer and network technology, quantitative in-vestment is becoming more and more popular among traders. Through the construction of quantitative models, to predict market trends[3]. The use of computers to achieve efficient investment behavior, to obtain high returns, and can avoid artificial negative effects, through the computer strategy to manage the emotions and cognition, more accurate judgment and analysis for the investment object, can balance risk and return. Quantitative in-vestment enables more and more investors to realize the dream of stable income[3].

2. Assumptions and notations

We use the following assumptions.

● When considering a risk prediction model, the government assumes that risk prediction can be achieved by using trend analysis alone.

● There is only one kind of product that is bought or sold in each day's transaction.

● It is assumed that social, economic, political and other factors do not have a great impact on commodity prices.

● The effect of convergence divergence on the predicted value is assumed to be less than the mean increase.

3. Notations

The key mathematical notations used in this paper are listed in

Table *1*.

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Table 1: Notations used in this paper

Symbol	Description
σ	Gold market opening parameter
$R_x(i)$	The amount of increase on i day of product x
$V_x(i)$	The forecast price on i day of product x
$Vl_{(x)}(i)$	The real price on i day of product x
$R_{agx(c)}(i)$	The average amount of increase for c days before the i of product x
$s_{bbx}(i)$	Bull bear market pre-evaluation index on i day of product x
$S_{kx}(i)$	Risk index on i day of product x
$Y_{x(c)}(i)$	The good rate for c days before the i of product x
$S_{bbx}(i)$	Bull bear market evaluation index on i day of product x
Q	Decision value

4. Model construction and solving

To maximize returns for market traders, we need to explore how the daily trading strategy works, namely the specific allocation of cash, gold and Bitcoin. Since every transaction comes with a commission, we cannot take the strategy of frequent transactions, so we need to minimize the number of transactions. Bitcoin can be traded daily, but gold can only be traded on market open days. Based on the above limitations, we need to develop a corresponding model to find the best daily trading strategy suitable for market traders.

4.1 Data Cleaning and Preprocessing

Market traders have given us daily prices for gold and bitcoin from 9/11/2016 to 9/10/2021, we can only develop the model based on the data provided. Through preliminary data analysis, we find that the price list of bitcoins is complete, but data are missing in the price list of gold and the market is closed on some days.

Through the analysis of the opening date of the gold trading market, we know that the trading market is generally open from Monday to Friday and closed on Saturday and Sunday. When Christmas comes, trading markets are closed. Based on the above analysis, we get the details of the opening of the gold trading market. Therefore, for subsequent calculation, we define parameters σ to indicate whether the gold trading market is open or not. The notation σ is defined in formula (1).

$$\sigma = \begin{cases} 0, M \in M_{close} \\ 1, M \in M_{open} \end{cases} \tag{1}$$

Except for Christmas, Saturday and Sunday, there are a few days when there is no corresponding gold price. To enhance the accuracy of the result and find the optimal trading strategy as far as possible, we cannot ignore the day corresponding to the vacancy value, so we need to complete the data[4].

For this problem, we need to pursue accurate function values, achieve accurate predictions, to develop the optimal trading strategy. Therefore, the newton interpolation method was selected to supplement the vacancy value.

Newton's interpolation method is based on the value of the function around the difference quotient formula fitting interpolation polynomial, using polynomial to calculate the missing data to obtain the result.

$$f\left[x_0, x_1, ..., x_n\right] = \frac{f[x_0, x_1, ..., x_{n-1}] - f\left[x_1, x_2, ..., x_n\right]}{x_0 - x_n} \tag{2}$$

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After calculation, missing data can be obtained. The missing data is shown in Table 2.

Table 2: Supplementary value and corresponding time of missing data

Time	**12/23/2016**	**12/13/2016**	**12/22/2017**	**12/19/2017**	**12/24/2018**
Value	1119.07	1150.37	1259.88	1299.19	1243.28
Time	12/31/2018	12/24/2019	12/31/2019	12/24/2020	12/31/2020
Value	1281.87	1489.01	1519.70	1851.66	1897.67

4.2 Establish an Arima model to predict the price

To establish the Arima model to predict the price of bitcoin and gold, there are severe steps.

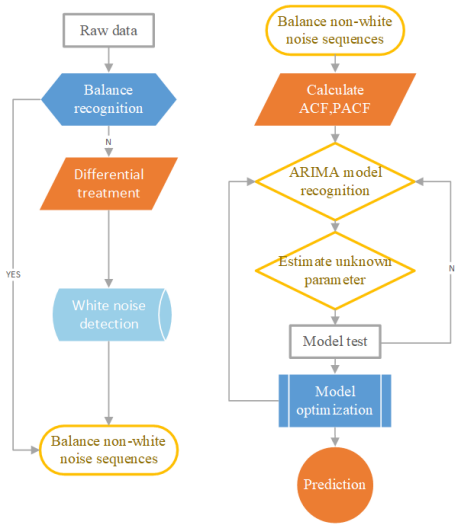

Figure 1: Flow chart of Arima model establishment

Flow chart of Arima model establishment is shown in Figure 1.

Step 1: According to the raw data, the graphs of price changes are shown in Figure 3. By observing the graphs, we find that price is volatile.

Step 2: For non-stationary time series, we need further judgment. Based on the above conditions, we come up with the autocorrelation function (ACF), which describes the linear correlation between time-series observations and their past observations[5].

$$ACF(k) = \rho_k = \frac{Cov(y_t, y_{t-k})}{Var(y_t)} \tag{3}$$

$Cov(x, y)$ stands for covariance of x and y. $Var(x)$ stands for the variance of x. Based on the formula (5), the autocorrelation graphs can be plotted in Figure 2 and Figure 2.

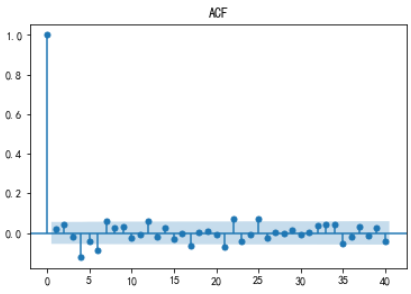

Figure 2: The ACF graph of bitcoin

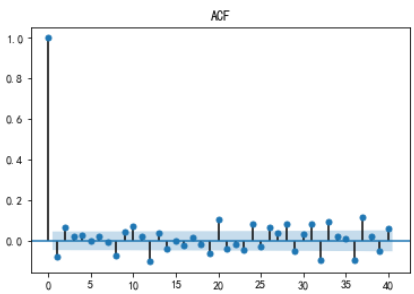

Figure 3: The ACF graph of gold

According to the ACF graph, we can find that the autocorrelation coefficient is greater than 0 for a long time, it indicates that the series has a strong long-term correlation, so the trend is not stable. Therefore, difference calculation should be performed and tested successively.

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Step 3: By differentiating the data multiple times, the raw data can be changed into stationary time series. We find that the second-order difference is stable enough to satisfy the requirement.

Step 4: Perform white noise detection to get the stationary non-white noise sequences. We can find p far less than 0.05, so the sequence is a stationary non-white noise sequence.

Step 5: The autocorrelation coefficient (ACF) and partial autocorrelation coefficient (PACF) of stationary time series are gotten, and the optimal level P and order Q are obtained by analyzing autocorrelation and partial autocorrelation graphs.

$$\rho_{X_t, X_{t-k} | X_{t-1}, \ldots, X_{t-k+1}} = \frac{E[(X_t - \hat{E}X_t)(X_{t-k} - \hat{E}X_{t-k})]}{E(X_{t-k} - \hat{E}X_{t-k})^2} \tag{4}$$

Step 6: BIC was used to further determine the order.

$$BIC = In(n) * c - 2In(a) \tag{5}$$

In formula (7), n is the sample size. A number of parameters is expressed as c, the maximum likelihood function value is expressed as a.

Step 7: The corresponding Arima model is established according to the parameters.

$$y_t = \mu + \sum_{i=1}^{p} \gamma_i y_{t-i} + \varepsilon_t + \sum_{i=}^{q} \theta_i \varepsilon_{t-i} \tag{6}$$

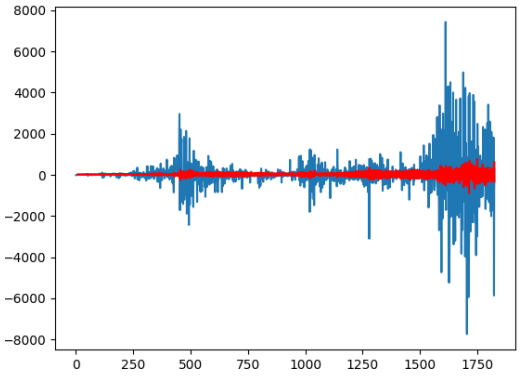

Figure 4: The chart of bitcoin price gains

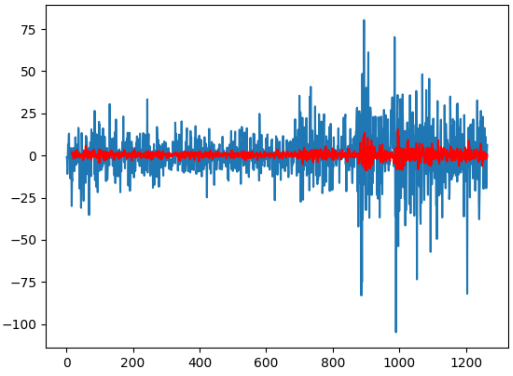

Figure 5 The chart of gold price gains

The chart of bitcoin price gains and the chart of gold price gains is shown in Figure 4 and Figure 4.

4.3 Bull or bear market prediction model

Due to the volatility of the market being influenced by many factors, there is no rule, the specific results of using the Arima model to predict the price is not accurate, but we found that the price trend prediction accuracy is high, so the estimate the price only can be used as a reference, not as a decision value, therefore, we put forward the cow bear market model for up and downtrend for further discussion.

Our team suggests that data on an uptrend is a bull market and data on a downtrend is a bear market. Hence, we need to find some parameters to determine whether the market is bullish or bearish. We define the forecast price of gold and bitcoin on the day i is expressed by $V_g(i), V_b(i)$. The real price of gold and bitcoin on the day i is expressed by $Vl_g(i), Vl_b(i)$. Besides, we also put forward the definition of the amount of increase, which is shown in formula (7).

$$\begin{cases} R_b(i+1) = V_b(i+1) - Vl_b(i), Bitcoin \\ R_g(i+1) = V_g(i+1) - Vl_g(i), Gold \end{cases} \tag{7}$$

Through literature search, we find the bull and bear market mainly determined by two parameters, one is the average price of the product in the first 30 days, the other is a good rate. Hence, the calculation

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of the average price of the product in the first 30 days and good rate is shown in formulas (8) and (9).

$$R_{agx(c)}(i) = \frac{\sum_{n=1}^{c} R_x(i-n)}{c} \tag{8}$$

$$Y_{x(c)}(i) = \frac{Vl_x(i)}{\frac{\sum_{e=1}^{c} Vl_x(i-e)}{c}} \tag{9}$$

From the price trend chart, we can find that bitcoin has a wide range of ups and downs, suitable for a short-term investment, gold ups and downs of small, suitable for long-term investment. Since bitcoin is highly volatile and suitable for short-term investment, we will take a small number of days to analyze bitcoin. In the case of small fluctuation of gold, we will increase the number of days appropriately during the analysis to conform to the actual situation. To make sure that the bull market is greater than 0 and the bear market is less than 0 in the short term. Specific selection criteria are shown in Table 3.

Table 3: Specific selection criteria for gold and bitcoin

	Average days of the amount of increase	Days of convergence and divergence	Number of days for calculation
Gold	60	15	90
Bitcoin	30	5	60

For the gold market:

$$s_{bbg}(i) = R_{agg(60)}(i) * t_1 + Y_{g(15)}(i) * t_2 \tag{10}$$

For the bitcoin market:

$$s_{bbb}(i) = R_{agb(30)}(i) * t_1 + Y_{b(5)}(i) * t_2 \tag{11}$$

Then, we will calculate the final bull bear market evaluation indicators to sum all the bull bear market pre-evaluation indicators.

For the gold market:

$$S_{bbg}(i) = \sum_{i-90}^{i} s_{bbg}(i) \tag{12}$$

For the bitcoin market:

$$S_{bbb}(i) = \sum_{i-60}^{i} s_{bbb}(i) \tag{13}$$

If the decision factor is greater than 0, it is bull market. If the decision factor is less than 0, it is bear market.

4.4 Risk prediction model

For this question, our team choose trend analysis method to predict the risk of investment due to the limited data. Finally, we choose the Mann-Kendal trend analysis method.

For Mann-Kendal trend analysis method, the original formula is shown below.

$$S = \sum_{r=1}^{n-1} \sum_{k=i+1}^{n} \operatorname{sgn}(X_k - X_i) \tag{14}$$

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$$\operatorname{sgn}(\theta)=\begin{cases}1,\theta>0\\0,\theta=0\\-1,\theta<0\end{cases} \tag{15}$$

When we put this model into our situation, the corresponding formula is shown blow.

$$S(i)=\sum_{n=i-90}^{i-1}\sum_{k=n+1}^{i}\operatorname{sgn}(Vl_g(k)-Vl_g(n)) \tag{16}$$

$$Var=\frac{i(i-1)(2i+5)}{18} \tag{17}$$

$$Z=\begin{cases}\dfrac{S-1}{\sqrt{V}},S>0\\0,S=0\\\dfrac{S+1}{\sqrt{V}},S<0\end{cases} \tag{18}$$

$$S_k=\frac{1.96}{(Z-0.025)} \tag{19}$$

In the above formula, Z stands for the Z statistic and Var stands for the variance of sequence.

4.5 Decision trading model

Based on the above three models, we propose the final trading decision model. To make buying and selling decisions, we need to use the results of the above three models to establish an analytic hierarchy process model.

The AHP method should be used to evaluate whether to decide is based on the results of the three models mentioned above.

The factors contained in the problem are stratified. The factors are divided into three levels, which are the highest level (to screen out the sightings with high credibility), the middle level (to realize the indicators of screening), and the bottom level (all sightings).

Based on four indicators selected from eyewitness reports: time, image, position and notes. Construct the judgment matrix of the first-grade evaluation index.

$$n=\begin{bmatrix}\frac{W_1}{W_1}&\frac{W_1}{W_2}&\frac{W_1}{W_3}\\\frac{W_2}{W_1}&\frac{W_2}{W_2}&\frac{W_2}{W_3}\\\frac{W_3}{W_1}&\frac{W_3}{W_2}&\frac{W_3}{W_3}\end{bmatrix} \tag{20}$$

After the judgment matrix is constructed, the relative weight of each element in two levels is calculated by the judgment matrix, and the consistency test is carried out. It is not allowed for the judgment to deviate too much from the consistency, so the consistency test of the judgment matrix is needed. The specific test steps are as follows:

Step 1: Calculated consistency index CI:

$$CI=\frac{\lambda_{\max}-n}{n-1} \tag{21}$$

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Step 2: Check the criteria for testing the consistency of the judgement matrix from the relevant data $RI(n)$

Step 3: Calculate the random consistency ratio of the judgment matrix CR

$$CR = \frac{CI}{RI} \tag{22}$$

The consistency ratio is less than 0.1, the judgement matrix of AHP has satisfactory consistency, namely its consistency degree is acceptable.

The results are shown in Table 4 and Table 5.

Table 4: Index judgement matrix

	Forecast price	Risk index	Evaluation index
Forecast price	1	3	2
Risk index	1/3	1	2
Evaluation index	1/2	1/2	1

Table 5 Evaluation index and weight

	Forecast price	Risk index	Evaluation index
Weight	0.2448	0.2673	0.4879

After normalization, the score comparison chart can be plotted. The score comparison chart of gold (left) and bitcoin(right) is shown in Figure 6

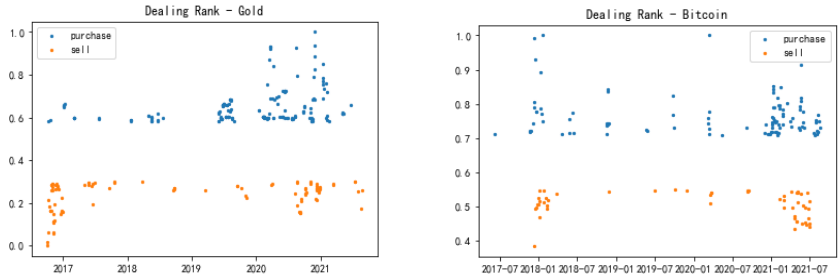

Figure 6: The score comparison chart of gold (left) and bitcoin(right)

In the process of buying and selling, we can buy gold if the decision value is bigger than 0.77 and sell gold if the decision value is less than 0.3. In the similar way, we can buy bitcoin if the decision value is bigger than 0.71 and sell bitcoin if the decision value is less than 0.3.

When gold yields are higher, we will buy gold, and when bitcoin yields are higher, we will buy bitcoin.

Based on this model, we can calculate the result, total assets is 1810237 dollar. The graph of an asset over time is shown in Figure 7.

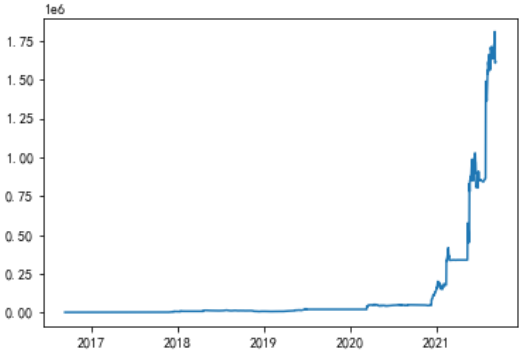

Figure 7: The graph of an asset over time

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5. Conclusion

In this paper, we establish a decision trading model for market traders that can obtain the maximum return in the market. This model is based on the combination of time series pre-diction model, bull and bear market prediction model and risk prediction model, and finally makes decisions together to ensure the accuracy of the decision.

We first preprocessed the data in the question, supplemented the incomplete data with Newton interpolation to ensure the integrity of the data, and found the rule of the gold market closing, and dealt with the situation of the gold market closing. Then, the Arima model in the time series model is used to forecast the future market price. Although the numerical prediction effect is not good, we find that the trend predicted by THE Arima model is very accurate and basically consistent with the real data. Based on the conclusion of Arima model, we use the average rise and convergence divergence ratio and other parameters to establish a bull and bear market prediction model to forecast the trend of market prices. Considering the risk of investment in the market, our team used MK trend analysis method to predict the risk. Finally, based on the results of the three models, the analytic hierarchy process is used to determine the weight of the three results, and the decision trading model is established.

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