# Daily Trading Decisions Based on Prediction and Optimization

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**Abstract.** With the continuous development of the social economy, people's disposable income continues to increase, and more and more families begin to enter the ranks of financial investment. In order to seek greater investment returns, it is necessary to formulate the best trading strategy. In this paper, BP neural network is used for price forecasting, and according to the principles of controlling risks and increasing returns, a daily transaction decision-making model based on forecasting, optimization and risk control is established to determine the optimal investment portfolio. And through the volatility assessment, the final decision on whether to buy or sell gold and bitcoin. At the same time, this paper establishes a trading strategy evaluation model based on Analytic Hierarchy Process (AHP) to evaluate three trading strategies. The analysis shows that the trading strategy evaluation model can serve as the basis for optimal strategy evaluation.

**Keywords:** BP neural network prediction, optimization decisions, risk control, AHP.

## 1. Introduction

With the continuous development of social economy, more and more families start to invest, trying to seek greater benefits through reasonable investment and financial management. [1] Among many investment channels, gold is becoming more and more favored by investors because of its ample market trading patterns and smooth liquidity. Gold has become the most active investment tool and the best channel to avoid risks. [2] Bitcoin has attracted a large number of investors due to its high market price volatility, large profit margins and low participation threshold. The purpose of investment is to obtain profits. However, in the process of investment, the profits are always accompanied by risks. In order to reduce risks and obtain more profits, investors will invest in a combination of two or more assets. [3] Therefore, it is necessary to choose the right trading timing and the suitable investment portfolio.

In this paper, BP neural network prediction model is established and volatility analysis is carried out to determine whether assets should be sold. At the same time, a linear programming model and a risk control mechanism are established to determine the optimal portfolio. In order to evaluate the investment strategy, this paper chooses three dimensions of income, forecast risk and market risk, and then establishes the investment strategy evaluation model by using analytic hierarchy process.

## 2. Establishment

### 2.1 Optimal decision-making model based on BP and risk assessment

Based on the BP neural network model and volatility assessment, we can determine whether to buy or sell gold and bitcoin. Second, the purpose of building a gold and bitcoin portfolio is to avoid risk and pursue maximum returns. Therefore, this paper establishes a linear programming model with the maximization of total assets as the objective function.

#### 2.1.1. BP neural network prediction model

Deciding whether to buy or sell is an important part of a trading strategy. When deciding whether to buy or sell, the most information people want is the future price of an asset. Therefore, in this part, this paper builds a BP[4] neural network model and predicts the future prices of gold and bitcoin through the BP neural network, providing key information for trading strategies.

### 2.1.2. Volatility assessment

When the prices of gold and bitcoin do not change significantly, a problem will inevitably arise, if quantitative trading is carried out every day: although the daily trading strategy can ensure the maximum single-day return, the absolute value of the daily return is still small. And because of the existence of trading commissions, in the medium and long term, the returns from holding positions are not even as high. The risk of market volatility is complex, and factors such as the policy environment, economic cycle, and interest rate adjustments will have an impact on capital operations and lead to market risks [4]

To solve this problem, we establish a volatility assessment formula based on the standard deviation. Volatility is assessed on the price of the last 20 days of the trading day, of which the first 15 days are historical prices and the last 5 days are predicted future prices.

$$\sigma=\sqrt{\frac{\sum_{i=1}^{15}\left(x_i-\overline{x_i}\right)^2+\sum_{j=1}^{5}\left(x_j-\overline{x_j}\right)}{20}} \tag{1}$$

where $x_i$ represents historical price on day i , $\overline{x_i}$ represents historical average price, $x_j$ represents historical price on day j、 $\overline{x_j}$ represents average price in the future.

According to the volatility assessment formula, we get an indicator that can quantify volatility. Next, we need to set a threshold and only trade when the volatility is greater than the threshold.

### 2.1.3. Optimal decision-making model based on BP and risk assessment

Since the benefits and risks of gold and bitcoin are different, a reasonable allocation of funds between gold and bitcoin can effectively diversify risks. How to combine gold and bitcoin to control risks[5] and maximize returns is a problem that must be solved when we formulate optimal[6] strategies. Therefore, we build a linear programming model to determine a portfolio of gold, bitcoin, and cash.

Denote the total assets by f, and the total assets can be expressed as: $\max f=c+Bx_B+Gx_G$,where c represents the amount of dollars, $B,G,x_B,x_G$ represent the unit price of bitcoin, the unit price of gold, the quantity of bitcoin, and the quantity of gold, respectively. The amount of assets held after the transaction is equal to the amount of assets held before the transaction plus the amount of change, so the following formula can be derived：

$$\begin{cases} x_{B_0}+\Delta x_B=x_B \\ x_{G_0}+\Delta x_G=x_G \end{cases} \tag{2}$$

Besides, the total assets before the daily trade is equal to the total assets after the trade plus the trading commission, so we can get the following formula:

$$c+B_0x_{B_0}+G_0x_{G_0}=c+B_0x_B+G_0x_G+\Delta x_B\cdot 2\%+\Delta x_G\cdot 1\% \tag{3}$$

Lastly, in order to ensure that our transaction can be profitable, the difference between the profit and the transaction cost needs to be greater than 0 So we get the following formula:

$$\begin{cases} \Delta x_B(B-B_0)-\Delta x_B\cdot B_0\cdot 2\%>0 \\ \Delta x_G(G-G_0)-\Delta x_G\cdot G_0\cdot 1\%>0 \end{cases} \tag{4}$$

According to the actual situation, USD holdings, bitcoin holdings, and gold holdings are all positive. Therefore, there are the following constraints:

$$c>0,x_B>0,x_G>0 \tag{5}$$

The linear programming model is as follows:

$$\max f=c+Bx_B+Gx_G$$

$$s.t.\begin{cases} x_{B_0}+\Delta x_B=x_B \\ x_{G_0}+\Delta x_G=x_G \\ c+B_0x_{B_0}+G_0x_{G_0}=c+B_0x_B+G_0x_G+\Delta x_B\cdot 2\%+\Delta x_G\cdot 1\% \\ \Delta x_B(B-B_0)-\Delta x_B\cdot B_0\cdot 2\%>0 \\ \Delta x_G(G-G_0)-\Delta x_G\cdot G_0\cdot 1\%>0 \\ c>0,\ x_B>0,\ x_G>0 \end{cases} \tag{6}$$

Whether investing in Bitcoin or gold, there are market risks [7]. For a model that can predict future prices, a sufficiently accurate forecast can hedge some market risk. However, it is impossible to predict future prices with 100% accuracy, so forecast errors also bring us a certain risk, which we call forecast risk.

Therefore, this paper establishes a risk control mechanism to enhance the anti-risk capability of the model. A variable "risk" is introduced, which represents the confidence of the predicted outcome, and its initial value is 0.6. This variable varies daily with the accuracy of the predicted outcome. When the predicted result and the actual situation change in the same direction, the risk value is set to increase by 0.01. The formula is as follows:

$$risk = risk + 0.01 \tag{7}$$

When the predicted result is opposite to the actual situation, the “risk” value is reduced according to the following formula:

$$risk = risk - |(B - B_1)/B_1| \tag{8}$$

where B represents prediction results, $B_1$ represents the actual situation. After mitigating the risks of forecast errors, we need to analyze market risks.

When the price of gold does not drop, the gold held will always account for 40% of the total assets. That is to add constraints:

$$\frac{G \cdot x_G}{(D + B \cdot x_B + G \cdot x_G)} > 40\% \tag{9}$$

Don't buy new gold when predicting a drop in gold price. That is to add constraints:

$$\Delta x_G = 0 \tag{10}$$

It is predicted that the price of gold will drop and the volatility of gold is greater than the threshold, that is, when gold falls sharply, 60% of the gold held will be thrown out to alleviate the losses caused by the sharp fall of gold. That is to add constraints:

$$G = 40\% \cdot G_0 \tag{11}$$

We do not trade in gold. At this time, the proportion of gold held increases and the ability to resist market risks is enhanced. That is to add constraints:

$$\Delta x_G = 0 \tag{12}$$

## 2.2 A trading strategy evaluation model based on analytic hierarchy process (AHP)

When we pursue greater gains, there is usually greater risk. But for models that can predict future price trends, market risk is no longer the main source of risks [8], because a sufficiently accurate forecast can hedge against the risks brought about by market fluctuations to a certain extent. At the same time, predicting the future price trend is inherently risky, so the risks brought by the accuracy of the prediction has become the main source of risks.

Based on the above analysis, we prioritize the following factors: C1≫C2＞C3

Where C1 represents returns, C2 represents the risks from forecasting (namely forecast risks), and C3 represents the risks from market changes (namely market risks) [9]. According to the priority between factors, we get a comparison matrix.

$$\begin{array}{c c} & \begin{array}{ccc} C_1 & C_2 & C_3 \end{array} \\ \begin{array}{c} C_1 \\ C_2 \\ C_3 \end{array} & \begin{bmatrix} 1 & 3 & 4 \\ 1/3 & 1 & 2 \\ 1/4 & 1 & 1/2 \end{bmatrix} \end{array}$$

Where $C_i$ for i = 1,2,3 represents returns, forecast risks, market risks

After determining the comparison matrix, we use the consistency index CI, the random consistency index RI, and the consistency ratio CR to test the consistency of the comparison matrix:

$$\mathrm{CI} = \frac{\lambda_{max} - n}{n-1} \qquad \mathrm{RI} = \frac{\lambda\prime_{max} - n}{n-1} \qquad \mathrm{CR} = \frac{CI}{RI}$$

Likewise, we compare the priorities of the three options in terms of returns, forecast risks, and market risks:

returns：P2>P1>P3

control of forecast risks：P1>>P3>P2

control of market risks：P3>P1>P2

According to the priority of each plan in these three aspects, we can get three comparison matrices:

$$\begin{array}{c|ccc} & P_1 & P_2 & P_3 \\ \hline P_1 & 1 & 1/2 & 5 \\ P_2 & 2 & 1 & 6 \\ P_3 & 1/5 & 1/6 & 1 \end{array} \qquad \begin{array}{c|ccc} & P_1 & P_2 & P_3 \\ \hline P_1 & 1 & 9 & 7 \\ P_2 & 1/9 & 1 & 1/2 \\ P_3 & 1/7 & 2 & 1 \end{array}$$

$$returns \qquad control\ of\ forecast\ risks$$

$$\begin{array}{c|ccc} & P_1 & P_2 & P_3 \\ \hline P_1 & 1 & 6 & 1/2 \\ P_2 & 1/6 & 1 & 1/9 \\ P_3 & 2 & 9 & 1 \end{array}$$

$$control\ of\ market\ risks$$

Where $P_i$ for i= 1, 2,3 represents our strategy, all buy bitcoin, all buy gold

# 3. Model Solution And Analysis

## 3.1 Optimal decision-making model based on BP and risk assessment

Based on the Optimal decision-making model based on BP and risk assessment, we get the following results:

Table 1: Portfolio of assets

| | Quantity(1) | Daily price(2) | Total(3)=(2)*(1) | Proportion |
|---|---|---|---|---|
| Cash | 3012383.833 | - | 3012383.833 | 42% |
| Bitcoin | 27.46761052 | 46368.69 | 1273637.1172426 | 18% |
| Gold | 1563.850531 | 1794.6 | 2806486.1629326 | 40% |
| Total assets | - | - | 7092507.1131752 | 100% |

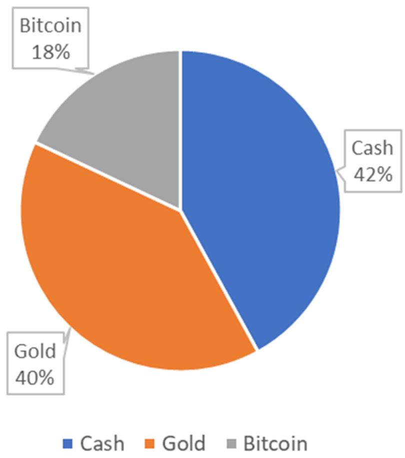


Figure 1 Asset composition

On September 10, 2021, the initial $1,000 investment was worth $7,092,507, of which cash accounted for 42%, bitcoin 18%, and gold 40%.

## 3.2 A trading strategy evaluation model based on analytic hierarchy process (AHP)

CR = 0.0937<0.1 can be obtained by MATLAB calculation, indicating that the consistency test is passed. We also use MATLAB to normalize the eigenvectors corresponding to the largest eigenvalues to obtain the weights (connection weights) of each factor: revenue 0.6146, forecast risks 0.2366, and market risks 0.1488.

Likewise, we use MATLAB to perform consistency checks and weights (connection weights) calculations on the three comparison matrices above. We calculate the product of the two groups of connection weights, and get the weights of each scheme: P1=0.4070, P2=0.3803, and P3=0.2127.

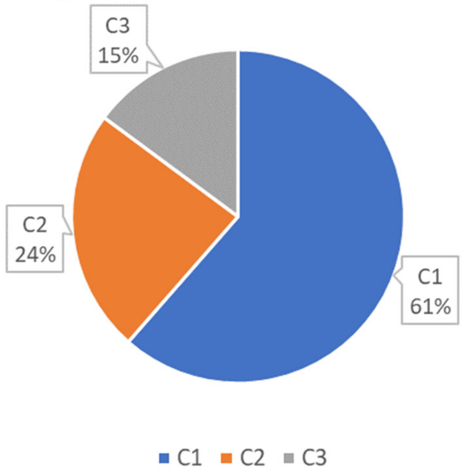


Figure 2 Weight of each factor

In order to get the maximum return in the investment process, we need to choose the appropriate investment strategy, therefore, we develop the best investment strategy selection model and investment strategy evaluation model.

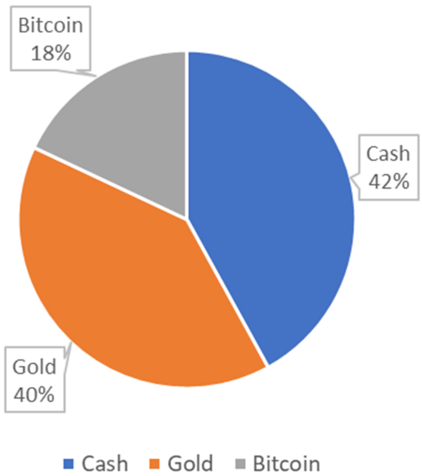


Figure 3 Investment portfolio

On September 10, 2021, the value of the initial investment of $1,000 became $7,092,507, of which cash accounted for 42%, bitcoin accounted for 18%, and gold accounted for 40%. The appreciation rate of bitcoin is very fast. We make dynamic risk investment in bitcoin with 60% of the funds. After the rough calculation, the total assets in five years can be greater than 10 million US dollars, but the risk is high. Taking into account the factors of return and risks, our investment strategy is the optimal strategy.

### 3.3 Daily trading decisions model based on prediction and optimization

We believe that the best investment strategy should include two aspects: when to buy and sell, and asset portfolio. Therefore, our models are mainly built to solve these two problems. In order to determine when to make a buy and sell trade, firstly, we use the BP neural network model to predict the future price. In order to avoid the problem of high transaction costs caused by frequent transactions, we use the volatility evaluation formula to calculate an indicator that can quantify volatility. When the volatility is greater than this indicator, we will buy and sell transactions. In order to determine the asset portfolio, that is, the proportion of gold, bitcoin, and cash.

Firstly, we establish an optimization model with the maximum return as the objective function, Next, in order to improve our optimization model, we carry out risk control from two aspects: for predicting risk, we introduce the variable “risk”, and the value of “risk” is adjusted according to the accuracy of the prediction. The larger the value of “risk”, the more accurate the predictions of our model, and the less bitcoin assets to keep. For market risks, according to historical data, the price of gold is relatively stable, while the price of bitcoin fluctuates greatly. Using these features, we can defend against the market risks by adjusting our holdings of gold.

In order to prove that the investment strategy [10] we established is the best, we evaluate the investment strategy from three aspects: return, the control of forecast risk, and the control of market risk. Firstly, we use the AHP to determine the weights of the three factors, and establish the evaluation model of the trading strategy. The evaluation model can be used to score different trading strategies. The higher the score, the better the strategy.

## 4. Evaluation Of The Models

The model is particularly comprehensive, considering both benefits and risks. By investing in bitcoin to ensure greater returns, while retaining a certain amount of gold can reduce risks. Our model introduces a degree of trust to defend against the risks of inaccurate predictions. The model provides ideas for solving the problem of large single-day returns but small medium and long-term returns.

## 5. Authors’ Contributions

We provide the best investment strategies to help households invest through the model we have built in this article. In order to solve the two problems of when to buy and sell, a decision model based on BP neural network and volatility evaluation model is built. In order to determine the asset portfolio, namely the proportion of gold, bitcoin and cash, an optimization model was established with maximizing returns as the objective function. At the same time, the investment strategy is evaluated from three aspects of income, predictive risk control and market risk control.

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