Portfolio investment decision model based on price forecasting model and risk assessment model

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Abstract. Investors often use gold and Bitcoin to reduce the risk of financial investments by combining them due to their low correlation and different dynamic correlation. Therefore, it is essential to study how a combination of the two can be invested to maximize returns. In this paper, we combine the BP neural network model and the gray correlation analysis model from the future unpredictability and risk quantification of portfolio investment. We want to use the model to construct a price prediction model and risk assessment model to build a model for portfolio investment decisions based on past-day price flow only. To be specific, this paper first builds a price prediction model based on a BP neural network prediction model. At the same time, the prediction needs to be performed in a cycle, and the training set of the neural training model is increased each time. Each prediction is recorded for the next day's data and aggregated to obtain the daily price flow prediction. Next, this paper builds a risk assessment model through gray correlation analysis. In order to measure the riskiness of the daily investment, this paper selects three indicators, namely, forecast price accuracy, recent price trend, and price volatility. It uses gray correlation analysis to score them quantitatively and then gives the daily investment risk assessment results. Finally, a sensitivity analysis was performed to determine the model's sensitivity to transaction costs by varying the transaction costs of gold and bitcoin. It was found that as the transaction costs become more extensive, the number of transactions becomes smaller and the total assets acquired become smaller.

Keywords: Price forecasting, Risk assessment, Portfolio investment, BP neural network

1. Introduction

Gold and bitcoin are two investable assets with large price fluctuations in the market. Because of their low correlation and the difference in dynamic correlation, the combination of them is beneficial for investors to reduce risks in financial investment. Therefore, market traders often maximize returns by combining these two assets [1].

However, because there is no obvious regularity in the price fluctuation frequency of gold and bitcoin markets, the investment strategy based on traditional qualitative analysis is risky. With the rapid development of computer science and technology, the quantitative in- vestment analysis method based on obtaining accurate ultra-high returns and stable returns is increasingly favored by investors [2]. Most financial time series data are nonlinear and noisy. Neural network models can handle nonlinear and high-noise data problems well, and are widely used in quantitative investment analysis [3]. Problems of market trader is shown as figure 1.

Figure 1. Problems of Market trader

2. Assumptions and justifications

To simplify the problem, we make the following basic assumptions. And explained its reasonableness as shown below:

Assumption 1: Traders only trade gold or bitcoin once a day based on the day's cash flow and do not repeatedly revise their decisions based on price movements all day long.

Justification: In real life, bitcoin and gold prices are updated in real time and can

be traded at any time. Since the data given in the question is only a composite of the en- tire day, we assume that traders only make one trade strategy per day.

b_{ij}

Assumption 2: Excluding the potential volatility of gold and bitcoin prices caused by unexpected political events during this period.

Justification: The policies issued by the Chinese and US governments for Bitcoin

have a large impact on its price in the short term, and it is difficult for us to predict whether the government will issue relevant policies during the model prediction period, which is not considered in this paper to simplify this issue.

Assumption 3: The market trader stays on the sidelines for the first 20 days and does not trade in the market.

Justification: Because a certain amount of data is needed to make the BP neural

network prediction model as a training set, too little data of the training set will affect the accuracy of the final simulation results, so this paper takes the training set of the first

training 20 days before. In order to reduce the trading risk, *this paper assumes that the market trader does not trade in the first 30 days.*

2.1 Data Description

Since the question clearly states that only data from the two spreadsheets provided: LBMA-GOLD.csv and BCHAIN-MKPRU.csv. can be used, we did not perform data collec-tion and processed the data given in the question directly.

Analyzing the two tables LBMA-GOLD.csv and BCHAIN-MKPRU.csv., we find 10 missing value for the daily price flow of gold, except for the days when the market is open. For the presence of missing values in the tables, it can be found that every two missing value dates are spaced relatively close to each other. We divided them into five groups and used Lagrange Interpolation Polynomial to fill the data.

Unlike Bitcoin, which has no restrictions on trading time, gold can only be traded on days when the market is open. In the actual calculation it is difficult to directly filter out the days when gold cannot be traded, which poses great difficulties in giving the correct trading strategy. In order to facilitate the model calculation, this paper uses an EXCEL table to fill the data of the days when gold cannot be traded, and the filling rule is the same as the price that appears before the data is missing. Since the raw data sizes for gold and bitcoin are relatively different and the range is highly variable. The increase in variability affects the accuracy of the prediction results, so the data tables after

supplementing the missing data need to be normalized. Converting all data to a number between [0,1] can eliminate the bias caused by the data being of different sizes, and ultimately the prediction results are subjected to an inverse normalization reduction process. There are many methods for data normalization, and this paper adopts the maximum- minimum method for normalization.

2.2 Data Visualization

Correcting the data in the table given in the question and plotting it gives the actual daily price flow trend for gold and bitcoin from September 11, 2016 to September 10, 2021, as show Fig.2.

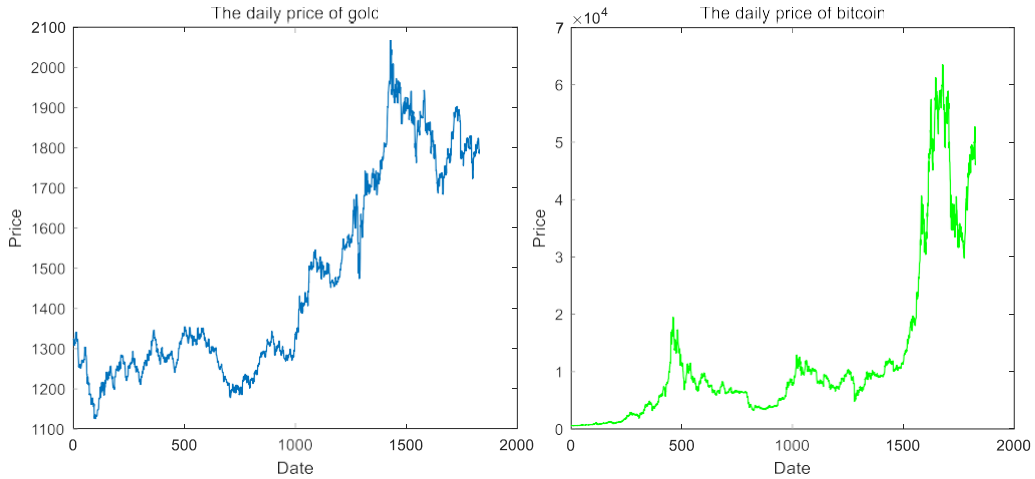

Figure 3. The daily price of gold and bitcoin

3. Price prediction model based on Back Prop- agation neural network

3.1 Risk assessment model based on Grey comprehensive evaluation method

This paper needs to give to build a model to give the best daily investment strategy for market traders, financial investment also involves riskiness, and how to assess the risk of port- folio investment also needs to be considered in the model. For the assessment of riskiness,this paper quantifies the possible risk indicators and scores them for assessment based on grey correlation analysis.

Grey relational comprehensive evaluation method based on grey correlation analysis theory as the instruction of quantitative and qualitative analysis and comprehensive evalua- tion method. In grey comprehensive evaluation, the evaluation process can be recycled, the previous evaluation results of the process, can be used as a process after the evaluation of the input data. Therefore, through multi-level grey evaluation, can meet the requirements of the evaluation of complex systems. The main evaluation matrix and weight matrix is used to cal- culate the grey correlation matrix, the ranking compared to comprehensive evaluation.

Its main idea is: if the parameter values of the evaluated object corresponding to the big- ger the better, which take the maximum index in the evaluation of the evaluation objects for the optimal criteria; Instead, take the smallest of them. In the three indicators in this paper, the higher the volatility and the higher the risk, that is, the maximum value. Accuracy calculation is on and before the predicted average of the predicted value of the reaction is stable, the smaller the average forecast is more stable, namely to take minimum [4,5].

Based on the importance of indicators, corresponding weights are given to them accord- ing to the analytic hierarchy process. The weights of each indicator based on the hierarchical analysis is shown in Tab.1.

Table 1. The weights of each indicator based on the hierarchical analysis

Z	A1(accuracy)	A2(trend)	A3(volatility)
A1(accuracy)	1	9	4.5
A2(trend)	1/9	1	0.5
A3(volatility)	2/9	2	1

The assessment results were quantified and plotted as Fig.4:

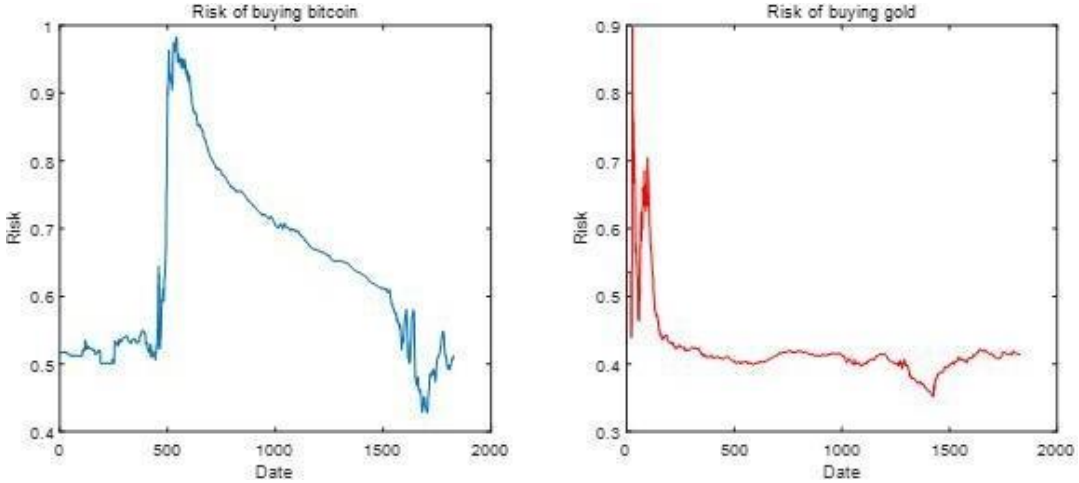

Figure 4. The daily risk assessment results

3.2 Investment decision model based on dy- namic planning model

The ultimate goal of forecasting the daily price of gold and bitcoin is to develop a quanti- tative investment strategy based on the forecast results in the hope of maximizing returns.

The daily investment strategy derived from the portfolio investment decision model is shown as Fig.5, Fig.6 and Fig.7:

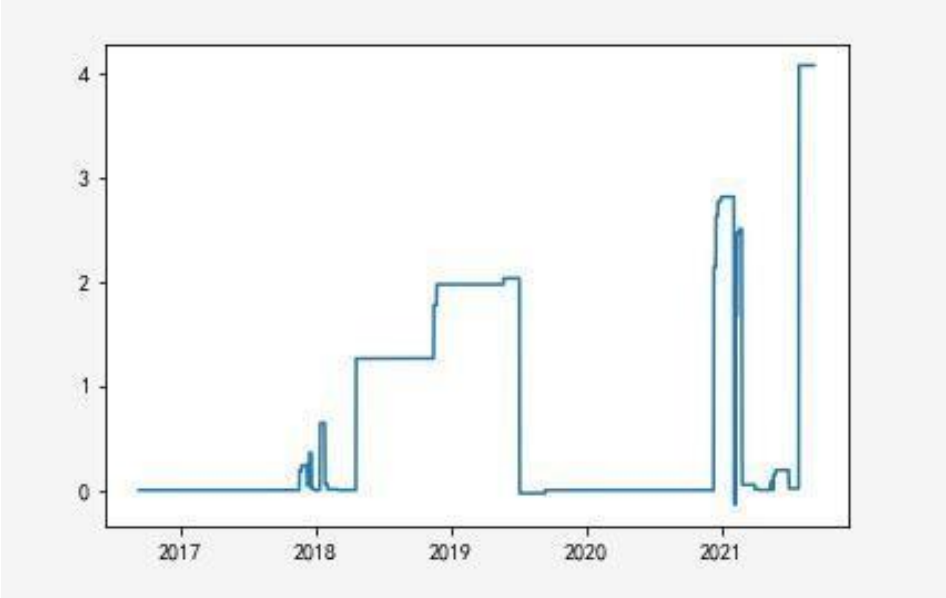

Figure 5. Daily Portfolio Investment Strategy for Bitcoin

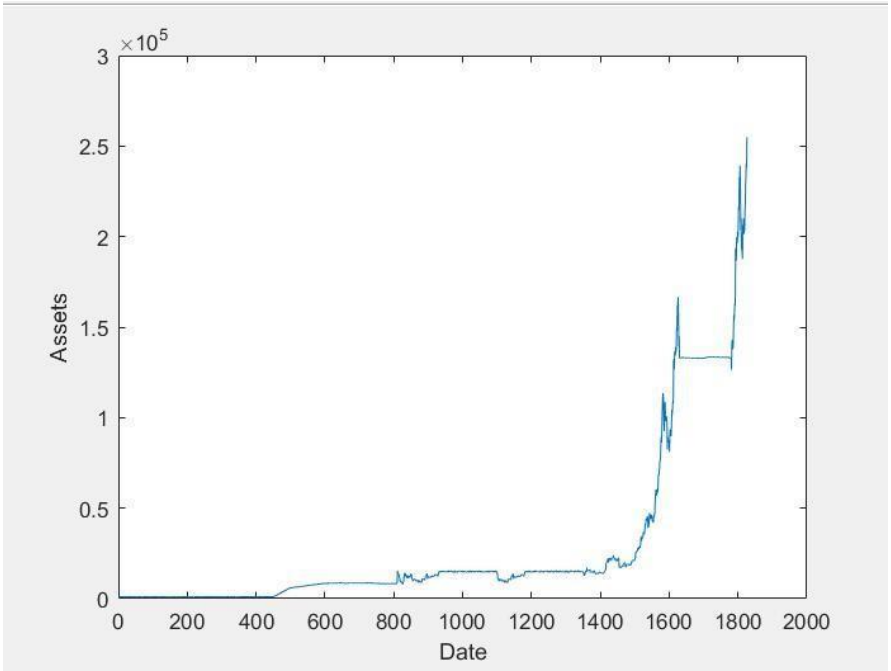

Figure 6. Daily Portfolio Investment Strategy for Bitcoin

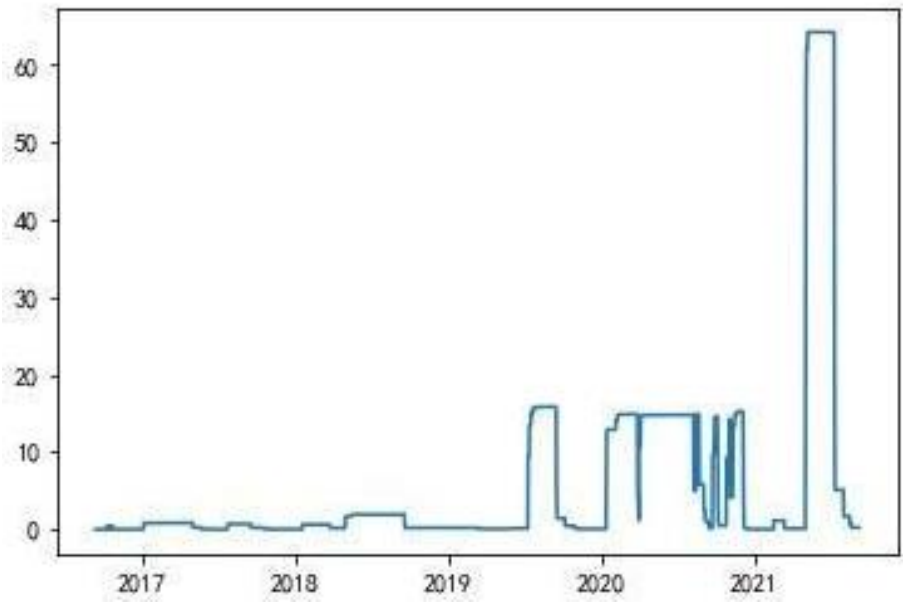

Figure 7. Total value of portfolio assets after daily investments

4. Proximity of price forecasts to actual values

Since the forecasted price is a very important influence indicator for making decisions about investment options, the more accurate the forecasted price, the more successful the de- cision made. A plot of the closeness of the price forecast to the actual value is shown in the following Fig.8:

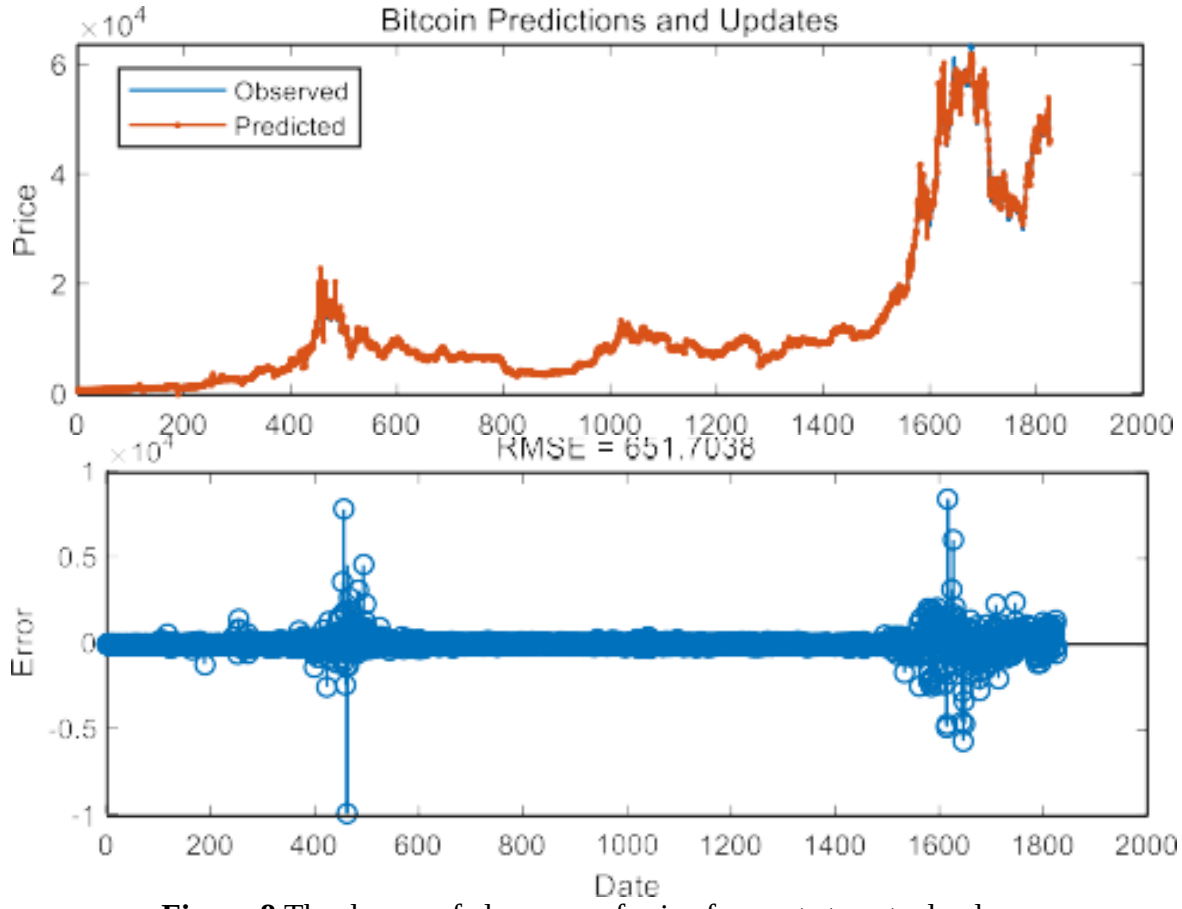

Figure 8. The degree of closeness of price forecasts to actual values

5. Calculation of final investment return

The final investment return is also an important indicator to judge whether the decision made by the model is the best or not. In this paper, the final return is judged by making ran- dom changes to the decision situation. The final investment return when the strategy is ran-

domly changed is shown as Fig.9:

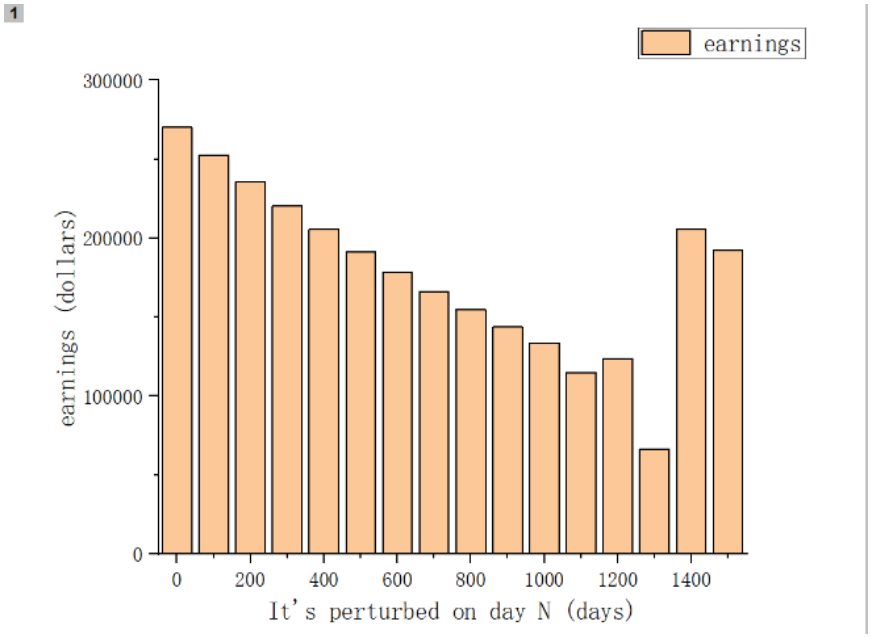

Figure 9. Comparison of final returns after making random changes to the decision situation

6. Model Evaluation

6.1 Strengths

The problem that gold can only be traded on open days is skillfully solved through zero-one planning in the model.

The idea of greedy algorithm is used in the planning model, and the total maximum value is converted into the maximum value every day for the convenience of model calculation.

In the risk evaluation, the grey correlation method is used to quantify the risk degree, and the weight is obtained by the analytic hierarchy process, so that it has a certain scientific nature.

6.2 Weakness

BP neural network algorithm needs a certain number of days as a training set, so ef- fective investment may not be made for the first 20 days.

Because the planning model is based on the daily maximum value, not the final maximum value, the results of the model will have some inaccuracy.

7. Conclusion

In this paper, a decision model for portfolio investment based on past-day price flows is developed based on a price forecasting model and a risk assessment model. Specifically, this paper first makes price forecasts based on a BP neural network forecasting model and past- day price flow data. Since only the price flow data of the same day and the previous day are known on the forecast date, it is necessary to loop through the forecast, recording the data of the next day in each loop and aggregating them to obtain the daily price flow forecast. Next, this paper establishes a risk assessment model through gray correlation analysis, and selects three indicators as risk assessment indicators: forecast price accuracy, recent price trend, and price volatility, and quantifies and scores them to obtain daily investment risk assessment re- sults. After that, a portfolio planning decision model is established based on dynamic planning ideas, combining the price forecasting model and the risk assessment model. The final result of the investment strategy conducted daily shows that the initial $1,000 ends up with an in- vestment value of $26,3974.28.

In order to demonstrate whether the trading strategy given by the model developed in this paper is optimal, this paper demonstrates each of the two aspects. On the one hand, the daily predicted prices of gold and bitcoin are very close to the actual prices, and on the other hand, after perturbing the trading strategies given by the model, it is found that the final re- turns are lower than without perturbation. Accordingly, it can be judged that the strategy given for the model is the best one. Finally, a sensitivity analysis was performed to determine the sensitivity of the model to the transaction cost by varying the transaction cost of gold and bitcoin, and it was found that as the transaction cost becomes larger, the number of transac- tions becomes smaller and the total assets obtained becomes smaller.

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