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Trading Strategy of Gold and Bitcoin Based on Optimization Algorithm

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Abstract: *With the development of economy, gold and bitcoin have gradually become two important investment assets. However, due to the high volatility of them, the investment process is often accompanied by huge risks, and it is common to gain losses. This paper proposes a gold and Bitcoin investment strategy model based on a combination of grey prediction and linear programming. We predict future markets through grey prediction to calculate the relative strength index in economics, according to which and market openness we select linear programming or equation solving in order to maximize future returns and obtain the best portfolio strategy. In the process of solving linear programming, the standard deviation rate is also introduced for risk control. What's more, we judge the merits and demerits of the model by proving prediction accuracy, comparing future market volatility, and observing risk aversion. Average absolute percentage error is introduced to measure prediction accuracy. Experiments have shown that the overall forecast accuracy is high, the predicted volatility trend is roughly the same as the actual volatility trend, the risk aversion is effective, and our model is reliable and forward-looking.*

Keywords: *Grey prediction; Linear program; Mean absolute percentage error; Standard deviation rate*

1. Introduction

The daily trading of gold and Bitcoin requires scientific portfolio strategies as a backing. Investment strategies often need to be formulated according to the future price trends of investment projects, and follow the principle of buying at a low price and selling at a high price.

There has been a lot of research on predicting the future price trend of investment projects, including statistical-based methods, machine learning-based methods, and deep learning-based methods and so on. Due to the high degree of volatility in the price of gold and Bitcoin, the use of statistically based methods such as Moving Average does not work well for forecasting volatility data, and machine learning or deep learning requires a large amount of data as a support to improve the prediction accuracy, this paper selects the grey prediction model GM (1,1), which is a prediction method by establishing mathematical model to make prediction only use a small amount or incomplete information. Relative strength index (RSI) is a technical curve based on the ratio of the sum of rising and falling points over time [1]. It can be used for qualitative analysis of trading strategies. The linear programming model is simple and widely used, and it can be used to quantify trading strategies to maximize the returns obtained.

We will model based on daily price data for gold and Bitcoin from September 11, 2016 to September 10, 2021.First, we predict the trend of the price by grey prediction. Then, we calculate the value of RSI from the predicted data to judge the best behavior of trading. When trade markets are both open and the relative strength index indicates buying, we convert this problem as a linear programming problem. We use standard deviation rate to measure risk and further control the proportion of investment. In other cases, we will figure out this problem by solving an equation.

2. Grey Prediction

Before the prediction, we do the grade ratio test. The data that failed the grade ratio test were translated. Since the gold market didn't open on the first day, so we fill it with the price value of the next open day. With the GM (1,1) model, we use the first 24 days price data of gold to predict the following 4 days' prices and use the first 25 days price data of bitcoin to predict the following 5 days' prices, so that we can predict the exact trading portfolio from day 25. Five-days price will be predicted every time.

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By grey prediction, we can obtain the value of $\boldsymbol{yc(i)_1}$(predicted 5 days' gold price after day $\boldsymbol{i}$, $i = 25,26,27$ ...), and $\boldsymbol{yc(i)_2}$(predicted 5 days' bitcoin price the next 5 days after day $\boldsymbol{i}$, $i = 26,27,28$ ...).

3. Portfolio Model

Relative strength (RS) means the relative intensity ratio, which compares the rising trend with the falling trend. If the rising trend is larger, the calculated index will rise. If the downward trend is larger, the index will drop. Hence, RS can measure the strength of the market trend. It can be calculated by the following formula: (j=1,2; 1 for gold and 2 for bitcoin).

$$RS = \frac{m(i)_j}{n(i)_j} \tag{1}$$

Where $m(i)_j$ means value of sum of bitcoin or gold closing price rise in 5 days. By RS, we can calculate RSI:

$$RSI = 100 - \frac{100}{1+RS} \tag{2}$$

If $RSI < 20$, we'd like to sell some assets; If $RSI > 80$, we'd like to buy; If $20 < RSI < 80$, we choose to maintain existing assets.

According to this, we use mathematic language to say it:

$$k(i)_j = \begin{cases} -1, & sell \\ 0, & maintain \\ 1, & buy \end{cases} \tag{3}$$

There are two situations for this problem. $\boldsymbol{w(i)_1}$ represents the Market opening situation of gold on day i. $\boldsymbol{w(i)_2}$ represents Market opening situation of bitcoin on day i.

If $w(i)_1 = 1$ and $k(i)_j = 1$, we will use linear programming to solve it.[2]

Else, we solve an equation to obtain the solutions.

Here our initial amount is \$1000. And it is assumed that the cost of gold and the cost of bitcoin are 1% and 2% of the trade value respectively. $x(i)_1$ is the asset gold trading volume on day i, $x(i)_2$ is the asset bitcoin trading volume on day i.

The total spends on day i should be bigger than the accumulated total return cash for the previous (i-1)days. That is, existing assets cannot be negative. The following inequality can be listed:

$$g(i-1)x(i)_1 + b(i)x(i)_1 + 1\%x(i)_1 g(i-1) + 2\%x(i)_2 b(i) - (1000 -$$
$$1.01\sum_{i=25}^{i} k(i)_1\, w(i)_1 g(i-1)x(i)_1 - 1.02\sum_{i=25}^{i} k(i)_2\, w(i)_2 b(i)x(i)_2) \geq 0 \tag{4}$$

If we buy gold and bitcoin at the same time, we will get higher income with the increase of risk at the same time, so we will avoid the risk in this case when $k(i)_1 = k(i)_2 = 1$.

Calculate the gold normal deviation rate of the past 25 days on day i and the bitcoin normal deviation rate of the past 13 days on day i by the following equations, where $\overline{g(i)}$ and $\overline{b(i)}$ are the mean values of gold and bitcoin respectively. The smaller V value, the smaller deviation, and the smaller risk.[3]

We define the risk comparative value as $e(i)$:

$$e(i) = \frac{V_{g(i)}}{V_{b(i)}} \tag{5}$$

To compare investment in gold and bitcoin, we defined the investment amount rate of gold and bitcoin by $E(i)$:

$$E(i) = \frac{g(i-1)\cdot x(i)_1}{b(i)\cdot x(i)_2} \tag{6}$$

Based on the above analysis, under different normal deviation, we will have different restrictions on $E(i)$.

a) If $e(i) > 1$, we have $E(i) \leq 1$;

b) If $e(i) < 1$, we have $E(i) \geq 1$;

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Hence, we can transform this problem into a linear programming. The objective equation is the cash converted from forecast future earnings minus the commission cost of the current day's transaction. $m(i)_1$, $m(i)_2$, $n(i)_1$ and $n(i)_2$ represent mean value of sum of gold closing price rise in 5days, mean value of sum of bitcoin closing price rise in 5days, mean value of sum of gold closing price drop in 5 days and mean value of sum of bitcoin closing price drop in 5 days respectively.

$$\begin{aligned} \text{Max} f(i) &= (m(i)_1 - n(i)_1) \cdot x(i)_1 + (m(i)_2 - n(i)_2) \cdot x(i)_2 \\ &-(1+1\%)x(i)_1 \cdot g(i-1) \ -(1+2\%)x(i)_2 \cdot b(i) \end{aligned} \tag{7}$$

$$\text{s.t.} \begin{cases} g(i-1)x(i)_1 + b(i)x(i)_1 + 1\%x(i)_1 g(i-1) + 2\%x(i)_2 b(i) - 1000 + \\ 1.01\sum_{i=25}^{i} k(i)_1 w(i)_1 g(i-1)x(i)_1 + 1.02\sum_{i=25}^{i} k(i)_2 w(i)_2 b(i)x(i)_2 \le 0 \\ g(i-1) \cdot x(i)_1 - b(i) \cdot x(i)_2 \le 0, e(i) > 1 \\ b(i) \cdot x(i)_2 - g(i-1) \cdot x(i)_1 \le 0, e(i) < 1 \\ x(i)_1 \ge 0, x(i)_2 \ge 0 \end{cases}$$

4. Experimental Results

4.1. Strategy results

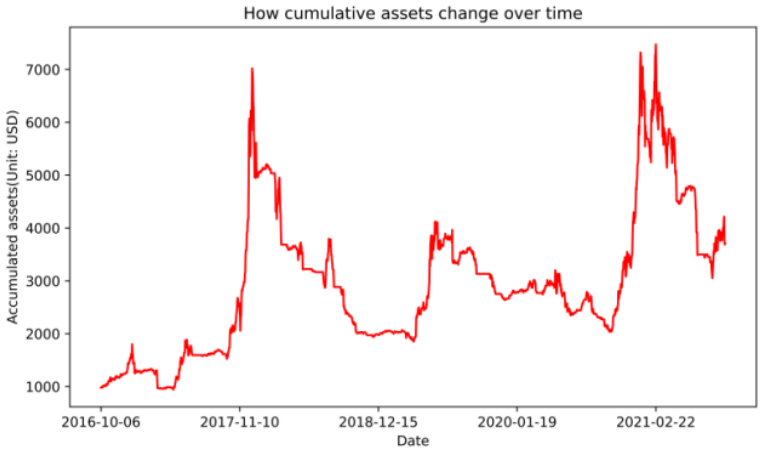

Figure 1: Accumulated assets

From this plot, in our strategies, there is no case that the accumulated assets after loss are lower than the original dollars, which indicates our strategies can make profit. That shows the feasibility of our model to a certain extent. In addition, it can also be found that as of February 22, 2021, the assets rose first and then declined, which may be related to the instability of the market and the accuracy of the grey prediction model.

4.2. Forecast accuracy

We use MAPE to measure the accuracy of grey prediction. MAPE is calculated as follows:

$$\text{MAPE} = \sum_{i=1}^{n} \left| \frac{y(i)_{test} - \widehat{y(i)_{test}}}{y(i)_{test}} \right| \times \frac{100}{n} \tag{8}$$

According to our results, the grey prediction has a good prediction accuracy for gold price. In most cases, the MAPE value is below 2%, and a few of them are above 8%, but they are still below 10%. As to bitcoin, the overall MAPE value is higher than that predicted for gold, most of the data are within 10%, and a few are close to 50%, so the prediction is generally good.

4.3. Comparison of future market volatility

We forecast the average price fluctuation of gold and bitcoin in the next five days, and compare it with the real fluctuation, and get the following two figures:

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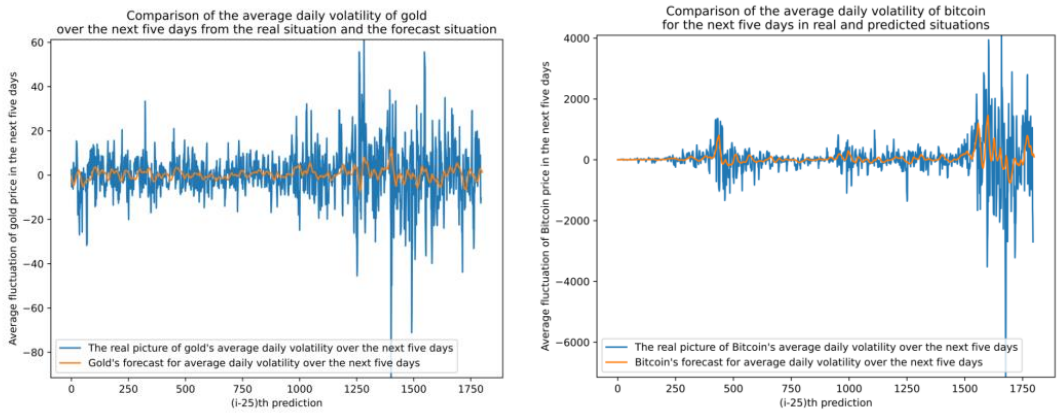

Figure 2: Average price comparison

As can be seen from the figure, our model can predict the general trend of the price fluctuation of gold and bitcoin in the next five days, which is of great help to get accurate investment strategies, so it can show that the strategies obtained through our model have certain reliability.

4.4. Investment risk

By the change of investment risk, we can adjust the model strategy accordingly. According to the risk ratio and the trading situation of gold and bitcoin, we draw the following two plots. In the figures, the positive value of gold and bitcoin represents the quantity of purchase, the negative value represents the quantity of selling, and 0 represents no trading behaviors. The results are shown in the figures below:

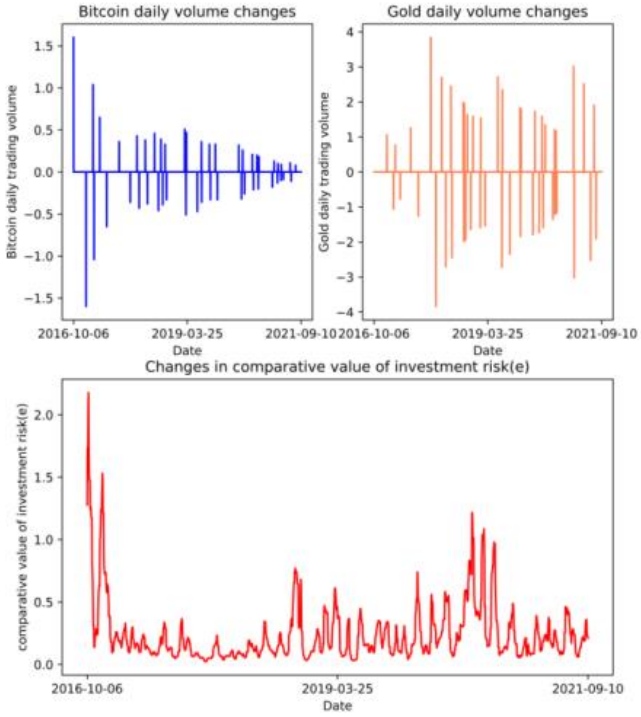

Figure 3: Risk ratio versus trading situation

From Figure 3, when the risk ratio is large, the purchase amount of bitcoin is larger than that of gold, and the larger the ratio, the larger the difference between the purchase amount of bitcoin and gold; On the contrary, when the risk ratio is small, the bitcoin purchase amount is less than the gold purchase amount, and the smaller the ratio, the larger the difference between the purchase amounts. Through the risk ratio, we can control the investment ratio of gold and bitcoin, so as to avoid risks to a certain extent, improve the return on investment and make the model get better results.

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5. Conclusion

Aiming at the investment strategy problems of gold and Bitcoin, this paper proposes an optimization algorithm that combines grey prediction and linear programming. According to our strategy, the accumulated assets of cash, gold and Bitcoin on a daily basis are generally on the rise. This model finally achieved high prediction accuracy. The prediction of fluctuation can predict the general trend. The model also adopts methods to avoid risks, which is forward-looking and original.

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