

A Study on the Optimal Investment Strategy Portfolio of Gold and Bitcoin Assets Based on Grey Prediction and Programming Models

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Abstract. Nowadays, Gold and Bitcoin are popular traded products in trading market. In order to build a trading portfolio that maximizes returns, this paper selects a gray prediction model at first, to predict the price of the traded products on the 6th day based on the historical data of the first 5 days of the trading day, and then conducts rolling analysis by using the historical data of each trading day. By following the principle of currency value maximization trading strategy, this paper selects the objective planning model and establishes the objective function representing the currency value and the constraint function of daily trading volume. Finally, the programming model is solved according to the results of the gray prediction model, and obtain the change in the value of the currency held in five years.

Keywords: Grey Prediction Model; Programming Model; Investment Strategy Portfolio.

1. Introduction

With the rapid progress of economy and science and technology, more and more people nowadays choose to trade volatile assets and take advantage of the volatility characteristics of assets to achieve the ultimate goal of profit. Of course, there will also be losses and un-changed transaction cost in the transaction process. Therefore, a good trading strategy is crucial to maximizing the total return. Bitcoin is a new type of asset, known for its decentralized character, but also because of this feature, the price of bitcoin has many influencing factors, which also led to the price of bitcoin market fluctuates violently [1]. under the strong impact of covid-19 epidemic, the global crude oil market experienced a significant decline, some scholars used gold and bitcoin with crude oil respectively for investment portfolio testing, and Eventually discovered the safe-haven advantage of gold [2]. After investigation and research, the combination of bitcoin and gold has great risk aversion and hedging advantages due to the superior safe-haven advantage of gold [3]. Given the current market trends, Bitcoin is in the early stages of development, but with the inherent characteristics of gold, it may still have sufficient time and greater market capacity to prove that it can reach the investment status of gold in the world[4].Combining the needs of market traders, for both gold and bitcoin trading products, this article analyzed market data and built a mathematical model that maximizes total returns.

2. Price prediction models and portfolio for gold and bitcoin

2.1. Data Description

The data available for this paper only includes gold and bitcoin prices from September 11, 2016 to September 10, 2021.It is Easy for data processing because of the small time range[5]. There are many missing values in the gold price data (Figure 1) and there are non-trading days (Saturdays, Sundays and holidays). This paper try to linearly interpolate the missing value of the trading day according to the price before and after. Gold price of non-trading day was unchanged (unchanged from the previous day) (Figure 2).

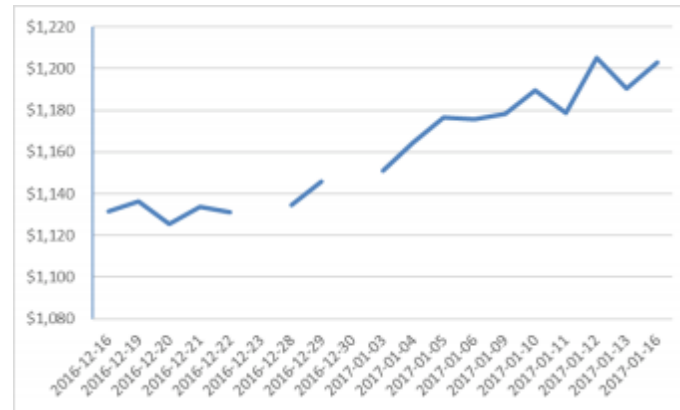


Figure 1. gold prices with missing values.

The horizontal axis is time, and the vertical axis is gold price in dollars.

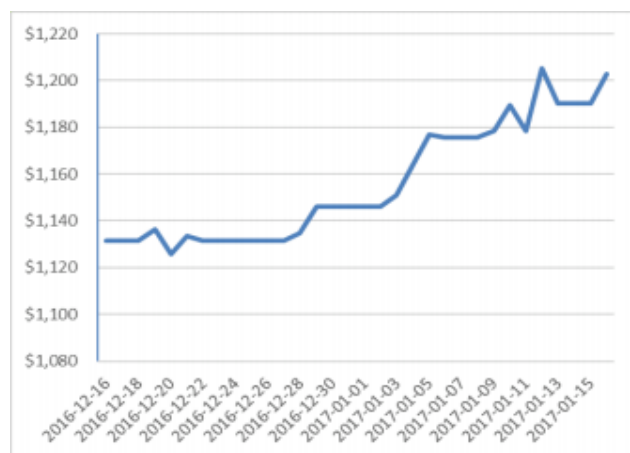


Figure 2. Gold prices without missing values.

The horizontal axis is time, and the vertical axis is gold price in dollars.

2.2. The Establishment of Prediction Model

The price changes of gold and bitcoin are affected by a variety of factors, such as supply and demand, international political situation, currency and financial trends, etc. All these factors have contributed to the price volatility of gold and bitcoin.

By observing the price trend of gold and Bitcoin (Figure 3 and Figure 4, actual data after linear interpolation), it can be found that the price fluctuates greatly in the short term and shows an overall exponential upward trend. Therefore, it is more appropriate to use the data of five days as data samples to predict the price of the day. The grey prediction model can fit the small sample data well, mine the data trend, and make a good prediction to the short-term goal[6]. Therefore, the grey prediction model can better approach the actual price trend of gold and bitcoin.



Figure 3. Real gold price data.

The horizontal axis is time, and the vertical axis is gold price in dollars.



Figure 4. Actual Bitcoin price data.

The horizontal axis is time, and the vertical axis is bitcoin price in dollars.

2.2.1. Grey Prediction Model

The gold and bitcoin prices of the i -th day are shown in Figure 4, where $B(0)(i)$ is the bitcoin price of the i -th day and $G(0)(i)$ is the gold price of the i -th day. It can be found that the price trend of gold and bitcoin is similar to exponential growth, so it is appropriate to use grey prediction model for prediction[7].

It is necessary to check step ratio before making prediction.

$$\lambda = \frac{B^{(0)}(k-1)}{B^{(0)}(K)}, \quad k=(2, \dots, n) \quad (1)$$

$$\lambda = \frac{G^{(0)}(k-1)}{G^{(0)}(k)}, \quad k = (2, \dots, n) \quad (2)$$

In formula (1) and (2), $B(0)$ and $G(0)$ represent the original sequence of actual data, which is distinguished from the cumulative array $B(1)$ and $G(1)$ of the actual data in the following steps. Five days of data are used to predict prices, so $n=5$. (In order to ensure trading after obtaining reasonable analysis data and avoid risks, trading was not carried out in the first five days according to the trading strategy.)

According to the grey prediction model, when all λ values are in the acceptable range θ , the data in the array can be used for grey prediction, θ is calculated by the following formula (3).

$$\theta = (e^{-\frac{2}{n+1}}, e^{\frac{2}{n+2}}) \quad (3)$$

After testing, the data in array $B(0)$ and $G(0)$ can be used for grey prediction. The prediction process of grey model is as follows. First, create the cumulative array $B(1)$, $G(1)$ (formula (4)).

$$\begin{aligned} B^{(1)} &= (B^{(0)}(1), B^{(0)}(1) + B^{(0)}(2), \dots, B^{(0)}(1) + B^{(0)}(2) + \dots + B^{(0)}(n)) \\ G^{(1)} &= (G^{(0)}(1), G^{(0)}(1) + G^{(0)}(2), \dots, G^{(0)}(1) + G^{(0)}(2) + \dots + G^{(0)}(n)) \end{aligned} \quad (4)$$

Then the cumulative sequence is used to calculate the mean array $z(1)$ (formula 5).

$$\begin{aligned} z^{(1)} &= (z^{(1)}(2), z^{(1)}(3), \dots, z^{(1)}(n)) \\ z^{(1)}(k) &= 0.5 \times x^{(1)}(k) + 0.5 \times x^{(1)}(k-1), k = (2, 3, \dots, n) \end{aligned} \quad (5)$$

$$x^{(0)}(k) + az^{(1)}(k) = b, k = (2, 3, \dots, n) \quad (6)$$

Then, the grey differential equation (formula 6) is established.

By solving the grey differential equation, can get the accumulative array of predicted prices $b(1)$ 、 $g(1)$, And calculate the array of predicted prices $b(0)$ 、 $g(0)$ (formula 7)

$$\begin{aligned} b^{(0)}(k+1) &= b^{(1)}(k+1) - b^{(1)}(k), k = (1, 2, \dots, n-1, \dots) \\ b^{(0)} &= (b^{(0)}(1), b^{(0)}(2), \dots, b^{(0)}(n), \dots) \end{aligned} \quad (7)$$

After the results are calculated, the predicted values can be used to continue the prediction in theory, but the further the prediction time distance, the worse the prediction effect. So this article only forecast the price for one day. In the formula (7), the predicted price on the first day ($b(0)(1)$) is equal to the actual price ($B(0)(1)$).

As the prediction process goes on, the prices of gold and bitcoin keep changing and show an overall upward trend, which has a great impact on the transaction.

2.2.2. Results

The parameters of grey differential equation are obtained by least square method, The corresponding solution equation of Formula (6) is as Formula (8):

$$\begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \dots & \dots \\ -z^{(1)}(n) & 1 \end{bmatrix} \times \begin{bmatrix} a \\ b \end{bmatrix} = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \dots \\ x^{(0)}(n) \end{bmatrix} \quad (8)$$

Formula (8) can be abstracted into the formula $B^T B \alpha = B^T Y$.
Result α is as Formula (9)

$$\alpha = (B^T B)^{-1} B^T Y \quad (9)$$

According to the above parameter results and prediction formula, the price trend of gold and bitcoin in five years can be obtained, as shown in the Figure 5 and Figure 6.



Figure 5. predicted value of gold price.

The horizontal axis is time, and the vertical axis is gold price in dollars.



Figure 6. predicted value of bitcoin price.

The horizontal axis is time, and the vertical axis is bitcoin price in dollars.

2.3. Transaction Programming Model

For those who make gold and bitcoin investments, it is ideal to avoid risk and to maximize the total value of one's holdings relative to the maximum return. Therefore developing a sound trading strategy requires planning based on the daily changes in the total value of one's holdings.

2.3.1. Programming model

The total value of currency holdings comes from three components: gold, bitcoin, and US dollars. In trading, gold and bitcoin are both in US dollars, so to calculate the total value of currency holdings, the model need to divide the value of gold and bitcoin holdings by yesterday's price, convert it to ounces and units, and multiply it by the forecast value for that day. So the total value of the currency holdings is

$$MAXQ = \frac{g^{(0)}(k)}{G^{(0)}(k-1)} (GM(k-1) + x_1) + \frac{b^{(0)}(k)}{B^{(0)}(k-1)} (BM(k-1) + x_1) + M(k-1) \quad (10)$$

In formula (10), Q denotes the total value of currency holdings, g(0) and b(0) denote the predicted price of gold and bitcoin, G(0), B(0) denote the actual price of gold and bitcoin, GM(k-1) and BM(k-1) denote the amount of gold and bitcoin held by the person before the transaction in dollars, x1 and x2 denote the amount of gold and bitcoin traded on that day, also in dollars, M(k-1) denotes the dollars owned by the person before the transaction on that day[8].

Also need to bound the transaction amount x1 and x2.

$$\begin{aligned} -GM &\leq x_1 \\ -BM &\leq x_2 \\ x_1 + x_2 &\leq M \end{aligned} \quad (11)$$

Formula (11) indicates that the transaction amount of buy-in cannot exceed the number of dollars currently held and the selling transaction cannot exceed the amount of gold and bitcoin currently held.

$$\begin{aligned} 0.01 \times x_1 &\leq g^{(0)} - G^{(0)} \\ 0.02 \times x_2 &\leq b^{(0)} - B^{(0)} \end{aligned} \quad (12)$$

Formula (12) indicates that a day's profit should be at least greater than the commission of the day's transaction.

After the transaction is completed, update GM(k), BM(k), M(k) (formula13).

$$\begin{aligned}
 GM(k) &= \frac{G^{(0)}(K)}{G^{(0)}(K-1)} (GM(K-1) + (1-a_1)x_1) \\
 BM(k) &= \frac{B^{(0)}(K)}{B^{(0)}(K-1)} (BM(K-1) + (1-a_2)x_2) \\
 M(k) &= M - \frac{G^{(0)}(K)}{G^{(0)}(K-1)} x_1 - \frac{B^{(0)}(K)}{B^{(0)}(K-1)} x_2
 \end{aligned} \tag{13}$$

2.3.2 Model solution

On the first day, choose to purchase \$500 in Bitcoin and \$500 in gold on the second day (The first day is not trading day, so choose to buy gold on the second day). After that, no trading is done for four days, then collecting the data, and trading continues on the sixth day[9]. With the help of python, the above programming model is implemented to make a reasonable programming for total value of money each day.(Figure 7).



Figure 7. strategy-guided, total monetary value per day.

The horizontal axis is time, and the vertical axis is total value in dollars.

3. Conclusions

Gold and bitcoin are popular trading products in today's trading market. Gold is rare and has the property of value preservation. Bitcoin is a virtual currency in the context of the Internet. The price of bitcoin varies significantly from day to day and the overall price is on the rise[10]. This makes it difficult for traders to judge when and how to trade. The purpose of this model is to establish a currency price forecast model, and develop trading strategy based on predicted prices to help traders maximise the value of their currency in five years' time. This topic has two main tasks: to establish the prediction model, to establish the transaction planning model.

For the question of establishing the prediction model, this model cleans the data of the historical price of gold and bitcoin and then selects the Grey Prediction Model according to the limitation of data and the internal connection of data. The currency price of the sixth day is predicted based on the historical data of five days before the trading day, and then the historical data of each trading day is used for rolling analysis. The results are shown in the figure 3 and figure 4. This result lays the foundation for the planning of the transaction.

For the question of establishing the transaction planning model, it is clear that maximizing the value of the currency is held in the principle of trading strategy, and it chooses to use Programming Model to guide trading and establishes the objective function representing the currency value and the constraint function for the daily trading volume. Based on the prediction results of the Grey Prediction

Model, the Programming Model is solved to obtain the change of the value of the currency held within five years, and the final value can rise to \$40033, as shown in the figure 7.

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