

A quantitative investment model based on an improved turtle trading strategy

Rongjie Diao^{*, 1st}, Zhiwen Wu^{1st}, Yuke Bai^{1st}

Huazhong University of Science and Technology, Wuhan, Hubei, 430074

*Corresponding author: diaorongjie0301@163.com

Keywords: grey forecasting model, turtle trading model, return, investment risk, sensitivity.

Abstract: With the continuous development of the social economy, investment has become one of the effective means for people to accumulate wealth. As an essential component of the financial market, the gold market continues to attract attention. At the same time, the new electronic currency "bitcoin" is also sought after by many investors due to its limited quantity, anonymous trading, and low transaction costs. Combining gold and bitcoin is an effective way to invest in a portfolio between the less risky gold and the more risky bitcoin and can achieve the desired returns by specifying a reasonable investment strategy. The purpose of this article is to develop an optimal portfolio investment strategy for gold and bitcoin and analyze the rationality and sensitivity of the strategy.

1. Introduction

1.1. Background

In financial asset trading, market traders need to buy and sell financial assets frequently to maximize the return, but the data of financial assets are non-linear and noisy, and their prices often deviate from their value, with uncertainty and sudden changes. Therefore, to avoid risks and obtain more benefits, it is essential to accurately and quickly predict the price trend of financial assets so that traders can predict the future price trend of financial assets to reduce the risk of decision-making and improve decision-making benefits. It is also a long-standing struggle for investors to develop investment strategies that match their risk appetite with consistent and stable returns. In traditional trading, market traders' decisions are often subjective and blind due to their knowledge, timing, and emotional factors, preventing them from gaining more profit while avoiding risks. Therefore, in this paper, we use the five-year price changes of bitcoin and gold to build a model to predict the price trends of financial products to capture the best time to trade and make decisions to maximize returns.[1]

1.2. Problem analysis

We construct a trading strategy model based on forecast prices and past prices. We improve on the Turtle model by considering that Bitcoin and gold are different from stocks. If one day in the next three days exceeds the highest value in the last 20 days, i.e., if it breaks the upper resistance line of Donchian, we buy it with a portion of our current capital. Similarly, if one day in the next three days is below the last 20 days, i.e., below the lower Tangible support line, sell all of the money.

2. Data Processing

In data preprocessing, we need to process the missing values. Since gold is not traded on the day of the missing gold price, this paper uses the previous day's trading price to fill in the missing rows. We then calculated the daily price increase and the number of consecutive up and down days for gold and bitcoin based on the processed data for later solving the problem.

3. Analysis and Modelling

3.1 Establishment of the best daily trading strategy

3.1.1. Forecast future prices

For question, in order to be able to provide better daily trading strategies, this paper first needs to predict the future prices of gold and bitcoin accurately. The price changes of gold and bitcoin are related to many factors, and there is a complex non-linear relationship between the price and the influencing factors, with grayness and uncertainty. The gray prediction model has the characteristics of simple calculation and fewer data needed, and the gold price system and the bitcoin price system are regarded as gray systems in this paper to predict them, respectively.

(1) Gray Forecast Model

There are many quantitative analysis models for forecasting, such as causal regression analysis, time series analysis, neural network, etc. This paper only needs to predict the future price direction based on the past daily price. So far, by observing the daily price direction graph, we found that the price prediction of gold and bitcoin has the characteristics of significant data fluctuation and considerable data uncertainty, so this paper decided to apply the knowledge of gray system theory and build a Gray Forecast Model.

Gray Forecast Model is a forecasting method that builds a mathematical model and makes predictions with a small amount of incomplete information. It is an effective tool for dealing with small sample forecasting problems, while for small sample forecasting problems regression, methods such as neural networks may not be effective enough.[2] Considering that the price movements of gold and bitcoin are closely related to the prices of the approaching days and not so much to the prices of very long ago, building a gray prediction model for price prediction is a feasible method in this problem.

Gray prediction, the prediction of the development of changes in the characteristic values of the system behavior, is the prediction of gray processes that vary within a specific range and are related to the time series. Gray refers to a system with incomplete information and is a widely used method for problems with little data and small information. The basic principle of the GM(1,1) gray prediction model is to generate a new set of series with a more pronounced trend of change using the cumulative method for the data series, model and predict the new data series, and then reverse the calculation by cumulative subtraction to obtain the original series as a way to obtain the prediction results.

(2) Establishment of the grey prediction mod

In this question, "Date-price" is a gray system. We know a corresponding connection between date and price, but we do not know the specific expression and cannot directly find the predicted price.



Figure 1 Gold daily prices

For example, in the case of gold, the price-date image does not show any pattern, and it is difficult to predict the next day's trading price, which is also the pattern of the gray system itself. So this paper generates a new set of data by the first-order accumulation of the original data, and the accumulation generates the sequence formula as follows.

$$x^{(1)}(k) = \sum_{i=1}^k x^{(0)}(i) \quad (1)$$

Some data are visible in the following table

Table 1. Gold daily prices

Serial number	1	2	3	4	5	6	7
date	9/11/2016	9/12/2016	9/13/2016	9/14/2016	9/15/2016	9/16/2016	9/17/2016
price	1324.6	1324.6	1323.65	1321.75	1310.8	1308.35	1308.35
The cumulative price	1324.60	2649.20	3972.85	5294.60	6605.40	7913.75	9222.10

New images are drawn using cumulatively generated sequences:

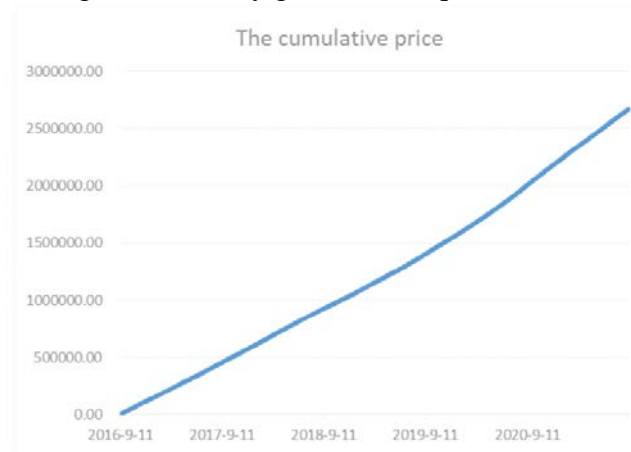


Figure 2 cumulative price

It can be seen that the new image of the sequence and date looks like an exponential function compared to the previous original image, which is the law of cumulative generation. This paper then fits the exponential function expression through known data and thus predicts the future price.

(3) Model application and predictive results

Considering that the price movements of gold and bitcoin are closely related to the prices of the next few days, this paper constructs a prediction model using the prices of the next seven, eight, nine, and ten days respectively, and predicts the price of the next day in turn, and uses the average of the four results as our actual prediction. After getting the predicted price for the first day of the future, for the second day of the future, we also use the prices of the previous days, eight days, nine days, and ten days to build the prediction model and predict the price, and use the average value as the actual prediction value. For the third day of the future, the previous day's price will be used. At this point, the predicted prices for the next three days are obtained by using the data before each day.

(4) Model application and predictive results

Error analysis was performed using the built GM (1,1) model, and the results are shown in Fig.

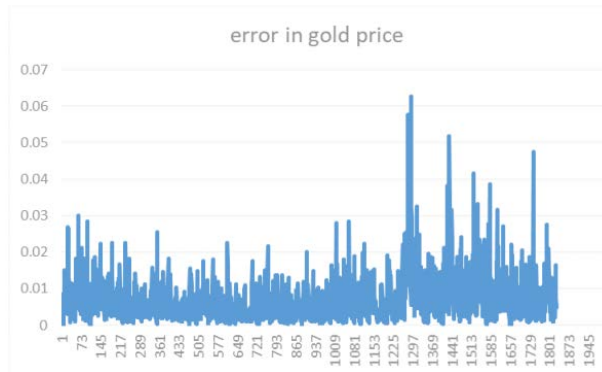


Figure 3 gold_error

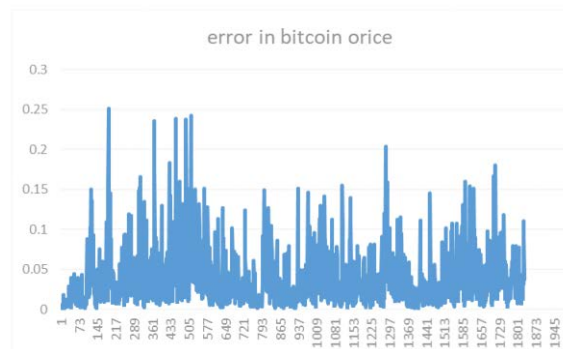


Figure 4 bit_error

To demonstrate the degree of model fit more intuitively, we made price increase images:

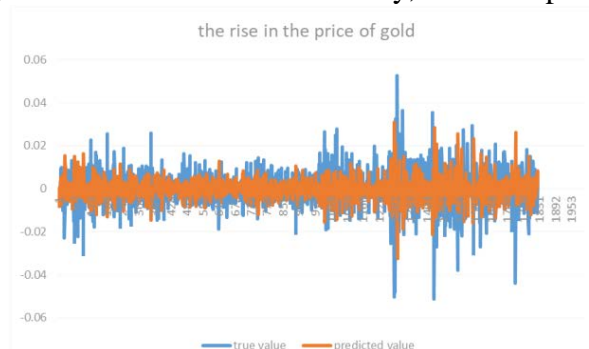


Figure 5 gold_rise

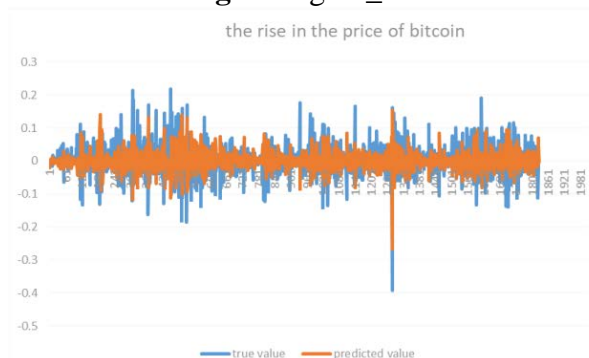


Figure 6 bit_rise

As can be seen from the above chart, the prediction results are basically the same as the real price direction, in which the average prediction error of gold price is 0.70%, and the average prediction error of bitcoin price is 3.75%. In theory, the gray-scale prediction model can be used to predict the future price of gold and bitcoin, with good prediction accuracy and practical value.

3.1.2. Forecast future prices

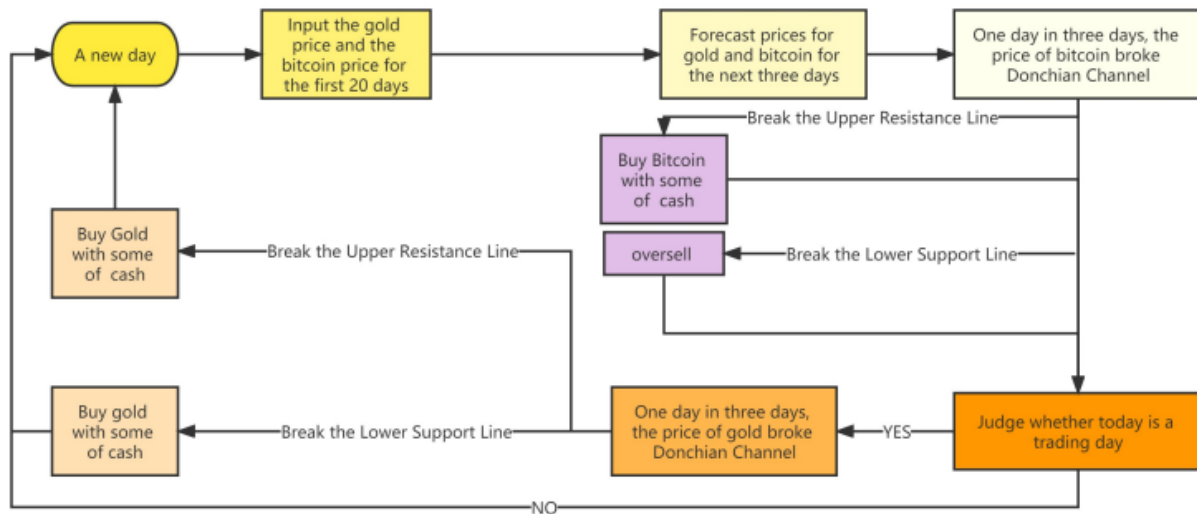


Figure 7: flow chart

Under the background of the rapid development of the financial market, quantitative trading and investment behavior began to appear. The advantage of quantitative investment strategy is that it can ensure that investors choose investment objects more scientifically and effectively. Establishing the model can understand the dynamic market development in the first time to obtain excess benefits. Turtle trading strategy, which originated in the United States in the 1980s, is a simple and effective quantitative trading strategy. It is based on the Donchian channel to track the trend to generate the trading signal, decide whether to trade on the day, add or reduce positions, use ATR to add positions, or reduce positions in batches to change stop profit, and stop-loss dynamically.

A significant technical indicator in the turtle trading strategy is mainly composed of the Upper Resistance Line and the Lower Support Line. The Upper Resistance Line has the highest price in the first N_1 day, while the Lower Support Line has the lowest price in the first N_2 days.[3] The specific calculation formula is as follows:

$$\text{UpperResistanceLine} = \max(\text{Highestprice}, n)$$

$$\text{LowerSupportLine} = \min(\text{Lowestprice}, n)$$

If we predict that the price of the next day is higher than Upper Resistance Line, then we will buy part of the holdings today, if the predicted price of the next day is lower than Upper Resistance Line, we will sell part of the holdings today, this is the core idea of the turtle trading strategy, this article will gradually optimize the process.

In the model established in this paper, we first predict the prices of gold and Bitcoin in the following day and compare them with the Upper Resistance Line and the Lower Support Line to decide whether to add or reduce positions. After this through the previous price forecast after three days of gold and bitcoin price, if three days after at least one-day forecast price is higher than the Upper Resistance Line, we will add positions today, if any day forecast price is lower than the Lower Support Line, we are reduced today, by comparison, we found that the latter method is suitable. We can also intuitively see that if the forecast price in the next three days is higher than Upper Resistance Line, the appropriate purchase can wait for gold or bitcoin to increase, and the price below the Lower Support Line is similar, which is far better than predicting the day.

In the specific implementation of the model, if the predicted price of gold in the next three days is lower than its the Lower Support Line, all gold will be sold, and Bitcoin will be treated the same, considering the updated gold and bitcoin holdings and dollar holdings after the fee. Due to the different nature of gold and bitcoin, we prefer to do gold in medium and long-term trading. Bitcoin does short-term trading, so it is divided into giving weight. The specific value is 0.3,0.7.

If both gold and bitcoin are more predicted than their Upper Resistance Line, respectively. The dollar bought gold and bitcoin as weighted on that day. If the gold's forecast price is higher than the Upper Resistance Line, Bitcoin's predicted price is no higher than Upper Resistance Line by multiplying the dollar holdings by the weight to buy gold. Bitcoin holds the same amount; If the gold forecast price is not higher than the Upper Resistance Line, Bitcoin predicts higher than Upper Resistance Line, Like buying Bitcoin; If neither price is higher than Upper Resistance Line, Both gold and bitcoin holdings remain unchanged. According to the above process, this article is updated daily with [C, G, B], namely the capital, gold, and bitcoin holdings, and the total assets property is expressed in the following formula:

$$\text{Property} = \text{dollar} + \text{gold} * \text{gold_price} + \text{bit} * \text{bit_price}$$

According to the above process, it was intuitively shown in the form of a line chart, and we found that the revenue is good in the early stage, but in the late period when bitcoin increased, the revenue is still relatively small.

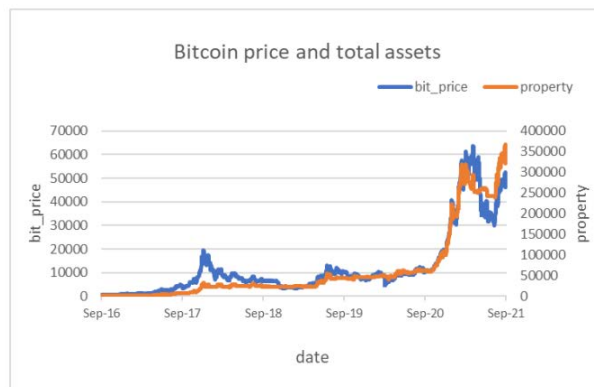


Figure 8: bit_property

Therefore, we want to divide the model into two sections. We should buy more in the early stage, and sell more in the later stage. The amount of the buying and selling is related to the highest minimum value of how many days before. Therefore, we use different mathematical formulas to calculate the upper Lower Support Line in the previous and later stages:

earlier stage:

$$\text{gold_high} = \max(\text{gold_price}(i - 20 : i))$$

$$\text{gold_low} = \min(\text{gold_price}(i - 5 : i))$$

$$\text{bit_high} = \max(\text{bit_price}(i - 12 : i))$$

$$\text{bit_low} = \min(\text{bit_price}(i - 23 : i))$$

later stage:

$$\text{gold_high} = \max(\text{gold_price}(i - 45 : i))$$

$$\text{gold_low} = \min(\text{gold_price}(i - 45 : i))$$

$$\text{bit_high} = \max(\text{bit_price}(i - 12 : i))$$

$$\text{bit_low} = \min(\text{bit_price}(i - 12 : i))$$

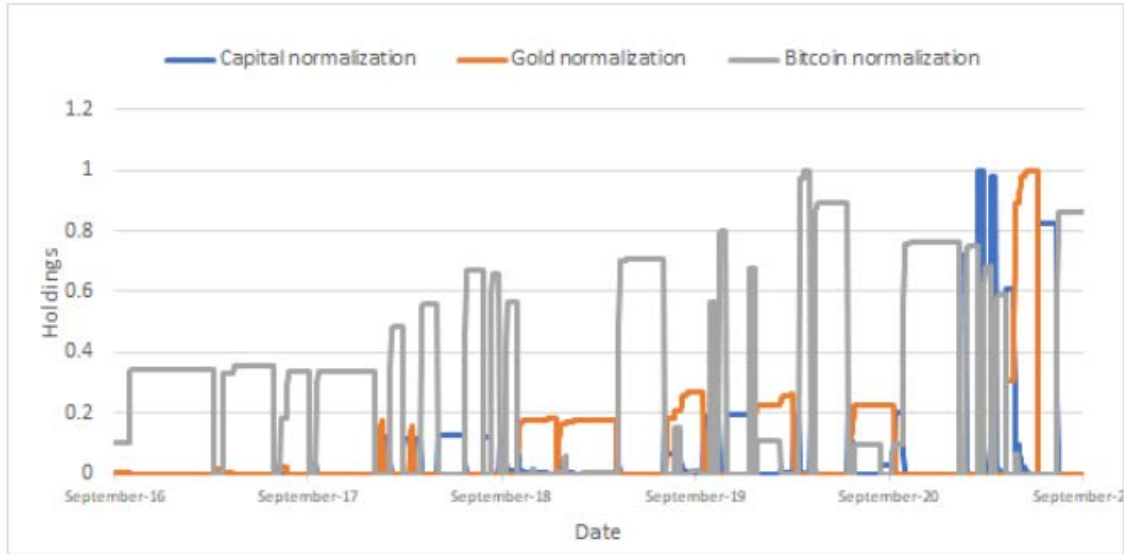


Figure 9: Change in Holdings

In the model, we also need to set the initial value, and after some debugging, we found that the results at $[C, G, B] = [300, 300, 400]$ are better and less risky, namely gold for \$300 on the first day, \$400 for buying bitcoin, and the remaining \$300 as liquidity.

In the end, we got the change value of total assets over time and made a line map with the price of bitcoin. The above images show that the changing trend of total assets in the past five years is almost the same as the increase of bitcoin, which is also very reasonable. Because of the fast growth of bitcoin, we will buy more bitcoin in the early stage and wait for it later for it to appreciate. The price of bitcoin has two peaks. Relying on the first small peak, we made a small and steady investment in the middle. At the second peak, because we already had a certain number of Bitcoin, and the price of Bitcoin soared, our total assets also increased significantly. Mainly relying on these two peaks, we earned the last \$3,07,138.09, 48,473,095.



Figure 10. Change in price and property

4. Strength and Weakness

4.1 Strength

- Using a Grey Forecast Model, better results are obtained with fewer data and more discrete.
- This paper considers both the final return and the risk level, which can guarantee a high return with a relatively small risk level, and has a certain degree of robustness.

- We focus on the characteristics of gold and bitcoin and treat them differently to make the model fit better than the previous result.
- Take into account the seasonality and cyclicity of the time series of price movements, and analyze the trend of price changes from a long-term perspective.
- Combined with the situation based on the classic turtle trading strategy to improve and get outstanding results.

4.2Weakness

- Failure to take into account social and policy factors.
- The model is built based on the past transactions of gold and bitcoin, and the generalization of other financial products is not studied in-depth in this paper.

References

- [1] Zhou, Brilliant Yun. Bitcoin investment prospect analysis [J]. Time Trade, 2014 (5).
- [2] Mathematical Modeling Grey prediction and Python implementation,crossous, <https://www.jianshu.com/p/a35ba96d852b>
- [3] JINGXIAN XU, JUNHAO ZHENG. Improved Turtle Trading Strategy and Empirical Analysis[C]. 2018. DOI:10.2991/icesem-18.2018.279.
- [4] SAULIUS MASTEIKA, ALEKSANDRAS VYTAUTAS RUTKAUSKAS. Research on futures trend trading strategy based on short term chart pattern [J]. Journal of Business Economics and Management, 2012, 13(5):915-930. DOI:10.3846/16111699.2012.705252.
- [5] FANG, YUJIE, CHEN, JUAN, XUE, ZHENGXUAN. Research on Quantitative Investment Strategies Based on Deep Learning [J]. Algorithms, 2019, 12(2):35.