

Dynamic Asset Planning Model via Polynomial - ARIMA Prediction and Risk Analysis via Improved Volatility & EWAM

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Abstract. This paper investigates the trading strategies for gold and bitcoin. Based on past data, future gold and bitcoin prices are given by single-step forecasting, and optimal investment strategies are also proposed. In this paper, a polynomial-ARIMA model is developed using quadratic polynomial fitting and ARIMA algorithm depending on the size of the data. This forecasting model was used for single-step forecasting of gold and bitcoin prices. After that, a GA-based dynamic programming model was proposed based on the forecasting results and the results were obtained by it.

Keywords: Polynomial Fitting; Prediction Model; Dynamic Programming; ARIMA.

1. Introduction

In today's trading market, gold and bitcoin are in the spotlight [1-2]. However, due to the volatility of the market, it is difficult to make strategic decisions regarding investments in gold and bitcoin, thus necessitating the development of a stable model for portfolio planning [3]. This paper combines bitcoin and gold price data from September 12, 2016 to September 10, 2021 to find the best trading strategy for that date. The problem also requires that the constructed model be used to predict how much a \$1,000 fund will be worth by September 10, 2021. Then, evidence is needed to prove the optimality of the strategy given by the above model. Next, consider different allocations of the initial \$1,000 fund, perform a sensitivity analysis of the model, and observe how well the model accommodates transaction costs [4].

2. The Fundamental of ARIMA Predict Model

2.1 Theoretical Basis

R^2 is a statistical measure of how close the data are to the fitted regression line. It is also called the coefficient of determination.

The relative error is the percentage of the absolute error to the true value. Its calculation formula is

$$\varepsilon_r = 1 - \frac{x^*}{x} \quad (1)$$

where x^* is predicted value and x is real value.

ARIMA model's full name is Autoregressive moving average model, it is a model used for conduct time series prediction and it is widely used in statistical model [5-6].

Bayesian information criterion (BIC) is a criterion for model selection among a finite set of models. The calculation formula of BIC Bayesian information criterion is as follows:

$$BIC = -2 \ln L + K \ln n \quad (2)$$

Where, L represents the maximum likelihood function of the model, K represents the number of model parameters, and n represents sample size.

For the early data, we adopt least square method and use multiple forms of formula to iteratively fit prices of gold and bitcoin respectively. Though adopting multiple forms of formula, we found that quadratic polynomial has the best fitting effect [7].

When using a quadratic polynomial fit, there are three unknown quantities. For both the bitcoin and gold data, the first three data are marked as missing data and the missing data are processed according to the subsequent fitting results. For data points other than the first three data, the regression function was fitted by using the data before that point and the prediction of that point was performed by using the obtained fitting function [8].

Using the regression function fitted by quadratic polynomial, the R^2 coefficient of determination fitted for 147 groups of bitcoin data is between 0.82 and 0.94, and the R^2 coefficient of determination fitted for 101 groups of gold data is between 0.8 and 0.92, which shows that both regression functions are more significant. Finally, the prediction effect is tested, relative error ε_r between the predicted value and the true value obtained of the two models is calculated, and the results of two models are both greater than 0.99, so we can see that prediction effect is satisfying [9].

The following figure 1 shows the last fitting results, which is the combination of two graphs of two fitting functions. These two fitting functions are obtained by using 147 bitcoin data and 101 gold data respectively. From these two graphs we can see that fitting results is satisfying.

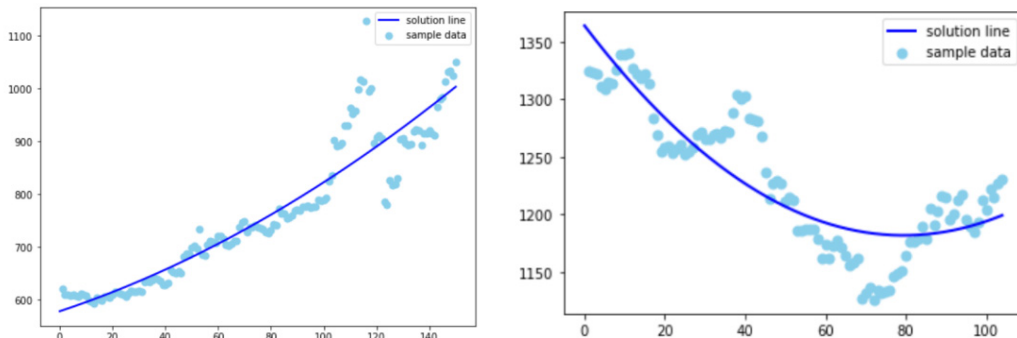


Figure 1. Two fitting graphs

Where fitting functions are

$$y_1 = 0.01x^2 + 1.65x + 578.736 \quad (3)$$

$$y_2 = 0.03x^2 - 4.59x + 1364.099 \quad (4)$$

For bitcoin and gold, we first visualized their price data respectively, so we decided to proceed difference operation of initial data tell processed data has good stationarities. The order of difference is d .

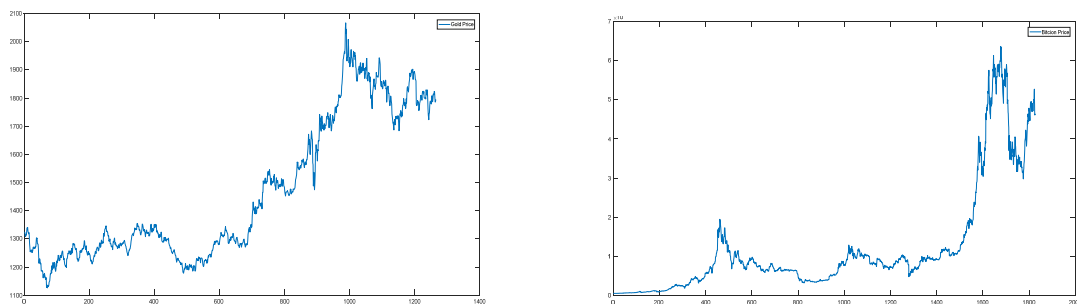


Figure 2. Left Graph shows gold prices and right graph shows bitcoin price

Using time series analysis toolbox in Matlab, calculate statistics of BIC and Durbin-Watson, and the parameters of the model are shown in the table 1 below.

Table 1. *ARIMA* parameters

Type	p	d	q
Gold	4	1	2
Bitcoin	2	1	3

Create training sets T_G and T_B as well as predicting set P_G and P_B of *ARIMA* model for gold and bitcoin respectively. previous data is stored in training sets T_G and T_B while predicted data is stored in predicting set P_G and P_B .

One-Step-Ahead Prediction for Future Data

Step 1: Obtain initial training sets T_{G0} and T_{B0} , in which T_{G0} is the data of previous 104 market days, T_{B0} is the data of previous 150 market days

Step 2: Use training sets to train model, predict data of day i , then put predicted results in predicting set P_G and P_B and add real data of day i in training set.

Step 3: Repeat step 2, predict all the prospective data, we visualized data from predicting sets and real data then compared themselves, results is shown in the figure 3, we can see that one-step-ahead prediction can well describe their future price trends

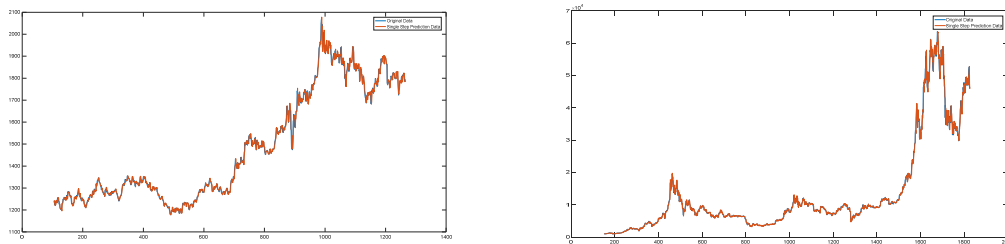


Figure 3. Left graph shows gold prices and right graph shows bitcoin price

2.2 Dynamic Planning Model based on GA

The calculation results of the above iterative prediction model can be used to obtain the prices of gold and bitcoin for the following day, therefore, based on this premise, a dynamic planning model can be developed and built. to solve the dynamic capital investment problem for gold, bitcoin, and cash in the investment cycle Γ [2].

A good objective function, which is contributed by the knowledges of dynamic planning, can greatly reduce planning difficulties, so we considered the relationship between the demand and the known quantities, for the market opening and closing times of the gold, two objective functions are built [9].

When the gold market opens.

$$\max_{t \in \Gamma} f = \frac{n_1(t+1)}{m_1(t)} (z_1(t) + x_1(t)) + \frac{n_2(t+1)}{m_2(t)} (z_2(t) + x_2(t)) + (z_3(t) + x_3(t)) \quad (5)$$

When the gold market is closed.

$$\max_{t \in \Gamma} f = z_1(t) + \frac{n_2(t+1)}{m_2(t)} (z_2(t) + x_2(t)) + (z_3(t) + x_3(t)) \quad (6)$$

Where $n_1(t+1)$ is the predictive price of gold on day $t+1$; $m_1(t)$ is the trading price of gold on day t ; $n_2(t+1)$ is the predictive price of bitcoin on day $t+1$; $m_2(t)$ is the trading price of bitcoin on day t ; $z_1(t)$ is the share of gold on day t ; $z_2(t)$ is the share of bitcoin on day t ; $z_3(t)$ is the amount of cash on day t ; $x_1(t)$ is the amount of gold traded on day t ; $x_2(t)$ is the amount of bitcoin traded on day t ; $x_3(t)$ is the amount of cash traded on day t . (in USD).

Under *python* environment, maximum values of the objective functions mentioned above is found. First, we architect the genetic algorithm framework, then write the objective function and

constraints, finally, combined the data predicted in the previous section with the real data, then make the combination of data run through the algorithm [10].

3. Results

3.1 The Establishment of Simulation Model

We write a summary of our daily trading strategies in Optimal programming.csv, and due to space limitations, the Table 2 only shows few rows at the beginning and ending of the table.

3.2 Analysis of Experimental Results

Solve for the optimal daily allocation of gold, bitcoin, and cash (not shown here due to space limitations) and the daily account value (as shown in Figure 4).

Table 2. Transaction details

Data	ΔG	ΔB	ΔC	Value_All/\$
2016-09-11	0	22.62350661	-23.08521083	1089.817078
2016-09-12	77.6956254	-76.91082111	0	1069.877637
2016-09-13	-178.6734964	176.8687136	0	1113.738973
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2021-09-08	0	8.26913E-07	-8.55472E-07	80515.48268
2021-09-09	-9.79773E-06	9.72593E-06	0	83480.78828

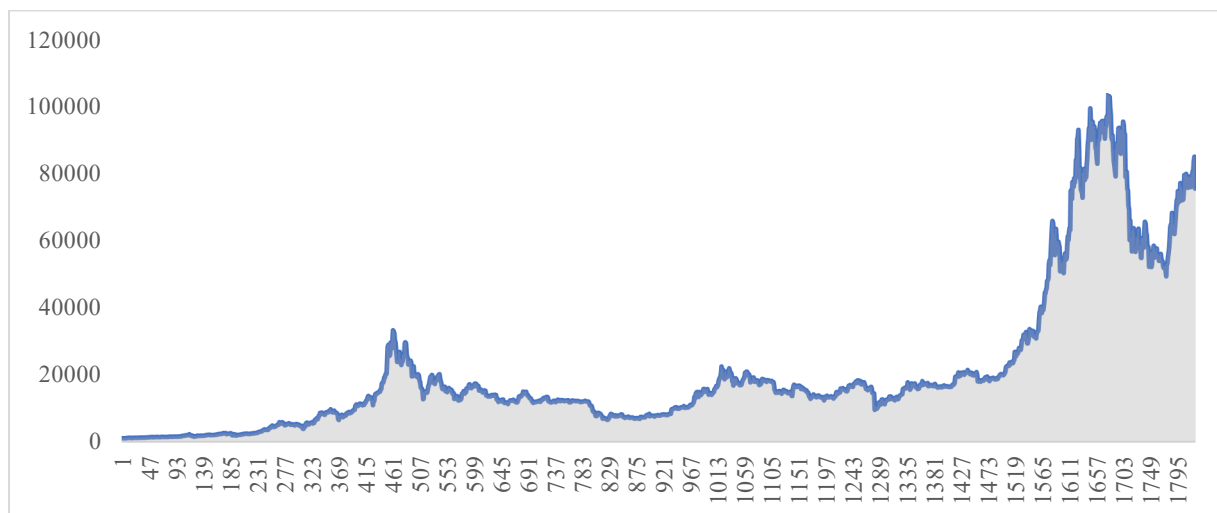


Figure 4. Daily account value

By selecting the load prediction results of 403 and 411 lines. We can see that the actual values of the lines basically match the predicted values, but there are also some errors, especially in the peak period of electricity consumption, as shown in Table.2.

4. Conclusion

This paper investigates the trading strategies for gold and bitcoin. Combining historical trading data, a polynomial-fitting model and an ARIMA model are constructed for gold price and bitcoin price forecasting studies, respectively, and optimal investment strategies are also proposed. In this study, a polynomial-ARIMA model is built and is used for single-step forecasting of gold and bitcoin prices. After that, a GA-based dynamic programming model was proposed based on the forecasting results and the results were obtained by it. The results show a return on investment of \$84,969 on October 9, 2021.

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