Feasible "Gold&Bitcoin Rush" Model Based on ARIMA Prediction and Dynamic Frequency Programming

Abstract

Bitcoin is a virtual P2P currency born in 2009.As a feasible means of getting rich,buying and selling bitcoin has set off an upsurge and attracted wide attention.It has become a trading currency comparable to gold.Therefore,we propose a bitcoin gold portfolio investment model that is generally applicable,easy to operate and most conducive to investors' operation to help investors make scientific investment decisions.

In the first part,we deal with the given five-year bitcoin and gold value data by standardization and first-order difference,establish a **multi cycle comprehensive** prediction based on **ARIMA** model,predict the data,calculate the prediction value sampled in each cycle and carry out arithmetic average processing,and then apply multi cycle data visualization Descriptive statistics and other methods to further construct the trading strategy of bitcoin and gold.

In the second part,based on the prediction model in the first part,we calculate the rise and fall rate of each sample data,calculate the median of the rise and fall rate,use the **Apriori association rule algorithm** to count the frequency distribution of rise and fall of different frequencies,obtain the quantile of continuous rise and fall rate,construct a reasonable bitcoin and gold trading scheme,and then simulate the predicted return curve.Based on the principal of US $1000,**the final return is US $87653.22** and **the success rate is 31.6%**.

In the third part,in order to further test the **accuracy** of the model,we establish a sensitivity analysis based on the transaction amount,and use the Markowitz portfolio model to evaluate the risk of the transaction strategy.There is a linear correlation between the transaction amount and the overall income,which proves the wide adaptability of the model.

In the fourth part,we present our trading strategy,model process,trading return and risk control theory to investors in the form of memorandum to guide them to invest in accordance with the methods we provide.

Keywords: Bitcoin,Gold,Multi-cycle Forecasting,ARIMA,Quantile,Markowitz Portfolio Model

Contents

1 Introduction

1.1 Problem Background

Market traders often buy and sell volatile assets with the goal of maximizing total return.There is usually a commission on every transaction.As two frequently traded assets,gold and bitcoin have attracted a lot of attention.Due to the complexity and dynamics of its price fluctuation, predicting its trend and how to maximize investment benefits have always been the focus of researchers.Therefore,how to make full use of the previous market transaction data and establish an accurate mathematical model for prediction is very important.

Figure 1 Bitcoin[8]

1.2 Clarification and Restatement

In this question,we will start with $1000 on November 9, 2016,using a five-year trading period from November 9, 2016 to October 9, 2021.On each trading day,traders will have a portfolio of cash,gold and bitcoin expressed in dollars,troy ounces and bitcoin.The initial state is [1000,0,0].The commission fee for each transaction is α% of the transaction amount.Assume αgold=1% and αBitcoin=2%.There is no cost to holding assets.

We will build accurate models based on five years of gold and Bitcoin data using appropriate methods.The model achieves the goal of using only the past daily price flow so far to determine whether a trader should buy,hold,or sell the assets in his portfolio each day.

Based on the above analysis,we summarize and list the following problems:

➢ ①Build a model that provides the best daily trading strategy based on historical data.Using this model and strategy, calculate the maximum return on an initial investment of $1,000 on October 9, 2021.

➢ ②Prove that the model provides the best strategy.

➢ ③Analyze the sensitivity of strategies to transaction costs and the impact of costs on strategies and results.

➢·④Write a memo to investors of no more than two pages, presenting trading strategies, models and results.

1.3 Literature Review

Ziaul Haque Munim et al. used regression comprehensive moving average (ARIMA) and neural network autoregressive (nnar) models to analyze and compare the prediction of bitcoin price.ARIMA,which is re-estimated by the model at each step,performs better than NNAR in the prediction period of two test samples.Through the Diebold Mariano test,it is verified that the prediction result of ARIMA model is better than that of NNAR model in the test sample period.Although NNAR is complex,Arima's prediction of fluctuating bitcoin prices is more lasting.[1]

Zhang yingchao and sun yingjun selected the closing price of Shanghai composite index as the original data and established ARIMA(4,1,4) model for prediction and analysis,whose fitting effect and prediction accuracy were relatively ideal.[2]

M. Khedmati et al. proposed and analyzed the modeling and prediction of bitcoin price based on classical ARIMA prediction model and machine learning methods such as Kriging,Artificial Neural Network (ANN), support vector machine (SVM) and random forest (RF).The proposed model is applied to the bitcoin price from December 18, 2019 to March 1, 2020,and the Diebold-Mariano statistical test shows that the ARIMA and Bayesian methods are superior to other univariate models.[3]

Markowitz portfolio theory is a mean-variance model of optimal asset allocation,which takes "maximum expected return" and "minimum risk" into full consideration.It can diversify investment by summarizing the probability of investment loss and the deviation degree between possible return and expected return.[4-5]

To sum up,we will use ARIMA model to predict the price of the forecast date,establish the forecast model and investment model,and finally use Markowitz portfolio theory to calculate the risk.

1.4 Notations

Symbols	Definitions
T_i	Selected data at intervals of I in the sample
Y_{ti}	The price forecast when the period is i
$\hat{Y}_t$	Predicted price
$\gamma 2$	Maximum rise/fall rate
S_i	Amount of add/subtract position i
$N_1 N_2$	The number of consecutive times when the sum of the product's rise/decline rate exceeded 90%
X_p	Return on portfolio investment
σp^2	Total portfolio risk

1.5 Assumptions

- ·All data are accurate and reliable,reflecting the real situation of the investment market.
- ·The investment market was stable and there were no major events that caused major market fluctuations.
- ·There is unit root in time series, and no other related random variable changes affect time series analysis.
- ·Only proceed from the conditions given in the question,not considering other factors.
- ·It is assumed that the investor's decision is based solely on the risk and return of the security, and no other factors affect it.
- ·Assume that at a certain level of risk, investors expect maximum return,and at a certain level of return, investors expect minimum risk.
- ·Forget about the liabilities of the short.

1.6 Overview of Our Work

Our main goal is to establish a more accurate prediction model,and with the help of the model to make scientific investment decisions to achieve the maximum return,the lowest risk,profit smooth.The whole modeling process is shown in the figure below.First,we innovatively integrated multi-cycle sample extraction method and ARIMA model to establish a multi-cycle ARIMA model as a price prediction model.After model testing,based on Markowitz portfolio investment model,a reasonable trading strategy is proposed by introducing association rules and other theories,and the trading starts when the corresponding conditions are met.Finally,the model of risk assessment,prove the model's accuracy and sensitivity to price,and calculate the maximum return you can get on your initial investment.

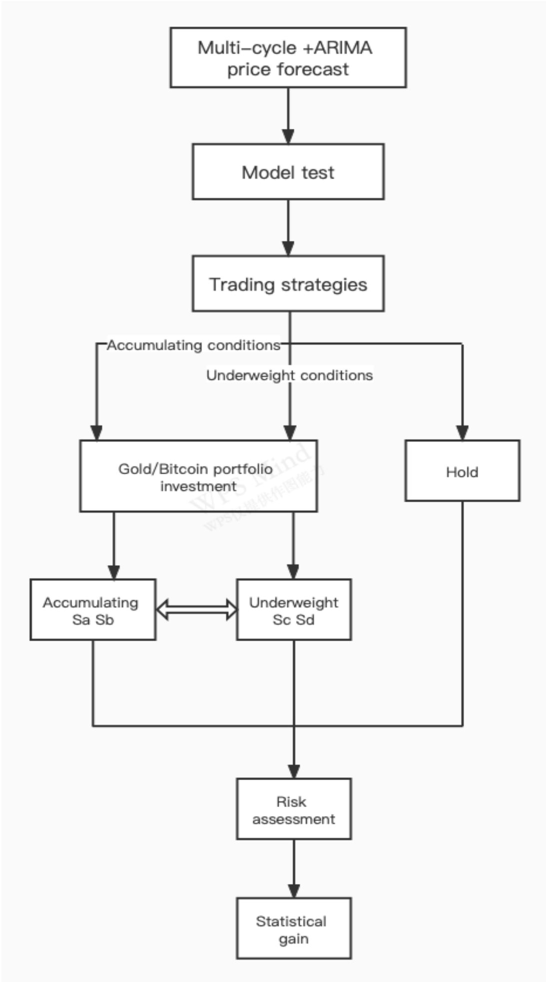

Figure 2 Modeling Process

2 Estimate and Optimize Prediction Model

2.1 Problem Analysis

The question provides data on the value of bitcoin and gold relative to the dollar over a five-year period.Therefore,the focus of this quiz is mainly on the full use of data.When solving the problem,it is necessary to use appropriate methods to preprocess the data,eliminate some interfering miscellaneous information,and accurately capture the effective information in the data set.Secondly, time series processing model method is used,ARIMA model is applied,through the unit root test,order determination,residual sequence test and other steps.Finally, the data are fitted and predicted.

2.2 Methodology

This part is divided into two sections.Firstly, the data are preprocessed,and then the sample data are selected in multiple cycles to make prediction with the help of ARIMA model.

2.2.1 Data preprocessing

This problem provides five years of market data,including bitcoin and gold coins,with a large amount of data.In order to better extract effective information in the data,the data need to be preprocessed.Data preprocessing in this paper can be divided into the following steps:

1. NAN values are excluded from gold data.
2. Different dimensions and units among gold,Bitcoin and U.S. dollar will affect the results of data analysis,so data need to be standardized.
3. Classify or eliminate outliers and unify the format of the data.
4. Visualized bitcoin and gold data after processing.
5. The continuous 30-day data of bitcoin and gold were selected and sorted into Excel tables.After no vacancy processing,30 data were obtained.15 data were obtained by single vacancy processing.Double vacancy processing is carried out to obtain 10 data.The ARIMA model was used to predict the data after the next day for fitting, and the results of the next day were obtained for statistics.
6. The arithmetic mean value of the results of the next day is taken,and the error analysis is made with the real results to calculate the accuracy of the fitting.

Figure 3 Gold - time variation diagram

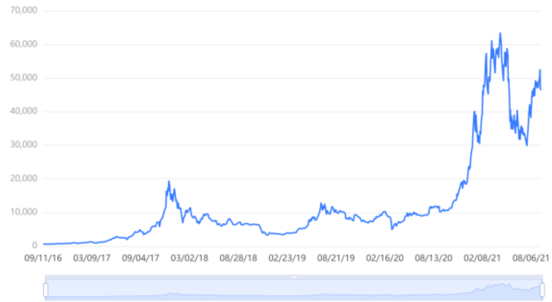

Figure 4 Bitcoin-time variation diagram

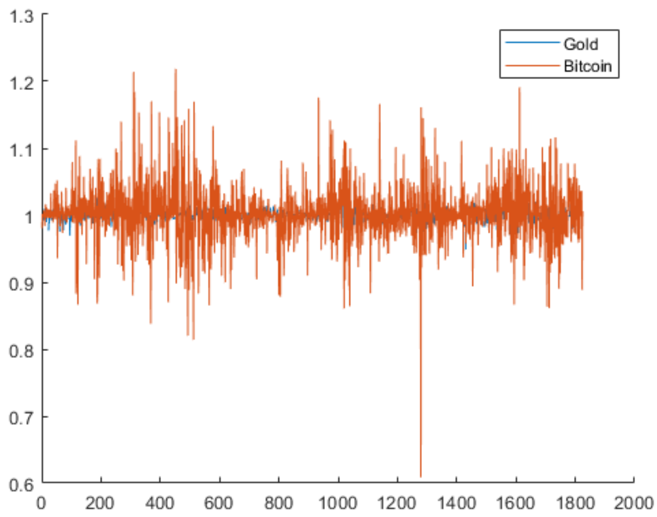

Figure 5 Bitcoin&gold First order difference diagram

2.2.2 Multi-period comprehensive forecast based on ARIMA

ARIMA(P, D, Q) stands for Autoregressive Integrated Moving Average model,combining Autoregressive model,Moving Average model and difference method [6].In the past relevant research on the market stock price prediction has a better performance.We make some improvements,and the multi-period comprehensive prediction based on ARIMA achieves very good prediction effect.

1.Select 30 consecutive data from BCHAIN-MKPRU and LBMA-GOLD starting from February 23,2019 respectively (GOLD vacancy date removed,data taken later) for non-vacancy,first-order vacancy and second-order vacancy processing (here to explain what our vacancy means),and select 0,1,2 vacancies. They are denoted as $T_{1（BTC）}$,$T_{2（BTC）}$,$T_{3（BTC）}$;$T_{1（GOLD）}$,$T_{2（GOLD）}$,$T_{3（GOLD）}$ 。

2.ADF unit root test was used to evaluate the smoothness of time series.Where, t is the parameter to evaluate whether it can significantly reject the sequence instability,and p is the criterion to judge the stability (if P is less than 0.05, the sequence is a stable sequence).AIC is a standard to measure the excellence of statistical model fitting.The smaller the value, the better.The comparison between the statistical values of the critical values of 1%, 5% and 10% that reject the original hypothesis and THE ADF Test result to varying degrees is that the ADF Test result is less than 1%, 5% and 10% at the same time indicates that the hypothesis is very well rejected.

Chart 1 $T_{1(BTC)}$ ADF test diagram

ADF check list

Variable	Differential Order	t	p	AIC	Critical Value		
					1%	5%	10%
Value	0	-2.79	0.060*	214.213	-3.679	-2.968	-2.623
	1	-6.722	0.000***	177.41	-3.833	-3.031	-2.656
	2	-1.458	0.554	170.298	-3.833	-3.031	-2.656

Chart 2 $T_{2\ (BTC)}$ ADF test diagram

ADF check list

Variable	Differential Order	t	p	AIC	Critical Value		
					1%	5%	10%
Value	0	0.641	0.989	91.477	-4.332	-3.233	-2.749
	1	-4.354	0.000***	83.816	-4.332	-3.233	-2.749
	2	-2.797	0.059*	86.906	-4.665	-3.367	-2.803

Chart 3 $T_{3\ (BTC)}$ ADF test diagram

ADF check list

Variable	Differential Order	t	p	AIC	Critical Value		
					1%	5%	10%
Value	0	0.49	0.985	63.103	-5.354	-3.646	-2.901
	1	-3.262	0.017**	62.392	-5.354	-3.646	-2.901
	2	-2.37	0.150	56.969	-6.045	-3.929	-2.987

Chart 4 $T_{1\ (GOLD)}$ ADF test diagram

ADF check list

Variable	Differential Order	t	p	AIC	Critical Value		
					1%	5%	10%
Value	0	-2.292	0.175	133.211	-3.679	-2.968	-2.623
	1	-4.909	0.000***	128.581	-3.689	-2.972	-2.625
	2	-5.725	0.000***	129.001	-3.711	-2.981	-2.63

Chart 5 $T_{2\ (GOLD)}$ ADF test diagram

ADF check list

Variable	Differential Order	t	p	AIC	Critical Value		
					1%	5%	10%
Value	0	-2.627	0.088*	66.363	-4.012	-3.104	-2.691
	1	-2.618	0.089*	55.731	-4.665	-3.367	-2.803
	2	-4.398	0.000***	64.603	-4.223	-3.189	-2.73

Chart 6 $T_{3\ (GOLD)}$ ADF test diagram

ADF check list

Variable	Differential Order	t	p	AIC	Critical Value		
					1%	5%	10%
Value	0	-3.092	0.027**	48.878	-4.473	-3.29	-2.772
	1	-3.916	0.002***	50.919	-4.665	-3.367	-2.803
	2	-3.753	0.003***	39.782	-6.045	-3.929	-2.987

3.Parameter estimation and model establishment

Rank determination criterion based on AIC:determine the values of parameters p and q,so that $\min AIC = n\ln\hat{\sigma}\varepsilon^2 + 2(p+q+1)$.Where n is the sample size, $\hat{\sigma}\varepsilon^2$ is the estimated value of $\sigma\varepsilon^2$, and is related to p，q.When p=$\hat{p}$, q=$\hat{q}$, the value of minAIC can be obtained, and the sequence is considered to be ARMA ($\hat{p}$,$\hat{q}$).p and q values were taken between (1 and 5),respectively,to fit the time series.AIC function value and corresponding AIC coefficient can be obtained from p and Q of each dimension.When minAIC is obtained,p and q are calculated by maximum likelihood estimation.

4.P, D, Q test of ARIMA model

The autocorrelation coefficient and partial autocorrelation coefficient of the differential sequence are shown in the figure below.Both the autocorrelation coefficient and partial autocorrelation coefficient of the differential sequence are in a trailing state,which further indicates that the values of P, D and q above are relatively accurate.

Figure 6 T_{1} (BTC) ACF test diagram

Figure 7 T_{1} (BTC) PACF test diagram

Figure 8 T_{2} (BTC) ACF test diagram

Figure 9 T_{2} (BTC) PACF test diagram

Figure 10 T_{3} (BTC) ACF test diagram

Figure 11 T_{3} (BTC) PACF test diagram

Figure 12 T_{1} (GOLD) ACF test diagram

Figure 13 T_{1} (GOLD) PACF test diagram

Figure 14 $T_{2\,(GOLD)}$ ACF test diagram

Figure 15 $T_{2(GOLD)}$ PACF test diagram

Figure 16 $T_{3\,(GOLD)}$ ACF test diagram

Figure 17 $T_{3\,(GOLD)}$ PACF test diagram

5. The optimal P,D,Q value of ARIMA

Chart 7 Best PDQ value of ARIMA of bitcoin/gold with different vacancy values

T_1（BTC）	T_2（BTC）	T_3（BTC）	T_1（GOLD）	T_2（GOLD）	T_3（GOLD）
ARIMA (0,1,1)	ARIMA (0,1,0)	ARIMA (0,1,1)	ARIMA (0,1,0)	ARIMA (0,2,1)	ARIMA (0,0,0)

Solve Forecast Price:

Data selected for prediction: set the period as T_i(i=1，2，3......n).T_1 means data is selected every other time in the sample data.T_2 means data is selected every two times in the sample data......T_n, in the same way,means that data is selected every n points in the sample data.Suppose the forecast price is Y_t and the forecast value of the next cycle is Y_{ti},then $Y_t = \frac{\sum_{i=1}^{n} P_{ti}}{n}$ .The forecast price Y_t on March 25 is the average value in the table below, and other cases can be solved similarly.

Chart 8 25th forecast price Y_t (select the data of consecutive 30 days until March 25th)

Cycle	T_1	T_2	T_3	Average	Real value
Bitcoin forecast value	4011.623	4002.800	4056.921	4023.780	3994.110
Gold forecast value	1286.981	1289.023	1299.125	1,291.709	1300.000

The data of 30 days before the forecast is taken as sample data,and new sample data are selected to predict the price of the forecast day in multiple cycles.Finally, the average value is taken to obtain the forecast price.

Finally, the error analysis of the prediction model is carried out: $\eta=\frac{\hat{Y}_t-Y_0}{Y_0}\times 100\%$ .Set $\hat{Y}_t$ as the predicted value and Y_0 the real value,the accuracy of the model is **99.257%** for bitcoin and **99.358%** for gold respectively.

Chart 9 25th forecast price Yt (select the data of consecutive 30 days until March 25th)

Cycle	T_1	T_2	T_3	Average	Real value	Accuracy
Bitcoin forecast value	4011.623	4002.8	4056.921	4023.78	3994.11	99.257%
Gold forecast value	1286.981	1289.023	1299.125	1,291.709	1300	99.358%

3 Make Accurate Portfolio Strategy

3.1 Problem Analysis

In order to verify the problem a of the ARIMA model based on multiple cycles of accuracy, establish model can provide scientific investment strategy,we use the five years of data,through the simulation forecasting during a specific time to market prices,and compare with the real market price,contrast the error rate and accuracy, prove model curve fitting degree is high,provide scientific investment direction.

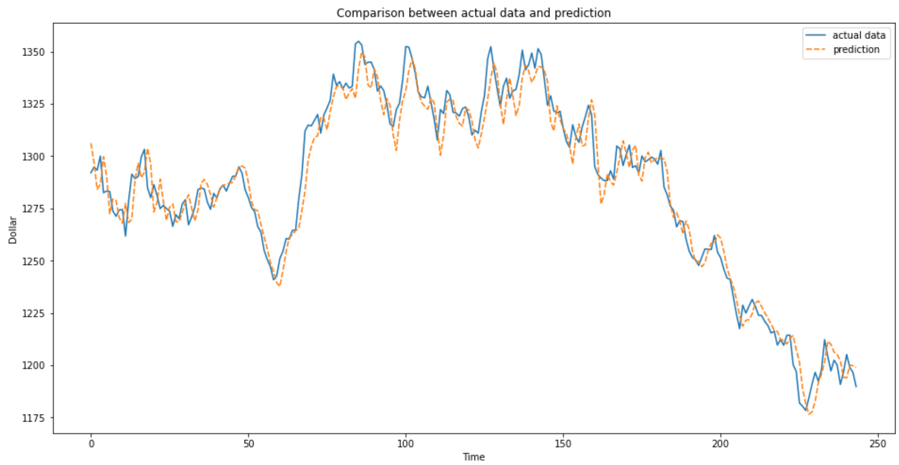

Figure 18 Gold fitting sequence diagram

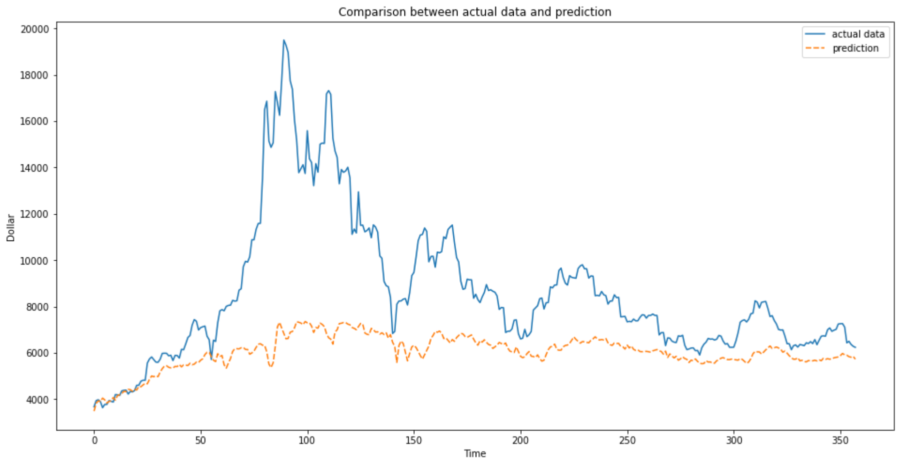

Figure 19 Bitcoin fitting sequence diagram

3.2 Methodology

3.2.1Calculate prices based on predictive models

The price can be predicted by the prediction model,and then the trading direction can be determined.According to the investment rules,when the short-term continuous decline,you can choose to hold or buy appropriately.When the short-term continuous rise to a certain price,you can sell in time.

1.Take bitcoin as an example: if the price of the previous day is Y0 and today's price is Yt, it is easy to list the rise/fall rate as $\eta = \frac{Y_0 - Y_t}{Y_0} \times 100\%$ ①， the calculation idea is as follows:

1.Calculate the daily rise/fall rate of sample data before decision making from formula (1).

2.Program to get the median of the desired rise/fall rate, set to Y_{m1},Y_{m2}。

3.With the help of the association rule algorithm, the number of subsets that went up/down 2, 3, 4, 5, 6, 7 times in a row was counted.Suppose that the number of rising subsets corresponds to the statistical times:Y_2,Y_3,Y_4,Y_5,Y_6,Y_7,Similarly, the number of decreasing subsets corresponds to the statistical times:Y_2',Y_3',Y_4',Y_5',Y_6',Y_7'.

4.According to the above algorithm, the sum of continuous growth rates can be set: $\gamma_1 = \frac{\sum_{i=2}^{m} Y_i}{\sum_{i=2}^{7} Y_i} \times 100\%$ .The number of times when the sum of the continuous increase rate exceeds 90%:N_1=Y_m,at this time$(\gamma > 90\%)$, The processing of the original data results in: $\gamma_2 = \frac{Y_m - Y_n}{Y_m} \times 100\%$ （m-n=N_1）$\gamma 2$ is the maximum rise/fall rate.Find the quantile of all the maximum gains/lossesY_{q1},Y_{q2} ,Y_{q1} represents the quartile with the highest rising rate,and Y_{q2} represents the quartile with the highest falling rate.

5.Take the third quartile of γ_2.Quantile refers to dividing the probability distribution of a random variable into several equal numerical points.A Quartile is a kind of quantile in statistics,that is,all values are arranged in ascending order and divided into four equal parts.The value at the three points of division is a Quartile.The third quartile (Q3),also known as the "larger quartile,"is equal to the 75% of all values in the sample in ascending order.[7]

3.2.2 Model forecast yield curve

Assume that the number of consecutive rise/fall of bitcoin is M,the maximum cumulative rise rate is Y_{q3},and the maximum cumulative fall rate is Y_{q4}(the rate of each rise/fall is the same).Without considering other factors,when it goes down N times,it happens to go down Y_{q3},and if it goes up N+1 times,the rate of rise is Y_{M1}.Positions are added for N times during this period,profits can be made. If S_1 is added for the first time and S_2 is added for the second time, then $\left[S_2XY_{M1}+S_1X\left(\frac{Y_{q2}}{N_1}\right)Y_{M1}\right]=0$

The third increase is S_3, $(1-a\%)\left[S_3XY_{M1}+S_2X\left(\frac{Y_{q2}}{N_1}\right)Y_{M1}+S_1\left(\frac{Y_{q2}}{N_1}\right)^2Y_{M1}\right]=0$

.....

The NTH increment is

$S_n(1-a\%)\left[S_nXY_{M1}+S_{n-1}\left(\frac{Y_{q2}}{N_1}\right)Y_{M1}+\cdots S_1\left(\frac{Y_{q2}}{N_1}\right)^{n-1}Y_{M1}\right]=0$,

The list below：

Chart 10 Addition and corresponding amount

Addition	1	2	3	....	y
Amount	1150.71	1430.56	1756.65		3303.64

The linear fitting of the above table is obtained $y=ae^t$,thus,the decision model of stock addition is obtained.If the continuous rise or fall n times,set the cumulative rise rate as H, then $y_{plus}=ae\left(\frac{H}{Y_{q2}}N\right)$, $y_{\text{minus}}=ae\left(\frac{H}{Y_{q1}}N\right)$.Similarly, gold investment strategy can be obtained.

For the initial investment allocation, assume that the amount allocation of gold coins is $P_{gold}=\left(\frac{P_{total}}{N_1}\right)\times\frac{1}{2}$, the amount of bitcoin allocated is $P_{bitcoin}=\left(\frac{P_{total}}{N_2}\right)\times\frac{1}{2}$, N_1, N_2 respectively are The Times when the product continuously rises/falls more than 90%, and the historical data are used to simulate the yield curve by the above method.

3.2.3 Algorithm process

Input: data set D, support threshold αα,output: maximum frequent K item set

(1)Scan the whole data set to obtain all the data that have appeared,which is regarded as the candidate frequent item set,k=1,and frequent 0 item set is the empty set.

⑵Mining frequent K-term sets

a.Scan data calculation Support calculation of candidate frequent K item set.

b.Remove the data sets whose support degree of candidate frequent K-item set is lower than the threshold,and obtain frequent K-item set.If the frequent K-term set obtained is empty,the set of frequent K-1 term sets is directly returned as the algorithm result,and the algorithm ends.If only one frequent K-item set is obtained,the set of frequent K-item sets is directly returned as the algorithm result,and the algorithm ends.

c. Based on frequent K item set, the connection generates candidate frequent K +1 item set.

⑶set k=k+1 and proceed to Step 2.

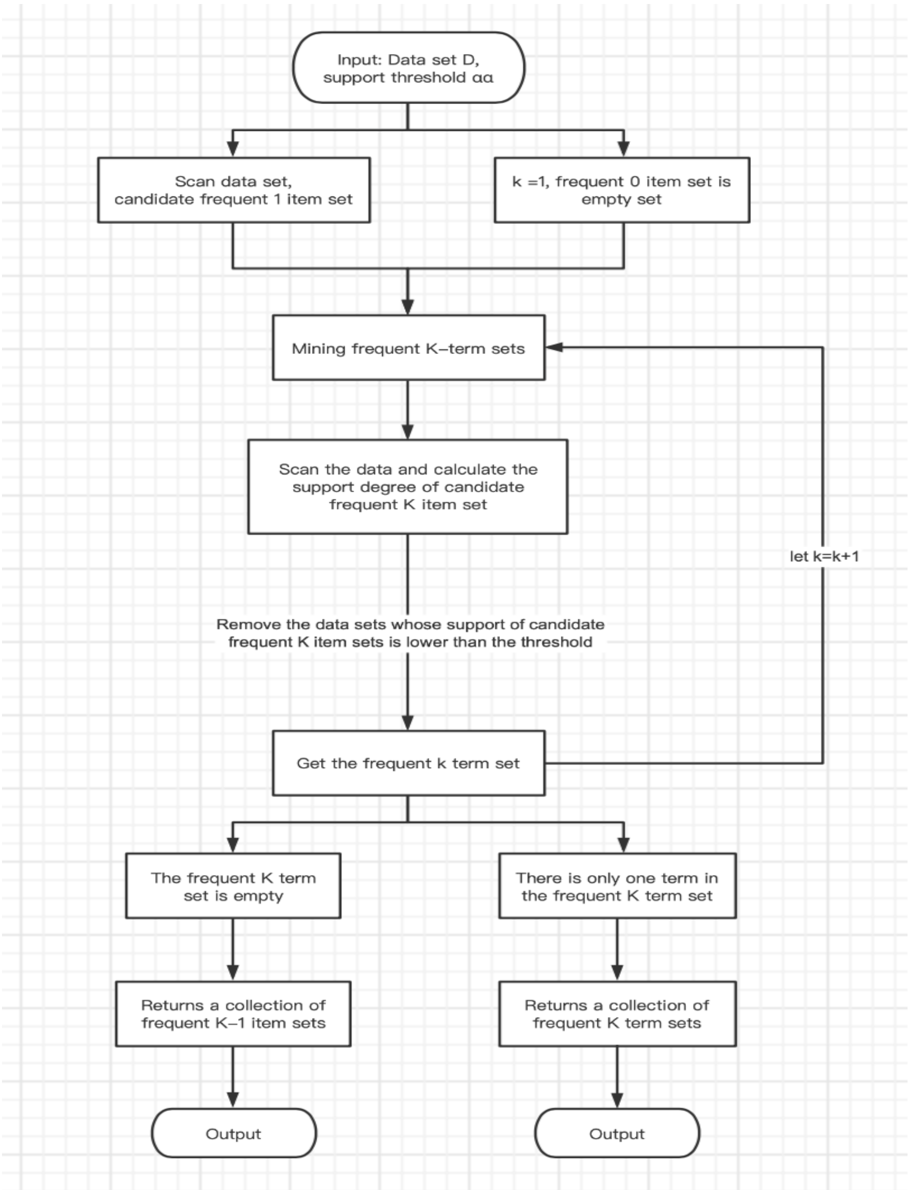

Figure 20 Algorithm process

3.2.4 Process visualization and result analysis

After the above data processing, we get the best time to buy and sell bitcoin and gold. The following is the visualized trading strategy diagram:

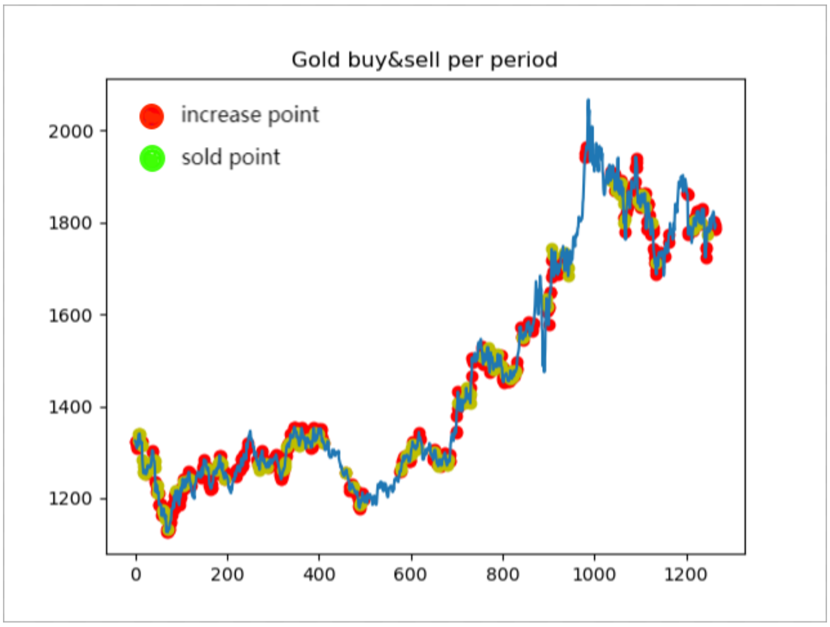

Figure 21 Gold buy and sell timing

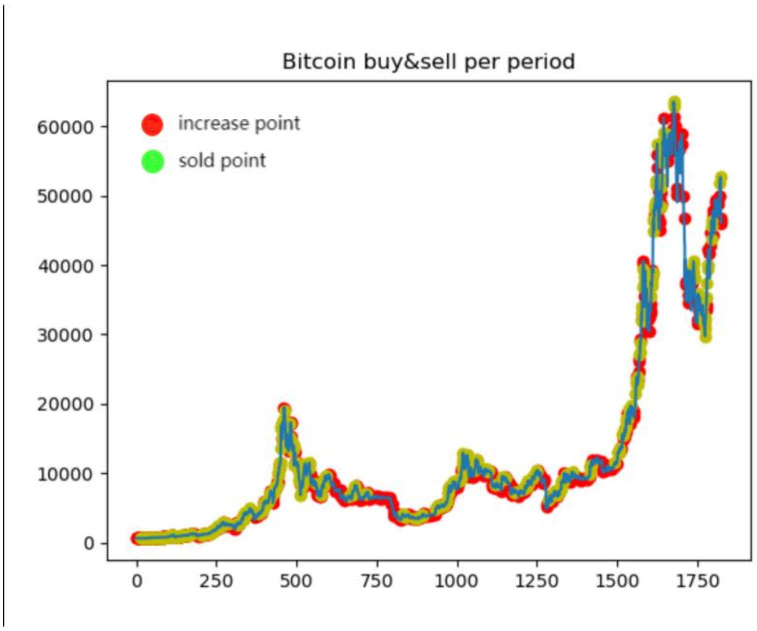

Figure 22 Bitcoin buy and sell timing

Finally, the predicted return curve is obtained. Based on the principal of $1000, the final return of commission is $87,653.22, and the correct investment rate of the model is 31.6%

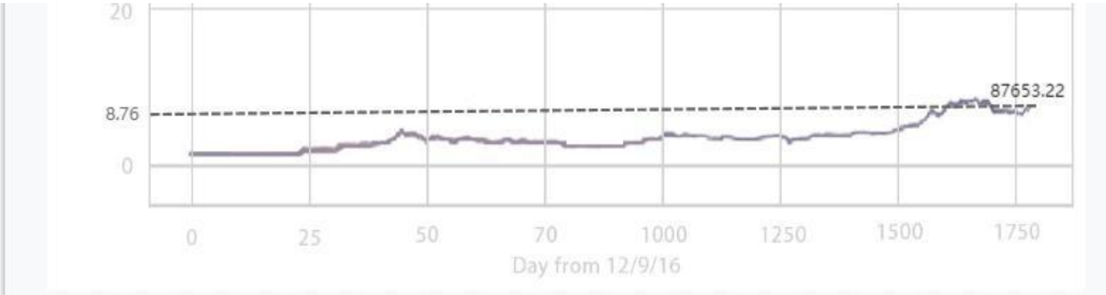

Figure 23 Result diagram of scheme fitting curve

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2016-09-12 00:00:00 True [727.9656043845737, 0.05076104537519869, 0.2773518270419395]
2016-09-13 00:00:00 True [712.7263340844928, 0.18052388508526362, 0.0058914824620958095]
2016-09-14 00:00:00 True [667.1925993240823, 0.0011231073736941988, 0.43976679829243775]
2016-09-15 00:00:00 True [451.6869095556513, 0.1260391340253797, 0.4964875393602795]
2016-09-16 00:00:00 True [570.1297848391649, 0.01211136538542995, 0.5307786849724415]
2016-09-17 00:00:00 False [693.2316879948381, 0.01211136538542995, 0.32195195297646306]
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2017-11-27 00:00:00 True [5.537219742031397, 5.810705164709627e-05, 3.9655572247077834e-05]
2017-11-28 00:00:00 True [2.979838558593148, 0.0008062533628534346, 0.00019455044809897317]
2017-11-29 00:00:00 True [0.8351909440925845, 0.0012887750479971514, 0.00034206955628535434]
2017-11-30 00:00:00 True [2.786474274185443, 0.0005267721565207893, 0.0002401550735143628]
2017-12-01 00:00:00 True [2.6921189599129014, 0.0009263460201196059, 0.00019417078938409357]
2017-12-02 00:00:00 False [4.295733929027191, 0.0009263460201196059, 3.510495411451704e-05]
2017-12-03 00:00:00 False [0.5435650389139234, 0.0009263460201196059, 0.00035842186662723546]
```

Figure 24 Program run judge demo diagram

4 Sensitivity and Risk Analysis

4.1 Problem analysis

For the model established above, we test its sensitivity to price.

4.2 Methodology

4.2.1.Sensitivity analysis

Chart 11 Transaction amount – Value return data sheet

	Transanction cost	Value
①	-0.5%	83779.04
②	-0.25%	85231.86
③	0	87653.22
④	+0.25%	88621.76
⑤	+0.5%	91043.12

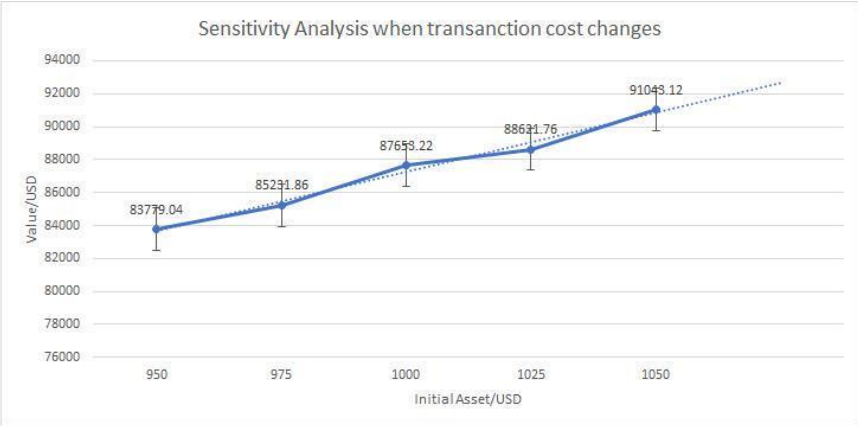

Figure 25 Sensitivity Analysis when Transanction cost changes

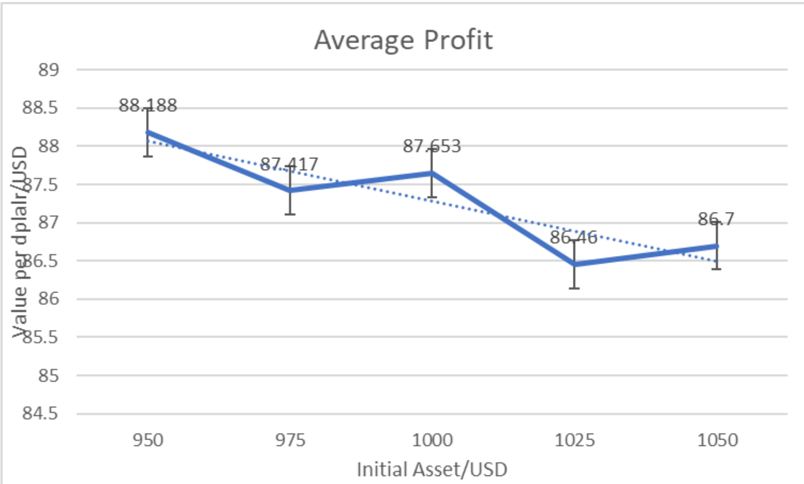

Figure 26 Average profit per dollar

The results show that with each step increasing by 2.5%,the overall return increases monotonously in a linear form,and the average return is relatively stable in a certain range.This is a reasonable result and can be explained.The trend of the curve obtained from the sensitivity experiment is almost consistent with the actual situation.

4.2.2 Risk assessment

We applied Markowitz portfolio model,whose central point was very consistent with the expectations established by the model.While pursuing high expected returns, risks could be avoided as much as possible.We adopted mean-variance model to make the final risk assessment.

Markowitz portfolio is a portfolio model,based on the two expectations of maximum return and minimum risk,by summarizing the probability of investment loss and the deviation degree of possible return and expected return, to diversify investment.Let gold, bitcoin and yield vector be denoted as $X=(X_1,X_2)^T$, The portfolio vector is called $W=(W_1,X_2)^T$, The covariance matrix of the two products is $\gamma=\left(\hat{\sigma}_{ij}\right)_{2\times2}$, Then the portfolio yield is $X_P=W^TX=\sum_{i=1}^{2}W_iX_i$, The total risk is written as $\sigma_p^2 = W^T VW$ 。

The objective function of the decision model is $\min \frac{1}{2}\sigma_p^2 = \frac{1}{2}W^T VW$,

The constraint conditions are $\left(e = (1,1,\cdots 1)^T\right)$，Where E (Xp) stands for Xp expectation, $\sigma(ij) = Cov(X)$,The covariance formula is zero $Cov(X,Y) = E(XY) - E(X)E(Y)$，If the yield rate is R and Pt is the price of gold on day t,then $r_t = \frac{P_t - P_{t-1}}{P_t} \times 100\%$, $R_{gold} = \frac{1}{T}\sum_{i=1}^{T} r_t (T = 30)$ 。

Markowitz portfolio model is a typical mean-variance model,so we evaluate the risk by calculating the variance of the objective function,and set the initial investment amount as W_0 , the standard deviation of investment return rate is σ_1 , μ is the average return rate of investmen,z is the sampling quantile of the normal distribution,getting the formula $1 - \xi = \int_{-\infty}^{Z} \frac{1}{\sqrt{2\Pi}} e^{-\frac{x^2}{2}} dx$, Where ξ is the 95% confidence level,and its value is 0.05.For the formula $VaR = W_0(Z\sigma + \mu)$,z is 1.96.

The combined risk in question value can be obtained by $VaR = \sum_{i=1}^{T} T_i (Z\sigma + \mu)\cdot(1 - a\%)(T = 30)$,where T_i is the amount received on day i and a% is the commission.Since commission has little relationship with investment risk,a can be set to 0 to simplify the venture capital model and facilitate calculation.

After weighted fitting,the Markowitz risk control curve as shown in the figure is obtained:：

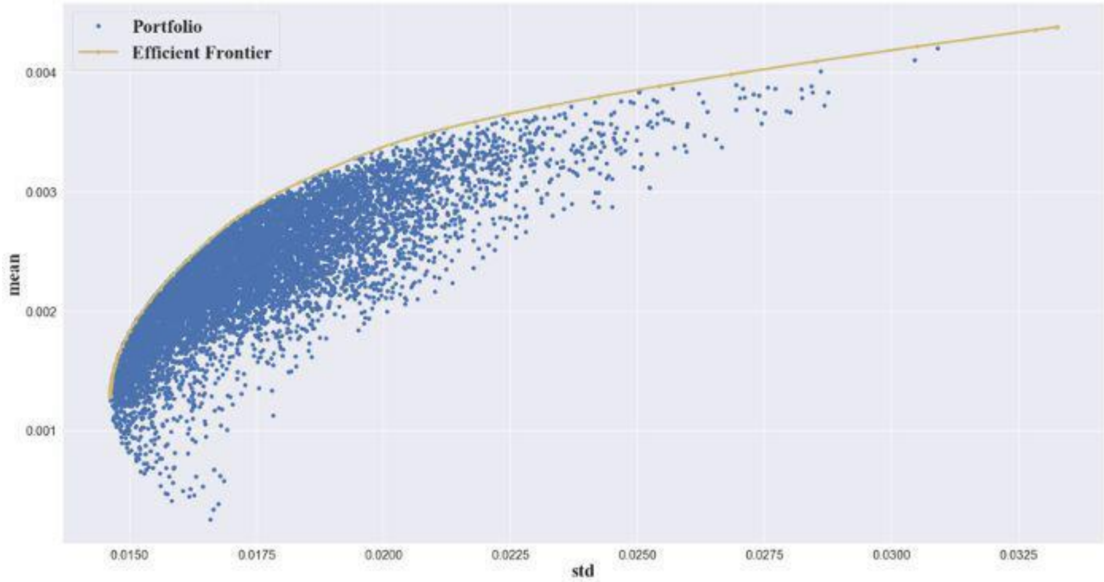

Figure 27 Markowitz risk edge effect fitting diagram

In the figure,mean stands for return and STD stands for standard deviation.According to the above model,we can solve and obtain a large number of portfolio points on the effective frontier.By fitting these points,we can obtain the effective frontier and obtain the optimal investment with the minimum risk.

5 Model Evaluation

5.1 Model Limitations

(1) The model has the defect of prediction error,which is considered under ideal conditions and ignores the changes of other random variables.When the external world changes a lot,it tends to have a large deviation,which is generally only used for short-term prediction.There are certain limitations to the complex and changing market in reality.

(2) Under the influence of objective things,especially economic phenomena, there will be various changes due to external factors,such as various policies and social influences such as news.If the time is longer,the possibility of major changes in market economic phenomena will be greater,and the model will be more unpredictable.

(3) The model has high requirements for the data of time series,and it needs to pass the stationarity test or be stable after differential differentiation,otherwise it is difficult to capture the rules,and data processing should be carried out in advance if necessary.

(4) Generally speaking,for market prediction, data are unstable and scattered,so it is less likely to form a perfect linear relationship,and there may be errors when using ARIMA model.

5.2 Model Strengths

We introduce association rules and portfolio to make decisions in the transaction process,which makes every decision more scientific,avoids risks and makes profits more stable.This paper avoids long-term reference investment, adopts short-term historical data,and also considers the influence of long-term historical data changes.It avoids the shortcomings of ARIMA model.

(1)The model combines multi-cycle selected data with ARIMA for comprehensive prediction,which greatly improves the accuracy of prediction,avoids the randomness of data and improves the scientificity of prediction.This is also one of our innovative points

(2)The ARIMA model that this model relies on is very simple.In calculation, only endogenous variables are needed without the help of other exogenous variables,and accurate prediction can be achieved only by processing its time series data,which is a simple modeling technology.

(3)In this case,compared with the volatile stock market,bitcoin and gold are more stable and less influenced by external society,while ARIMA model is good at dealing with stable investment data and has a low risk of prediction error.

5.3 Innovation Points of Model

Model innovation:Given that ARIMA model has certain errors and limitations in prediction.For example,when the data fluctuation is small,the prediction effect is better.When the data fluctuation is large,the prediction effect is inferior to LSTM model.

(1)We introduce the method of multi-cycle sample data selection. Combined with ARIMA, the prediction was made.

(2)The model is adopted for the data with abnormal fluctuation, which greatly avoids the investment risk and makes the return rate relatively stable and considerable.

(3)The introduction of association rules, algorithm-based portfolio investment model,based on data quantitative trading, avoid the risk of subjective decision-making,improve the scientific decision-making,make the rate of return stable, low risk.

5.4 Proof to be the Best Strategy

Prove the best strategy:our model can have a high success rate,and we greatly avoid the investment risk.Also,we maximize the return, and our return is stable,avoiding the odds.

6 Memorandum

TO:Dear Trader
From：Team 2223014
Date:February 22 ,2022
RE:Strategy to Maximumly Optimize Your Portfolio

As financial products,gold and bitcoin have good properties and are worthy of investors' consideration.For gold,it is a typical traditional financial product with light tax burden,convenient property transfer and high social recognition.It has been attracting the attention of investors.For Bitcoin,decentralization to a large extent can ensure the security and freedom of bitcoin,can be circulated around the world.There is no hidden cost in the transaction,also can be cross-platform mining.The owner can have exclusive ownership,currency stability, safe use,thus,investors can trust the trading assets.

The model usage process we provide for you is shown in the figure below.After data standardization,eliminating outliers,unified formatting and other data processing,the sample data set is firstly selected for multiple cycles to form a new sample set.Then ARIMA model is used to get the predicted value set,and then calculate the arithmetic average value of the predicted value set to evaluate the risk of the model.Finally, portfolio investment decision model is used to start trading,so as to achieve the maximum return and return stability under lower risk.

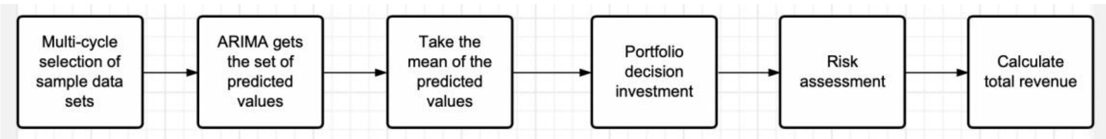

Figure 28 Model usage flow chart

Secondly,in order to make the model more consistent with the real market environment,we simulate how the model will change the predicted trajectory when the transaction amount changes,that is,we conduct sensitivity analysis of the trading decision based on the transaction amount.We also found through data visualization that when the market price drops,the revenue will increase slightly and then fall，when the market price rises,the revenue will decrease slightly and then grow rapidly.With our model and decision,\$1000 can bring you up to \$87,653.22.At the same time, through the risk control curve,we also found that the risk rate is very low,and the benefits are stable.The entire model is also very simple to use.

Finally,you will be introduced to the attributes of the model.We calculated the ARIMA sensitivity of the model to the price,and the error between the model predicted value and the real value was 99.4%.According to the fitted Markowitz investment risk margin curve,the model has a strong ability to fit the data,and the prediction accuracy of the model is 31.6%.The 42% success rate of Buffett,the genius of comparison stocks,has been excellent enough, and his ability to adapt to the market can be reflected through the change of transaction amount.

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