

## WHO MOVE MY MONEY?

### Summary

Through cases given data and the graphic model is used to solve the problem of final income maximization, and consider model is related to the commission rate given by the model of the data, two models of the income of different operating mode can achieve ideal, can be adapted to the topic given.

According to the operation of the current stock market, the two **currencies** given in the question can increase reasonably within the expected range, and the currencies in hand can be sold at will according to the trading rules of the stock market.

The variables involved in the model are mainly: the number of three currencies in hand, the final return, the total price invested in the stock market at present, and the expected return tomorrow, etc.

To establish the best daily trading strategy is the core of the problem, and we firmly hold it through the paper.

We develop two models that gives the best daily trading strategy trained by price data up to that day. In both models we designed, **Time Series predictions** were used to predict The price of gold and bitcoin in the future. The first model, which may sound crazy, cast all money a to maximize the profit of "tomorrow". According to the data of expected earnings, it can judge whether the trading of tomorrow can make a profit after deducting the commission fee. If profits can be made, all assets will be invested in such financial assets.

The second model is much more careful, it uses **Scoring System** to quantitatively describe the **valuable opportunities of trading**, with the system, we **score** bitcoin or gold from 0 to 1 every day. The higher the score, the more suitable it is to buy, and the amount of buying is also positively correlated with the score. So it is necessary to have **thresholds**. When the score is greater than the high threshold, it indicates that it can be purchased. If it is less than the low threshold, no transaction will be made. The establishment of **thresholds** use the **Bull -Market model, the risk prediction model**, BESIDES Time Series predictions.

Using the model, the initial \$1000 investment worth on 9/10/2021 becomes nearly \$1,800,000, which make us really amused. Before we leave to invest in the stock market in real-world and become the **next Buffett**, we present evidence that our model provided the best strategy.

In order to explore the impact of transaction commission on the final benefit, we change the value of commission and draw the curve of assets changing with the proportion of commission. We find that the curve **decreases in periodic shocks**.

We finally conduct sensitivity analysis, dissect pros and cons of our model and present a memo of our work to the traders.

**Keywords:** Virtual currency transaction; Time series prediction; ARIMA; Moving average; Bull market model; Risk prediction model

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## **1 Introduction**

### **1.1 Problem Background**

Nowadays the investment market is more and more diversified, many investors will introduce a lot of advanced technology to assist their investment decisions; Now, the topic asks us to build a set of investment decision model for an investor. According to the closing price of gold and bitcoin on each trading day and the current trading day, we can decide whether to buy or sell today. The initial investment is just \$1,000 over a period of five years from September 11, 2016 to September 10, 2021, and you should also consider the 1% (2%) commission that gold (Bitcoin) charges on each transaction (buy or sell).

### **1.2 Restatement of the Problem**

Considering the background information and restricted conditions identified in the problem statement, we need to solve the following problems:

1. According to the decision model we established, what is the profit and loss situation of investors after five years?
2. Prove that our model is the best decision
3. Whether the model and parameters are determined by the transaction commission, and in what way does the transaction commission affect the investment strategy and investment results?
4. Submit strategy, model and investment results.

### 1.3 Our Work

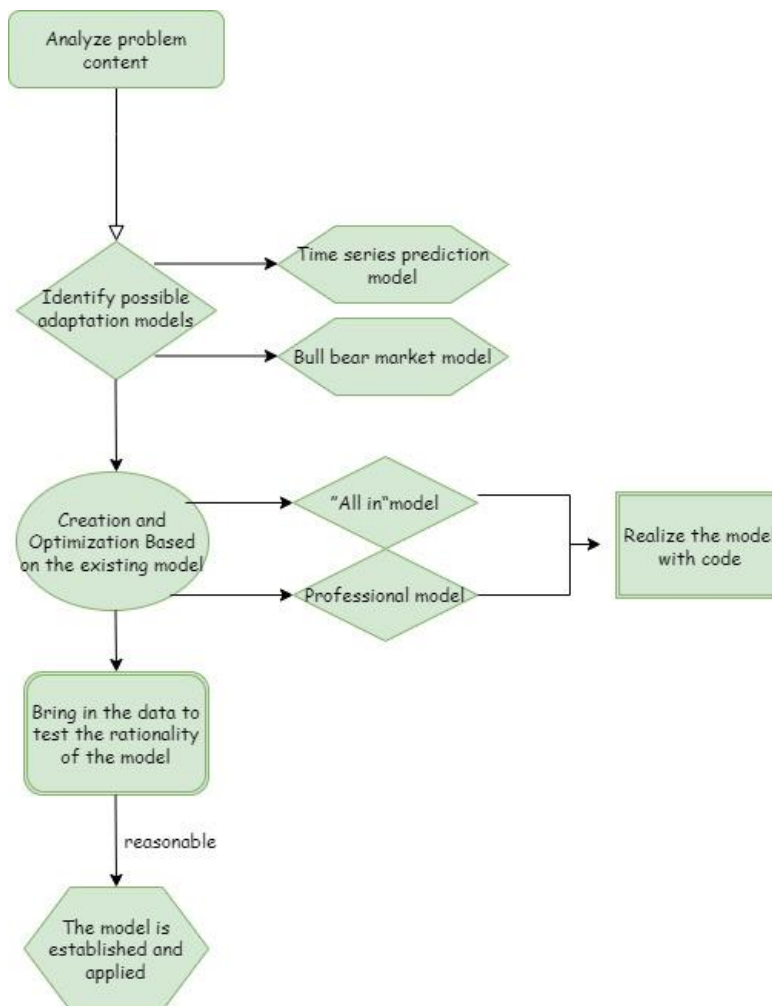


Figure 0 OUR WORK

## 2 Basic Assumptions

**Assumption 1.** Markets can function smoothly without crashing, and the transaction will be carried on smoothly.

**Assumption 2.** The price of gold or bitcoin is fixed on each day of the transaction, it will not fluctuate during this day.

**Assumption 3.** On the day of the transaction, we buy or sell gold or bitcoins first or do not change the amount of gold or bitcoins held. After the transaction is completed, we calculate the assets on the day of the transaction.

**Assumption 4.** The market does not limit the minimum amount of each transaction.

### 3 Notations and Definitions

#### 3.1 Notations

The key mathematical notations used in this paper are listed in Table 1.

**Table 1: Notations used in this paper**

Symbol	Description	Unit
$W_1$	Total assets earned that day	dollar
$W_2$	Assets drawn from total assets	dollar
$T$	It represents a certain day	day
$BM$	Bull_index , it quantitatively reflects the asset prospect	
$P_{avg}$	Average price in n days	dollar
$DT$	Reflect the deviation of the current price from the average	
$RE$	Rise Index ,according to the time series prediction model, it reflects the asset appreciation	
$SCORE$	Comprehensive indicators for determining the investment strategy of the day	
$State[\#][T]$	The amount of currency in No.T day, “#”can be cash,gold,bitcoin	

#### 3.2 Definitions

**Time series prediction:** *TIME series* is a series of data points arranged according to the sequence of time occurrence. Usually, the time interval of a set of time series is a constant value (such as 1 second, 5 minutes, 12 hours, 7 days, 1 year), so time series can be analyzed and processed as discrete time data.

**Single index sequential prediction:** given the historical change of an index, predict its change over a period of time.

**Full position holding:** stock speculation do not put all the money on the account all buy, must have a part of the cash, if the stock price falls larger, can be bought through the follow-up to amortize the cost of holding, if all one-time buy, then you have no money to amortize this cost, easy to cause larger losses.

**Moving average:** referred to as *MA*, *MA* is a technical indicator used to observe the trend of stock price changes by averaging the stock price (index) in a certain period and connecting the average values of different times.

**Bull - Bear market model:** *Bull market* and *bear market* are two different trends in the stock market. A

**bull market** is a technical term for predicting a bullish and optimistic stock market, while a **bear market** is a bearish and pessimistic stock market.

**Risk prediction model:** A tool for combining multiple prediction variables by assigning multiple weights to each prediction variable to obtain a risk or probability.

## 4 Data Description

Firstly, we use **Python** to convert original data of time to Standard date format.

Secondly, it is worth noting that *Gold Market* is **CLOSED** on holidays while *Bitcoin* can be traded every day, so we use a variable **Flag** to determine whether the gold market is open. And The price of gold on a no trading day shall be supplemented by **the price of the previous trading day**.

$$\text{Flag} = \begin{cases} 1, & \text{open ( Gold )} \\ 0, & \text{close ( Gold )} \end{cases} \quad (1)$$

Thirdly, to handle the data and the indexes we will calculated in the future, we use **Normalization** often.

$$\text{Linear normalization} = (\text{current value} - \text{min}) / (\text{maximum value} - \text{min}) \quad (2)$$

Normalization aims to make the relative size of the data clearer, and can more intuitively observe the rise of bitcoin and gold. At the same time, the accuracy of the data can be improved and the operation speed of the gDA training model can be accelerated.

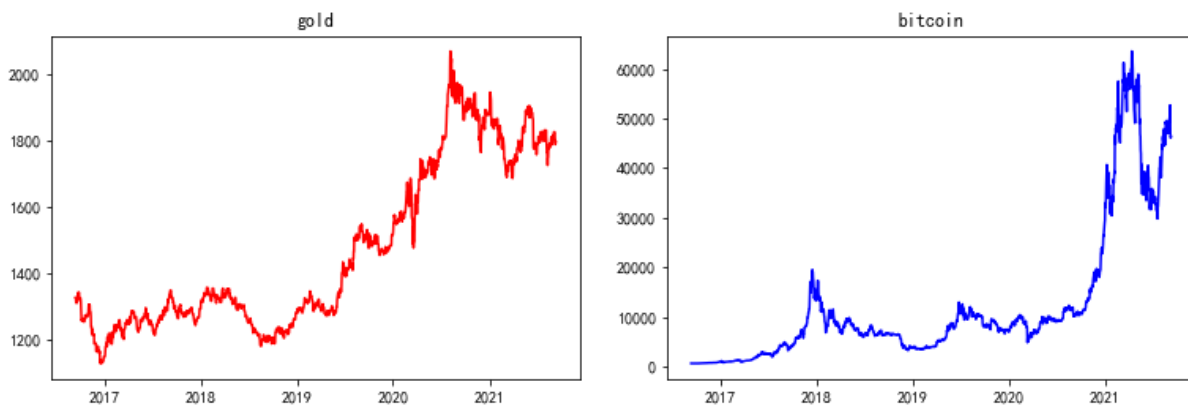


Figure 1 Gold and bitcoin daily prices

After data visualization based on the two CSV data files given in the title, we can clearly find the characteristics of gold and Bitcoin transaction data.

The market price of gold and bitcoin has been constantly rising and falling. The short-term change of the gold market is relatively frequent, while the long-term change is relatively stable and less volatile. In addition, considering the commission of each transaction, gold

should try to avoid short-term trading and adopt long-term trading. Bitcoin, on the other hand, does not have obvious short-term changes, but it has multiple peaks and large fluctuations in the trading cycle, so short-term trading strategies can be adopted.

However, it should be pointed out that due to the commission issue, we should try to avoid ultra-short-term trading (such as buying on T day and selling on T+1 day) in both places, and choose to hold as much as possible.

And life based on the actual experience shows that both the gold COINS to buy when prices are low, the price is high when the sell will not loss, and if each and every one in the picture to buy low price, price peak sell holdings of gold or the currency amount is increasing, in order to achieve the maximum number of holding, The biggest gains can be made by waiting for prices to peak and selling out. However, in terms of the title and the actual situation, we cannot predict the long-term future, and can only predict the short-term. Therefore, the model adopts the comparison between each day and the next day to obtain the optimal solution of each day, so as to achieve the global optimal solution and maximize the benefits.

## 5 ARIMA model

### 5.1 Model Preprocessing

Time series prediction method is actually a regression prediction method, which belongs to quantitative prediction. Its basic principle is: on the one hand, it acknowledges the continuity of the development of things, uses the past time series data for statistical analysis, and **predicts the development trend of things**; On the other hand, the randomness caused by the influence of accidental factors is fully taken into account. In order to eliminate the influence of random fluctuations, historical data are used for statistical analysis, and the data are properly processed for trend prediction.

In this case, the unit price of each day before the trading day can be regarded as a set of time series data, from which the unit price of the next day can be inferred.

At the beginning of model building, we should first judge whether the series can be predicted by time series. From the perspective of time, a sequence can be basically divided into **three categories**:

1. Purely random sequences (white noise sequences), at which point the analysis can be stopped because it is as random as predicting which side of a coin will come up next.
2. The mean and variance of stationary non-white noise sequences are constant. For such sequences, AR, MA, ARMA and other models can be used to fit the future development of the sequence.
3. Non-stationary sequences are generally converted into stationary sequences and fitted according to the algorithm of stationary sequences. If it is stable after difference, ARIMA model should be used for fitting.

Next, we need to know which series our daily unit price sequences of gold and Bitcoin belong to, also known as stationarity test.

We use the **unit root test** to test the price of gold:

$$adftest(A)$$

```
A=data_gold(n-13:n);
h = adftest(A)
```

Running results:

$H = 0$  (Bitcoin runs with the same result)

This shows that the price sequence of gold and bitcoin belongs to non-stationary sequence, and the next step is to select an appropriate algorithm and establish an appropriate model for this group of non-stationary sequence.

## 5.2 The Establishment of the ARIMA

The first is to use the difference method to transform the non-stationary sequence into a stationary sequence to solve, and the stationary sequence autocorrelation graph and partial autocorrelation graph are either trailing or truncating. Truncation means that after some order, the coefficients are zero; The trailing is something that tends to decay, but it's not all zero.

If autocorrelation is trailing and partial correlation truncates, AR algorithm is used.

If autocorrelation truncates and partial correlation drags, MA algorithm is used.

If both autocorrelation and partial correlation are trailing, the ARMA algorithm is used.

The autocorrelation and partial correlation judgment of gold price are shown in the figure below:

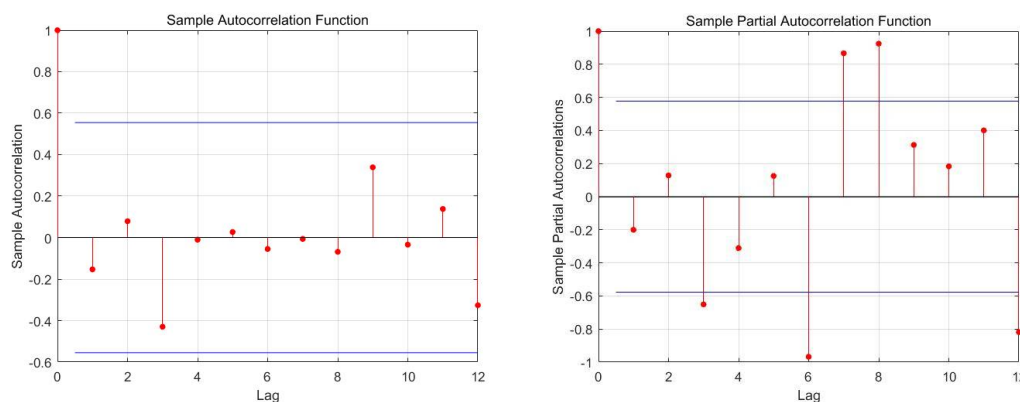


Figure 2 Autocorrelation and Partial Autocorrelation Function

Ontology can be seen from the picture of gold and currency autocorrelation and partial correlation diagram for the tail, and is not smooth, we established ARIMA model to as an extension of the stationary series ARMA algorithm, in order to predict non-stationary autocorrelation and partial correlation for the purpose of the truncated sequence change trend, the purpose of ontology, to predict the price of gold and currency changes.

The most commonly used model to fit stationary series is ARMA model, namely autoregressive moving average model.

The ARMA(p, q) model contains P autoregression terms and Q moving average terms. The ARMA(p, q) model can be expressed as:



$$X_t = c + \varepsilon_t + \sum_{i=1}^p \varphi_i X_{t-i} + \sum_{j=1}^q \theta_j \varepsilon_{t-j} \quad (3)$$

When  $q=0$ , it's the AR $\phi$  model

When  $p=0$ , it's MA( $q$ ) model

General analysis steps:

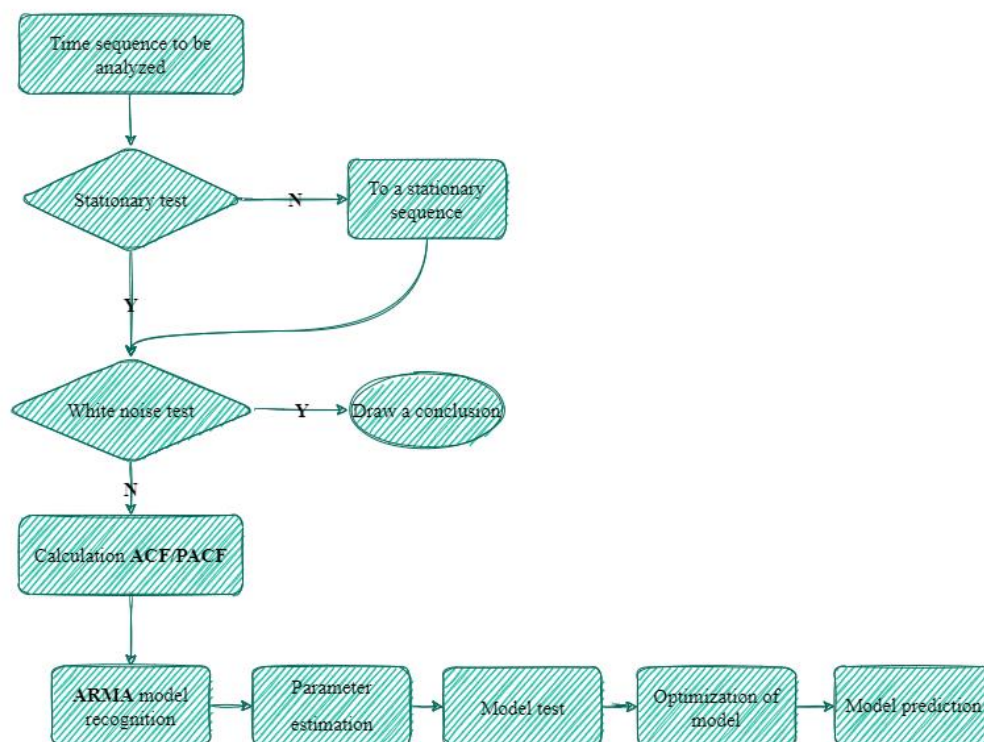


Figure 3 General analysis steps to use ARMA model

### 5.3 The improvement of the ARIMA model

1. We use Data stationarity of Adffuller unit root test, which is more precise.

```
(-0.43415247222844744, 0.9042384812941653, 23, 1231, ('1%': -3.435673305025808, '5%': -2.863890744031555, '10%': -2.56802156936202), 9957.827619599739)
(-8.158681091879238, 9.269711421536524e-13, 22, 1231, ('1%': -3.435673305025808, '5%': -2.863890744031555, '10%': -2.56802156936202), 9948.53365765105)
(-12.8767768886967274, 4.750971956332491e-24, 23, 1229, ('1%': -3.4356819860439574, '5%': -2.863894574114006, '10%': -2.568023609111511), 9993.297129597462)
(-15.443541928994083, 2.8443744636896075e-28, 23, 1228, ('1%': -3.4356863371792095, '5%': -2.8638964938393667, '10%': -2.568024631481501), 10131.546643110885)
```

Figure 4 Operation results in python

In the output result:

**The first** is the result of the ADT test, called the a-value for short, which represents the t-statistic. **The second**, called p-value for short, represents the probability value corresponding to the t-statistic. **The third is delay. The fourth** is the number of tests.

And the **fifth one**, in conjunction with the first one, is the critical ADF test at 99%, 95%, 90% confidence intervals.

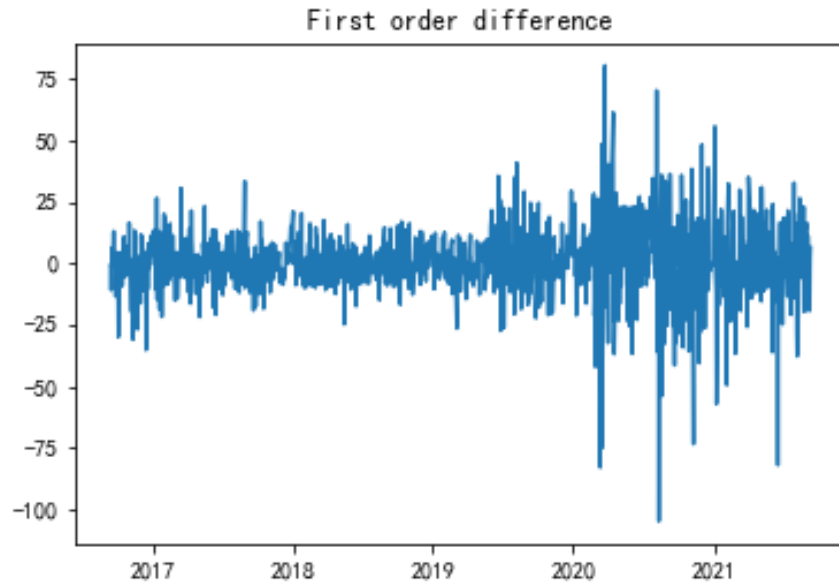


Figure 5 First order difference

In summary, the original data is not stationary and the first order difference is stationary (at 95% confidence intervals)

## 5.4 Moving Average Line

We compare stocks, futures and other financial products with gold & bitcoin transaction. *Moving average (MA)*, also known as moving average, is a common tool for analyzing time series in technical analysis. Common moving averages include *simple moving average (SMA)*, *weight moving average (WMA)* and *exponential moving average (EMA)*. Their main difference is that the formula for calculating the average value is different.

simple moving average is calculate by

$$SMA_t = \frac{P_1 + P_2 + \dots + P_n}{n} \quad (4)$$

“n” is the interval days

If the data of a single day time point fluctuates greatly, the data of a certain point cannot well represent its own characteristics, so we thought, can we use the data of a range to represent, so that the accuracy of the data is better? According to the characteristics of different financial liquidation, bitcoin's moving average cycle should be determined to adopt 5,10,15 and 20 cycles in the short term, medium term and long term respectively to ensure the sensitivity of the model to market price changes and to ensure certain stability.

So how to understand the concept of “moving average” and how to use it?

We draw the picture below :

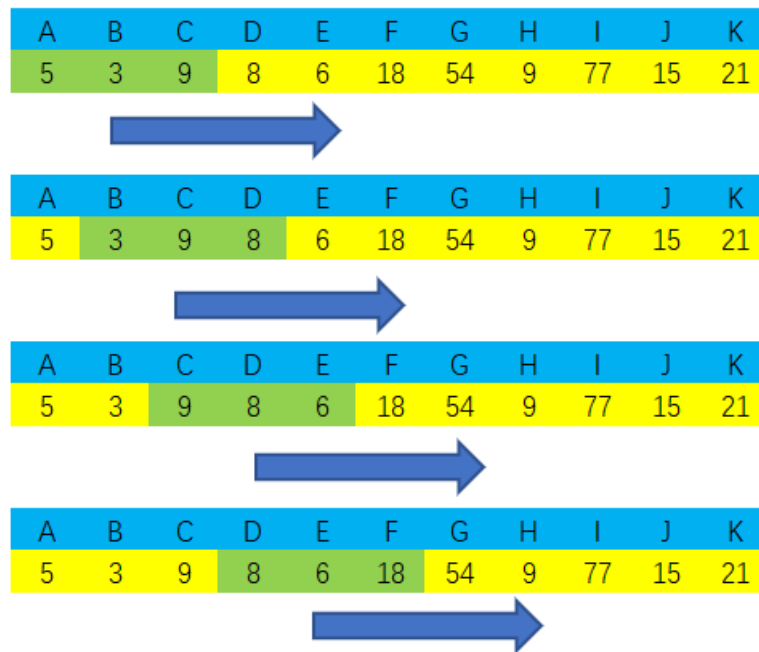


Figure 6 What does “moving” mean?

Imagine sitting on a right-hand **train** and looking out through the window, you can see many trees with different bifurcation numbers, and you can only see three trees at a time.

So when you try to calculate the average bifurcation number of the three trees outside the window, your status updates with the movement of the train, which is the meaning of “moving”.

## 6 Trading strategy model

### 6.1 All-in trading strategy based on time series prediction model

Based on data analysis, we put forward the first set of trading strategies -- all-in trading strategy under time series prediction model. All-in strategy follows the following two principles:

1. On T day, the trading data running time series prediction model from T-13 to T day (a total of 14 days) is used to predict the trading price on T+1 day, and 100% trust the prediction results (the prediction results are relatively accurate in the actual solving process);
2. Analyze the profitability of gold and bitcoin on T+1 day through the prediction model (calculate the commission), and choose the one with better performance to invest all the money.

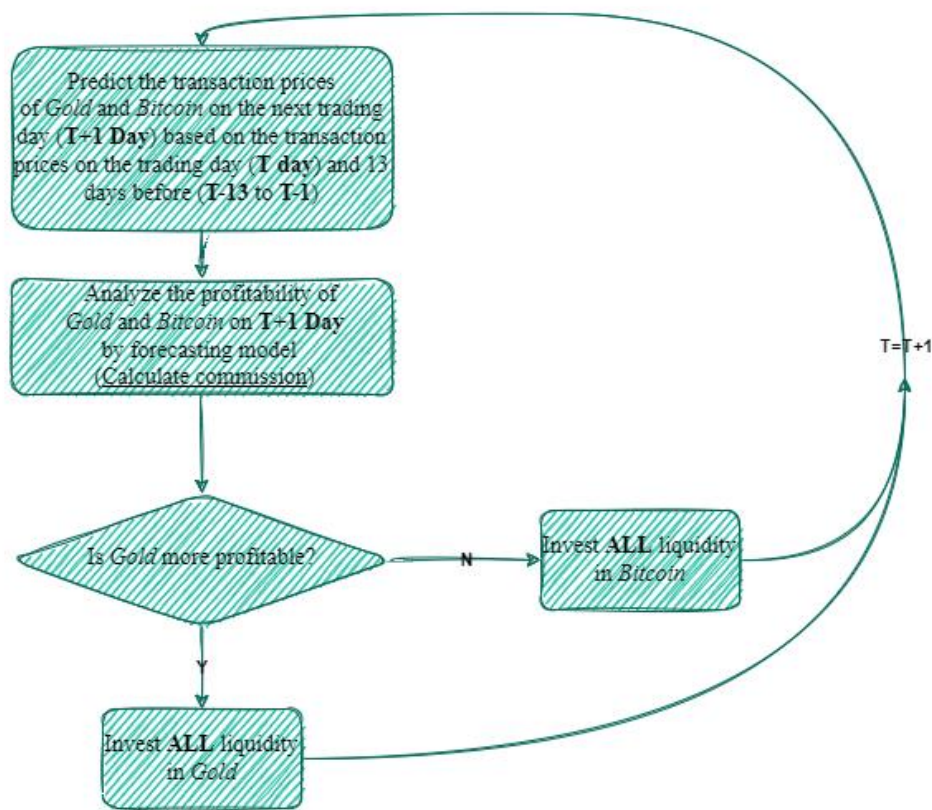


Figure 7 Working mode of model "All in"

However, in the subsequent operation, we observed that around 2018, due to the high commission, the capital stopped flowing for a long time and could not bring benefits. Therefore, we proposed the third trading principle:

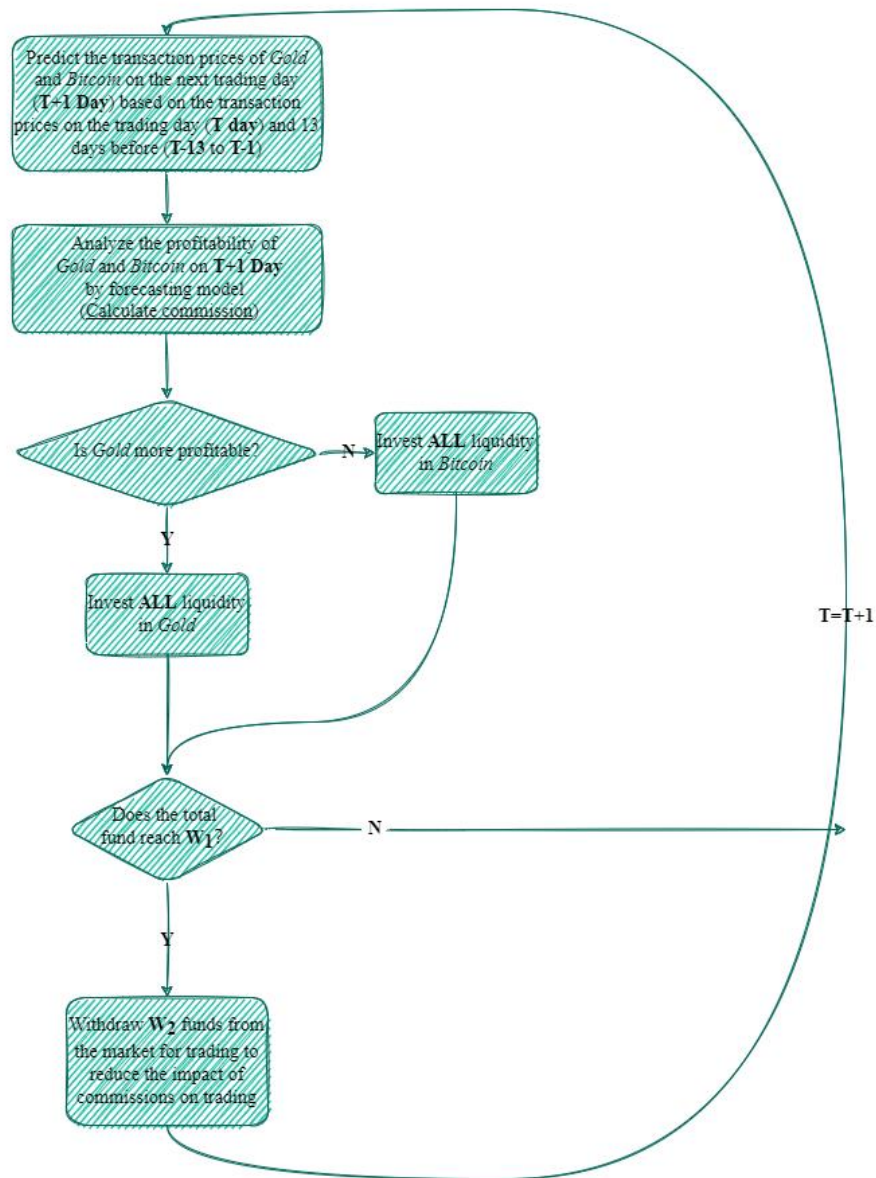


Figure 8 The improvement of model "All in"

After the adjustment, the trading strategy worked well.

After comparing a large number of  $W_1$  and  $W_2$  to the final funds, we found that when  $W_1$  was as small as possible and  $W_2$  was as half of  $W_1$ , the trading strategy could obtain the maximum benefits. Therefore, we selected  $W_1=2000$  and  $W_2=1000$  to run, and finally gained \$1,138,000.

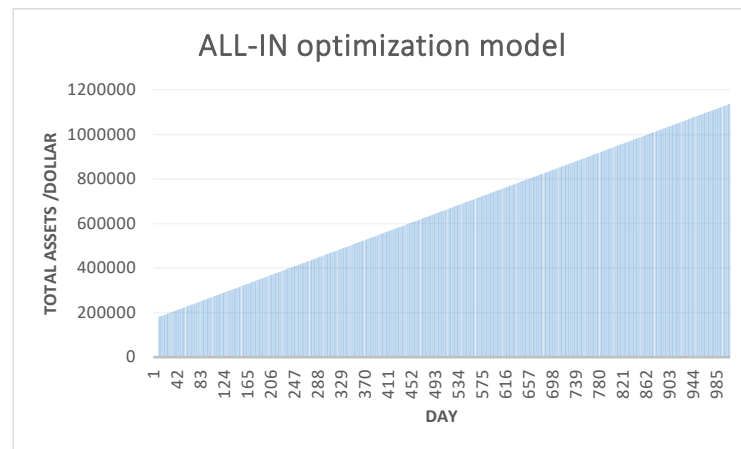


Figure 9 Assets Daliy in model “All in”

3. When the total capital reaches  $W_1$ , we will propose that the capital of  $W_2$  should stop flowing into the market for trading, which not only reduces the impact of commission on trading, but also meets the strategy of avoiding full position holding in economics.

The chart of total assets translated into DOLLARS on a daily basis is as Figure 9:

## 6.2 Scoring system

There is no need to think too much about putting all your money into a certain asset at one time, we have to admit it heroic. **HOWEVER**, here is a saying: don't put all your eggs in the same basket, which means small negligence leads to global collapse.

Therefore, we need to use our money carefully and carefully to reduce the bankruptcy caused by the sharp decline of some assets. There are two main questions: **when is the best time to invest and how much money to invest each time?**

In order to quantitatively describe the valuable opportunities of trading, we use the scoring system to **score** bitcoin or gold from 0 to 1 every day. The higher the score, the more suitable it is to buy, and the amount of buying is also positively correlated with the score. Set the threshold. When the score is greater than the threshold, it indicates that it can be purchased. If it is less than the threshold, no transaction will be made. This leads to another question, **how to set the threshold objectively and reasonably?**

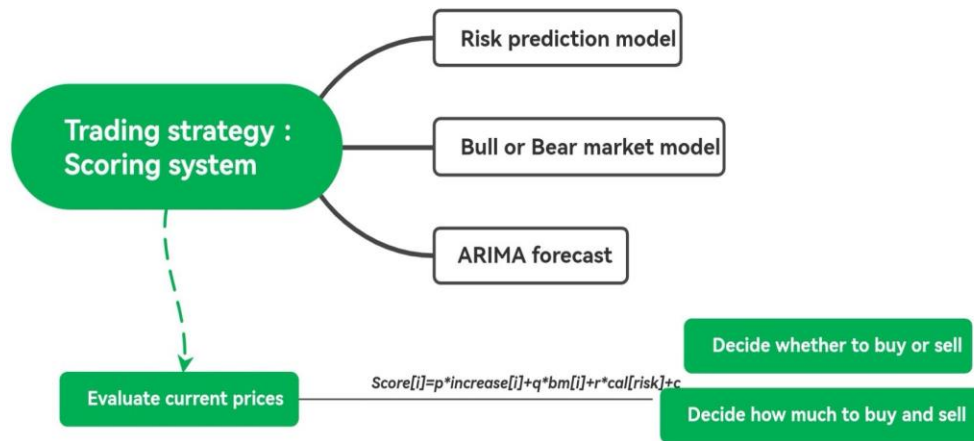


Figure 10 component of SCORING SYSTEM

We have three weapons in the system:

Bull Market assessment, Risk assessment ,besides ARIMA forecast Mentioned above.

$$Score[i]=p*increase[i]+q*BM[i]+r*RE[i]+c \quad (5)$$

In the equation, increase[i] stands for the increase of bitcoin or gold in No.i day than No.(i-1) day, and BM[i] is the BULL\_INDEX, which quantitatively reflects the asset prospect, while RE[i] is the risk rate. p, q, c is **constants**, which need adjustment and training.

### 6.2.1 BULL MARKET assessment

Bull market and bear market are two different trends expected in the stock market. Bull market is a special term for predicting that the stock market is bullish and the prospect is optimistic. Bear market is a special term for predicting that the stock market is bearish and the prospect is pessimistic.

Our team use the voting method to determine the bull and bear market time according to the index. For example, if it is concluded that today is a gold bull market according to the index, it is a bull market from a quarter ago to today. However, if it is calculated as a bear market yesterday and tomorrow is also calculated as a bear market, the error of today's calculation result may be large. In order to solve this error, the initial value at all times is 0. If it is currently calculated as a bull market, the value of the previous quarter will increase by 1, and if it is a bear market, it will decrease by 1. If the final result is greater than 0, it is a bull market and less than 0 is a bear market.

$$BM = m*P_{avg} (currency,90)+n*DT(currency,15) \quad (6)$$

$P_{avg}$  is average price in n days,  $P_{avg} (currency,90)$  means the average of gold in 15 days, and

DT is the deviation rate, which is measure the degree to which the current price deviates from the moving average is defined:

$$DT = (current\ price - n\ average\ price) / n\ average\ price \quad (7)$$

And m ,n is constant which also need to adjustment.

### 6.2.2 Risk assessment

Risk assessment(RE) is the opposite of BULL MARKET assessment; It measures the risk of the investment.

$$RE = DT * a + b / BM \quad (8)$$

In the equation , a, b are constants. It is obvious that RE is inversely proportional to BM.

### 6.2.3 SCORE SYSTEM IS AWESOME

Using the Score System, we can calculate the score of each day and thresholds (Normalized),now we can to the last step.

For example, when the Score of gold bigger than 0.595, buy gold with the amount equal to score\*cash last day, namely:

$$Buy\_gold[i] = State[cash][i-1] * score[i][gold] \quad (9)$$

With the trading strategy, earn a lot money:

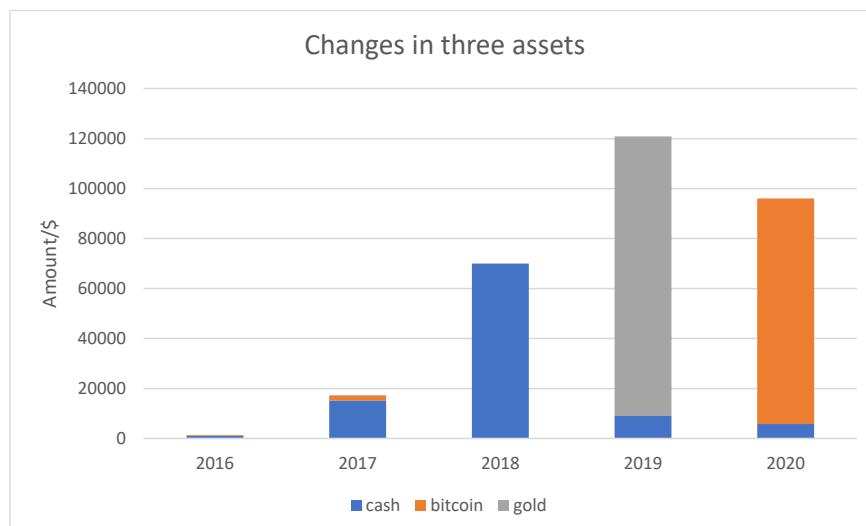


Figure 11 The composition of total asset(all in dollar)



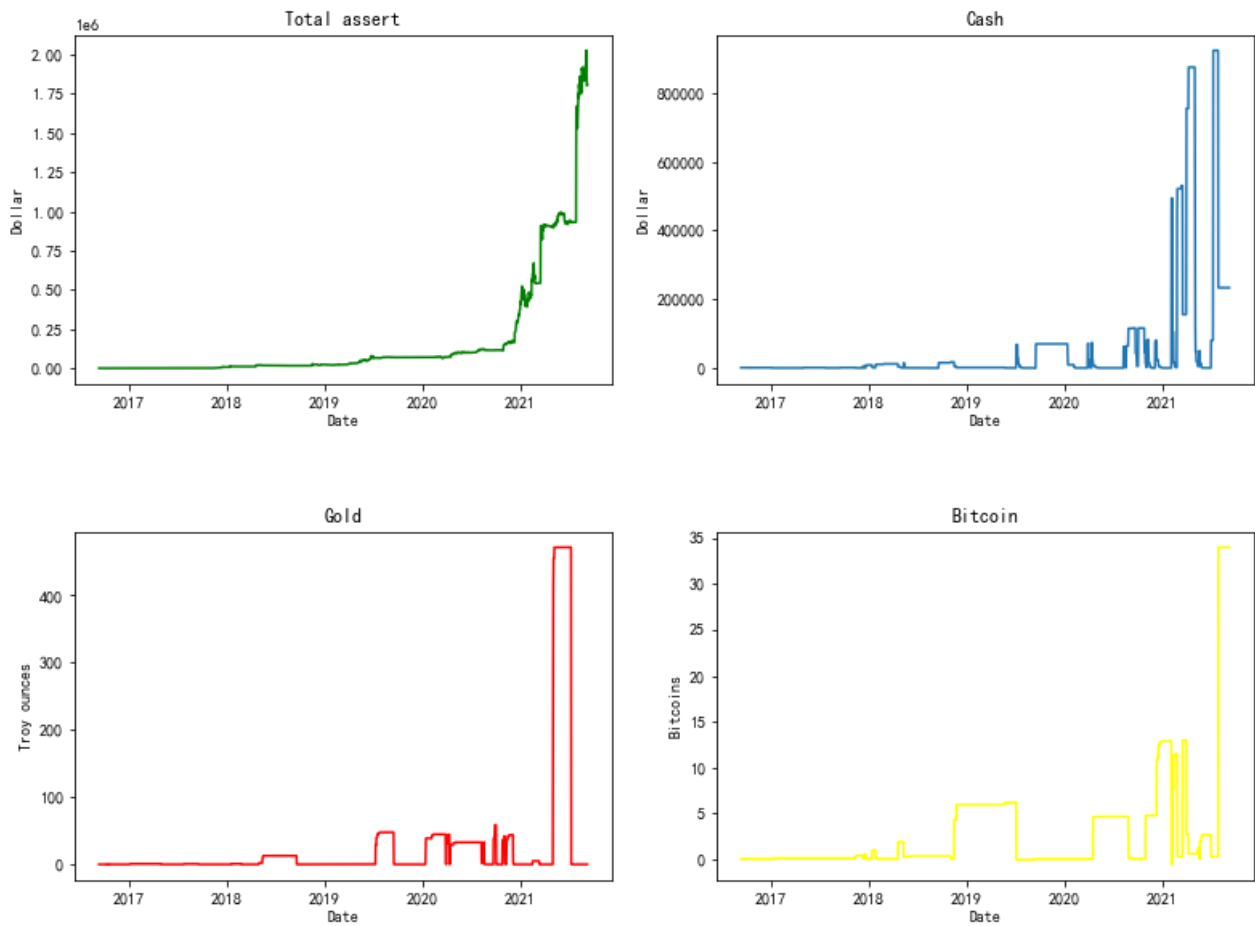


Figure 12 *The total asset, gold, bitcoin and cash*

## 7 Model analysis and test

### 7.1 Model analysis and test of ALL-IN Trading strategy

Model	{	optimization model,	$w_1 = 2000, w_2 = 1000$
		test model 1,	$w_1 = 20000, w_2 = 10000$
		test model 2,	$w_1 = 10000, w_2 = 5000$
		test model 3,	$w_1 = 2000, w_2 = 1500$ .

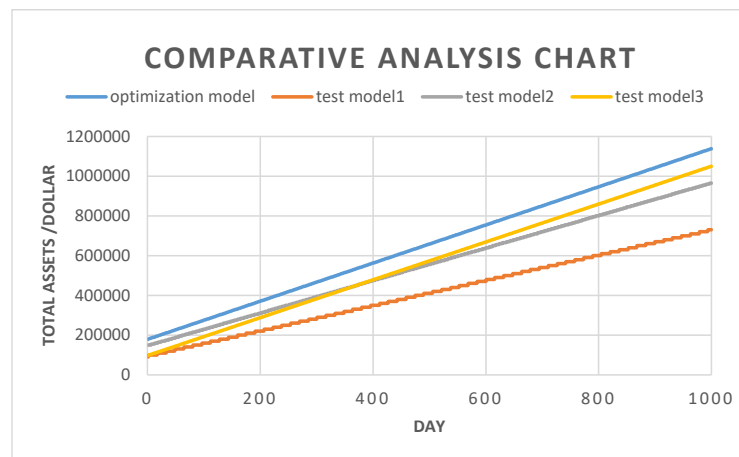


Figure 13 Model "All in" different parameter

Two groups of parameters are tested respectively. The profit value of test model 1 is  $W_1=20,000, W_2=10,000$ ; test model 2 is  $W_1=10,000, W_2=5000$ ; test model 3 is  $W_1=2000, W_2=1500$ . By putting together the yield curves of the four models, it is easy to conclude that when  $W_1$  is as small as possible and  $W_2$  is half of  $W_1$ , namely,  $W_1=2000$  and  $W_2=1000$ , the trading strategy can obtain the maximum benefits, which is the optimal model.

## 7.2 Model analysis and test of SCORING SYSTEM Trading strategy

In order to determine the impact of transaction cost on transaction strategy: our team calculates the change curve of total assets with commission by changing the Commission of bitcoin and gold transactions

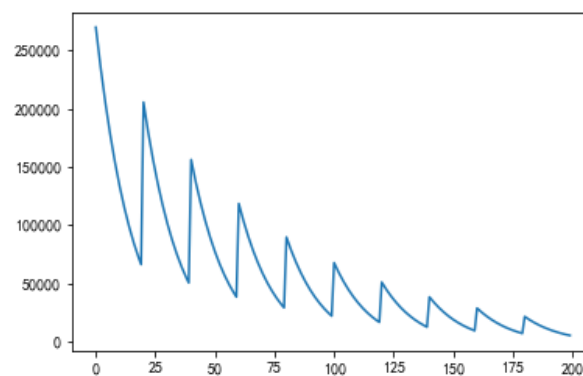


Figure 14 The results are sensitive to commission changes

It is wonderful that the curve **decreases in periodic shocks**.

## 8 Model Evaluation and Further Discussion

### 8.1 Strengths

#### 8.1.1 Strengths of ALL-IN Model

1. The current optimal solution is obtained through the comparison of daily prices to ensure that each transaction itself must be profitable, and in the long run, the accumulation of profits will be formed. Even for other different stock market changes can also achieve the purpose of stable returns.

2. With all single pressure method for stock trading, if you encounter a substantial growth, you can obtain the maximum current profit to the greatest extent, even if the stock market has been depressed, you can also ensure the holding of the principal rather than the currency floating with the stock market, to ensure the stability of the currency value in the hands.

#### 8.1.2 Strengths of SCORING SYSTEM Model

1. Creatively set up comprehensive indicators to evaluate transactions: **SCORE**. The score

solves not only “when to transaction” but also “how much to transaction”, and easy to use.

2. Many new variables are creatively defined to describe the price rise and fall of gold and bitcoin, future trend and so on

## **8.2 Weaknesses**

### **8.2.1 Weaknesses of ALL-IN Model**

1. For example, if gold is profitable on the same day and tomorrow, two additional handling fees will be incurred when it is run according to the code, which will reduce the profits already earned. For the model that is settled every day, if there is a small increase can be profitable situation will be judged as not to do business due to the fee problem, which will ignore some small increase in total assets.

2. According to the actual situation, in the stock market, there will rarely be all-buy and all-sell operation of the assets held by shareholders, so the applicability of this model is not very strong and it cannot be used to trade with most currencies.

### **8.2.2 Weaknesses of Scoring system Model**

The setting of some parameters is too subjective, and the amplification of scientifically determined parameters is not proposed

## **9 Conclusion**

The rate of return of this problem is the point that all design contents need extra attention. The two models in this paper try to solve this problem from part to whole respectively. Of course, both models end up with very objective returns. However, from a practical point of view, the practicality of model 1 is weaker than that of model 2. In actual trading, it is rare to use all the money in hand to buy one currency. However, according to the data given in this question, it can indeed achieve the purpose of high yield, but it is not clear for other data. Therefore, our second model tries to solve the problem with "the public" as the starting point, which ensures a high rate of return and expands its applicability, which is more in line with the choice of rational investors. At first, our team only focused on the optimization and design of the first model, and then we considered the applicability of the model, so the second model came into being. This problem comes from the reality, and the design of the model should also return to the reality, so as to avoid the situation that the theory is larger than the reality.

## **10 Memorandum**

## Wanna be the next Buffett?

DATE:

To our respected customers

From: 2200356 team

Subject: introduce our model.

Thank you very much for your trust in our team. Bitcoin and gold markets are complex, and a small mistake may ruin your property. **Therefore, we introduce to you the help system with our respect.**

For this investment, we have designed two schemes for you to choose.

The first scheme is to use our code to judge the rise of the stock market price tomorrow, and invest your money in the trading of one currency in order to get the maximum profit now. In our calculation, for the daily market price, there is always a currency whose profit is higher, so we will find this currency for you and choose it to obtain greater benefits. Does it feel good? You can make a lot of money without thinking about anything.

For the second model, it may be more in line with the habits of stock market investors, that is, carefully weigh and compare, but we make all this simple, or choose our model, and we are half successful. Our team uses a score model to measure whether bitcoin or gold is worth buying. Using our model, when the stock market opens every day, you only need to input the price of the day. Our model will automatically calculate in combination with the previous data, and then you will get a value between 0 and 1. What, only one decimal? Relax, this number is obtained by combining a variety of scientific and objective data analysis methods (ARMA, moving average, bull market model \ risk model). Then compare this value with the threshold given by us. If it is greater than the upper limit, it will be sold and the amount sold will be calculated for you; On the contrary, if it is less than the offline, it will be sold.

There are risks in the stock market, so we should be cautious when entering the market, Our team sincerely hopes that you will have a lot of money!

Please contact us if you have any problems.

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## Appendices

### Appendix 1

Introduce: data.py which is data processing

```
#import the packages
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import datetime
```

```

import matplotlib
from statsmodels.tsa.stattools import adfuller
import statsmodels.tsa.stattools as st
from statsmodels.tsa.arima_model import ARIMA

#import the orignl data
bt_df = pd.read_csv('org_data/BCHAIN-MKPRU.csv')
gold_df = pd.read_csv('org_data/LBMA-GOLD.csv')

bt_df.head()
gold_df.head()

#convert the data type from time to date
gold_df['Date']=gold_df['Date'].apply(lambda x:datetime.datetime.strptime(x, '%m/%d/%y'))
bt_df['Date']=bt_df['Date'].apply(lambda x:datetime.datetime.strptime(x, '%m/%d/%y'))
gold_df.head()
gold_df.to_excel('gold_date.xlsx')
bt_df.to_excel('bitcoin_date.xlsx')

bt_df.head()
##fix the table together,and set a flag to indentfy whether the gold-
transaction-day
# (We use '1 'to symbolize gold-transaction-day,and' 0' vice versa)
##TIPS: In order to simplify the model, the price of gold on a non
trading day
# is supplemented by the price of the previous trading day
df = gold_df.merge(bt_df, on='Date',how='outer')
df=df.sort_values(by='Date')
df.index=[i for i in range(df.shape[0])]
df['DealDay']=df['USD (PM)'].apply(lambda x:int(not np.isnan(x)))
df=df.fillna(method='ffill')
df.to_excel('gold-bitcoin-trancation.xlsx')
df.head()

```

## Appendix 2

Introduce: “All in “model Trading strategy

clc;

```

clear ;
data_gold=xlsread('LBMA-GOLD.csv');
data_bitcoin=xlsread('BCHAIN-MKPRU.xlsx');
%state=[1000,0,0]; worth=1000;% gold=0;
bit=0;
a=[2000];
tot=0; predict=x(m1+1);
    data_gold(m1+1);
    predict_b=x_b(m1+1);
    data_bitcoin(m1+1);
    if (predict-data_gold(m1))*(worth/data_gold(m1))>0.01*worth&&(predict_b-
data_bitcoin(m1))*(worth/data_bitcoin(m1))>0.02*worth&&(predict-
data_gold(m1))*(worth/data_gold(m1))-0.01*worth>=(predict_b-
data_bitcoin(m1))*(worth/data_bitcoin(m1))-0.02*worth
        gold=(worth/data_gold(m1));
        elseif (predict-data_gold(m1))*(worth/data_gold(m1))>0.01*worth&&(predict_b-
data_bitcoin(m1))*(worth/data_bitcoin(m1))>0.02*worth&&(predict-
data_gold(m1))*(worth/data_gold(m1))-0.01*worth<(predict_b-
data_bitcoin(m1))*(worth/data_bitcoin(m1))-0.02*worth
            bit=(worth/data_bitcoin(m1));
            elseif (predict-data_gold(m1))*(worth/data_gold(m1))>0.01*worth&&(predict_b-
data_bitcoin(m1))*(worth/data_bitcoin(m1))<=0.02*worth
                gold=(worth/data_gold(m1));
                elseif (predict-data_gold(m1))*(worth/data_gold(m1))<=0.01*worth&&(predict_b-
data_bitcoin(m1))*(worth/data_bitcoin(m1))>0.02*worth        bit=(worth/data_bitcoin(m1)
);
        elseif (predict-data_gold(m1))*(worth/data_gold(m1))<=0.01*worth&&(predict_b-
data_bitcoin(m1))*(worth/data_bitcoin(m1))<=0.02*worth
            worth=worth;
        end
    if bit~=0&&gold~=0
        worth=bit*data_bitcoin(m1+1)*0.98+gold*data_gold(m1+1)*0.99;%   while wo
rth>=2000;
        worth=worth-1000;
        tot=tot+1000;
    end
    a(n)=tot;
end
for m=14:1827
    a(m)
end

```



### Appendix 3

#### Introduce: SCORE SYSTEM Trading strategy

```

per_gold = 0.01
per_bt = 0.02
throld1=0.578
throld2=0.324
throld3=0.789
throld4=0.324
for i in range(1,state.shape[0]):
    bt = df['b_mark'][i]
    state['N_R'][i]=df['N_R'][i-1]+df['G_I'][i-1]*df['G_H'][i-1]
    df['N_B'][i]=df['N_B'][i-1]+df['B_I'][i-1]*df['B_H'][i-1]
    df['G_H'][i]=df['G_H'][i-1]
    df['C_H'][i]=df['C_H'][i-1]
    df['B_H'][i]=df['B_H'][i-1]
    if df['DealDay'][i]: # Judgment trading day
        gold = df['G_M'][i]
        if gold > throld1:
            if bt > throld2:
                if gold-0.58>(bt-0.71)*2:
                    df['G_H'][i]=df['G_H'][i-1]+df['C_H'][i-1]*gold*(1-
per_gold)/df['USD (PM)'][i-1]
                    df['C_H'][i]=df['C_H'][i-1]-df['C_H'][i-1]*gol
                else:
                    df['B_H'][i]=df['B_H'][i-1]+df['C_H'][i-1]*bt*(1-
per_bt)/df['Value'][i-1]
                    df['C_H'][i]=df['C_H'][i-1]-df['C_H'][i-1]*bt
            else:
                df['G_H'][i]=df['G_H'][i-1]+df['C_H'][i-1]*gold*(1-
per_gold)/df['USD (PM)'][i-1]
                df['C_H'][i]=df['C_H'][i-1]-df['C_H'][i-1]*gold
#                 print('buy gold',df['G_H'][i])
        if gold<throld1:
            df['G_H'][i]=df['G_H'][i-1]-df['G_H'][i-1]*(1+gold-throld)
            df['C_H'][i]=df['C_H'][i-1]+df['G_H'][i-1]*(1+gold-
throld)*(1-per_gold)*df['USD (PM)'][i-1]
#                 print('sell gold',df['G_H'][i],df['C_H'][i])

```