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A MV Portfolio Investment Strategy Model based on Economic Indicators

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Abstract: Market traders buy and sell volatile assets frequently, with a goal to maximize their total return. we conduct a single factor sensitivity analysis on transaction costs, commissions, for our model. Firstly, keeping the output result of the portfolio strategy model unchanged, we solve the reference value range of commissions. Secondly, we use ablation study to obtain the relative sensitivity of commission of gold and bitcoin to the portfolio strategy model. The results show that the reference value range of gold commission and bitcoin commission are [0.96%, 7.22%] and [1.89%, 4.36%] respectively, and the model is more sensitive to the transaction costs of bitcoin than gold. we communicate with traders by memorandum about the structure of our model, the method of use, the robustness of the model, the solution results and gave suggestions on how to use the model.

1. Introduction

Market traders buy and sell volatile assets frequently, with a goal to maximize their total return. There is usually a commission for each purchase and sale. Two such assets are gold and bitcoin. In this problem, we are given two data that we may only use in two spreadsheets: LBMA-GOLD.csv and BCHAIN-MKPRU.csv, and the data include the gold daily price, US dollars per troy ounce, bitcoin daily price and US dollor per bitcoin from 9/11/2016 to 9/10/2021. We are asked by a trader to develop a model that uses only the past stream of daily prices to date to determine each day if the trader should buy, hold, or sell their assets in their portfolio.

2. Assumptions and Notations

The trader will not be disturbed by emotional factors such as subjective wishes and work experience in making portfolio investment decision, and only makes decisions based on the results output by the model.

Table 1

Symbol	Discription
r_1	The trade income of trader from bitcoin
r_2	the trade income of trader from gold investment
x_1	the trade income of trader from gold investment

x_2	the trade income of trader from bitcoin investment
δ_{ij}^2	the risk correlation between portfolio i and Portfolio j
t	time
p_g	the closing price of gold of specific day
p_b	the value of bitcoin of specific day
ζ_i	control variables that decisions whether or not to trade
∂_1	commissions for gold
∂_2	commissions for bitcoin
α	The weigh which is the degree of trader's willing to accept risk in trading

3. Date Processing

The data we use in the problem spans five years, so the data we use have remarkable difference in order of magnitude. In order to study the following problems reasonably and scientifically, build models and calculate various required indicators, we process the original data, and the specific processing methods are as follows. Normalize the data according to the formula:

$$y_{ij} = \frac{x_{ij} - \min(y_i)}{\max(y_i) - \min(y_i)}, i - 1,2,..., M; j = 1,2,...S \tag{1}$$

$$x_{ij} = \frac{x_{ij} - \min(x_i)}{\max(x_i) - \min(x_i)}, i - 1,2,..., M; j = 1,2,...S \tag{2}$$

where S = L + 1 − N − M, x_{ij} is the price of gold and y_{ij} is the price of bitcoin.

Wavelet denoising is a local analysis of time and frequency. It decomposed the original signal into high frequency signal and low frequency signal according to the threshold set before, and then repeat the process until the best decomposition layer is obtained. After the decomposition, the decomposed signal constitutes a new signal. In this paper, the main reason why we choose wavelet denoising is that wavelet denoising has timing feature, and the effect of denoising is resultful. Timing feature is significant to the analysis of gold and bitcoin trend lines. Realization flow chart of wavelet noise is shown in Figure 1.

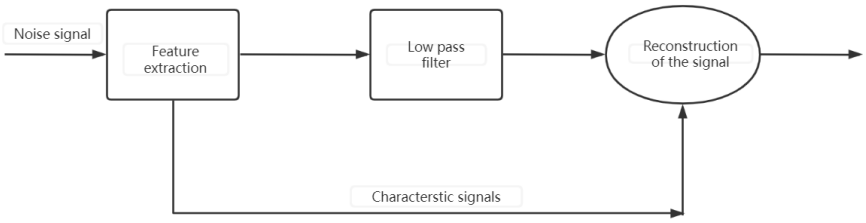

Figure 1: The process of wavelet noise reduction

In the figure, we can see that the curve after denoising by wavelet is closely fitted with the initial data curve, and the curve after denoising is smoother and can better reflect its original trend.

4. Problem 1: Daily Trading Strategy and Solutions

In problem 1, we need to establish a trading strategy model is based on the data inculding gold's closing price and the value of the bitcoin in five years prior to October 9, 2021. Obviously, the data

we use are time sequence, so first we consider to get the price change daily trend of gold and bitcoin through more accurate prediction of time series in preparation for the next trading strategy adoption. Meanwhile through consulting a large number of economic data, we find that the market price characteristics of gold and bitcoin, as tradable assets, are similar to those of stocks and bonds.

Thus, we consider to select economic indicators as the technical indicators [2] for our prediction modal, so as to increase the accuracy and scientificity of the prediction model and expect better results.

Nextly, the trading strategy decision modal comes to build, considering that in the trading of bitcoin and gold market, profits always coexist with risks, we take both the benefits extending and risks avoidance into account, and establish a portfolio investment decision model to give an exact trading strategy. As shown in Figure 2.

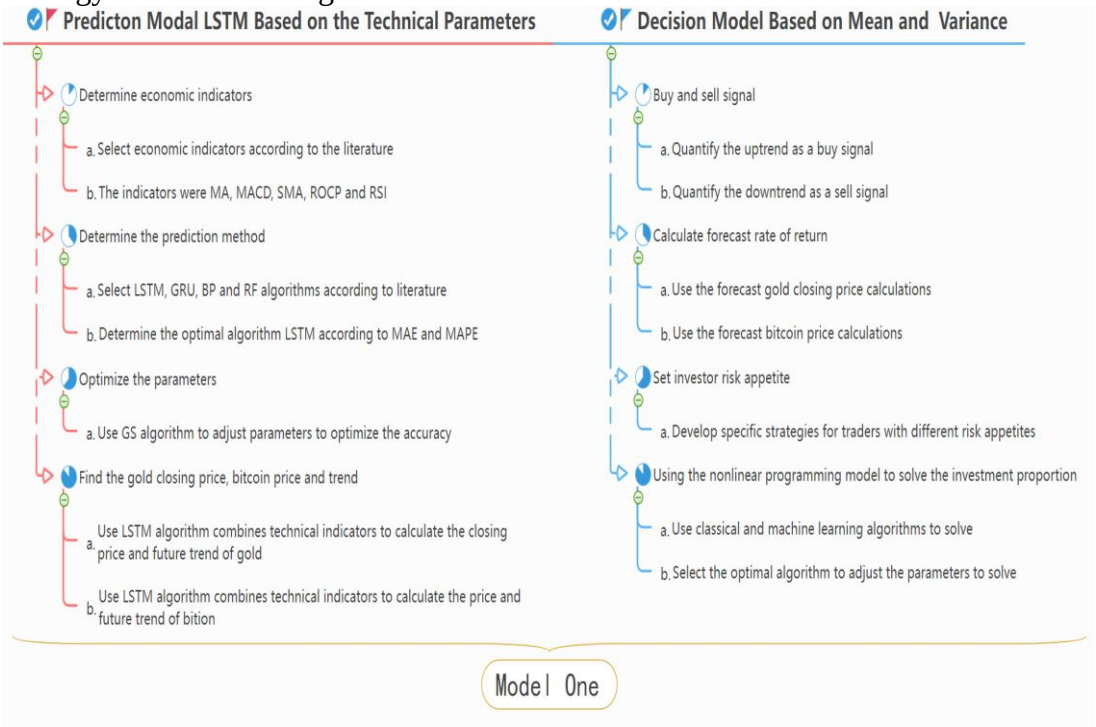

Figure 2: Model overview of model one

There are the technical indicator we use as the characteristics of the prediction model: moving average (MA), moving average convergence / divergence (MACD), relative strength index (RSI) and price change rate percentage (ROCP). To improve model accuracy, grid search is used in the model to turn the parameters, in order to build gold and bitcoin LSTM prediction model based on technical indicators.

MA is a statistical method that averages the price (index) of gold and bitcoin over a certain period of time, and connects different time averages to track trends. It can be formulated as:

$$MA_{(N)} = \frac{P_t + P_{t-1} + \ldots + P_{t-N+1}}{N} \quad (3)$$

MACD indicators generally formed by a group of curves and the image. Firstly, we calculate the closing price respectively in the practical application of exponential smoothing of fast and slow moving average (EMA), Secondly, how fast speed is calculated from the data of exponential smoothing deviation between moving average value, expressed as the DIF line. Finally, calculate the DIF line and the difference of DEA line, represents MACD line, and the specific formula is as follows:

$$EMA_t^n(P_t) = \frac{\sum_{i=1}^{n}(n-i+1)P_{t-i+1}}{\sum_{i=1}^{n} i} \quad (4)$$

$$Dif_t = EMA_t^m(P_t) - EMA_t^n(P_t) \quad (5)$$

$$Dea_t = EMA_t^p(Dif_t), MACD_t = Dif_t - Dea_t \quad (6)$$

Where Pt is the price at time t, and m, n, p are generally setted as 12, 26 and 9. In this paper, we will use the grid search optimization to turn parameters to get better values. When MACD turns from negative to positive, buy signals belong to the long market, while sell signals belong to the short market when MACD turns from positive to negative.

Relative Strength Index (RSI) is a technology curve based on the ratio of rising points and drop point in a given period of time which can reflect the market prosperity index in a certain period, and it is formulated as:

$$SI = 100 - \frac{100}{1+RS} \quad (7)$$

Where RS is the quotient of the average gain over the past 14 days divided by the average decline over the past 14 days.

ROCP compares the closing price of the day with the closing price of N days ago. Calculate the percentage of the closing price change over a certain period of time, and applies the moving comparison of prices to measure the price momentum. It is formulated as:

$$ROCP = \frac{P_t - P_{t-N}}{P_t} \quad (8)$$

Where Pt is the price at time t and illustrate the closing price of the day minus the closing price of the NTH day divided by the closing price of the NTH day. Mean Absolute Error (MAE) and Mean Absolute Percentage Erro (MAPE) are two efficient predictive evaluation indicators, thus we ultilize MAE and MAPE to evaluation the four prediction methods including RF, GRU and BP.

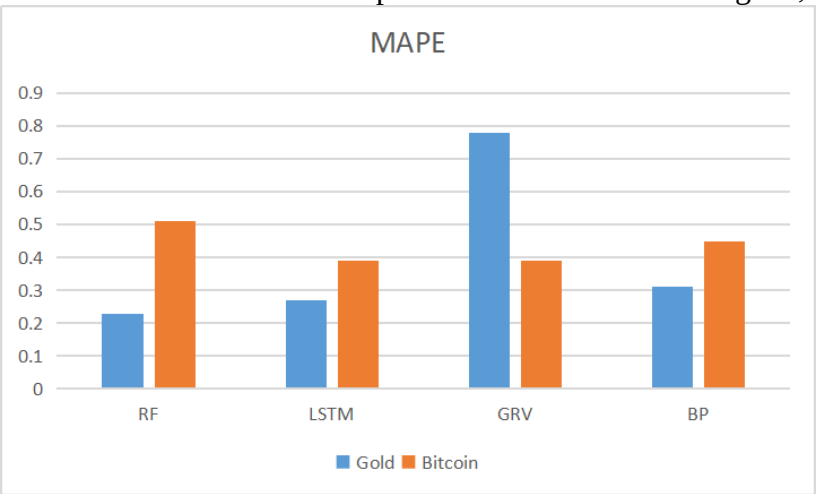

Figure 3: MAPE of the four prediction methods

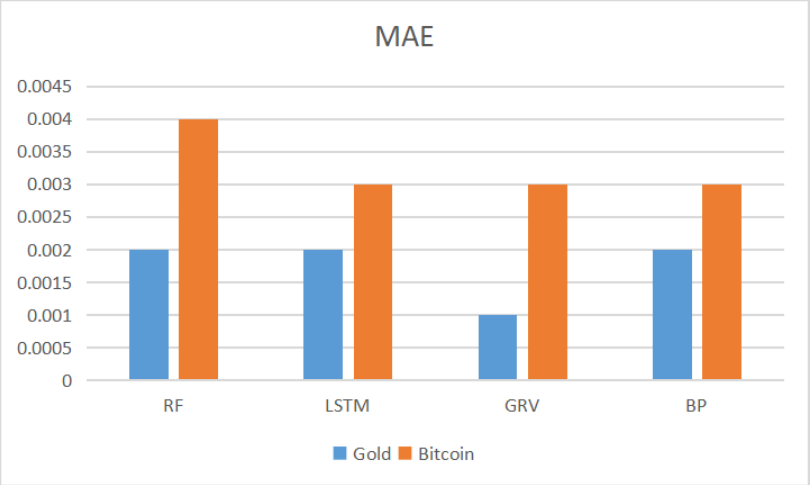

Figure 4: MAE of the four prediction methods

The key points that should be considered in the process of portfolio investment to improve returns and reduce risks: The first point is predicting the expected return of gold and currency, the point two is to take the volatility of earnings into consideration in term of that traders need to bear the risk of fluctuations. In this paper, gold and currency volatility reflet in the yield of variance. The point three, there is a proverb don't put the eggs in one basket, which illustrates that in the process of investment we should allocate as much cash as possible to a combination of marketable assets. the results of the evaluation indicators MAPE and MAE, the smaller the values of MAPE and MAE, the smaller the error between the predicted value and the real value, and the better the effect of the model. The comparison of four method is shown as the Figure 3 and Figure 4.

As the figure shown, it is easy to clarify that compare these four methods, the data of MAPE and MAE of LSTM are more substantial and it is easy to clarify from the figure that compare these four methods, the data of MAPE and MAE of LSTM are more substantial and LSTM have better effects.

The distribution of the daily return rates of gold and bitcoin output by the model over a period of five years is shown as follow. As shown in Figure 5.

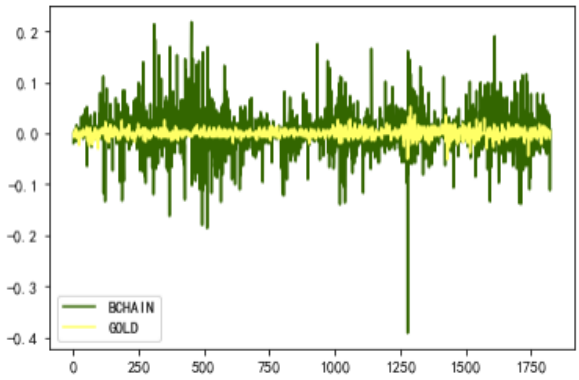

Figure 5: The daily yield distribution of gold and bitcoin

Using our portfolio investment model, the initial asset 1000 on 9/11/2016 accumulate into final asset on 9/10/2021 is 99767.1233.

5. Problem 2: The Evidence of Model Providing the Best Strategy

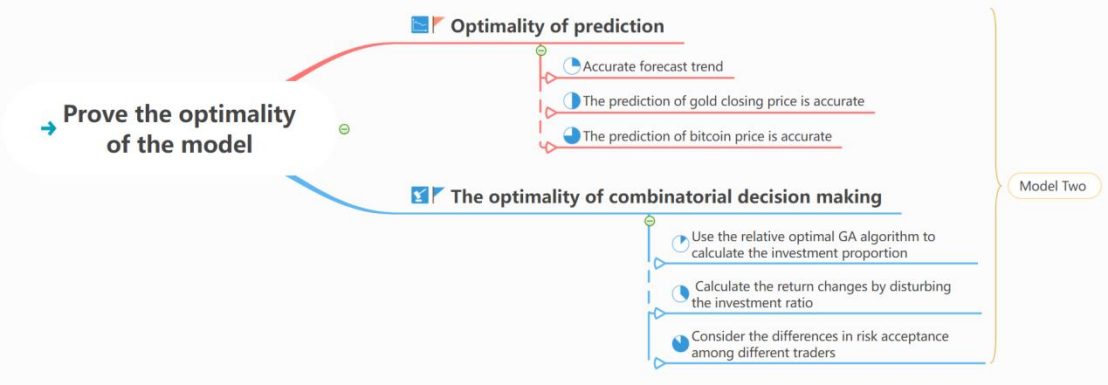

Figure 6: The overview of model two

As shown in Figure 6. Firstly, we elaborate on the importance of the accuracy of the prediction model to the results of the whole model. In the last section of problem 1, the role of making predictions for the model has been fully illustrated: on the one hand, we derive the trend indicators from the predictive models and quantify them as signals for traders to buy, hold or sell. On the other hand, the price obtained from the prediction model is used to predict the future return rate of gold and bitcoin, which is used to act as the investment ratio of gold and bitcoin in the decision. Next the two indicators will decide directly whether traders are investing in gold and bitcoin and what percentage of their money they will buy and sell.

Secondly, on account of the accuracy of our prediction model, which is considered the basis for making the best strategies. We take MAPE and MAE as evaluation indexes to evaluate four feasible prediction models, including RF, GRU, LSTM and BP. Finally, we conclude that LSTM has the best prediction result after the introduction of technical parameters, which we end up utilizing. It suggests that our predictions are remarkably accurate in comparison.

We consider using the following two methods to prove its validity: The first one is the variable perturbation and the second one is a horizontal comparison.

Method 1: In order to prove that the decision model provides us with the optimal strategy, we disturbance the triad [x0, x1, x2] of the bid-sell ratio derive from the optimal strategy given by the model.

$$[x0, x1, x3] \pm \varepsilon$$

Where x represents the ratio of cash invested in gold or bitcoin to assets in transactions, ε is a random number between 0-1.the results after the disturbance are compared to the results before disturbance to prove that the existing strategy is the best.

Method 2: Four types of outcome indicators are used as evaluation indicators, including Total Annual Return (TAR), Excess Interest Rate (Alpha), Sharpe Ratio (SR) and Max Drawdown (MD). Then evaluate Genetic Algorithm (GA), Back Propagation Neural Network (BP), Penalty Function Method and Conjugate Gradient Method (PCG). And the results show us that our existing strategy is optimal.

Solution of Method 1: The result obtained by method 1: the triplet [x0, x1, x2] of the buying and selling ratio is disturbanced by plus or minus an arbitrary value ε. Next, we compare the result after the disturbance with the result before the disturbance after A certain number of experiments. After comparing, we can conclude that the output result of our model is the best before the disturbance, so our strategy is the best strategy in this situation.

Solution of method 2: Our decision model is a constrained linear programming problem. With

regard to Linear Programming with Constraints (NIP) problems, numerous solutions have been proposed since such problems are put forward, but the exact optimal solution can't be solved all the time, only a more accurate solution can be found. Therefore, we try x models including four machine semesters and classical algorithms, and then evaluate the quality of their answers by using evaluation indicators. After many experiments, we choose the optimal algorithm of GA to give the strategy, so our strategy is optimal in such cases.

6. Problem 3: Sensitivity Analysis on Transaction Costs

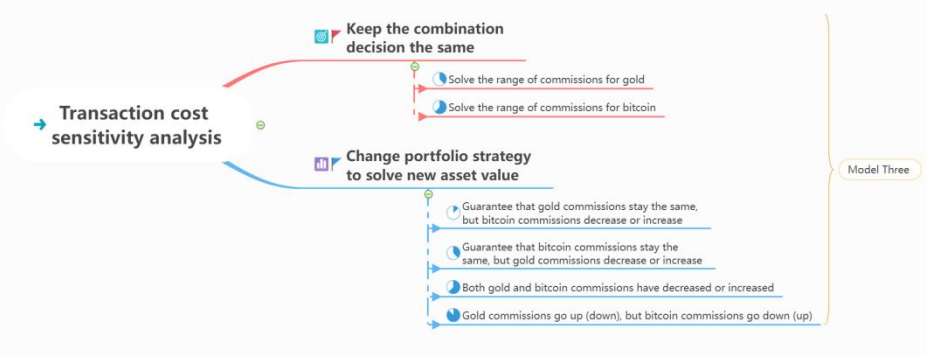

Figure 7: The overview of model three

As shown in Figure 7. It can predict the possible risk degree of investment, and prompt us to take improvement measures on original plan or find alternative plan, when the change of transaction cost exceeds the safety range, change the decision method to avoid loss, improve the investment effect. By comparing the sensitivity of the strategy model to the transaction costs of gold and bitcoin, the sensitivity of the two is distinguished. It is helpful for traders to provide a reference for more careful consideration when making decisions.

Our conclusion of sensitivity analysis is that when the strategy given by the model can maintain considerable profits, the range of bitcoin commission rate is [1.89%, 4.36%], and the commission rate of gold is [0.96%, 7.22%]. Meanwhile the model is more sensitive to the change of gold commission rate than to the change of gold rate.

7. Strengths and Weaknesses

Strengths: Considering the different risk preferences of users, we define a parameter in the model, and traders can get their own strategies by adjusting this parameter. Therefore, our model can apply Wider application. Our model fully considers the two aspects of expanding returns and coping with risks, so as to improve returns and avoid risks as much as possible and make progress steadily in the portfolio investment market.

Weaknesses: Since the model is based on prediction and operations research, it combines the common model defects of the two. No matter how advanced models are used to make predictions, there are still errors, and once predictions are wrong, we will make completely wrong decisions.

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