Research on Quantitative Trading of Gold Bitcoin Based on Markowitz Portfolio Theory

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Abstract:

Gold has a monetary function since ancient times. Bitcoin, as a bearer currency product, circulates in many countries. Bitcoin, a high-risk asset, will bring higher returns. The stability of gold, a low-risk asset, can resist high risks. How to maximize investors' profits by combining the stability of gold and the high returns of bitcoin? Based on Markowitz's portfolio theory, this paper uses Monte Carlo model to obtain the volatility and return of the weighted portfolio such as the optimal risk portfolio and the minimum variance portfolio, and determines the return of the optimal risk portfolio under the maximum sharp ratio. Finally, through the simple moving average method, trend moving average method and yield average method, the prices of gold and bitcoin are predicted by sliding window rolling. Finally, it is found that the cumulative yield of MACD strategy is the highest by using trend moving average method under the optimal risk portfolio, which becomes the best strategy of the highest yield model under the optimal asset portfolio.

Keywords: Investment portfolio, Sharpe ratio, Moving average.

I. INTRODUCTION

As a volatile asset, bitcoin is a currency that lacks intrinsic value. The total amount of bitcoin is fixed, and the mining speed has been programmed. There are 21 million bitcoins until the end of mining. Gold, which is often mentioned together with bitcoin, has not only a commodity function but also a currency function, which is mainly manifested in maintaining value, resisting inflation and optimizing asset allocation. Global gold holdings are still increasing every year. The mining speed and gold price affect each other, and the specific amount of gold is still unknown. The most essential difference between the two as volatile assets is that bitcoin and gold are very different in terms of supply and demand[1]. At the same time, they also bring different purchasing power stability. As an investor, bitcoin has high short-term income, but it is not stable enough, with large increases and decreases, high risks and great benefits; Gold has a small increase or decrease, which is suitable for long-term holding, but the profit is low and the risk is low. How to determine the best proportion of comprehensive income from investing in gold and bitcoin? How will the transaction cost affect the strategy and results, and how?

II. RESEARCH FRAMEWORK

Best investment portfolio for gold and bitcoin. Firstly, based on Markowitz's portfolio theory, the optimal risk portfolio, minimum variance portfolio and equal weight portfolio are compared to determine the best portfolio. best price prediction model for gold and bitcoin. Determine the investment ratio and weight of gold and bitcoin with the best investment portfolio, and then select the best model according to the prediction results in the simple moving average method, trend moving average method, and return average method according to the weight. best backtesting strategy for gold and bitcoin[2]. On the basis of the best model prediction of the best combination, in the MACD strategy and the stop-loss return strategy, the cumulative return, Sharpe ratio and maximum drawdown are used to evaluate the backtest results of the two strategies to determine the best combination. Gold- Bitcoin optimal strategy under the model. As shown in Fig 1.
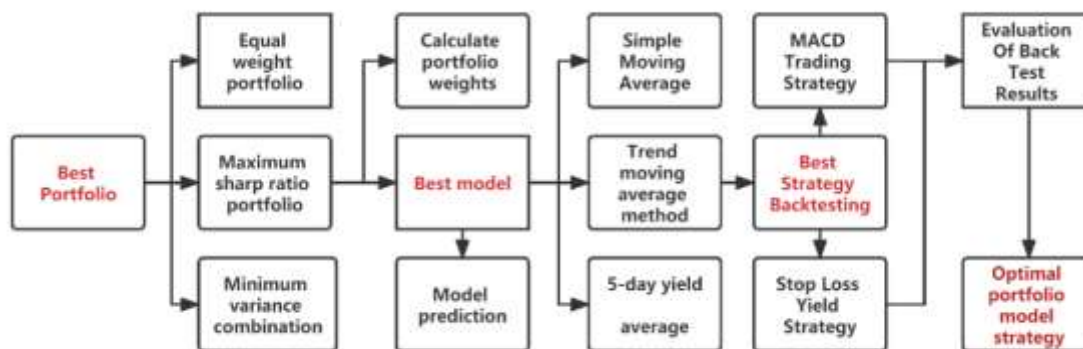

Fig 1: Research Framework

The weight of each influencer appearing in the graph (the number of influencers having followers as a whole) is counted on the basis of the music influence network graph, and the results are shown in TABLE I. below (all not appearing in the table are influencers with weight 1).

TABLE I. Artist Impact

ARTISTS	WEIGHT	ARTISITS	WEIGHT
Soundgarden	30	Allan Sherman	3
PJ Harvey	20	Sonic Youth	2
P.O.D.	18	Bad Brains	2
Pam Tillis	12	Black Flag	2
All That Remains	6	Metallica	2
t.A.T.u.	4	Special Duties	1
Tony Furtado	3	......	1

III. Measurement of Similarity of Music Features

3.1 Calculate the Rate of Return

A visual analysis of the cumulative returns of Bitcoin and gold from 2016 to 2021, as shown in the chart above, found that the price of Bitcoin experienced its first sharp rise from August to December 2017, reaching as high as $ 35, very different from the initial starting point, and then the trend in the next two months dropped sharply by almost half of the height. After that, the price of Bitcoin fluctuated at almost the same level for two years and nine months. September 2020 At the beginning, the price of Bitcoin experienced a second sharp rise[3]. Compared with the previous rise, the price almost tripled until it reached its peak in mid- 2021, and the peak price even exceeded $ 100. The new crown epidemic in the United States has basically stabilized. Under the influence of the new crown epidemic in 2020, the yield of assets such as US treasury bonds is basically zero. Under such circumstances, investors choose higher-risk investment products in pursuit of high profits. Bitcoin is a higher-risk investment product in the market. one of the products. From this point of view, the development prospects of Bitcoin are still relatively objective, and many people are willing to choose high-risk and high-yield assets. In contrast, the development trend of gold is obvious, very stable, and continues to rise slowly. From this point of view, gold is a low-risk, low-yield asset in comparison. As shown in Fig 2.
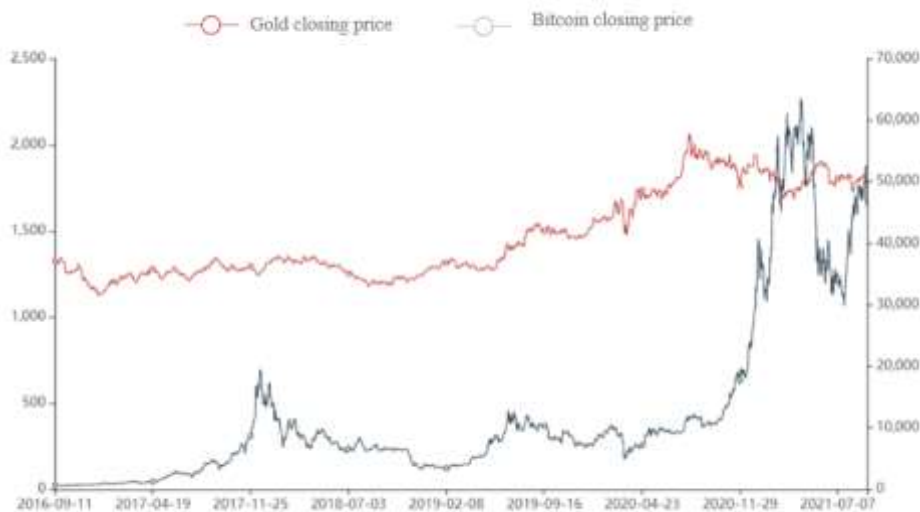

Fig 2: Cumulative Yield for Bitcoin and Gold

3.2 Musical Similarities within and between Schools

As shown in the figure, the red curve represents the efficient frontier. The portfolio on the efficient frontier is profitable[4]. The portfolio above the efficient frontier is suitable for people with high risk tolerance, and the portfolio below is suitable for risk averse people. The blue dashed line represents the capital market line, a ray that shows a simple linear relationship between the expected return and the standard deviation of the efficient portfolio. It is a portfolio consisting of risky assets and riskfree assets

along the efficient frontier of the portfolio. The position of the blue star represents the optimal risk portfolio, which has the largest Sharpe ratio and is the best choice for the majority of risk-averse people. The position of the black star represents an equal-weight portfolio, which is a 1:1 portfolio of yield and volatility. The yellow star represents the position of the global minimum volatility, where both the return and volatility are the minimum. As shown in Fig 3.
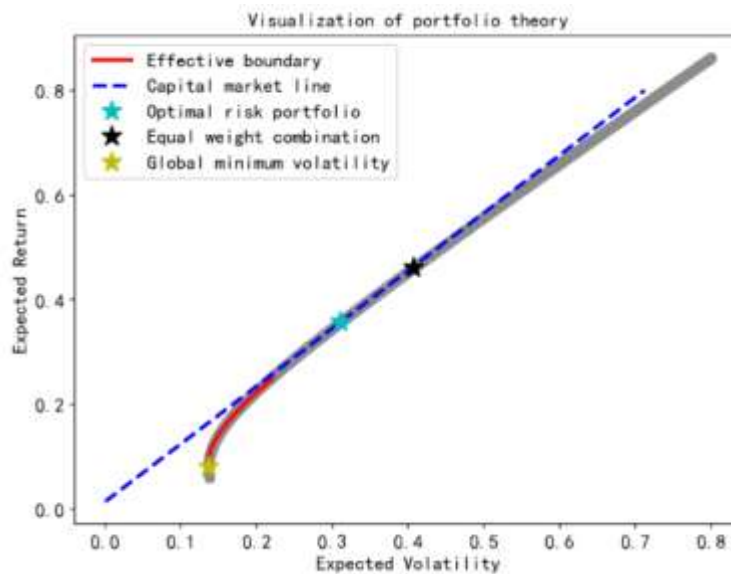

Fig 3: Visualization of Portfolio Theory

3.3 Weights Calculate Expected Returns of Portfolios

The optimal risk portfolio is obtained through the Monte Carlo simulation above. Since then, the default portfolio is the optimal risk portfolio, that is, the portfolio with the highest Sharpe ratio. Compared with high-risk-tolerant investors who pursue high-risk high-return, risk-averse investors make up the vast majority[5]. Risk-averse investors generally do not have the ability to take risks. For different investment products with the same return, they are more inclined to choose low-risk investment products. Daily return line chart of the portfolio that is the optimal risk portfolio from .September 11, 2016 to September 10 , 2021 .As shown in Figure 4 , the cumulative return of the optimal risk portfolio is very impressive. The blue curve represents the cumulative return curve of the optimal risk portfolio, and the yellow line represents the cumulative return curve of the qual-weight portfolio. Comparing the two broken lines, it is not difficult to see that the cumulative return of the optimal risk portfolio is still very considerable compared with the cumulative return of the equal-weighted portfolio.
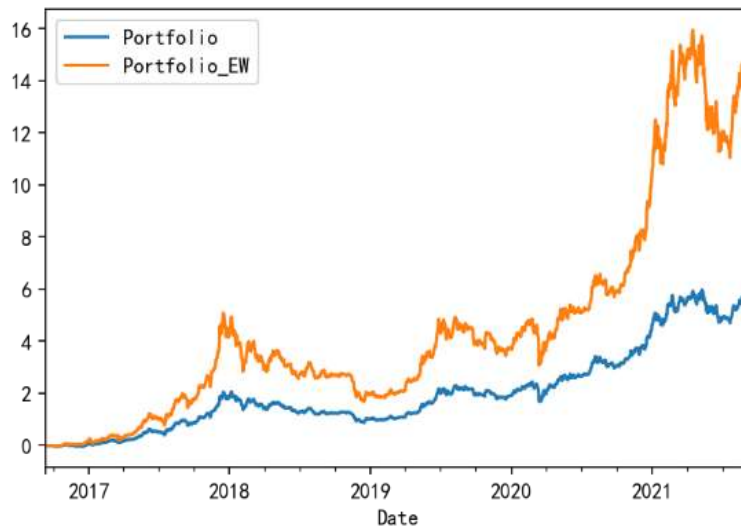
Fig 4: Portfolio Return Curve

VI. ESTABLISHMENT OF GOLD BITCOIN MODEL

4.1 Evaluation Metrics

MSE (Mean Squared Error) mean squared error in mathematical statistics refers to the expectation of the square of the difference between the parameter estimate and the parameter value. MSE is a more convenient method to measure the "average error". MSE can evaluate the degree of change in the data[6]. The smaller the value, the more accurate the accuracy of the data described by the prediction model.

$$MSE = \frac{1}{N} \sum_{i=1}^{N} \left(y_i - \hat{y}_i \right)^2$$

(1)

MAE, mean absolute error, the mean of the absolute value of the error between the observed value and the true value.

$$MAE = \frac{1}{N} \sum_{i=1}^{N} \left| y_i - \hat{y}_i \right|$$

(2)

4.2 Simple Moving Average

The moving average method is a simple smoothing forecasting technique. Its basic idea is to calculate the average value of the time series containing a certain number of items in turn according to the time series data, item by item, so as to reflect the longterm trend.Set the number of time series items used for prediction here to 5 days, that is, use the closing prices of the past 5 days to calculate the rate of return for each day, and use it to predict the rate of return for tomorrow. So extract the closing price five days before

the t day.

$$A = (A_{t-1} + A_{t-2} + \cdots + A_{t-5})/5 \qquad (3)$$

A - the daily rate of return to be predicted; $A_{t-i}(i=5)$- The rate of return for the five days before t.TABLE II shows the daily yield and closing price of gold for the five days before t.TABLE III shows the daily yield and closing price of Bitcoin for the five days before t.

TABLE II: Gold t five days ago yield and closing price

Date	t-1	t-2	t-3	t-4	t-5	Gold
2016-09-16	-0.0083	-0.0014	0.0000	0.0000	0.0000	1308.35
2016-09-17	-0.0019	-0.0083	-0.0014	-0.0007	0.0000	1314.85
2016-09-18	0.0050	-0.0019	-0.0083	-0.0014	-0.0007	1314.85

TABLE III: T five days ago yield and closing price

Date	t-1	t-2	t-3	t-4	t-5	Bitcoin
2016-09-16	-0.0083	-0.0014	-0.0007	0.0000	0.0000	609.11
2016-09-17	-0.0019	-0.0083	-0.0014	-0.0007	0.0000	607.04
2016-09-18	0.0050	-0.0019	-0.0083	-0.0014	-0.0007	611.58

4.3 Five-day Sliding Window Average Prediction Method

TABLE IV: Forecast Daily Mximum Expected Return and Closing Price

Date	t-1	t-2	t-3	t-4	t-5	Max_ Sharp Ratio_ Optimal_ Risk _Portfolio
2016-09-16	-0.0083	-0.0014	-0.0007	0.0000	0.0000	1093.9672
2016-09-17	-0.0019	-0.0083	-0.0014	-0.0007	0.0000	1097.8397
· · ·	· · ·	· · ·	· · ·	· · ·	· · ·	· · ·
2021-09-10	0.0013	-0.0090	-0.0107	-0.0012	-0.0012	15460.7481

The return in TABLE IV is the predicted result, and Max Sharp Ratio Optimal Risk_Portfolio is the return under the optimal risk portfolio.

4.3 Trend Moving Average

Using the moving average prediction, when win =1 , m se and m ae are the smallest. is because the

most recent value is the closest to the value to be predicted. When win increases , both m se and mae increase[7]. The smallest m se:46 mae:30. The left side of the above figure is the gold sliding window average forecast, and the right side is the Bitcoin sliding window average forecast.the results are shown in TABLE V.

TABLE V: Sliding window prediction process

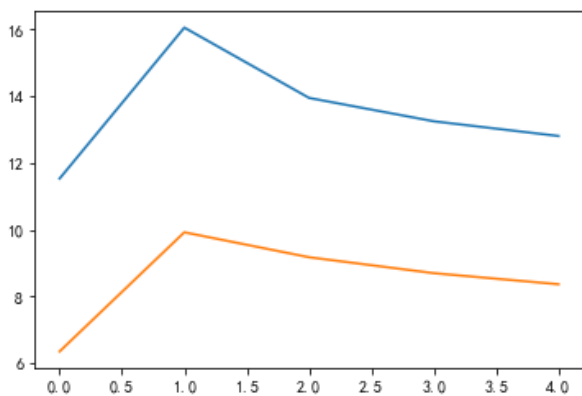| Date	t-1	t-1-pred	t-2	t-2-pred	t-3	t-3-pred	t-4	t-4-pred	t-5	t-5-pred
2016/9/11	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null
2016/9/12	1324.6	1324.6	Null	Null	Null	Null	Null	Null	Null	Null
2016/9/13	1323.65	1324.6	1323.65	1324.6	Null	Null	Null	Null	Null	Null

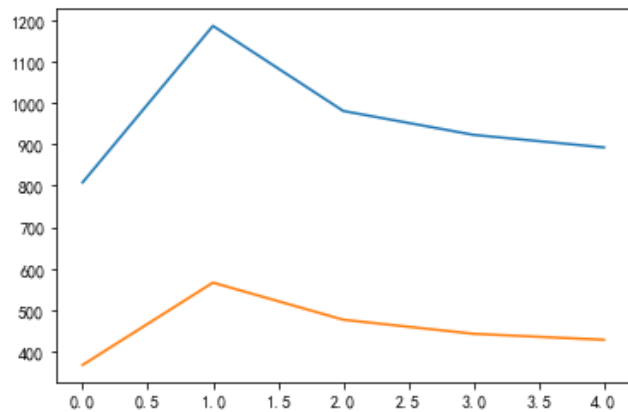Fig 5:The gold trend forecasting

Fig 6:The Bitcoin trend forecasting

Using the moving average prediction, when win =1, m se and mae are the largest. is because the most recent value is the closest to the value to be predicted. When win increases , both mse and mae increase . Fig 5 shows the gold trend moving average method prediction chart, and Fig 6 shows the Bitcoin trend moving average method prediction chart.

V. IMPLEMENTATION OF BACKTESTING OF GOLD BITCOIN STRATEGY

5.1 MACD Trading Strategy

MACD, also known as the index dispersion indicator, is a further development of the moving average principle[8]. This technical analysis tool was proposed by Gerald Appel in 1979 and has been very popular in stock market investment. The MACD indicator generates a fast line and a slow line by smoothing the closing price of the asset price . The MACD indicator can well reflect the strength and energy of the recent price trend of the stock, and grasp the accurate buying and selling points of the stock by analyzing the fast and slow lines. The MACD indicator has two obvious advantages:

1) Compared with the moving average, the MACD indicator reduces the defects of frequent false signals;

2) According to the recent trend of the moving average, it is suitable to judge the beginning and end of the rising or falling market, which is suitable for judging the medium and long- term trend.
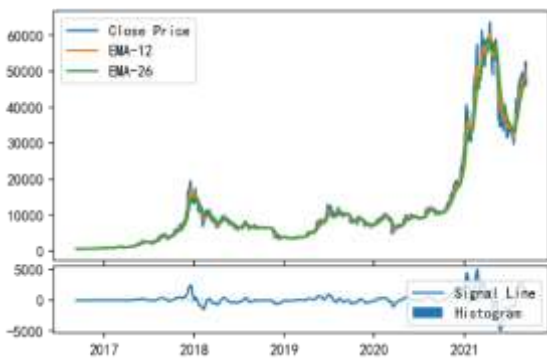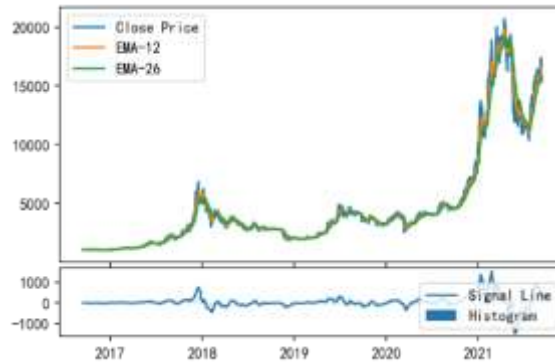
Fig 7:The MACD forecast of Bitcoin   Fig 8:The optimal risk combination

The optimal risk portfolio protects three times the risk relative to a single bitcoin stock. Figure7 shows the MACD forecast of Bitcoin,Figure 8 shows the MACD forecast of the optimal risk combination (the combination with the highest Sharpe ratio) . In contrast, there is no significant difference in the line trend of the two charts, but a closer inspection will find that the range of the vertical axis of the Bitcoin MACD forecast chart is three times higher than the vertical axis of the optimal risk portfolio MACD forecast chart. It shows that the optimal risk portfolio protects three times the risk relative to a single Bitcoin stock.

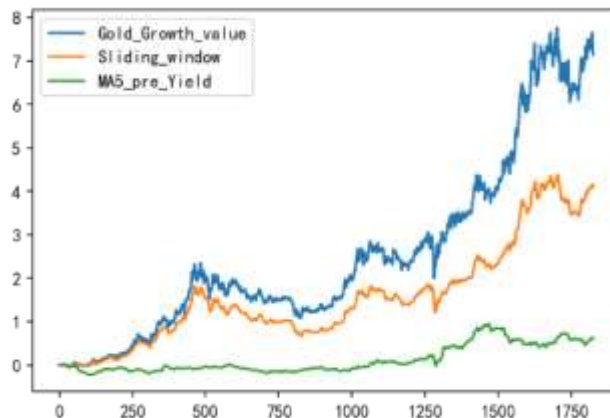5.2 Evaluating the Effectiveness of the Strategy

Fig 9:Comparison of Comprehensive Returns of Three Models

Comparing the rate of return of the three strategies, it is obvious that the cumulative return of Gold

_Growth _Value > the cumulative return of Sliding _Window > the cumulative return of MA5_Pre_Yield .As shown in Fig 9.

Under the MACD strategy, according to the results of the three models in Markowitz's portfolio theory, it is obvious that the cumulative return of the trend moving average sliding window is higher to 7.145 , with a 7-fold increase in five years. The maximum drawdown - 0.738 is slightly higher than the 5-day sliding window method - 0.715 and the M A5 method - 0.729 , and also has very low risk, so it proves that the trend moving average method is the best strategy under the best asset allocation combination The highest yield model.As shown in TABLE VI.

TABLE VI: Comparison of three models

	Sharpe ratio	Maximum drawdown	cumulative rate of return
MA5_pre_Yield	0.063	-0.729	5.551
Sliding_window	0.116	-0.715	4.099
Gold_Growth_	0.057	-0.738	7.145

Highest value on September 10, 2021 is the sliding window averaging method, and with the stop loss rate from 0.00% to 2.00% , the asset value also increased from 8384.59 to 8565.21 , an increase of $ 180 , indicating that setting the stop loss rate will Significant increase in asset value. However, there is a conflict with the trend moving average method, which is the highest yield model under the best strategy under the best asset allocation portfolio . It is likely because the trend moving average method has too many transactions and high commissions, resulting in 21 years of 9 The month 10 value is not as good as the sliding window averaging method .As shown in TABLE VII.

TABLE VII Value on September 10, 2021

Stop loss rate	0.00%	1.00%	1.50%	2.00%
Gold_Growth_	7886.02	7875.08	7872.04	7866.86
Sliding_window	8384.59	8417.46	8572.12	8565.21
MA5_pre_Yield	7908.70	7886.00	7880.07	7877.21

Looking at the trend moving average method and the 5-day sliding window method, the disadvantage of the trend moving average method is that the number of transactions is too large. When the stop loss is set at 2 % , 1,746 of the 1,826 days are traded, so it means that A large number of commissions cause the value of 9/21/21 to be higher than the sliding window average method , so a sensitivity analysis of transaction costs is required as follows.As shown in TABLE VIII.

TABLE VIII: Number of transactions table

Stop loss rate	0.00%	1.00%	1.50%	2.00%
Gold_Growth_	1806	1781	1767	1746
Sliding_window	1755	1734	1750	1723
MA5_pre_Yield	1734	1644	1559	1498

VI.SENSITIVTTY ANALYSIS OF TRANSACTION COSTS TO STRATEGIES

6.1 Introduction to Sensitivity Analysis

Sensitivity analysis is a method to study and analyze the sensitivity of the state or output changes of a system (or model) to changes in system parameters or surrounding conditions. In optimization methods[9], sensitivity analysis is often used to study the stability of the optimal solution when the original data are inaccurate or changed.

Implementation steps:

1) Control other parameters unchanged

2) Change the value of an important parameter of the model, which is the transaction commission in the transaction cost sensitivity analysis[10]. To observe the changes in the results of the model, mainly observe the value of sensitivity. Where "S1", "S2", "ST" represent the first-order sensitivity, second-order sensitivity and total sensitivity, respectively. (A second-order sensitivity will involve two variables), and the corresponding name plus _conf indicates the corresponding confidence (95%). MACD strategy under the optimal risk combination (gold: bitcoin is 0.69: 0.31), the commission range of bitcoin is 1,000 random consecutive values of 0.15%-0.25% , and the commission of gold is 0.05%-0.15% 1 000 random continuous values of,the impact on the trading results, view the sensitivity results analysis as follows.

6.2 Sensitivity Analysis of Optimal Risk Portfolio

Optimal risk portfolio , bitcoin is a high-volatility asset risk asset. Although it accounts for only 0.31 in the investment portfolio , its market value has been very high in recent years, and the transaction gold is 2 % per transaction , so it is very important. It is clearly found that Bitcoin has a high sensitivity in the optimal risk allocation combination. Explain that there are high transaction costs.As shown in Fig 10.
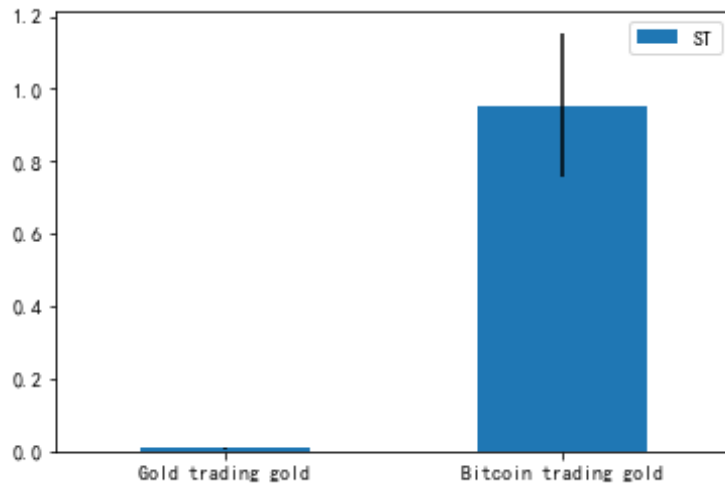
Fig 10: Sensitivity analysis of optimal risk allocation portfolio

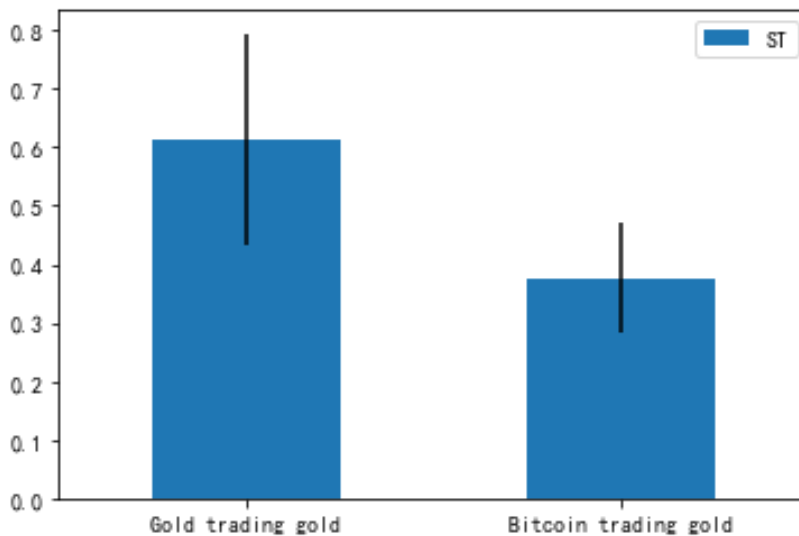6.3 Sensitivity Analysis of Minimum Variance Combinations

Fig 11: Minimum variance combination

In the minimum variance allocation portfolio, gold accounted for only 0.97 of the investment portfolio, and the transaction gold was 2 % per transaction , so it is obvious that gold is more sensitive in the best risk allocation portfolio. However , the sensitivity analysis results show a negative number, indicating that the sensitivity is small, and some statistical errors have occurred because the sample is too small, and it is not credible in this performance interval.As shown in Fig 11.

VII. SUMMARY

In the investment portfolio of gold and bitcoin, the optimal risk combination under the maximum Sharpe ratio has more balanced risks and returns than the equal weight combination method and the minimum variance combination method. Trend moving average method trend moving average method is the highest return model under the best strategy under the best asset allocation portfolio, and its sharp ratio is also small Models and strategies with too many transactions mean huge commissions, which makes the trend moving average method inferior to the high-yield 5-day sliding window method on 9-10-2021. Commissions are important in the investment system.

REFERENCES

[1] Liu Zhiqiang. Modern Portfolio Theory and Equilibrium Model of Capital Market.. Economic Science.

[2] Application of extreme value statistical theory in financial risk. Wang Xu, Shi Daoji Research on quantitative economy and technical economy 2001(08).

[3] Research on fluctuation characteristics and risk of China's gold futures market. Wang Zhaocai Fudan University 2012.

[4] Research on extreme value theory and its application in risk measurement of Shanghai and Shenzhen stock markets. Science Press, Hua Yongjun, 2011.

[5] Analysis of the impact of Internet virtual currency on Microeconomics. Xia Yutong, Ji Renjie, Wang Jianfeng, Chen Jie, Cai bin Brand research 2019(14).

[6] Brent crude oil futures market volatility structure catastrophe prediction. Chen Jian, Lin Yu, Huang Dengshi, Chen Yanxiang Journal of system management 2019(06).

[7] An empirical study on the weak form efficiency of China's gold futures market. Fan Yongzhen Graduate Journal of Zhongnan University of economics and law 2019(05).

[8] An empirical study on the weak form efficiency of China's gold futures market. Fan Yongzhen Graduate Journal of Zhongnan University of economics and law 2019 (05).

[9] Research on Compilation and application of mixed asymmetric financial climate index -- Empirical Analysis Based on mf-ms-dfm model. Zhou Decai, Zhu Zhiliang, Ji Yingxin, Yu Yonglei Management review 2019(08).

[10] Research on the distribution characteristics of return rate of virtual financial assets -- Taking bitcoin as an example. Huang zhehao, Li Zhenghui, Dong Hao Systems Science and mathematics 2018(04).