

The Prediction of Stock Index and Gold Price Using ARIMA Model

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Abstract. This study uses ARIMA modeling to forecast how the behavior of the US stock market and gold prices following an interest rate hike by the Federal Reserve. This paper also provides valuable decision-making guidance to investors with respect to the stock market and gold price indices. The primary dataset utilized in the methodology section revolves around the S&P 500 Index, whereas the secondary dataset mainly focuses on gold Price. Based on these findings, it is projected that the S&P 500 will experience a decline over the next three months, while gold prices, on the contrary, are expected to witness an increase. Based on these findings, it is recommended that investors allocate a larger proportion of their investment towards gold, while simultaneously reducing their exposure to stocks in the foreseeable future. This strategic approach aims to optimize potential gains and mitigate risks, aligning with prudent investment practices in a volatile market environment.

Keywords: Time Series Analysis, Stock Market, Gold Price, Interest Rate Hike.

1. Introduction

In 2020, the outbreak of COVID-19 led to the implementation of extremely loose fiscal and monetary policies by the US government to rescue the market. This large-scale fiscal and monetary stimulus drove a rapid recovery of the US economy from the pandemic-induced recession. The contraction in the US economy was 3.4% in 2020, but it recorded a growth rate of 5.6% in 2021 [1]. Looking ahead to 2022, the US economy is still expected to grow by 2.2% [2]. However, there are two factors contributing to the rising inflation rate in the United States, the significantly higher economic growth rate than the potential growth rate and the faster recovery of domestic consumption compared to production.

By February 2022, the US Consumer Price Index (CPI) had experienced a year-on-year growth rate of 7.9%, reaching a 40-year high. Excluding food and energy prices, the core CPI growth rate reached 6.4% year-on-year, also reaching a historical high since 1982. Simultaneously, the Federal Reserve significantly revised its projection for inflation growth in the United States in 2021 to a 3.4% increase, whereas the actual situation revealed a higher rate of 4.6% [3]. These indicators, coupled with robust economic growth, elevated inflation levels, and a constrained labor market, prompted the Federal Reserve to expedite the implementation of stringent monetary policy measures. Moving into 2023, the Federal Reserve continued with two more interest rate hikes. They announced their latest interest rate policy decision, which was to maintain the target range of the Federal funds rate between zero and 0.25%, aligning with market expectations. At the same time, the Fed sharply raised its forecast for inflation growth in the United States in 2021 by 3.4%, but the actual situation is actually higher at 4.6% [4].

Many economists and market participants have stated that the US economy may fall into recession later this year due to factors such as weakened growth momentum, aggressive rate hikes by the Federal Reserve, and banking crises. Some Democratic lawmakers, including U.S. Senator Elizabeth Warren, recently wrote a joint letter to Powell urging the Federal Reserve to stop raising interest rates and warning that excessive rate hikes will cause more unemployment, destroy small businesses, and plunge the US economy into recession [5].

2. Methodology

According to the S&P 500 index and gold opening first order differences sequence ACF and PACF figures, in the lag 30 SP 500 index and gold opening first order difference sequence has a certain degree of autocorrelation and partial autocorrelation, and two kinds of financial assets of PACF graph show in lag 30 is a certain degree of tail phenomenon, so ARIMA (p, 1, q) model can be used for prediction.

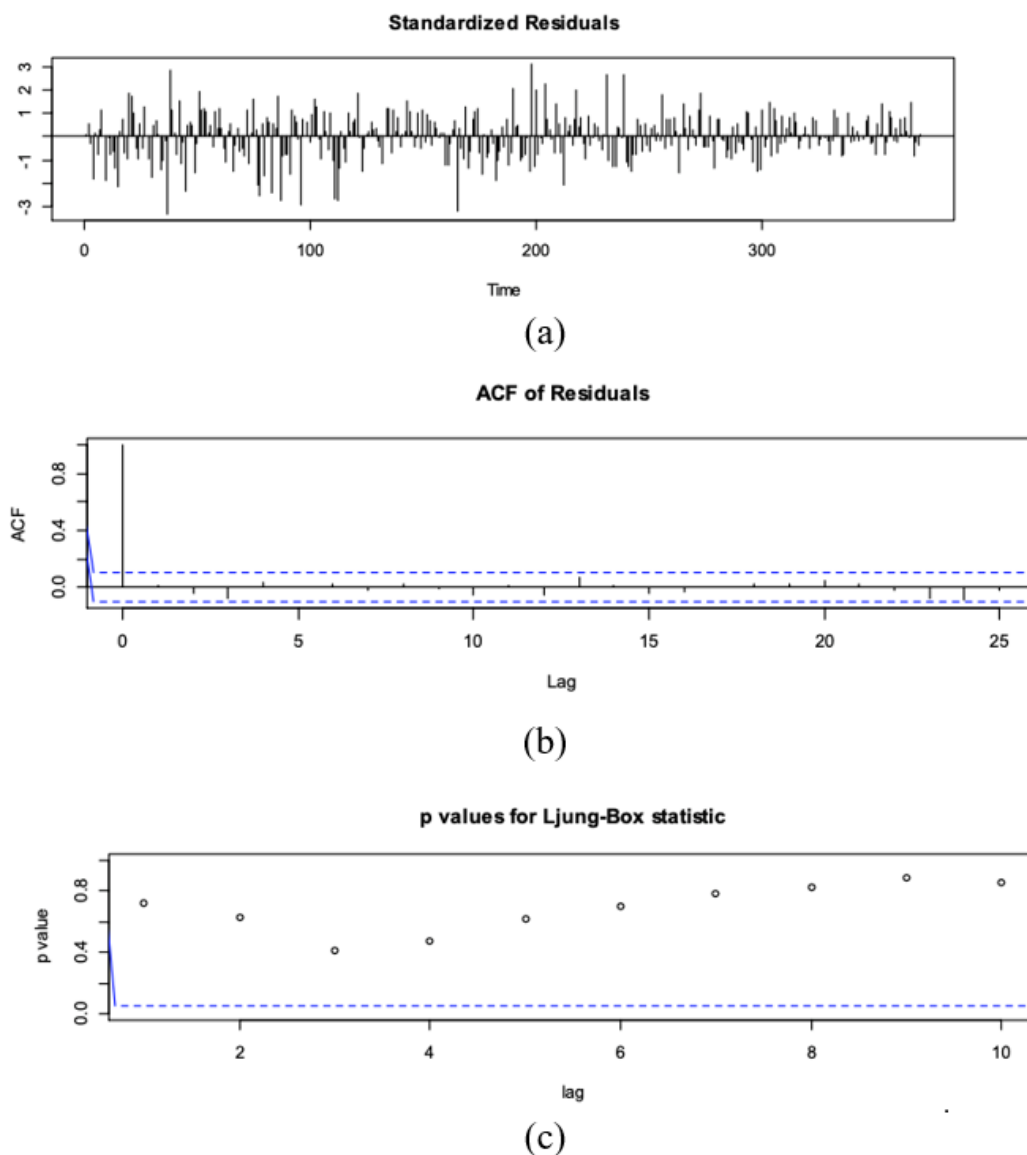


Fig. 1 ARIMA (2,1,2) model residual correlation test (Photo credit: Original).

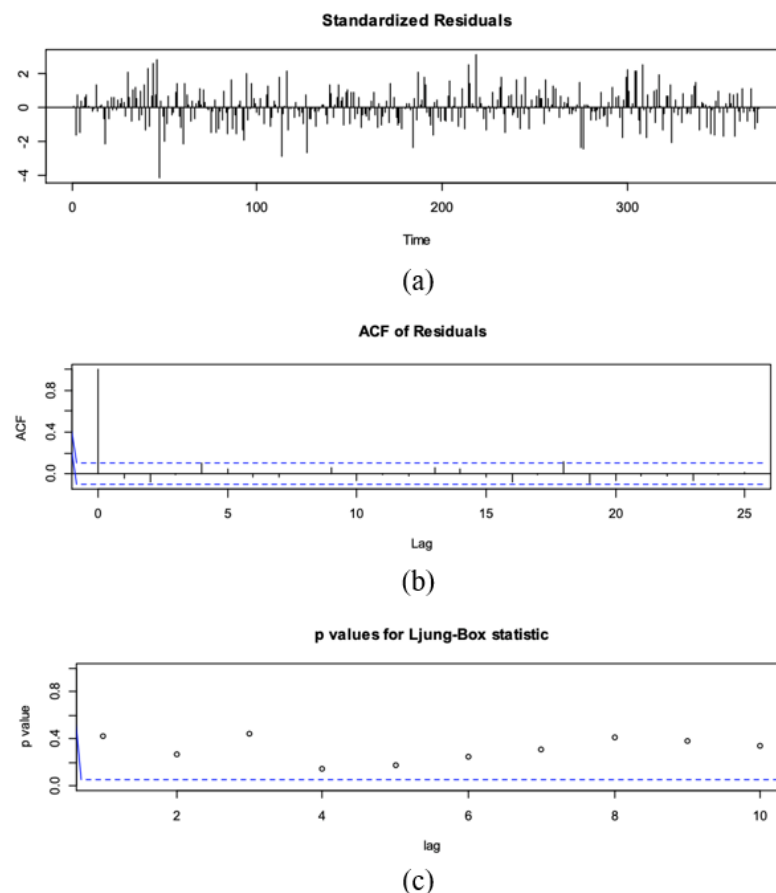


Fig. 2 ARIMA (1,1,1) model residual correlation test (Photo credit: Original).

To better forecast the future data of the SP 500 index and the gold opening price and predict the future expected trend of the opening price of the two financial assets in this paper through the AIC criteria from the ARIMA with a drift term (1,1,1), ARIMA(1,1,0), ARIMA(0,1,1), ARIMA(2,1,1), ARIMA(1,1,2), ARIMA(0,1,2), ARIMA(2,1,0), ARIMA(2,1,2). The optimal model is selected from the ARIMA model with different lag order for fitting. From the AIC minimum criterion, the AIC value of the ARIMA (1,1,1) model with the drift term is 3185.75, which is the minimum value of the gold opening price of the five types of the ARIMA model. Therefore, the ARIMA (1,1,1) model with the drift term can better fit the gold opening price data during the sample period. For the ARIMA (2,1,2) model with drift term, the AIC corresponding to the opening price of the S&P 500 index is 3962.75, which is the minimum value of the opening price of the S&P 500 index in the sample period of the five ARIMA models. Thus, the ARIMA (2,1,2) model with drift term can better fit the opening price data of the S&P 500 index in the sample period.

In summary, the ARIMA (2,1,2) model (see Figure 1) and ARIMA (1,1,1) model (see Figure 2) can fit the SP500 and gold day opening price series from January 3, 2022 to June 23, 2023 well, so the corresponding time series can be predicted with this model respectively.

3. Results

3.1. Model Residual Checking Result

This paper uses the Root of unity test (ADF test) to judge the stability of the sequence. According to the Root of unity test results of gold and SP500 index opening prices under different difference orders in Table 1, the corresponding P values of the ADF test of the original gold opening price sequence and the original SP500 index opening price sequence are 0.6968 and 0.4994, respectively, which are greater than 0.05. The original hypothesis of "containing Root of unity" is accepted at the 5% significance level, The original sequence of gold opening price and SP500 index opening price is

unstable. However, the first-order differences of the opening price of gold and the S&P500 index corresponds to a P value of 0.01 less than 0.05 in the ADF test, which rejects the original hypothesis of "containing Root of unity" at the 5% significance level. The first-order difference series of the opening price of gold and the S&P500 index is a stable time series.

Table 1. ADF test corresponding to the different of difference orders.

Order	GOLD's P	S&P500's P
Origin	0.6968	0.4994
First order	0.01	0.01

3.2. Prediction

The S&P500 dataset's forecast plot is shown in Figure 3. The forecast's semi-elliptical interval in this graphic has a distinct dispersion characteristic. This suggests that several outlier points since 2022 have significantly disrupted model runs; however, since these outlier points represent the significant growth intervals following interest rate increases by the Federal Reserve, which are relevant to this study, they are left in the Methodology stage. Nevertheless, despite the fact that such an interval suggests significant unpredictability, it is still feasible to determine from the prediction's curve a forecast of high index shocks over the following three months. It is also clear from the curve changes between 2022 and 2023 that such a period of decline will eventually result in a permanent 25–50 units decline in the index, a phenomenon that is also likely to happen in changes after 2022.

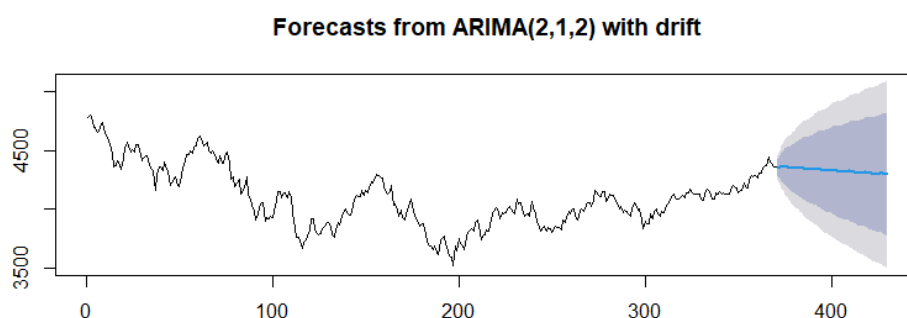


Fig. 3. The S&P500 dataset's forecast plot (Photo credit: Original).

Fig 4. is the interpretation of the forecast plot of the gold. In this plot, similar to the forecast of the S&P500 index, the forecast of the gold index has a large scatter range for the same reason as the S&P500 index, i.e., there is a large number of outliers in the data after 2022. However, the gold index had the same localized upward trend in the same range in the first quarter of 2022, and then shot up to all-time highs directly after the S&P500 index rebounded, which proves the strong correlation between the two indexes.

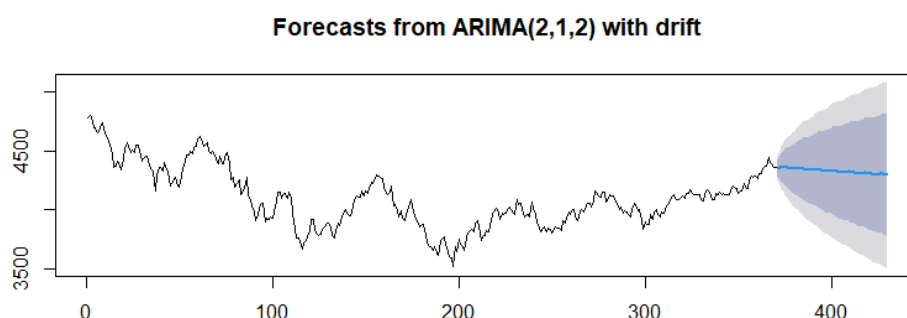


Fig. 4. The gold price dataset's forecast plot (Photo credit: Original).

The forecasts in Table 2 and Table 3 are the specific prediction value, while the LO80 and HI80 are the upper and lower-end prediction values with the interval of the end of this time. Value means that the actual values in the S&P500 Index and the opening price of the gold opening price in the next 60 days will have a probability of 80% and 95%, respectively. It can be seen from the forecast value

that the development trend of the SP500 index and the opening price of gold in the next 60 days will gradually decrease with the extension of time. The extended development trend, its value increased from 1919.394 US dollars to 1932.909 US dollars. It means that the SP500 index and the gold opening price of the SP500 index and the opening price of the gold are accompanied by the opposite time. Among them, the opening price of the SP500 Index has gradually decreased, and the opening price of the golden market shows a gradually increased increase with the extension of time.

Table 2. Prediction of S&P 500 Index.

DAY	Forecast	LO 80	HI 80	LO 95	HI 95
372	4355.38	4261.20	4449.56	4211.34	4499.41
373	4359.13	4242.78	4475.48	4181.19	4537.07
374	4361.99	4226.94	4497.05	4155.45	4568.54
375	4362.01	4210.83	4513.18	4130.51	4593.20
376	4358.64	4193.41	4523.87	4105.94	4611.34
377	4353.06	4175.32	4530.80	4081.23	4624.89
378	4347.50	4158.27	4536.73	4058.10	4636.90
...	...	...	...	...	...
425	4299.66	3804.51	4794.82	3542.40	5056.93
426	4301.77	3801.96	4801.58	3537.38	5066.16
427	4302.12	3797.74	4806.51	3530.73	5073.51
428	4300.02	3791.21	4808.83	3521.86	5078.18
429	4295.97	3782.89	4809.05	3511.29	5080.66
430	4291.47	3774.22	4808.71	3500.41	5082.52

Table 3. Prediction of gold price.

DAY	Forecast	LO 80	HI 80	LO 95	HI 95
372	1919.39	1896.59	1942.19	1884.51	1954.26
373	1919.18	1886.34	1952.03	1868.96	1969.41
374	1919.83	1879.83	1959.84	1858.65	1981.02
375	1919.67	1873.23	1966.12	1848.64	1990.70
376	1920.28	1868.50	1972.06	1841.10	1999.46
377	1920.16	183..27	1977.04	1833.16	2007.15
378	1920.73	1859.40	1982.05	1826.94	2014.52
...	...	...	...	...	...
425	1931.50	1760.82	2102.18	1670.47	2192.53
426	1931.76	1759.52	2104.01	1668.33	2195.19
427	1931.97	1758.16	2105.78	1666.15	2197.79
428	1932.23	1756.88	2107.58	1664.05	2200.41
429	1932.44	1755.55	2109.32	1661.91	2202.96
430	1932.69	1754.29	2111.10	1659.85	2205.54
431	1932.90	1752.99	2112.82	1657.75	2208.06

4. Discussion

As a result of the impact of COVID-19, the Federal Reserve has taken a loose monetary policy stance by releasing significant amounts of cash to restore domestic economic development, which is mentioned in the introduction section. However, a high amount of inflation was caused by the abundance of different currencies present in the market. The CPI increased 9.1% year-on-year last June, which is the largest increase since November 1981 [6]. The Federal Reserve has been increasing interest rates over the last two years in an effort to lower inflation [7].

Following the raising in interest rates, there is a decrease in the amount of dollars in circulation on the market. By tightening monetary policy, suppresses inflation and stabilizes prices. Additionally,

the Federal Reserve's interest rate increase will result in an increase in the interest rate on US Treasury bonds, a narrowing of the spread between stock market yield and Treasury bond interest rates, money moving from the stock market to the bond market, and a temporary decline in stock price after the stock market's liquidity is reduced, which is consistent with our forecasts for the S&P 500 in the modeling section [8].

Conversely, the Federal Reserve interest rate hike will lead to higher gold prices to a certain extent, the main reason is that gold plays a more risk-averse role in the market. If the US economy does not respond positively after the interest rate hike, such as the unemployment rate rising soon, economic growth slowing down significantly, and the stock market downturn, then investor confidence will be affected to a certain extent, and the stock market will be pessimistic. In order to avoid risk, people will buy gold conservatively, resulting the rising of the price of gold.

However, in fact, combined with the data and actual situation, the negative impact of the Fed's interest rate hike on U.S. stocks is very limited, because monetary policy is an important tool for the Fed to smooth economic fluctuations, so the interest rate hike cycle often overlaps with the rising or boom period of the business cycle [9]. Stocks generally perform well, supported by sound economic fundamentals, and growth in corporate earnings often offsets the negative impact of interest rate hikes on stock prices. Moreover, since entering the 21st century, the communication ability of the Fed and the market has been increasing, and the impact of interest rate hikes has usually been absorbed by the market before it officially begins [10]. This also explains why the downward trend in the forecast graph in the methodology section is slight.

5. Conclusion

In conclusion, the findings of this study indicate a notable shift in investor preferences towards more conservative and stable financial planning strategies, attributing it to the reduced market liquidity resulting from interest rate hikes. While theoretical analysis suggests a less favorable outlook for the stock market in the near term, practical analysis reveals that the overall impact of U.S. stocks during an interest rate hike cycle is relatively limited. The study identifies that the initial and final stages of interest rate hikes have the most significant influence on the market. Consequently, it is recommended that investors consider reducing their exposure to U.S. stocks in the foreseeable future and instead explore opportunities in the more liquid and conservative asset class of gold. However, it is important to note that in the long run, U.S. stocks are not necessarily bearish in an absolute sense. Therefore, it is crucial for investors to adopt a rational perspective when assessing the conditions of the U.S. stock market post-rate hike.

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