Prediction of COMEX Gold Futures Prices During the Epidemic Based on the ARIMA Model

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ABSTRACT

Since the COVID-19 appeared in 2019, the price of gold futures has been quite different from the past. We analyzed the supply and demand of gold futures during the epidemic and found some of the reasons for the rise in gold futures prices. Besides, we expect to use the ARIMA to model the COMEX gold futures price during the epidemic and we choose 589 data from December 2, 2019, to April 4, 2022. After some testing, we found that the ARIMA(1,1,3) quite fit the actual prices, although a few points have a large gap between the predicted value and the actual value. We roughly divide these points into three intervals. By analyzing these points, we get the direction of improving the accuracy of this model and give some suggestions in the article. This article can help investors predict the price of COMEX gold futures in a short period, but it cannot completely avoid the impact of some events that have huge fluctuations in the international economy.

Keywords: COVID-19, Demand and supply, Arima model, Prediction

1. INTRODUCTIONTION

1.1 Background

In December 2019, the COVID-19 outbreak broke out and quickly spread across the country, with rising numbers of infections. The epidemic has had a great impact on the world economy, and many industries have been hit hard as a result, and stock prices have fallen dramatically. However, the futures industry is one of the few industries that can make money in an environment of heightened uncertainty. At the same time, gold has value preservation as a precious metal and has become a good choice for resisting risks. Therefore, gold futures performed well under the epidemic situation, and the price showed an overall upward trend.

It is necessary to study the price movements of gold futures. It is inconclusive how long the epidemic will last, with the number of infections still rapidly rising. We can foresee that in the short-term future, we will still coexist with the epidemic. Therefore, it is also necessary to study the price trend of gold futures during the epidemic, because this can help us maintain profitability in the future environment of uncertainty, and then resist risks.

1.2 Related research

The research by Hanitha et al. was conducted on the price of the Composite Stock Price Index of the Indonesian Stock Exchange with the world gold prices, additional covid-19 positive cases, and IHSG from July 2020 to December 2020. The result showed that both Covid-19 cases and the world gold prices have a positive effect on JCI [1]. Moreover, Mensi et al. research studies the impact of the Covid-19 pandemic on the multifractality of gold and oil prices. The research has highlighted that there is high asymmetric multifractality with the increasing scale of intensity. The authors observe a trend reversal, citing that there is a higher downside (upside) trend for Brent oil and gold during the covid-19 pandemic [2]. Akhtaruzzaman et al. investigate the safety of gold and its hedging capacity during the Covid-19 pandemic. The authors use high-frequency data to analyze their argument. The authors highlighted that gold did act as a haven asset for the markets during the first covid wave (phase). However, this was not true in the second wave phase, as hedging costs increased significantly during this phase [3].

The study by Salisu et al. also studies the hedging relationship between US stocks and gold during the Covid-19 pandemic. The authors apply a multivariate volatility framework to find hedging effectiveness between gold and sectoral stocks. According to their analysis, gold proved to be a valuable asset class in a portfolio with stocks and improved the portfolio's risk-adjusted-performance [4]. Furthermore, a study by Salisu et al. intrinsically studies the haven property of gold during the covid-19 pandemic. Using high-frequency data, the authors argue that gold has acted as a haven during the pandemic in the United States. This was in comparison to US stocks as well as other precious metals such as silver and platinum [5]. Drake conducts another study investigating the haven argument for gold. The authors argue a misplaced belief that gold and stocks returns are negatively correlated in times of crisis. To formulate the argument, the authors have used the granger causality test in the time series to argue that the gold-stock relationship is positive during times of negative real returns [6].

A study by Gharib et al. studies the bubble contagion effect of the Covid-19 outbreak, using crude oil and global prices, and the causal relationship between the two. This research also uses the Granger causality test to determine a bilateral contagion effect of bubbles in both oil and gold markets during the Covid-19 outbreak [7]. Similarly, Shaikh studied the relationship between the Covid-19 outbreak and oil, gold prices, gold mining, silver, and energy markets. The authors argue that implied commodity volatility was at an all-time high during the pandemic. The unprecedented volatility rise reflected the positive correlation between volatility and the covid-19 outbreak. There was also an increase in options hedging on these commodities [8]. Salisu et al. focused on hedging the oil price risk with gold during the pandemic. Using the VARMA-GARCH model, the authors argued that gold was an effective commodity to hedge against sudden oil shocks. Their research also went beyond using gold alone as a hedging option and focused on silver, platinum, and palladium as well. The authors highlighted that all three metals were viable hedging options against oil price shocks [9]. Lastly, Sikiru and Salisu studied gold as a hedging option against travel and tourism stock. The authors use data from January 2016 to July 2020 and argue that gold provides an excellent hedge against travel and tourism stock in an optimal portfolio [10].

1.3 Objective

In this paper, we firstly analyze the Gold futures from the supply and demand side under the impact of the epidemic and then we choose the ARIMA (p, d, q) model to forecast the price of gold futures. Finally, we select dates with a high margin of error and study the cause of the error. Through this article, we want to find out the accuracy of this model fitting and its significance for future gold futures price prediction.

2. THE IMPACT OF THE EPIDEMIC ON THE SUPPLY AND DEMAND OF GOLD FUTURES FROM A MACRO PERSPECTIVE

According to the COMEX Futures main contract price, the price of gold future rose from 1593.4 dollars per ounce in January to 1901.6 dollars per ounce in December. From January to March, the gold futures price increased significantly from 1593.4 to 1591 dollars per ounce due to the panic emotion in the market. Then, from March to August, the trend of gold future price saw a second sharp rise from 1591 dollars per ounce to 1973.9 dollars per ounce. On 20 August 2020, it reached its peak at around 2089 dollars per ounce. After that, as Russia announced the registration of COVID-19 vaccines and the yield of American stock and European bonds went up, the attraction of gold went down from August to the end of the year.

Compared with the Dow Jones Industrial Average, we can saw a different trend in gold and stock. the Dow Jones Industrial Average saw a significant drop from 9372 in January to 6797.83 in April in the first season of 2020 due to the widespread COVID-19. However,the price of gold futures rose from1531.6 to 1693.1 at that period of time. It fully reflects the particular demand for safe-haven assets.

Figure1. Dow Jones Industrial Average from January 6, 2020, to November 4, 2021.

Compared with the gold future, the price of other futures suffered a lot due to COVID-19. For instance, the price of NYMEX oil decreased from 61.18 dollars per barrel in January to 13.12 dollars per barrel in April. This fact emphasizes again the importance of gold as a tool to hedge risks.

2.1 The demand side of gold futures

At the beginning of 2020, COVID-19 spread through the whole world, which causes a great influence on the world economy, especially on the future market. For many future products, it may not be good news, but it is great for gold futures.

2.1.1. loose monetary policy

One of the reasons for gold's price rise due to the outbreak may be the loose monetary policy brought about by the outbreak. Since the outbreak of the crisis caused by the epidemic, the Federal Reserve has continuously adopted quantitative easing policies, and the world's economic powers are also implementing loose monetary policies. The implementation of quantitative easing will push up the price of gold. If the quantitative easing policy is not implemented, the upward trend of gold will be slow. If gold does not rise anymore, it can be said that the world economy will stagnate, that is, the Great Depression of the world economy is coming, so the implementation of Quantitative easing is the best way to stimulate the economy, thereby driving gold to rise. The information provided by COMEX (NYSE) database evaluates how gold futures prices have fared against real interest rates (as represented by H15X5YR Index):
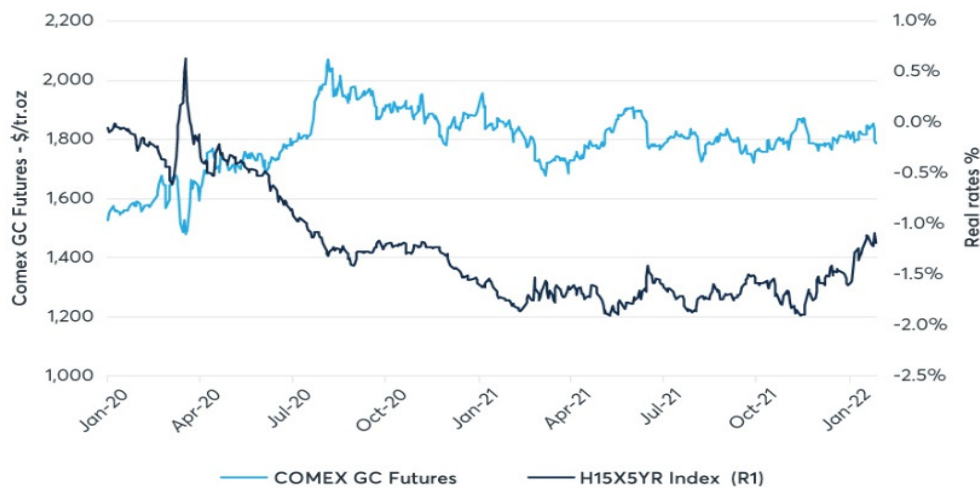

Figure 2. The comparison of COMEX GC Future price and real interest rate from January 20, 2020, to January 22, 2022

The graph above is an indication of how gold futures have fared against the non-inflation index. The low-interest rate reduces the cost of carrying the gold.

2.1.2 hedging risks

At a time when other traditional investment alternatives such as equity were witnessing significant falls, gold futures continued to increase in value, thereby implying that on a macro level, the investor sentiment is favorable towards gold as a commodity. Amid the pandemic, the panic brought by the high infection and death rate of COVID-19 also cause great panic among investors all over the world. Under the circumstance of great uncertainty about the risk of the epidemic, the futures industry is a good choice for hedging. The value-preserving properties of gold make gold futures more attractive. Therefore, in the case of large fluctuations in the capital market, the continuous appreciation of gold futures makes sense.

Since the economy is moving back towards normalcy, one could not completely write off the probability of future volatility. Hence, gold futures can continue to gain value largely due to the fluctuations in the prices of other securities and the inherent safe nature of gold as a commodity. This is something that has been underlined through the price analysis of gold futures in the past couple of years along with findings of different researchers and scholars.

2.1.3 other benefits

In addition, the break-out in cross-border transportation is impossible for spot transactions. So investors search for ways to avoid risks and reduce their stake in other assets such as stock, which lead to the high demand for gold futures.

2.2 The supply side of gold futures

The supply of the world gold market mainly comes from the following aspect: mine production and regenerated gold. However, because of the decrease in international air traffic and the close-down of mines around the world, gold cannot be supplied to the market at a normal price so the amount of gold supply cannot keep up with the demand, which leads to the panic market and price soar in the gold market.
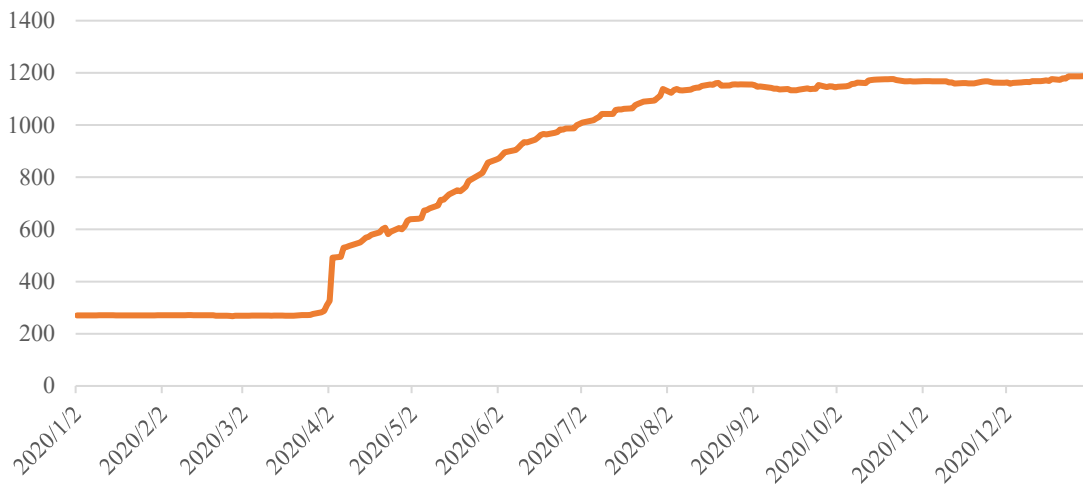

Figure 3. COMEX Gold inventory from January 2, 2020, to December 2, 2020.

3. MODELING AND FORECASTING OF COMEX GOLD FUTURES PRICES

3.1 Basic theory of ARIMA model and its modeling steps

3.1.1 Basic theory of the ARIMA model

The ARIMA model, also known as the autoregressive moving average model with a difference, includes three main parameters: the autoregressive order (p), the moving average order (q), and the different order (d). For a non-stationary time series model, we need to differentiate it d times to make it a stationary model in

the modeling process, and then use ARMA(p, q), then the original time series is an ARIMA(p,d,q) model.

3.1.2 The modeling steps of the ARIMA model

The modeling process mainly includes the following five steps:

Step 1: Pre-processing of time series. Using the analysis results of the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the time series to identify the stationarity of the time series. If the time series is non-stationary, the data needs to be differentiated to determine the order d of the ARIMA (p, d, q) model;

Step 2: Identify the model. According to the Akaike information criterion (AIC criterion) and Bayesian information criterion (BIC criterion) to determine the appropriate ARIMA (P, d, q) model P and q values for fitting;

Step 3: Determinate the model. Find the corresponding formula according to the determined parameters in the previous section.

Step 4: Hypothesis testing of the model. Check whether the residual sequence is white noise;

Step 5: Predict. Use the ARIMA model to make short-term predictions on the future trend of the original sequence.

3.2 Model the COMEX gold futures price

3.2.1 Source of sample data and its pre-processing

The data selected in this paper comes from the closing price (USD/oz) of each trading day of COMEX gold on the New York Mercantile Exchange. The data range is from December 2, 2019, to April 4, 2022, with a total of 589 data. We use the software MATLAB R2018a to complete.

The gold price series is a non-stationary process, so it is necessary to perform differential processing on the data to eliminate the trend and seasonality of the data. It is found that after the first-order difference of the original data, the influence of the long-term trend is eliminated, and the sequence tends to be stable. Therefore, an ARIMA (p, 1, q) model can be established.

3.2.2 Identification of the gold futures price model

Since d is determined to be 1, it is necessary to identify the p and q values of the model. We use the AIC criterion and the BIC criterion to determine the optimal p and q values.

$$AI = -2\ln(L) + 2k \tag{1}$$

$$IC = -2\ln(L) + k\ln(n) \tag{2}$$

L is the likelihood function of the model parameters, n is the width of the sequence, and k is the number of parameters.

The AIC criterion and the BIC criterion are the trade-offs between the likelihood function and the number of parameters. When the order p and q increase, $2\ln(n)$ will increase, and 2k will also increase. We want both the larger the likelihood function and the smaller the number of parameters. Therefore, there is an optimal value for AIC and BIC. Our search for the best order is to find the combination of p and q that maximizes AIC and BIC. By running the program, it is optimal that p takes 1 and q takes3. Therefore, the ARIMA (1,1, 3) model is selected to model the gold price series.

3.2.3 Modelling the gold futures price

According to the conclusion in the previous section, this paper selects ARIMA (1,1,3) model as the best prediction model of gold future price, and its corresponding formula is as follows:

$$gold\ future p_t = -0.91 * goldfuture_{t-1} -0.03 * \varepsilon_{t-1} -0.91 * \varepsilon_{t-2} -0.06 \quad * \varepsilon_{t-3} - 0.03 \tag{3}$$

Table 1. ARIMA(1,1,3) Model (Gaussian Distribution):

	Value	Standard Error	TStatistic	PValue
Constant	-0.031604	0.028168	-1.122	0.26187
AR{1}	-0.91498	0.18755	-4.8787	1.0679e-06
MA{1}	-0.032077	0.19733	-0.16255	0.87087
MA{2}	-0.90893	0.18703	-4.8598	1.1751e-06
MA{3}	-0.058995	0.043032	-1.371	0.17039
Variance	404.47	16.986	23.812	2.487e-125

3.2.4 Hypothesis testing of gold futures price model

After the unknown parameters of the model are estimated, the residual of the model needs to be tested by white noise. If the residual is white noise, it indicates that

the model fitting effect is good, and the residual is pure random data that cannot be captured. If the residual is not white noise, it indicates that the model still has some problems. If parameters are not properly adjusted, the model needs to be further optimized until the residual is white noise. Figure 5 shows the test results of the residual sequence tested by MATLAB(R2018a):
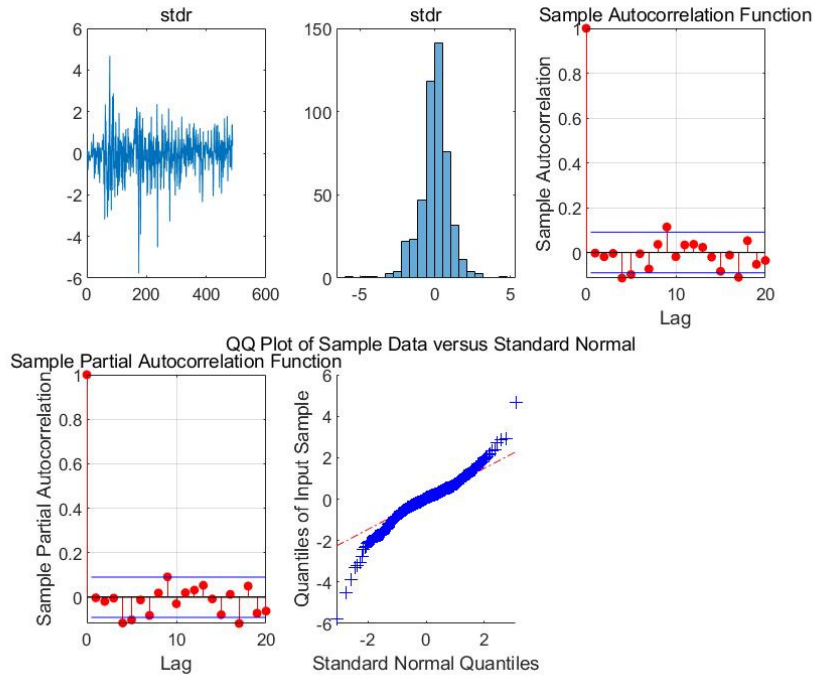
Figure 4. Residual results and ACF and PACF and Quantile-Quantile plot in the model

As can be seen from figure 4, residual results follow a normal distribution, and ACF and PACF are not significantly different from 0. Points in the Quantile-Quantile plot are approximately near a straight line, and the graph is a straight line, which further indicates that residual results follow a normal distribution. It means that there is little difference between the target accumulative distribution function graph and the standard accumulative distribution function graph.

At the same time, we use Durbin-Watson Test to test the autocorrelation of random error terms. The result of 2.002 indicates that there is no autocorrelation between error terms. Hence, it can be considered that the random error term of the established model is a white noise sequence, and the establishment of the model meets the requirements.

3.3 Forecast and analysis of gold futures price

The prediction of this model is based on the existing gold futures closing price time-series historical data, through the establishment of ARIMA model to predict the gold futures price in a period in the future. According to the prediction results of the first-order difference value, we can see that all predicted values fall within the 95% confidence interval, which further illustrates the prediction accuracy of this model.
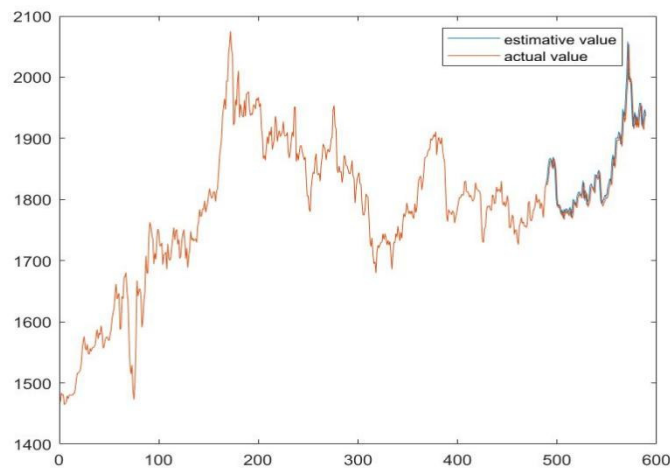

Figure 5. The Prediction result of stock price

From figure 5, we can see that the predicted value was very close to the actual value, it shows that the prediction effect of the model is very good and we can use it to predict the future price of gold futures.

4. DEVIATION ANALYSIS

The overall fitting effect of our model is perfect, our average percentage deviation is 0.72%. However, there are still some points with large deviations between the predicted and actual values. We conducted a specific cause analysis.

Table 2. the predict and data deviation percentage on the date December 16, 2021

date	actual price	predict price	deviation percentage
2021-12-16	1800.40	1774.48	1.44%

On December 16 the fed interest rates have been cut, and the non-ferrous futures market witnessed a significant amount of gap between actual and forecast prices. It was $25.919 less than the actual value with a deviation percentage of 1.44%(49.66% more than the average deviation percentage). Cutting interest rates was repressing the US dollar's short-term exchange rate, which constitutes a positive effect on the US dollar-denominated non-ferrous metal prices. In addition, inflation expectations in the US also rose, which might give a boost to precious metals such as gold.

Table 3. the predicted data and deviation percentage from February 11 to February 17 in 2022

date	actual price	predict price	deviation percentage
2022-02-11	1,860.60	1823.73	1.98%
2022-02-14	1,873.10	1857.02	0.86%
2022-02-15	1,855.10	1869.50	0.78%
2022-02-16	1,871.50	1851.49	1.07%
2022-02-17	1,900.70	1867.87	1.73%

During the period from February 11 to February 17, the average deviation percentage is 1.28% (43.5% above the average deviation percentage). The instability of the situation in Russia and Ukraine during this period has had a great impact on the world economy. Relations between

Russia and Ukraine have intensified since the U.S. Department of Defence announced on February 2 that it would send additional troops to Europe to deal with tensions on the Russian-Ukrainian border. On February 17, a military conflict broke out between the Ukrainian military and the eastern Ukrainian civilian armed forces. Tensions in eastern Ukraine continued to escalate. Russia and Ukraine, as important suppliers of global energy, industrial raw materials, and agricultural products, as well as important transportation channels connecting Eurasia, are important players in major global industries.

In addition, since the conflict between Russia and Ukraine, the United States and the West have imposed unprecedented sanctions on Russia. Financial sanctions are particularly severe. They have successively frozen the overseas assets of the Russian Central Bank and kicked Russia's major banks out of the Society for Worldwide Interbank Financial Telecommunication (SWIFT). The US Treasury Department even banned the Russian government from repaying US dollar debts through US bank accounts. Russia's reserve assets of up to hundreds of billions of dollars have been frozen, casting a shadow over the stability and reliability of the international monetary and financial system. Investors' risk aversion has increased again, so they seek the safety of hedged futures such as gold, resulting in our generally lower forecast for gold.

Table 4. the predicted data and deviation percentage from March 8 to March 9 in 2022

date	actual price	predict price	deviation percentage
2022-03-08	2,058.3000	1997.970707	2.93%
2022-03-09	1,995.7000	2054.45424	2.94%

On March 8, compared with the real data, forecasting is of low absolute deviation. It was $60.3293 less than the actual value with a deviation percentage of 2.93%. In fact, on that day, affected by the war between Russia and Ukraine, global stock markets suffered Black Monday again, with the Dow and S&P 500 falling more than 2% and the Nasdaq plunging 3.6%, plunging into a bear market. Germany's DAX and the Euro zone's Stoxx 50 also closed in the bear territory. In the contrast, U.S. and Brent oil closed up more than 4% on Monday; Lunni closed up more than 66 percent at its highest level since 2007. Affected by the uncertain factors such as the plunge of the ruble and the economic sanctions on Russian commodities brought by the war, risk aversion among investors was on the rise again, so they sought the safety of hedging futures like gold, which led to the lower prediction on gold on that day as we didn't take the impact of the war into account.

However, on March 9, the predictive value was $58.7542 higher than the actual value with a deviation percentage of 2.94%. The primary reason behind that may be being affected by the considerable increase in the price of gold future at the beginning of March, the price of the predictive value went up as well. However, it didn't predict the technical adjustments in the gold price. So the value shows a large deviation on that day. It also shows that models take little account of market sentiment.

5. CONCLUSION

Through the studies above, we use ARIMA (1,1, 3) model with 589 data from December 2, 2019, to April 4, 2022, to forecast the price of gold futures. Based on the examination of the model, we can guarantee the accuracy of the model and use it to predict and plot the price. We also select three time periods with a wider margin of variation to analyze the reasons behind them.

Under the impact of the epidemic, as people's hedge demand magnifies, the price of the gold futures rises significantly. We also find that this model cannot predict and counter fluctuations and emergencies that have a great impact on the international economy such as cuts in the interest rate and required reserve ratio, and the war between Russia and Ukraine as mentioned before.

In general, for investors, it is feasible to use this model to predict the future gold futures price. However, investors also need to keep an eye on international developments and policy changes which cannot be shown in modeling change investment strategies in time in case of great losses.

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