Dynamic Changes in Noble Metal during Period of Local Conflict: Evidence from Soaring Crude Oil Price

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Abstract. The Russia-Ukraine conflict officially began on February 24, 2022, when Russia conducted a special military operation in Ukraine. Crude oil prices have soared since the start of the conflict and have had a significant impact on the noble metals industry. In this paper, gold and silver are selected as the representatives of precious metals, and the data of crude oil, gold, and silver from June 2021 to August 2022 are captured. The VAR model is used to draw the impulse response diagram to explore the impact of oil price increase on gold and silver prices, finding that the sharp rise in international crude oil prices caused by the conflict between Russia and Ukraine led to the rise in your financial market. Then, the ARMA-GARCH model is used to study how the prices of gold and silver are affected by the conflict between Russia and Ukraine, concluding that the increase of oil price does not increase the volatility of gold return, but it has a significant positive impact on the volatility of silver yield. And as the conflict between Russia and Ukraine continues, this effect will gradually weaken.

Keywords: VAR model, ARMA-GARCH, crude oil, noble mentals.

1. Introduction

On February 24, 2022, Russia launched a military operation against Ukraine and the Russia-Ukraine conflict broke out in full force. As the situation between Russia and Ukraine continued to deteriorate, the U.S., Europe and other Western countries-imposed sanctions on Russia, strongly impacting Russian crude oil exports, causing crude oil supply tensions and price spikes worldwide, exacerbating the global energy crisis and the risk of economic stagflation.

Organization of Since the industrial revolution in the West, oil has been an important strategic material for the operation of modern industrial society, and it plays a pivotal role in the international political, economic, and financial fields. Russia is the world's leading oil producer and exporter. In 2020, its oil production was the second largest in the world, after the United States; its oil exports were also the second largest in the world, after Saudi Arabia. Russia's main oil exports are to Europe. 48% of Russia's crude oil and condensate exports in 2020 went to OECD European countries, with larger volumes going to the Netherlands, Germany and Poland, accounting for 11%, 11% and 7%, respectively [1]. After the outbreak of the Russia-Ukraine conflict, the U.S.-led Western countries launched energy sanctions against Russia, and Russia took countermeasures. Until August 2022, the energy struggle between the West and Russia has already had a major impact on the world's oil supply and prices, which reflected in the significant increase in crude oil prices and has led to profound changes in the global energy landscape (please see Figure 1).

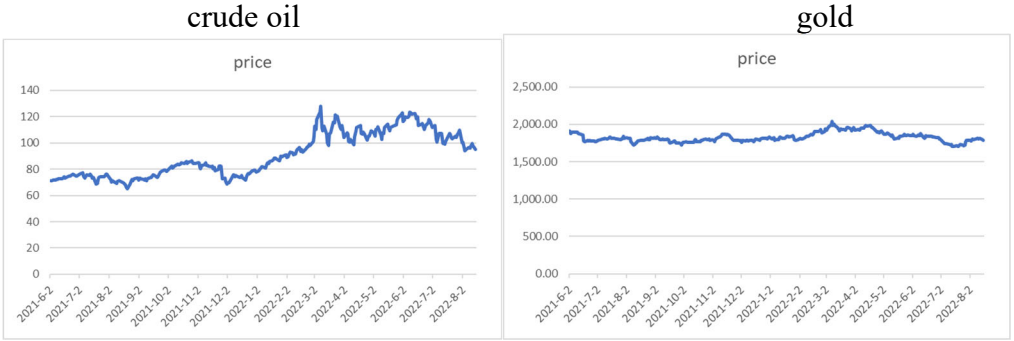

Fig. 1 Price of crude oil and gold

At the same time, the reserves of noble metals represented by gold and silver are taken by countries as an important means to protect their economic security and cope with inflation. Therefore, crude oil and noble metals are used as strategic reserves by countries all over the world. As noble metals and crude oil are actively traded on the international commodity market, their price changes will affect the world economy, and their relationship in the context of the Russia-Ukraine conflict is worth exploring.

The rest of this paper is organized as follows: Part 2 is the literature review, which includes the relevant research on the cause and the impact of the Russia-Ukraine conflict. It also contains the research gap in this literature, which is the question to be studied in this paper. After that is part 3, which uses VAR model and impulse and response graph to explore the impact on gold and silver yields as crude oil prices soar. Then part 4 will conduct ARMA-GARCH model to predict the gold and silver yields and volatility. Finally, part 5 will draw conclusions and give feasible and innovative suggestions for the investment in gold and silver.

2. LITERATURE REVIEW

2.1 Studies related to the Russia-Ukarine conflict

After the collapse of the Soviet Union, Russia, the successor of the Soviet Union's declining strength, once hoped to exchange compromise and concession for the acceptance of the Western camp, but faced with the continuous strategic squeeze of NATO led by the United States, with the Munich Conference in 2007 as a turning point, the Western attitude towards the United States turned to be stronger. With the five rounds of eastward expansion of NATO, the Commonwealth of Independent States (CIS) countries that are regarded as strategic barriers by Russia have joined NATO, and Ukraine has become the geopolitical intersection of NATO and Russia. Russia sees Ukraine as the last bulwark against NATO expansion; NATO actively courted Ukraine, signed a series of cooperation agreements, regularly held high-level talks, constantly conducted military exercises to deepen military cooperation... Ukraine with NATO's gradually close direct contact to touch the Russian defense of geopolitical "buffer" of the red line, the latter repeatedly urged NATO not seek, receive and surrounding countries such as Ukraine to join NATO is not deployed in these countries, threatening weapon, but did not get response, until February 24, 2022 in Russia, buss to launch a special military action, The conflict between Russia and Ukraine has officially erupted [2].

2.2 Studies related to the rise in crude oil prices after the Russia-Ukraine conflict

Russia is one of the world's largest producers and exporters of crude oil, with proven oil reserves of 107.8 billion barrels at the end of 2020, accounting for 6.2 percent of the world's total proven oil reserves, according to the BP Statistical Yearbook of World Energy (2021). In 2021, Russian oil production reached 10.5 million barrels a day, with a total output of 534 million tons, second only to the United States (557 million tons) and accounting for 12 percent of global crude oil production. Russia exported 229 million tons of oil in 2021, second only to Saudi Arabia, to 36 countries, according to Federal customs statistics [1].

Since 2022, geopolitical tensions, increased sanctions against Russia by the West, limited production increases by major oil producers, and expansionary economic policies of the US and other major economies have led to a sharp rise in global crude oil prices in the first quarter of 2022. On March 8, 2022, the price of Brent crude oil briefly breached $130/BBL, the highest since 2014. In June 2022, the spot price of Brent crude oil averaged $106.9/BBL, up 64.9% year on year; the average WTI crude oil price was $101.6/BBL, up 64.0% year on year. The OPEC basket averaged $105.0, up 64.2% from a year earlier [3]. Looking ahead, oil prices are likely to remain high as the end of the pandemic remains uncertain and the conflict between Russia and Ukraine continues in the near term [4]. The current trend of international oil price mainly depends on the duration of the conflict between Russia and Ukraine. When the conflict tends to ease, the international oil and gas price will gradually return to rationality [5].

Based on the current situation, if the conflict ends by the end of 2022, the average price of Brent crude oil is expected to be around $100 / BBL in 2022 and $70-80 / BBL in 2023. If the war goes on for a long time, international oil prices are expected to stay around $100 / barrel for a long time [5].

2.3 2.3 Studies related to the correlation between noble metals and crude oil

As a representative of precious metals, the price relationship between gold and crude oil is a research hotspot in recent years. Among them, Tam Yaling [6] analyzed the price of gold and crude oil in the late 19th century to the early 20th century from a variety of angles, and drew the conclusion that gold and oil prices were in the opposite direction. Narayan and Zhang verified the existence of long-term stable relationship between gold and oil market by using cointegration relationship, indicating that oil market can be used to predict gold market price [7].

2.4 Review of the literature

In general, there are many studies on the cause and process of the Russia-Ukraine war and its impact on the price of crude oil. However, there are few studies on the price changes of noble metals such as gold and silver under the background of the sharp rise in the price of crude oil. Some scholars have found that the correlation between gold and oil changes after special events. Liu Shasha divided the prices of gold and oil in 20 years into intervals and found that the correlation between them would change under special events [8]. Thus, it is difficult to predict the development and trend of noble metal investment industry in the future. Therefore, this paper hopes to further fill the gap in this field and use empirical data to prove the impact of the Russo-Ukrainian war on the development of the noble metal market.

3. RESEARCH DESIGN

3.1 Data source

This paper uses the wind financial terminal [9], a search engine, to search and obtain the data of gold price, silver price and brent crude oil futures price, from June 2021 to August 2022. The remainder of this article will use these data as the data source and data base for the empirical analysis of the impact of the Russian-Ukrainian conflict on the international noble metals market.

3.2 Data processing

Before the model deduction, the data need to be preprocessed to calculate the log prices and log returns of gold, silver and crude oil, so as to facilitate the stationarity test. The specific calculation formula is shown in below.

$$P_t = \ln(1 + p_t) \tag{1}$$

$$Y_t = \ln(1 + y_t) \tag{2}$$

$$y_t = \frac{p_t - p_{t-1}}{p_{t-1}} \tag{3}$$

Before analyzing the time series model, it is necessary to ensure that the time series are stationary. Therefore, after obtaining the logarithmic original series and the logarithmic rate of return, the ADF test is conducted on them, and its null hypothesis is that the series is not stationary. After importing the data into STATA and using ADF test, Table 1 shows that the p-values of logarithmic return rate are all 0, less than 0.01, so the null hypothesis is rejected and the logarithmic return rate series is stationary.

Table 1. ADF test

	Variables	t-statistic	p-value
Price			
	Gold	-2.441	0.3580
	Silver	-2.286	0.4417
	Brent	-2.292	0.4385
Yield			
	Gold	-13.815	0.0000***
	Silver	-12.963	0.0000***
	Brent	-12.703	0.0000***

3.3 Model specification: VAR model

The vector autoregression model proposed by Sims [10] in 1980 is a regression model to analyze the influence of the lag term of a variable on the current variable. The impulse response function included in the model can detect the influence of the change of each variable on the self and other variables. Therefore, this paper uses VAR model to explore the impact of oil price rise on gold and silver prices.

$$y_{1t} = \beta_{10} + \beta_{11}y_{1,t-1} + \cdots + \beta_{1p}y_{1,t-p} + \gamma_{11}y_{2,t-1} + \cdots + \gamma_{1p}y_{2,t-p} + \alpha_{11}y_{3,t-1} + \cdots + \alpha_{1p}y_{3,t-p} + \varepsilon_{1t} \quad (4)$$

$$y_{2t} = \beta_{20} + \beta_{21}y_{1,t-1} + \cdots + \beta_{2p}y_{1,t-p} + \gamma_{21}y_{2,t-1} + \cdots + \gamma_{2p}y_{2,t-p} + \alpha_{21}y_{3,t-1} + \cdots + \alpha_{2p}y_{3,t-p} + \varepsilon_{2t} \quad (5)$$

$$y_{3t} = \beta_{30} + \beta_{31}y_{1,t-1} + \cdots + \beta_{3p}y_{1,t-p} + \gamma_{31}y_{2,t-1} + \cdots + \gamma_{3p}y_{2,t-p} + \alpha_{31}y_{3,t-1} + \cdots + \alpha_{3p}y_{3,t-p} + \varepsilon_{3t} \quad (6)$$

Where y_{1t}, y_{2t}, y_{3t} represent the log returns of oil, silver and gold, respectively, They are also respectively used as the explained variables of the three regression equations, and the explanatory variables are the P-order lag values of the three variables, which constitute a tetradic VAR(P) system, where the lag order P needs to be determined by further experiments.

The VAR(P) system above can also be written as:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \\ \beta_{30} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \gamma_{11} & \alpha_{11} \\ \beta_{21} & \gamma_{21} & \alpha_{21} \\ \beta_{31} & \gamma_{31} & \alpha_{31} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \\ y_{3,t-1} \end{bmatrix} + \cdots + \begin{bmatrix} \beta_{1p} & \gamma_{1p} & \alpha_{1p} \\ \beta_{2p} & \gamma_{2p} & \alpha_{2p} \\ \beta_{3p} & \gamma_{3p} & \alpha_{3p} \end{bmatrix} \begin{bmatrix} y_{1,t-p} \\ y_{2,t-p} \\ y_{3,t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \quad (7)$$

Let $y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix}$, $\varepsilon_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$, $\Gamma_p = \begin{bmatrix} \beta_{1p} & \gamma_{1p} & \alpha_{1p} \\ \beta_{2p} & \gamma_{2p} & \alpha_{1p} \\ \beta_{3p} & \gamma_{3p} & \alpha_{1p} \end{bmatrix}$, Then it has

$$y_t = \Gamma_0 + \Gamma_1 y_{t-1} + \cdots + \Gamma_p y_{t-p} + \varepsilon_t \quad (8)$$

Then LR criterion is used to determine p.

3.4 Model specification: ARMA

$$x_t = \phi_0 + \sum_{i=1}^{p} \phi_i x_{t-i} + \varepsilon_t + \sum_{i=1}^{q} \varphi_i \varepsilon_{t-i} \quad (9)$$

From equation above, $\phi_0 + \sum_{i=1}^{p} \phi_i x_{t-i}$ represents the AR(p) model, which uses the historical log returns of gold and silver to predict future. While $\varepsilon_t + \sum_{i=1}^{q} \varphi_i \varepsilon_{t-i}$ represents the MA(q) model, which uses the past volatility to forecast the future.

3.5 Model specification: GARCH

In financial time series, cluster effect often occurs, and its variance is basically homogeneity, but there is a certain period or several periods of square difference and expected variance. Therefore, the analysis method based on homogeneity variance cannot be accurately fitted. Elasticity, in general, means that you should use the conditional variance model, and the ARCH (Autoregressive conditional heteroscedasticity) model proposed by Engle [11] is just a model to solve conditional heteroscedasticity, but in ARCH model, should the delay term be large, the sample size will be lost. Therefore, Bollerslev [12] proposed a GARCH (Generalized ARCH) model on the basis of his research to reduce the parameters to be estimated. The principle is that the autoregressive part of σ_t^2 is added to the ARCH model.

The model GARCH (p, q) is set as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \cdots + \alpha_q\varepsilon_{t-q}^2 + \gamma_1\sigma_{t-1}^2 + \cdots + \gamma_p\sigma_{t-q}^2 \quad (10)$$

In equation above, the term $\alpha_1\varepsilon_{t-1}^2 + \cdots + \alpha_q\varepsilon_{t-q}^2$ represents the ARCH part, and $\gamma_1\sigma_{t-1}^2 + \cdots + \gamma_p\sigma_{t-q}^2$ represents the GARCH part. σ_t^2 is the conditional variance of the disturbance term ε_t. σ_t^2 depends on the square of the disturbance term in the previous q periods.

GARCH model is designed to reduce the number of parameters. ARCH(p) can be simplified as GARCH (1,1) by iteration.

4. EMPIRICAL RESULTS

4.1 VAR model

4.1.1 Identify p: Order based on information criteria

The data is imported into Stata and the information criteria for the different methods are calculated as shown in Table 2.

Here using the LR criterion to determine the lag order p: when the increase of lag period of VAR model does not bring significant increase to the maximum likelihood function value, that is, when the value of LR statistic is less than the critical value, the newly added lag variable is meaningless to VAR model. In Table 2, increasing the lag order of LR statistic at the 10th order cannot bring a significant increase in the maximum likelihood function value, so the lag order is 10, that is, P =10.

Table 2. VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	2528.47				5.8e-12*	-17.3572*	-17.342*	-17.3193*
1	2531.96	6.9768	9	0.640	6.0e-12	-17.3193	-17.2586	-17.1678
2	2540.2	16.478	9	0.058	6.1e-12	-17.3141	-17.2079	-17.049
3	2545.6	10.813	9	0.289	6.2e-12	-17.2894	-17.1377	-16.9107
4	2553.19	15.176	9	0.086	6.3e-12	-17.2797	-17.0824	-16.7874
5	2559.77	13.158	9	0.156	6.4e-12	-17.263	-17.0203	-16.6571
6	2564.65	9.7625	9	0.370	6.6e-12	-17.2347	-16.9465	-16.6571
7	2569.24	9.1781	9	0.421	6.8e-12	-17.2044	-16.8706	-16.3713
8	2574.35	9.1781	9	0.332	7.0e-12	-17.1777	-16.7984	-16.231
9	2578.9	9.0914	9	0.429	7.2e-12	-17.1471	-16.7223	-16.0867
10	2586.98	16.158	9	0.064	7.2e-12	-17.1407	-16.6705	-15.9668
11	2592.47	10.988	9	0.276	7.4e-12	-17.1166	-16.6008	-15.8291
12	2596.65	8.3537	9	0.499	7.7e-12	-17.0835	-16.5222	-15.6823

4.1.2 Model test

The stability of VAR (10) model needs to be tested. The necessary and sufficient condition for VAR (10) model stability is that all eigenvalues of Γ_1 must be in the unit circle. The unit circle created using Stata is shown in Figure 2.

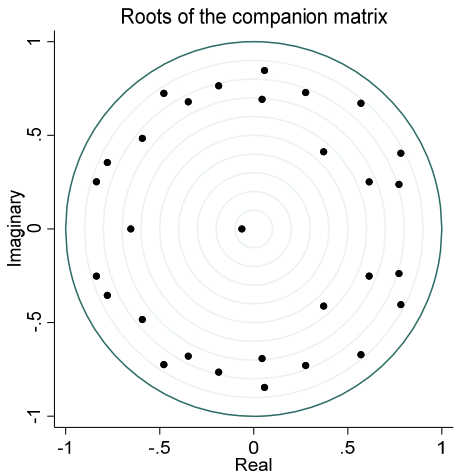

Fig. 2 Unit circle test

As can be seen from Figure 2, all points are in the unit circle, so the VAR (10) system is stationary.

4.1.3 impulse response function

In order to find the dynamic correlation between the price of gold and silver and the price of crude oil, the corresponding impulse and response plot should be made.

$$\frac{\partial y_{t+s}}{\partial \varepsilon_t'} = \psi_s \tag{8}$$

It expresses the influence on the value $y_{i,t+S}$ of the i-th variable in the (t+s)-th period when the error term a of the j-th variable in the t-th period increases by 1 unit. Treating $\frac{\partial y_{i,t+s}}{\partial \varepsilon_{jt}}$ as a function of the time interval s is the impulse response function.

The impulse response diagram is shown in Figure 3.

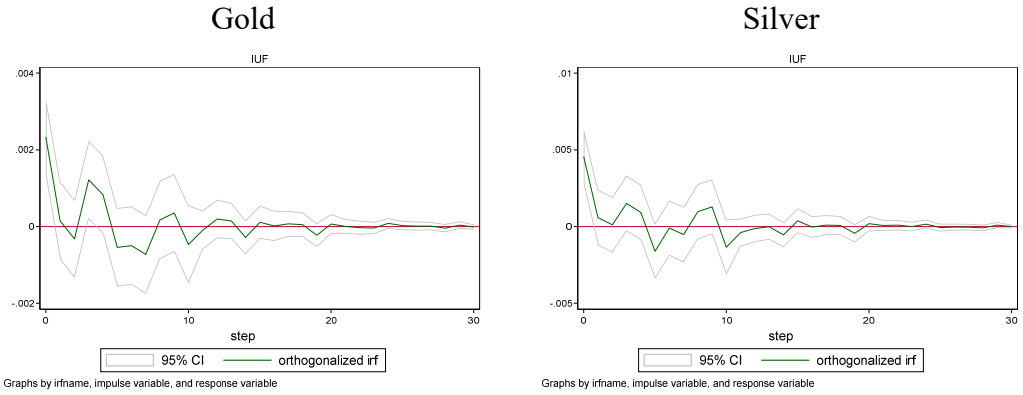

Fig. 3 Impulse and response

According to the estimated results of impulse response (Figure 3), the sharp rise in international crude oil price caused by the conflict between Russia and Ukraine led to the rapid decline of financial market.

Specifically, in the period t=0, the oil futures price rose by 1%, and the net effect on the gold yield was positive. The highest value appeared in the current period, which was slightly more than 0.2%, and the second highest value appeared in the third period, which was slightly more than 0.1%. Higher international crude oil prices have a greater impact on silver, with an effect of nearly 0.5% in period t=0, about twice that of gold. As far as the time effect is concerned, the shock in the current period

gradually disappears after 10 periods. Note that if the oil shock is sustained, gold and silver prices will continue to rise.

The above results show that the Russia-Ukraine conflict, as a regional conflict, has brought some panic to the international market to a certain extent, and the yield of haven assets has increased.

4.2 ARMA-GARCH

4.2.1 ACF and PACF

In this section of the article, it is first necessary to order the log-return series using the PACF and ACF pairs, the results of which are shown below.

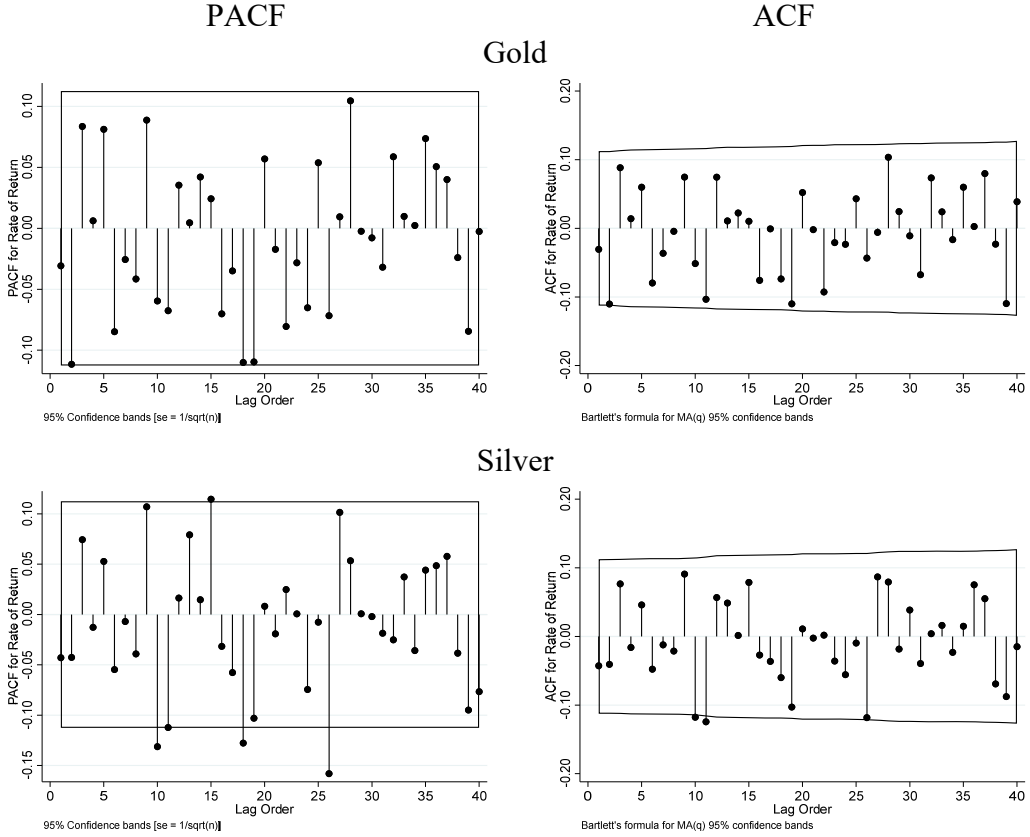

Fig. 4 PACF and ACF

From the fixed order result of the two images in the first row in Figure 4, Although some parts reach the edge of the receptive field, but not significantly beyond, for both PACF and ACF plots. So for the sake of simplicity, let's set AR(p) is of order 0, MA(q) is of order 0, that is, p = q = 0.

From the fixed order result of the two images in the second row in Figure 3. the first part beyond the x-axis is 10, so AR(p) is of order 10, MA(q) is also of order 10, so the value of p and q are all equal to 10.

4.2.2 Model results

To better forecast the variance of future gold and silver returns, the ARCH model is next used to look at the characteristics of gold and silver yield volatility. And the consequences are shown in Figure 5.

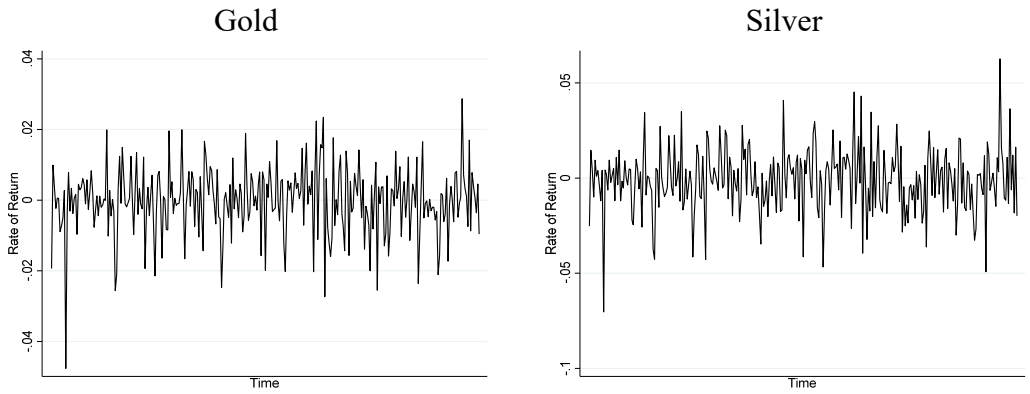

Fig. 5 Yield trend

The time series plot shows that there is a relatively significant aggregation of returns for gold and silver. In financial econometric language this means that when the volatility (variance) is greater in the current period or a few past periods, the volatility (variance) is likely to be greater in future periods, and vice versa. However, whether the effect is statistically significant requires further empirical testing. So the data will be imported into Stata and then the ARMA-GARCH model will be used to forecast the volatility of gold and silver returns using the log crude oil return as an external explanatory variable, and the results are shown in Table 3.

Table 3. ARMA-GARCHX estimation results, variance equation

VARiables	(1) Gold			(2) Silver		
	Coefficient	Std.err	p>|Z|	Coefficient	Std.err	p>|Z|
Crude oil	-1.0444	0.7629	0.171	20.5300	5.4487	0.000
ARCH (-1)	0.0299	0.0194		-0.0632	0.0174	0.000
			0.122			
GARCH (-1)	-0.9044	0.0836	0.000	0.8982	0.0592	0.000
Constant	-8.6547	0.0692	0.000	-10.1528	0.4440	0.000

The estimation results from the ARMA-GARCHX model (Table 3) show that the GARCH term for gold returns is significant, and both the GARCH and ARCH terms for silver returns are significant. The above results indicate that there is statistically significant conditional heteroskedasticity in the returns of both gold and silver for GARCH modeling. The results from the estimation of the external explanatory variables show that higher oil prices do not increase the volatility of gold returns, but have a significant positive effect on the volatility of silver returns. Specifically, a 1 unit increase in the log return of oil increases the volatility of silver returns by 20.5300 units.

5. Conclusion

The main objective of this paper is to explore the impact of the precious metals industry in the context of the sharp increase in crude oil prices caused by the conflict between Russia and Ukraine, and to predict the future trend of the precious metals market.

By constructing the VAR model and drawing the impulse response diagram, it can be seen that in general, the sharp rise in the national crude oil price caused by the Russia-Ukraine conflict will lead to the rise of the precious metal market, but this impact will not last, showing that the rise of the precious metal market will gradually decrease until it disappears after a period of time.

By using the ARMA-GARCH model, it can be seen that the increase of crude oil price has a more dramatic impact on the volatility of silver return, which means that the uncertainty of silver return is greater than that of gold purchase. However, as analyzed by the impulse response function before, the rise of crude oil price has a more significant impact on the return of silver. Combining the results of these two analyses, buying silver is likely to bring a greater return, but also a greater risk.

Looking forward, if there is no major change in the conflict between Russia and Ukraine, the volatility of the precious metals market will gradually abate as the current trend continues. Buyers should monitor the international situation during this period and maximize risk to maximize returns.

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