Crude Oil Price, Capital Flows and Changes in Noble Metal Market: A Short-term Perspective

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Abstract. Since the conflict between Russia and Ukraine, the rapid rise in oil prices, the depreciation of the ruble and the fluctuations in precious metals prices have become issues of concern for investors. This paper discovers the relationship between precious metals, oil and the exchange rate of USD and ruble in the context of the Russia-Ukraine conflict approved Impulse response, and ARMA-GARCH estimation. The study figures out that during the chosen period, the increase in oil prices at the beginning of the Russian-Ukraine conflict resulted in an increase in precious metal prices. Additionally, the decrease of USBRUB is as well positively correlated with the price of precious metals as the price of precious metals. This paper suggests investors to study the relationship between the precious dollars and US dollars before the investment on account of the use of the substitution relationship and the same direction change relationship between them can help to estimate the possible investment risk and return. As considering the interaction between the three, this paper suggests the government to build a strategic petroleum reserve and established the foreign exchange reserves.

Keywords: Oil Prices, Precious metal prices, US dollars index, Exchange rate of USDRUB, Russia-Ukraine conflict.

1. Introduction

On February 17, 2022, the situation in eastern Ukraine deteriorated. Due to that Russia's troop deployment in eastern Ukraine, the energy market was in a panic. Under the background of this, international oil prices started to rise, and then the Fed's rate hike triggered a second rise in oil prices. Furthermore, since the conflict between Russia and Ukraine, the Ruble has depreciated due to sanctions from Western countries, withdrawal of foreign capital and other factors.

As a "hard currency" with the attributes of both precious metals and currencies, gold and silver have the incomparable risk-aversion and hedging functions of other metal, and have been regarded as the safest investment in the long run. As a representative of industrial raw materials, oil is an important strategic reserve asset, which is influenced by many political and financial attributes in addition to economic attributes, leading to the world's attention to every move in oil prices. As the basic currency in financial transactions, the dollar is also the universal currency in the world, and the fluctuation of the dollar is widely followed by the world. Almost 90% of the world's foreign-exchange transactions involve the dollar as an intermediary. There is a special connection between oil, precious metal, and dollars. No matter in the invisible war in the economy or the actual war between two countries, resources will become the point of contention for each country, and precious metals, oil and dollar as the representative objects are therefore widely paid attention to by researchers. To a certain extent, the three have directly influenced the change and development of the international financial situation. Since the start of the conflict between Russia and Ukraine, the price of precious metals, crude oil and the dollar against the ruble exchange rate index have also been the focus of investors.

Because most scholars study of the relationship between the three is based on two analysis research, the study of relations between the three factors are relatively less. Additionally, most of the papers were published before the conflict between Russia and Ukraine, so there are not enough papers to figure out how the relationship between three factors change during the Russia-Ukraine conflict.

To sum up, this paper will study and analyze the relationship between precious metal, oil, USDRUB exchange rate index after the start of the Russia-Ukraine conflict, and find out how the relationship between the three will change under the special background of global events.

The remaining parts of this paper are organized as follows: Part 2 is the literature review; Part 3 is the research design, including data sources, unit root test and model specification; Part 4 is the Estimation result, including VAR Estimation, Impulse response, and ARMA-GARCH estimation.

2. Literature Review

Experts and scholars have different views on the long-term factors affecting the gold price. For example, Abken believed that the following four main factors affect the price of gold: Extreme political or economic uncertainty; Gold supply and demand factors; Inflation; and the government's auction policy [1].

However, according to Zhong Weikai's thesis, he believes that the six factors that affect the change in gold price are supply relationship, geopolitics, the American dollar index, oil price, real interest rate and inflation. Through co-integration test and Granger causality test, Zhong Weikai found that dollar index and oil price are two important factors affecting gold price [2].

This paper will select the supply and demand relationship; oil price; the American dollar index and special economic environment; furthermore and inflation as the factors influencing the precious metal prices to do the literature review.

Qingsong Ruan multiple correlations between gold spot price and trading volume in China and found a significant correlation between them [3].

And according to Fang Lei, because of the special nature of gold, it is not a simple reflection of the increase in supply and the fall in price like the general commodities. Gold is a corrosion-resistant and stable metal that will not wear out for a long time. The gold produced in the previous year was bought and circulated to the central banks or investors. The investors or banks would not use gold but will store it, which the stock of gold can be converted into supply in certain market conditions, thus will affect the price of gold [4].

Qidi Zhang indicated that theoretically, due to the influence of pricing factors, gold can hedge the risk of dollar depreciation to some extent, but whether it can hedge the exchange rate risk of other currencies is questionable. If the dollar rises, the price of gold is likely to fall due to pricing factors, while other currencies are also falling, thus providing no hedge against currency risk [5].

Through research, Hexuan Yu found that the impact of the dollar index on the gold price does not start from the 0 periods, and will be delayed to a certain extent. The influence of the American dollar index on gold price gradually reached the maximum value from the first period [6].

From Xingying Liu's essay, it is found that gold and the dollar have a strong inverse relationship. While there is a positive correlation between gold and dollars in some short runs, the research believes that the inverse relationship persists in the short and even the very short term. Because the gold price is disturbed by multiple factors, and the interference effect is stronger than the inverse relationship between the US dollar and gold in the short term, therefore the gold price and the US dollar will have the same trend in the short term. Over the long term, the US dollar index has moved in the opposite direction to gold, but the price of gold has risen more than the US dollar has fallen. Since 1986, the dollar index increased by 0.13% while the price of gold increased by 266%. The correlation between them is 0.632 [7].

Wang Jinlian indicated in her paper that the relationship between gold and oil can be roughly divided into the following five stages:(1) The period of stability before the 1970s (Bretton Woods). (2) The rising period from the early 1970s to the mid-1970s. (3) The rising period from the mid-1970s to the 1980s. (4) The 20-year period of low prices since 1981. (5) another uptick in the early 2000s [8].

Xu Li used the Granger causality test to test London gold price and WTI crude oil price, and found that the rising relationship between oil price and gold price was long-term stable and unidirectional [9].

And Fan Liu states in his thesis that Gold is positively correlated with oil. When oil prices rise, gold prices rise. When oil prices fall, gold prices fall. However, from the historical data, gold and oil do exist in the same direction, but in fact, oil prices and gold prices are not directly related. The main reason for the co-movement of the price of gold and oil is that oil and gold are affected by some common factors. When the common factors change significantly, they will drive the coordinated change of oil and gold prices respectively, and then show a positive linkage relationship in the data [10].

Peihong Xu made a different conclusion in his research, he indicated in his paper that the major petroleum exporting countries in the world are mostly concentrated in Arab countries, which are characterized by rich oil resources but a single industrial structure. As a result, to hedge their bets, they put the money earned from exporting oil into gold. Therefore, when oil goes up, the demand for gold from oil exporting countries goes up, and the price of gold goes up. On the contrary, when oil prices are low, oil exporting countries will reduce their investment in gold, increasing the supply of gold in the market, and the price of gold will naturally fall [11].

According to Jie Liu, oil prices and gold prices are also a microcosm of the international political situation. Their sensitive reaction to the international political situation or occasional events will lead to rapid price growth in the short term [12].

Hexuan Yu believes that the relationship between gold and oil prices and the dollar index will fall when the crisis hits [13].

Baur and Mcdermott pointed out that gold can withstand risks during periods of severe fluctuations in the global market [14].

Ruff and Childers found that gold price was significantly negatively correlated with the consumer confidence index, which showed the unique properties of gold as a safe haven asset. However, it should be indicated that risk aversion can only affect the gold price in the short term, and does not determine the long-term trend of the gold price [15].

Lei Fang states in her paper that in the long run, gold can act as a hedge against the risk of inflation, which becomes the main factor affecting the price of gold in the long run [16].

According to a report by Dipak Ghosh, the public policy research centre of the World Gold Council, gold's nominal price is usually greater than or equal to its real price, and it holds its value well, especially in the 1970s and 1980s, when rich-world inflation was high [17].

Yaping Xu and Xiaohong Ren made an empirical analysis of gold price and CPI in *Empirical Analysis of the Correlation between Gold Price and CPI* and found that gold price and inflation have a long-term equilibrium relationship and are mutually causal [18].

As this paper choose the time period between 8 months before to 6 months after the Russia-Ukraine conflict, which is considered to be a short-term study, therefore this paper is not going to consider inflation.

3. Research Design

3.1. Data Source

For the data resource of this paper, A search engine named Choice financial terminal in conjunction with https://cn.investing.com/ are used to search and obtain data on the price of West Texas Intermediate (Crude Oil), Gold, and Silver, additionally the exchange rate of USBRUB from 20th July 2021 to 20th August 2022. All these data sources and data basis will be as empirical to analyse the relationship between Oil, precious mental, and the exchange rate of USBRUD under the Russia-Ukraine conflict.

3.2. ADF Test

The first step this paper going to do is to perform a unit root test to see whether the data resource is smooth or not. This part assumes the original hypothesis is that the time series is not stable and feasible. By analyzing data with Stata and performing the ADF test, Table 1 ADF test shows that the p-value for the log returns of Gold, Silver, Exchange rate and WTI are all equal to zero, which are all less than 1%, so the original hypothesis can be rejected. As a result, the model is smooth.

Table 1. ADF test

Variables	t-statistic	p-value
Price		
Gold	-1.924	0.6423
Silver	-1.853	0.6788
Exchange rate	-1.501	0.8290
WTI	-1.833	0.6886
Yield		
Gold	-13.107	0.0000***
Silver	-11.952	0.0000***
Exchange rate	-9.982	0.0000***
WTI	-12.289	0.0000***

3.3. VAR Model Identification

$$X_t = \sum_{i=1}^{p} \prod_i X_{t-i} + U_t \quad (1)$$

For this formula, X_t is the Time series column vector and U_t is the Random error column vector. VAR models are usually used to estimate the dynamic relationship of joint endogenous variables. It is realized by using all current period variables in the model to perform autoregression on several period lag variables of all variables. The VAR model can be established without strict economic theory. Furthermore, the AR model does not impose zero constraints on the parameters, which is a benefit to estimate and forecast. When using the VAR model, the necessary and sufficient condition for the VAR model to be stationary is that all the eigenvalues of the coefficient matrix fall into the unit circle. In this paper, four variables log gold price, log silver price, log exchange rate of USDRUB and log price of WTI make up the VAR system. After the VAR model identification, this paper used the Impulse response function to examine how extent a one-unit shock causes other variables to change over time.

3.4. ARMA-GARCH Model

$$X_t = \emptyset_0 + \sum_{i=1}^{p} \emptyset_i x_{t-i} + \alpha_i - \sum_{i=1}^{q} \emptyset_i \alpha_{t-i} \quad (2)$$

As shown in the equation above, $\emptyset_0 + \sum_{i=1}^{p} \emptyset_i x_{t-i}$ demonstrate the part of AR(p) model, which uses the historical date of the exchange rate of USBRUB and the price of WTI to forecast the price of gold and silver. For the MA(q), it is represented by $\alpha_i - \sum_{i=1}^{q} \emptyset_i \alpha_{t-i}$. MA(q) estimates the future and the last part of the model by using the past volatility. For AR model, the paper collects the historical price of gold and silver, the exchange rate of USBRUB and from 2021.7.20 to 2022.8.20, which is about 8 months before the Russia-Ukraine conflict began. While the MA model uses the error term to forecast the future.

After completing the ARMA model, this paper assesses the correlation between the price of gold and silver, the exchange rate of USBRUB or the price of WTI, furthermore, how the correlation is affected by the conflict between Russia and Ukraine by constructing ARMA-GARCH models of the price of gold and silver, the exchange rate of USBRUB and the price of WTI.

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

$$\alpha_t^2 = \alpha_0 + \alpha_1 {\varepsilon_{t-1}}^2 + \ldots + \alpha_q {\varepsilon_{t-q}}^2 + \gamma_1 {\sigma_{t-1}}^2 + \ldots + \gamma_p {\sigma_{t-p}}^2 \quad (3)$$

The model In equation (2) above, the term $\alpha_1 {\varepsilon_{t-1}}^2 + \ldots + \alpha_q {\varepsilon_{t-q}}^2$ is ARCH part, σ_t^2 is the conditional variance of the disturbance term ε_t, the subscript t indicates that variance changes over time. σ_t^2 depends on the square of the disturbance term in the previous p periods.

GARCH model is set up based on the ARCH model, with the addition of auto regression of σ_t^2. In (4), the term $\gamma_1 {\sigma_{t-1}}^2 + \ldots + \gamma_p {\sigma_{t-p}}^2$ is GARCH part. GARCH model is designed to reduce the number of parameters. ARCH(p) can be simplified as GARCH (1,1) by iteration.

$$\alpha_t^2 = \alpha_0 + \alpha_1 {\varepsilon_{t-1}}^2 \gamma_p {\sigma_{t-1}}^2 + \beta_t WTI \tag{4}$$

$$\alpha_t^2 = \alpha_0 + \alpha_1 {\varepsilon_{t-1}}^2 \gamma_p {\sigma_{t-1}}^2 + \beta_t USDRUB \tag{5}$$

4. Estimation Results

4.1. VAR Estimation

Table 2 shows the results of the VAR identification. To find the number of p, this paper use the LR likelihood method to find the Maximum lag order k. When the LR statistic is less than the critical value, the lag order of the VAR model is considered moderate. Therefore, the minimum results in this table, which is labeled with a * symbol will be chosen as lag order to do the estimation, k is equal to zero.

Table 2. VAR identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	2758.59				4.9e-15*	-21.6046*	-21.5823*	-21.5491*
1	2765.89	14.601	16	0.554	5.2e-15	-21.5364	-21.4247	-21.2587
2	2777.69	23.587	16	0.099	5.4e-15	-21.5034	-21.3023	-21.0035
3	2794.41	33.438	16	0.006	5.4e-15	-21.5091	-21.2186	-20.7869
4	2808.59	28.372	16	0.029	5.4e-15	-21.4948	-21.115	-20.5505
5	2818.41	19.629	16	0.237	5.7e-15	-21.4463	-20.9771	-20.2798
6	2837.37	37.925	16	0.002	5.6e-15	-21.4696	-20.911	-20.0808
7	2846.23	17.718	16	0.341	5.9e-15	-21.4135	-20.7656	-19.8026
8	2855.21	17.959	16	0.326	6.3e-15	-21.3585	-20.6211	-19.5254
9	2864.55	18.696	16	0.285	6.6e-15	-21.3063	-20.4796	-19.251
10	2878.36	27.607*	16	0.035	6.7e-15	-21.2891	-20.373	-19.0116
11	2889.07	21.414	16	0.163	7.1e-15	-21.2476	-20.2421	-18.7479
12	2900.1	22.064	16	0.141	7.4e-15	-21.2086	-20.1137	-18.4867

Furthermore, to make sure the VAR model is stationary, the necessary and sufficient condition is that all eigenvalues of the coefficient matrix fall within the unit circle. As shown in Figure 1, for the data resource of this paper, all the eigenvalues are inside the circle. Therefore, the model is stable.

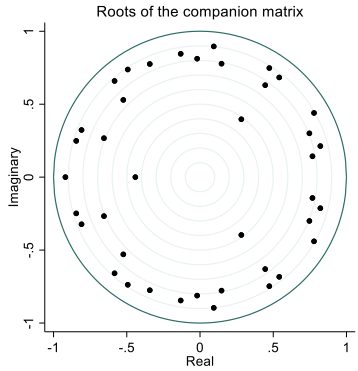

Figure 1. Unit root test (Photo credit: Original)

4.2. Impulse Response

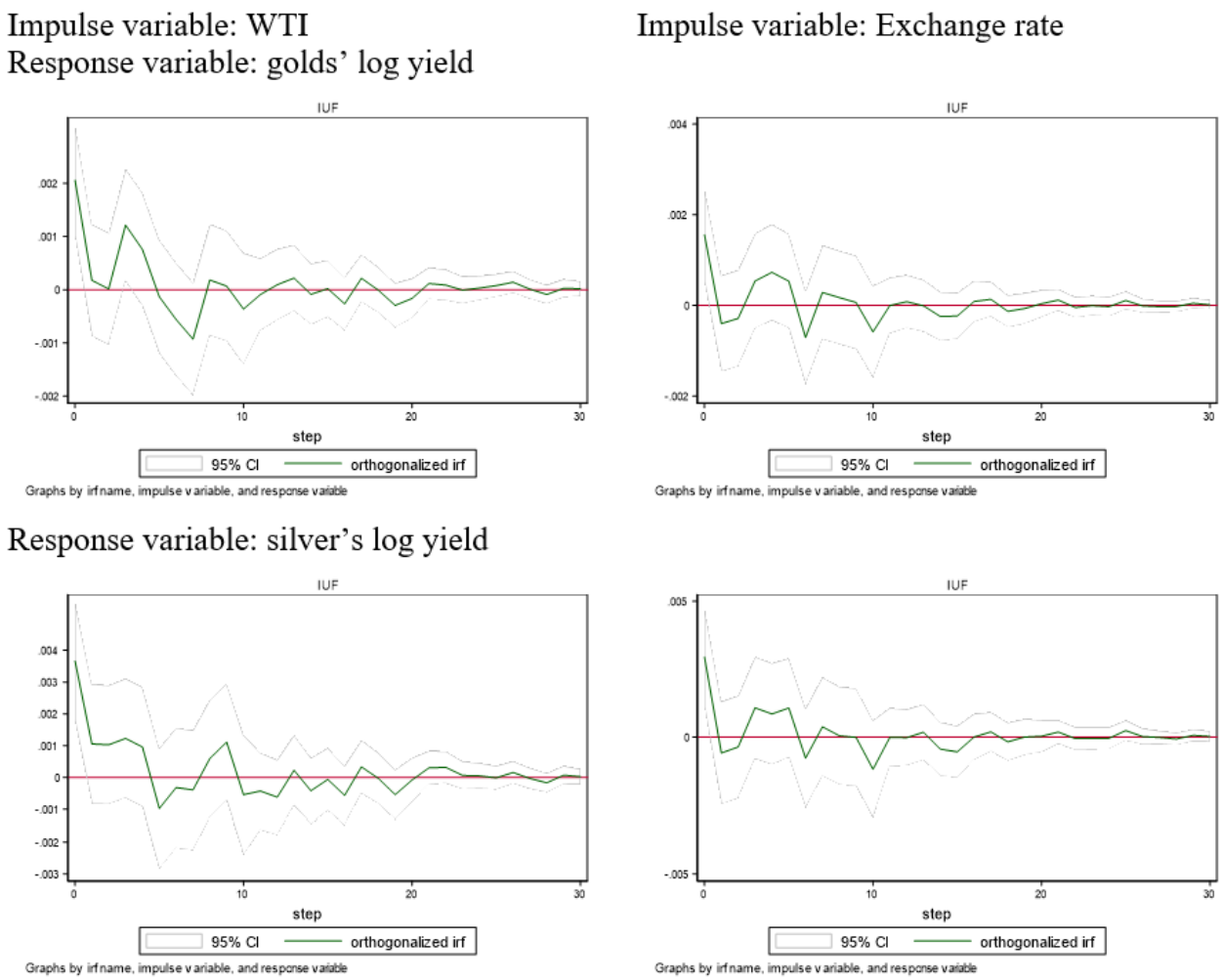

Figure 2. Impulse response function (Photo credit: Original)

From the estimation results of the impulse response (Figure 2), it can be basically inferred that the sharp rise in international crude oil price caused by the Russia-Ukraine conflict led to the rise of the precious metal market. Specifically, the 1% rise in crude oil futures price at t=0 has the maximum impact on both gold and silver yields in the current period, which are 0.2% and 0.35% respectively. Although there are few negative results, the net effect can be concluded to be positive. As for the time effect, the shock of the current period gradually attenuates after 20 periods. For the robustness of the conclusion, the cumulative response function is further calculated. From Figure 3, it can be found that the cumulative effect of the current shock on the return of gold and silver in the next 30 periods is about 8%. The above results show that to a certain extent, the conflict between Russia and Ukraine results in some panic in the international market, and then led to an increase of the yield of safe haven assets.

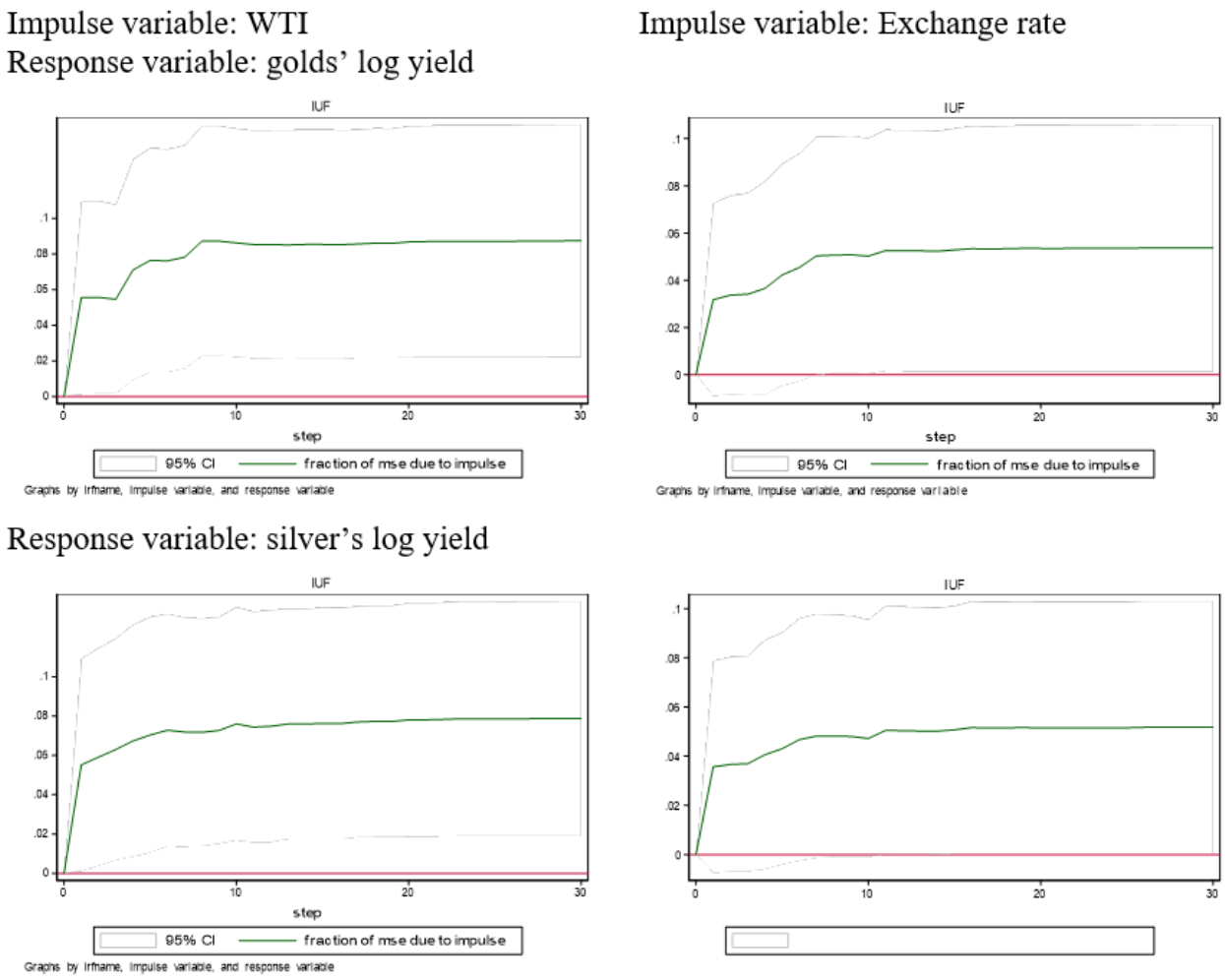

Figure 3. Cumulative response (Photo credit: Original)

From the estimation results of the impulse response, it can be basically inferred that the increase of the exchange rate of the US dollar against the ruble caused by the Russia-Ukraine conflict (the appreciation of US dollar) leads to the rise of the precious metal market. Specifically, the 1% rise in the exchange rate of USBRUB at t=0 has the maximum impact on both gold and silver yields in the current period, which are 0.0038 and 0.003 respectively. Although there are a small number of negative values, the net effect can be concluded to be positive. As for the time effect, the shock of the current period gradually attenuates after 20 periods. For the robustness of the conclusion, the cumulative response function is further calculated. From Figure 4, it can be found that the cumulative effect of the current shock on the return of gold and silver in the next 30 periods is about 5%.

These results suggest that the conflict between Russia and Ukraine, as a regional war, led to a devaluation of the ruble and therefore an appreciation of the dollar, which in turn led to higher yields on safe-haven assets.

4.3. Determining the Order of ARMA

In this section of the article, it is first necessary to order the first log-return series using the PACF and ACF pairs, the results of which are shown in Figure 4：

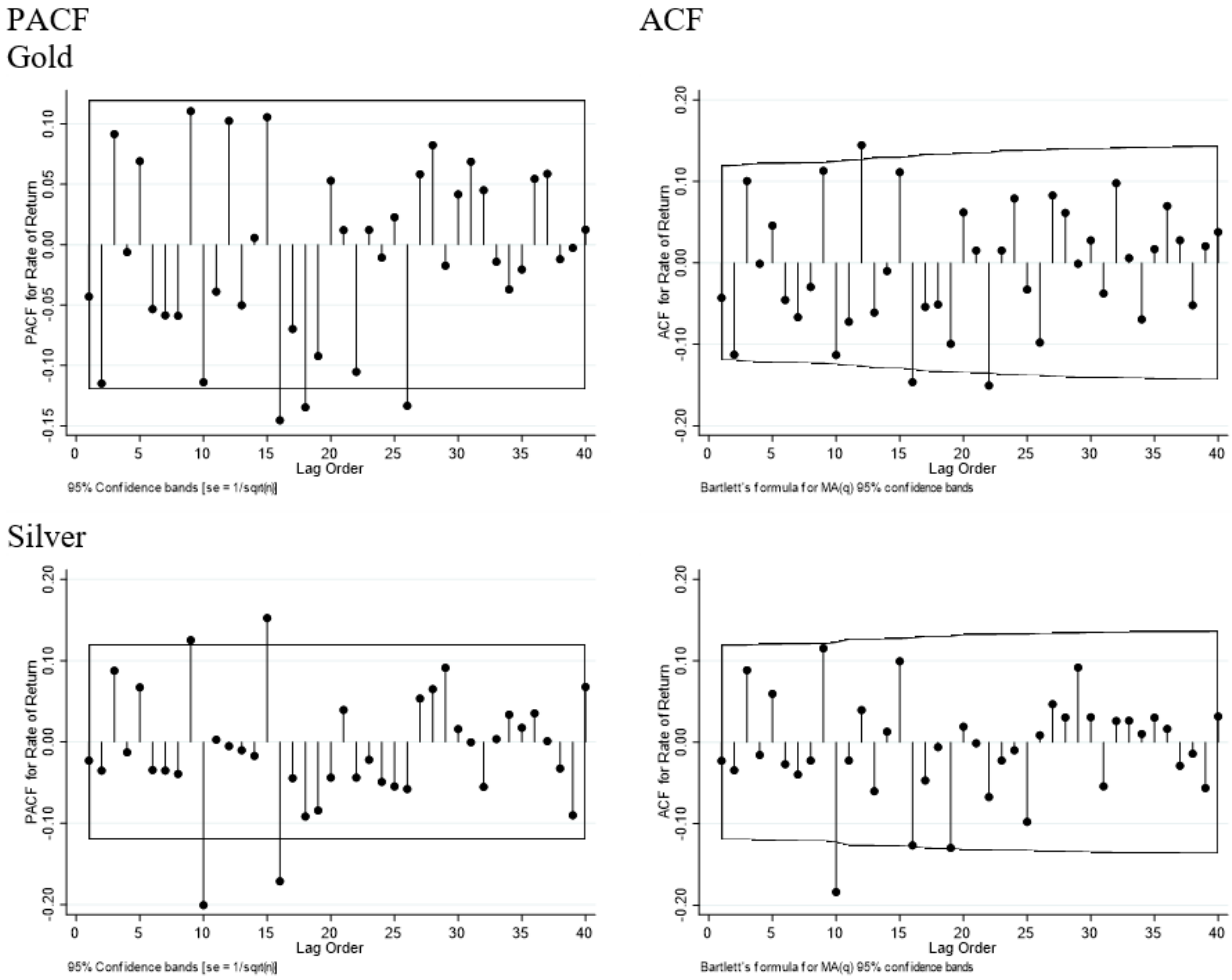

Figure 4. PACF and ACF (Photo credit: Original)

Note: The Y-axis is the dependent variable, PACF, and ACF of the log of Logarithmic return of gold and silver, and the X-axis is the time lag order. The area bounded by y = ±2 standard error refers to the 95% confidence interval for AR(p) and MA(q).

Before the ARMR-GRACH test began, it is necessary to order the log returns of gold. The results is shown above in figure4. From the fixed order result of the two images in the first row in Figure4, the first part beyond the x-axis of gold is 16, so AR(P) is of order 16 and MA(q) is of order 12. Then the paper needs to order the log-returns of silver and demonstrate the results in the figure above. From the fixed order result of the two images in the second row in Figure4, the first part beyond the x-axis is 10 for silver, so AR(p) is of order 10 for, MA(P) is also of order 10 so the value of p and q are all equal for silver.

4.4. ARMA-GARCH Estimation Results

After estimating the model, Table 3 demonstrates the estimation results of ARMA-GARCH model. According to the estimation results in Figure5, the ARCH term of the model in column one is significant, and the GARCH term in columns three and four are both significant, which indicates that the log returns of gold and silver still have statistically significant conditional heteroscedasticity after controlling the autocorrelation in the mean equation.

From the estimation results of external explanatory variables, crude oil and exchange rate yields have no significant impact on the volatility of gold and silver.

Table 3. ARMA-GARCH estimation results

Variable	(1)	(2)	(3)	(4)
	Gold		Silver	
WTI	2.0096		-.9716	
p-value	0.489		0.204	
Exchange rate		2.8392		.5067
p-value		0.390		0.287
ARCH, L1	0.1406**	0.0981	.0596	0.0509
p-value	0.047	0.124	0.182	0.175
GARCH, L1	-0.0575		-0.8926***	-0.9116***
p-value	0.845		0.000	0.000
Constant	9.4054***	-9.4101*	-7.5411***	-7.5293***

5. Conclusion

This paper uses ARMA-GARCH model to test the relationship between precious metal price, oil price and dollar ruble index after the start of the conflict between Russia and Ukraine to draws a conclusion.

First of all, in the selected time range, the rise in oil price caused by the beginning of the Russian-Ukraine conflict caused the rise in precious metal prices, so it can be considered that the relationship between the two is positive, which is basically the same as the conclusion in previous papers. However, the depreciation of the ruble, or the appreciation of the dollar, is also positively correlated with the price of precious metals, contrary to the conclusion of the previous studies. This abnormal result may be due to the chosen special time selection, the paper chose the time period of around 8 months before and half-year after the beginning of the Russia-Ukraine conflict to do a short-term study. Therefore, the rapid rise in the exchange rate and the rapid rise in the oil price reflects not only the depreciation of the trouble but also the panic of the people due to the Russia-Ukraine conflict, meaning that these two indicators reflect market sentiment to a certain extent but not only the relationship between precious metal and American dollars.

Based on the research results, this paper suggests that investors should understand the relationship between the US dollar and precious metals in advance when investing in them, as the substitution relationship and the same direction change relationship between them can be fully used to predict the investment risk and return. For the government policy, it is meaningful to establish a strategic petroleum reserves and foreign exchange reserves based on the interaction between the three.

This paper makes up for the lack of research on whether the relationship between precious metals, oil and dollar changes under the special relationship between the Russia and Ukraine conflict, the result in this paper can provide comparative data support for future research. However, this paper did not compare the results with the data a period of time after the end of the Russia-Ukraine war. Future research can further analyze whether there will be significant changes in the relationship between the three after the conflict between Russia and Ukraine has eased.

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