Dynamic Changes in Noble Metal Prices under Long-term Uncertain Situation: Evidence from Normalized Covid-19 Pandemic

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Abstract. Covid-19 has severely hit global financial market since its outbreak. Investors who withdrawal funds in other areas will seek protection under the precious metals, a market known for its safety. This paper assesses the global and China regional daily new confirmed cases' impacts on gold and silver price. A VAR and an ARMA-GARCH model are built to analyze the changes of the value and volatility. The paper finds that Chinese epidemic still has a positive impact on international precious metal market price while the effects other continents are little. As for volatility, the shock brought by the virus has no significant influence on gold and silver volatility. The paper aims to study how precious metal investors response to newly confirmed cases under normalized Covid-19 Pandemic. Based on the results, global gold and silver market overreacts to the cases in China in comparison with other lands; Thus, the research suggests Chinese Government to further stabilize local pandemics while investors decrease the reaction towards China side's epidemic.

Keywords: Coronavirus; Noble metal; VAR models; GARCH models.

1. Introduction

Two years has passed since the outbreak of COVID-19 firstly discovered in China Wuhan. With the confirmed infected and death case from the disease rapidly increase globally, the cumulative cases reach 572 million in the end of 2020 July. The shocking loss of coronavirus is out of the market expectation that the citizen lifestyle and industrial structure has to made adjustment under the press of the epidemic: communication and work are mostly conducted virtually. Most transaction are stopped, and productions are stagnated; under the threat of largest recession since great depression in 1939, industries are desperately prayed for the re-ignition of the economy.

How hard can a wide-spread virus devastate world economy? Scholars have already started to calculate the possible economic loss as early as 1999. Taiwan researchers leading by Yang analyzed the financial cost from a 2 year long pandemic. The estimated loss of foot-to-mouth disease in Taiwan is an astonishing 1.6 billion US dollar in 1997. Nevertheless, the disease mostly influences the Taiwan pork industry and did trigger significant casualties [1]. The virus transmit among crowds can be more destructive. By Halasa, Shepard and Zeng's report, the calculated annual loss from 2010 dengue fever in Puerto Rico is around 46.45 million US dollar [2]. Covid-19, the severest pandemic in past 50 years can only has higher numbers. On 2020 March 21, only a while after the virus boarding North America, 3.3 million American applied for unemployment benefit, and the account almost double in the following week [3]. At the same time, the American stock market reach the breaker mechanism four times consecutively in 10 short days. The scene is same pessimistic in oversea, the financial times stock exchange index in Europe drops more than 10 percent in one day [4]. Investors are withdrawing funds from the market due to wayfaring loss in the pandemic, and their worries come true in the following year.

Beside the potential loss, volatility, frequently associated with investment risk, is another core factor been largely considered while investing during the havocking COVID-19. Economist assumes that the majority of investors are risk averse. To demonstrate the impact of markets volatility, Marwanti analysis the price fluctuation in the commodity market, represented by oil and gold, in 2021. The research finds strong correlation between increasing price volatility and decreasing demand for

oil. On contrary, the investor shifts demand to gold, as gold's price continue increase. The article suggest that gold serve as a sanctuary for investor in the peril global market [5].

Most areas experience recession, nevertheless, certain markets are doing better than pre-COVID, heavy metals as gold and silver are on top of the list. In a research conducted in the early pandemic, the author pointed out that heavy metal's demand is counter-cyclical for it's a liquid and long-term stored asset [6]. Alali addressed goods such as Swiss Franc and Gold are "safe heavens" during disturbance period in Europe, which usually been pursued during time of uncertainty. A negative relation existed between potential volatility and demands for general goods. The safe heavens are goods universal stable price and less possibilities in sharp value falling [7]. Robiyanto tested empirical data in southeast Asia countries pre-COVID-19, suggest that gold serve as a robust Safe heaven in Singapore and Malaysia while silver consistently plays the role in the Singapore exchange market [8]. In Yousef's paper, the correlation between gold price, global cumulative case and daily new confirmed cases are examined. A strict positive relationship is realized in the safe heaven price and the pace of infected case in the mid-2020, the severest months of pandemic. The estimation made by Yousef is that as the cumulative cases continued to fly, the demand for heavy metal as a refuge for investor will continue to grow. The trend will only cease all the way until the vaccine come out to stabilize the ailing market [6].

Hedging is another core feature associate with the safe heaven nature of gold, which is a way to manage the risk among one's total wealth. In Salisu, Vo and Lawal's study, the effectiveness of gold as portfolio choice hedging during pandemic is elaborated. As previously mentioned, crude oil market experience great risk while the investor demands shift to precious metals. Through computing the optimal weight and hedge ratio of gold against the peril oil industry, the authors argue that gold is still a powerful hedging tool under COVID-19 [9]; however, the point require further study is that how long if the hedging behavior will last, will investor continue avoid volatility in crude oil until the virus cease?

The pervious findings did in the early pandemics finely shows the general trend in metal market; however, the earlier prediction can no longer match the empirical data for the gold price came to stable in the early 2022 even though the confirmed case still large. The complexity of investor's behavior under COVID-19 framework required further studies. Based on this, this paper will illustrate the relationship among gold, silver price and Chinese, worldwide new confirmed cases.

The paper's research contains two features of gold and silver market, value and volatility. The value, linked to the direct return, will be tested firstly by a VAR (11) model. VAR creates a system containing both two independent variables, China and Overseas daily confirmed cases. The advantage of VAR in this research is that two dependent variables, gold and silver, will exhibit mutual consistency in the result, for dependents are examined under a same system. Besides, VAR model can also be used for value prediction. But most importantly, impulse response can be drawn from the results to demonstrate how one unit of change can influence the entire system. The next topic is volatility, a reflection of price risk of heavy metal market. An ARMA-GARCH (1, 1) is built. Due to the restriction of the ARMA-GARCH, conditional heteroskedasticity is required within the time series gold and silver price. So, the yielding trend of variables are draw prior model building, to visualize possible volatility. The final conclusion draws more attention on GARCH part to demonstrate how the shock from shock influence future volatility.

The rest paper is organized as followings: Part 2 is research designed, divided to four sections, which include data source's introduction, unit root test explains, VAR and ARMA-GARCH models' specification. Part 3 contains empirical result with 3 sections. The result from VAR and ARMA-GARCH models and the impulse response graph are illustrated. The fourth part is discussion upon empirical result and the last part is a brief conclusion of findings.

2. Research Design

2.1 Data Source

The paper used data are all obtained from the choice financial terminal, which collected the total confirmed cases of China from the national health and family planning commission of the people's republic of China dataset and world data from the official site of WTO. The choice terminal also provides daily gold and silver closing prices to reflect the market fluctuations. The paper matches the confirmed case data with the daily price from late January 2020 to August 202. Since the metal trading only take place on the working days, the cases on the non-trading days are neglected.

Out of the research purpose, the paper calculates the daily confirmed case increment and the changing rate of the prices from the raw data. The logarithmic sequences with following form are also calculated to eliminate heteroskedasticity.

$$Log\ series\ of\ x_t = \ln(x_t + 1) \tag{1}$$

Stata is used to calculate and build model throughout the research.

2.2 Unit Root Test

Unit root test examined the stationarity of a sequence of data. The stationarity is essential for modelling as only time series with such property can summarize past and predict future. The stationary series has following properties for all t:

$$E(y_t) = \mu \tag{2}$$

$$var(y_t) = E(y_t - \mu)^2 = \sigma^2 \tag{3}$$

$$\gamma_k = E[(y_t - \mu)(y_{t+k} - \mu)] \tag{4}$$

The stationarity of the series must be checked before modelling with unit root test. The test assumes any time series can be written as:

$$x_t = c_t + \beta x_{t-1} + \sum_{i=1}^{p-1} \phi_i \Delta x_{t-i} + e_t \tag{5}$$

The null hypothesis is $\beta = 1$ which indicates the series is not stationary, while the alternative hypothesis is $\beta < 1$ which implies the opposite. Table.1 given the result of the unit root test of the logarithmic price, yielding rate and daily new confirmed cases.

Table 1. ADF test

Variables	t-statistic	p-value
	Price	
Gold	-2.938	0.1503
Silver	-1.530	0.8185
	Yield	
Gold	-18.233	0.0000***
Silver	-16.562	0.0000***
	New confirmed cases	
China	-3.720	0.0211**
Overseas	-15.313	0.0000***

Note: The magnitude for z-value is - 3.982 (1%), - 3.422 (5%), - 3.130 (10%). ***, **, and * indicate the level of significance of 1%, 5%, and 10%, respectively.

The logarithmic gold and silver price are not significant at any level from first two rows. So instead, the logarithmic changing rate of the price are tested; and both are significant at 99% confidence intervals. In comparison, the logarithmic newly confirmed COVID-19 cases perform better; 5% significance level for China cases and 1% for the overseas. The model can be built based on series above.

2.3 VAR Model Specification

Economist often cares about the forecasting of several dependent variables regarding on a same set of independent variables. In our case, the relation between two heavy metal price and the confirmed cases is explored. Either the regression of each single price can be run separately, or they can be put in one system, the VAR model, and doing the forecasting together.

VAR has firstly been proposed in 1980 by Sims to explore relationship among several time series [10]. To elaborate, consider a two-by-two VAR system with p lag term.

$$x_{1t} = \beta_{10} + \beta_{11}y_{1,t-1} + \cdots + \beta_{1p}y_{1,t-p} + \gamma_{11}y_{2,t-1} + \cdots + \gamma_{1p}y_{2,t-p} + \epsilon_{1t} \tag{7}$$

$$x_{2t} = \beta_{20} + \beta_{21}y_{1,t-1} + \cdots + \beta_{2p}y_{1,t-p} + \gamma_{21}y_{2,t-1} + \cdots + \gamma_{2p}y_{2,t-p} + \epsilon_{2t} \tag{8}$$

The system can be re-written in the vector and matrix form.

$$\begin{pmatrix} x_{1t} \\ x_{2t} \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \beta_{11} & \gamma_{11} \\ \beta_{21} & \gamma_{21} \end{pmatrix} \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \end{pmatrix} + \cdots + \begin{pmatrix} \beta_{1p} & \gamma_{1p} \\ \beta_{2p} & \gamma_{2p} \end{pmatrix} \begin{pmatrix} y_{1,t-p} \\ y_{2,t-p} \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \tag{9}$$

To further simplify.

$$x_t = \Gamma_0 + \Gamma_1 y_{t-1} + \cdots + \Gamma_p y_{t-p} + \epsilon_t \tag{10}$$

Here, x_t refers to the response variables, while Γ refers to the coefficient matrix. The disturbance term in the system is ϵ_t.

The result of a VAR can be tedious to analysis with multiple lag term. Thus, impulse response graphs are employed in this research to explore the interaction between variables. The impulse response function as following:

$$\frac{\partial y_{t+s}}{\partial \epsilon_j'} = \varphi_s \tag{11}$$

When the variable j has one extra unit of shock in the period t, it will impact the dependent variable y, in the period t+s, with amount of φ_s. The impulse response graphs are visualization of the function for each separate variable.

2.4 ARMA-GARCH Model Specification

Economist once assume that time series, most commonly, exhibit homoskedasticity which means the variance will not fluctuate with time. In 1982, Engle suggests that time series can exhibit autoregressive conditional heteroskedasticity (ARCH) [11]. An intuitive example of ACH is that if the price of stock is volatile in period 1, it is more likely that it will be also unstable in period 2; thus, the phenomenon is called volatility cluster. ACH is important for financial analysis for volatility always associated with risk. The ARCH model incorporate ARCH into consideration in similar way as AR model. An ARCH(p) model assumes that the estimated variance square (σ_t^2) in the present period is linearly depends on previous p periods' shock:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \cdots + \alpha_p \epsilon_{t-p}^2 \quad (12)$$

ϵ_{t-p}^2 stands for the variance square p periods before; while α_0, α_1, and α_p are all coefficients.

Sometimes p can be significantly large. To reduce the number of estimated coefficients, an ARMA-GARCH (1, 1) model can be utilized.

$$\sigma_t^2 = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \gamma_1 \sigma_{t-1}^2 \quad (13)$$

σ_{t-1}^2 is the estimated variance of the last period. The logic here is that σ_{t-1}^2 has already included previous terms' information for σ_{t-1}^2 equals to

$$\sigma_{t-1}^2 = \alpha_0 + \alpha_1 \epsilon_{t-2}^2 + \cdots + \alpha_p \epsilon_{t-p}^2 \quad (14)$$

To build an ARMA-GARCH model, heteroskedasticity will be the necessary condition. There are two ways to test this, first one is to see the trend of independent variables, to see if there is any obvious volatility cluster. If it is not apparent on the graph, then the most straightforward way is run the model directly and check if the coefficients before variance terms are significant.

3. Empirical Result

3.1 VAR model result

The first step is to find suitable order p of the $VAR(p)$ model with VARSOC selection-order criteria in Stata. Four stationary time series data: logarithmic silver and gold price change rate and logarithmic newly confirmed case in China and worldwide. The results are shown in Table 2.

Table 2. VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	616.028				1.2e-06	-2.27098	-2.25852	-2.23914
1	1469.18	1706.3	16	0.000	5.4e-08	-5.37728	-5.31503	-5.21811
2	1546.6	154.84	16	0.000	4.3e-08	-5.6052	-5.49313	-5.31868
3	1574.85	56.495	16	0.000	4.1e-08	-5.65064	-5.48877	-5.23678
4	1674.28	198.87	16	0.000	3.0e-08	-5.96023	-5.74855	-5.41904
5	2195.35	1042.1	16	0.000	4.7e-09	-7.83431	-7.57283	-7.16579*
6	2227.34	63.991	16	0.000	4.4e-09	-7.89367	-7.58238*	-7.0978
7	2243.93	33.173	16	0.000	4.4e-09	-7.89584	-7.53475	-6.97264
8	2265.89	43.918	16	0.000	4.3e-9*	-7.91795*	-7.50706	-6.86741
9	2270.33	8.8831	16	0.918	4.5e-09	-7.87507	-7.41436	-6.69619
10	2280.07	19.47	16	0.245	4.6e-09	-7.85182	-7.34131	-6.5466
11	2293.32	26.514*	16	0.047	4.6e-09	-7.84164	-7.28133	-6.40908
12	2303.81	20.976	16	0.179	4.7e-09	-7.82119	-7.21107	-6.26129

LR result indicates that a VAR model with 11 order of lag term will be used. The paper also checks the stability with VAR stable tool in Stata, and the condition is satisfied.

3.2 Impulse response graph of VAR model

Figure 1 shows the impulse response graph of gold. It can be seen that one unit of newly confirmed case in China will cause the gold price to rise in short term, and peak in t=3 at around 0.05%. While one extra unit of global confirmed case has a nearly negligible impact on the price, the positive and negative effects are basically offset. The increase caused by the Chinese case soon die out after ten periods; however, the impact caused by the overseas is still trivial even in long run.

Impulse variable: new confirmed cases in China Impulse variable: new confirmed cases overseas

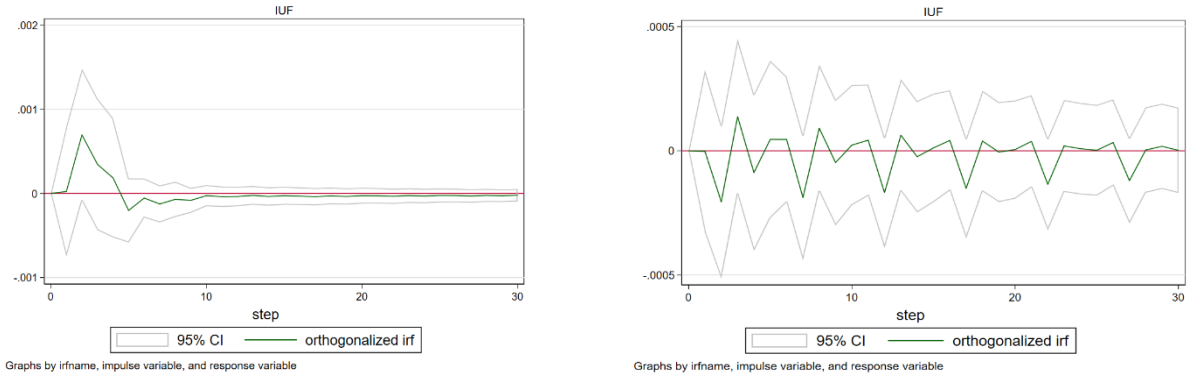

Fig. 1 Impulse and response, Gold

Figure 2 shows the story on silver price side. 1% increase in Chinese newly confirmed case cause short term price rise peak in t=3 at slightly lower 0.1%. The trend oversea is similar to the gold price in which the price is barely influenced by new cases. After around period 12, the change caused by China's side ceased and slowly rise to the starting point.

Impulse variable: new confirmed cases in China Impulse variable: new confirmed cases overseas

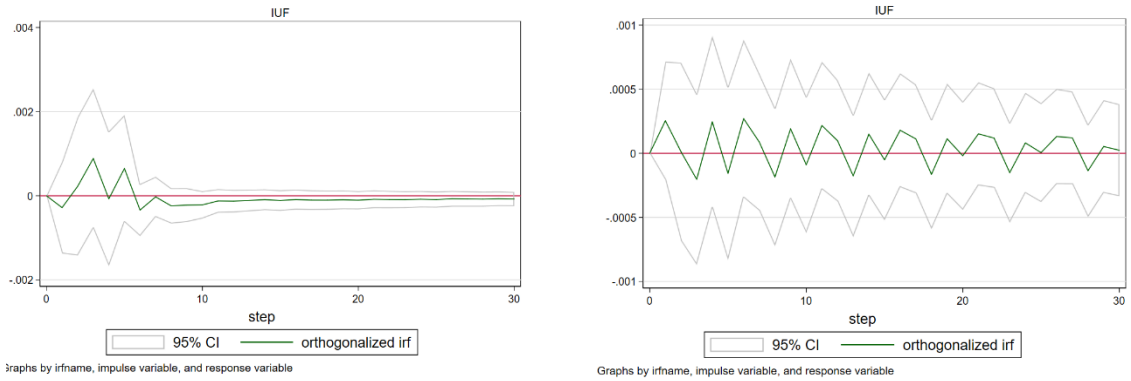

Fig. 2 Impulse and response, Silver

3.3 ARMA-GARCH model

To run an ARMA-GARCH model, heteroskedasticity is a necessary condition. Figure 3 shows apparent volatility cluster. It can be told that both prices exhibit conditional heteroskedasticity, yet still need further statistical evidence in the next step.

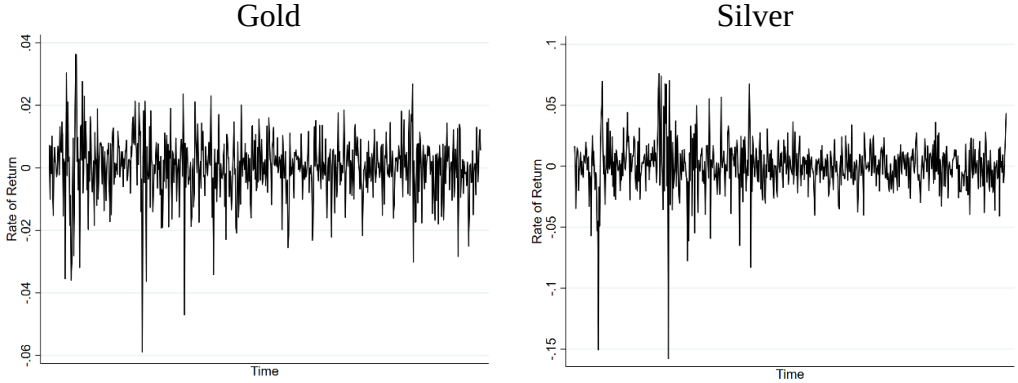

Fig. 3 Yield trend

Determining the lag term order is another essential for the ARMA-GARCH. The PACF and ACF tools in STATA are used to determine. The lag term order p will be determined through PACF and

ACF tests in this paper which can be run directly in Stata. The black rectangle marks out the significant level. Statists usually pick the lowest order that is significant. The results are shown in the following graphs.

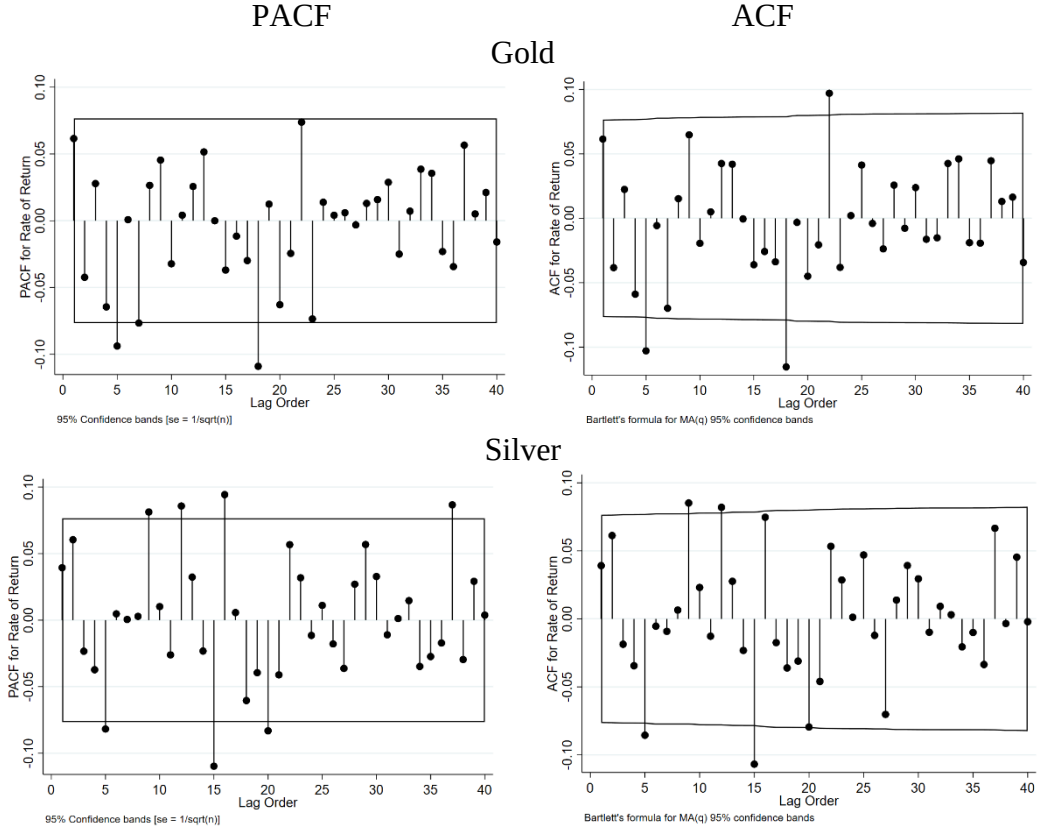

Fig. 4 PACF and ACF

The results are surprisingly consistent in that all 4 models have 5 orders of lag terms.

Table 3. ARMA-GARCH estimation results

Variables	(1)	(2)	(3)	(4)
	Gold		Silver	
	Newly confirmed cases			
China	0.0288		-0.1096*	
	(0.0638)		(0.0600)	
Overseas		0.0223		0.0408
		(0.4753)		(0.0512)
		GARCH (1, 1)		
ARCH (-1)	0.1014***	0.1083***	0.1829***	0.1543***
	(0.0270)	(0.0265)	(0.0225)	(0.0181)
GARCH (-1)	0.8015***	0.8029***	0.6915***	0.7602***
	(0.0552)	(0.0541)	(0.0423)	(0.0382)
Constant	-11.6411***	-11.8933***	-9.4573***	-10.7280***
	(0.4630)	(0.7243)	(0.2808)	(0.7087)

From models (1) to (4), the ARCH and GARCH coefficients are all significant at 99% confidence intervals which suggest strong conditional heteroskedasticity. From the result of newly confirmed case in which only variance in China's new case has 10% significance and all others are insignificant.

This suggests that the COVID-19 pandemic has already barely had a large impact on the volatility of gold and silver price, even though the shock from past terms still plays important role in the risk.

4. Conclusion

The research finds that the international precious metal market price is still positively related to the severity of the Chinese pandemic in short term. Remarkably, such trends didn't exhibit oversea. Apart from that, the newly confirmed case has already not affected the volatility from both sides. The most significant implication of the result is that the demand for precious metals will decrease as the virus comes commonplace in all industries. The investors no longer view pandemic as a significant threat and other industries, such as previously mentioned crude oil, are recovering from the shock. Naturally, the desire for haven assets is lowering.

The result is strictly contradicted by several estimations did in the early 2020s. The first wave of impulse just crashed the global market, people tend to believe that COVID-19 is a short but devastating shock and would end in late 2020. Thus, researchers are more likely to believe that restoring to the pre-COVID state will be the possibility to cool down the flying price in gold markets. As the pandemic becomes part of daily routine and most works shifted to the internet, the economy was gradually recovering in the following year. On top of that, the majority no longer viewed the pandemic as a temporary incidence, and response moderately to its daily increment. This research, conducted in mid-2022, incorporates the shifting altitude of investors in two different, thus coming to different conclusions.

Further research can start from the price volatility, the result shows that the past shocks have significant impacts on future fluctuations and the impact of pandemics has already been negligible. Future research can add other exogenous variables, such as unemployment rate which rise much in past two years, into the GARCH model to find the indicator with greater casualties.

COVID-19 has a huge change in global economy. While most industries barely survived under the havoc of the pandemic, precious metals, as safe heavens, are selling better than ever. This paper research how domestic China and global newly confirmed cases influence gold and silver prices. This paper focuses on the return rate based on the impact of its historical values and does further research on its volatility reaction. The research concludes that pandemic still increases the demand for safe havens for Chinese investors still consider the virus as a significant uncertainty, while the investors oversea no longer have much reaction to the newly infected cases. On both sides, pandemics don't have a significant influence on price volatility.

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