

The Impact of the Federal Reserve's Interest Rate Hike on Gold Futures Prices: The Dynamic Trend

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Abstract. This article aims to study how the increase in the Federal Reserve's Interest Rate is going to impact the gold futures prices under a global economic recession period. Through collecting historical gold prices in chronological order from 2010, the data are then adapted into ARIMA model. It is to investigate the predicted correlation between the macro indicators and performance of the financial derivatives. The result includes that the policy change will have more dominant effects in the long run than short run. The real-world analysis should also incorporate multiple factors that range from qualitative to quantitative to facilitate a more precise prediction of future derivative's price. The significance of the study is to suggest the time value of policy. Investors who hope to yield long-term return, should pick historical data, and learn the resultant change that happen only a few months after the policy announcement. The authorities should also take note of the intensity of the policy change, trying their best to achieve its economic goal at once, which would avoid rippling vicious effect and panic among the public.

Keywords: Fed rate; Gold; ARIMA; Derivatives.

1. Introduction

Gold Futures price has long been an important indicator of investors' confidence of the macro market. Throughout history, gold has held a pivotal position in societal structures. Ancient civilizations associated gold with divinity and utilized the metal in sacrificial rituals. In contemporary society, gold continues to serve as a primary store of value and medium of exchange. It is extensively adopted as a buffer against inflation, a safeguard against exchange-rate volatility [1], and as a tool for portfolio diversification [2]. The significant role of gold as a refuge during tumultuous periods has been acknowledged by both financial media and scholarly research [3].

While the supply of gold has remained relatively constant over recent decades, the introduction of financial derivatives, such as exchange-traded-funds, has precipitated shifts in the structure of gold demand. With an escalating engagement of both institutional and retail investors in the gold market, investment-driven demand now accounts for an estimated 35% of the total demand for this precious commodity. For astute portfolio decision-making, it becomes imperative for investors to comprehend the influence of macroeconomic announcements on returns, the associated return volatility, trading volume, and the parameters governing the efficacy of market price determinations.

In 2022, the US Fed decided to conduct multiple rounds of interest rate hike. Until July 2023, the US Central Bank has conducted up to 11 times of interest adjustments. This is to control the most serious inflation ever in the US history. From the initial 0% to the current 5.25%, the accumulative increase has hit 525 basis points. From the Economic and Financial Market perspective, the rate hikes have led to a slowdown in U.S. demand. A tightening of global financial markets, and further effects on employment income from the commercial market and the U.S. real estate market are foreseeable [4]. After the monetary policy meeting in June 2023, the Federal Reserve announced a pause in rate hikes, keeping the global investors on the sidelines [5].

This paper employs an Autoregressive Integrated Moving Average (ARIMA) model to analyze the historical before the 2023 Federal Reserve's interest rate hike, which then to forecast the trends in gold futures prices subsequent to the hike. The study utilizes the model's predictive values as a control group, isolated from the effects of the rate increase, to examine the impact of the Federal Reserve's 2022 monetary policy series on gold futures prices. The objective is to ascertain whether the monetary

policy shifts, particularly the interest rate hikes, have a statistically significant effect on the prices of gold futures in the financial markets.

The rest of the paper is organized as follows: Part 2 is the experiment design, which includes the data source, testing of unit roots. Following by Part 3 of empirical results and analysis. After that, more emphasis will be carried out to discuss the implications of this essay. The conclusion will then put an end to this discussion.

2. Experiment Design

2.1. Data Source

Through collecting historical gold price data from established website via cn.investing.com. The data ranges from January 2010 to August 2023. The author segregated the data into daily, weekly and monthly data, and set 16 Mar 2022 as the critical timing, T₀. The purpose of the experiment is to predict the scale of effects that the increase in Fed rates on the gold price. By transforming the gold price into index form, the changes in price can be observed in linear relationship.

2.2. Weak Stationarity Test

The variable $\ln r$ is created through the calculating the difference between the price of this period and the last period. The variable $\ln 2r$ is created through the calculating the difference between the price of this period and the period before the last period.

Table 1. Weak stationarity test.

	t	p
Daily		
Raw	-1.628	0.7814
1st order difference	-40.111	0.0000
2nd order difference	-69.490	0.0000
Weekly		
Raw	-1.557	0.8087
1st order difference	-18.408	0.0000
2nd order difference	-29.784	0.0000
Monthly		
Raw	-1.381	0.8664
1st order difference	-9.038	0.0000
2nd order difference	-15.252	0.0000

By carrying out the weak stationary test (Referred to Table 1), the P value of the raw daily data is 0.7814, which is larger than the critical value. Thus, the null hypothesis cannot be rejected and the model may not be stationary.

The P values of the raw weekly and monthly are at 0.8087 and 0.8664 respectively. Since both of them are higher than the critical value, it is reasonable to agree that the model cannot sufficiently reject the null hypothesis.

In STATA, results revealed that the proper estimation index could not be determined by using first order difference for all daily, weekly and monthly data. Thus, second order is used instead. This step is the preparation to determine the d in the ARIMA (p,d,q). The proper d value for all daily, weekly, and monthly model is constant at 2.

2.3. ARIMA Model

The ARIMA Model is chosen for its virtue that it offers a robust framework for analyzing and forecasting time series data, particularly when the data exhibit a clear trend. Gold prices, influenced by myriad factors, including federal rate changes, often demonstrate patterns and trends that are well-suited for ARIMA's predictive capabilities. ARIMA operates based on three primary components:

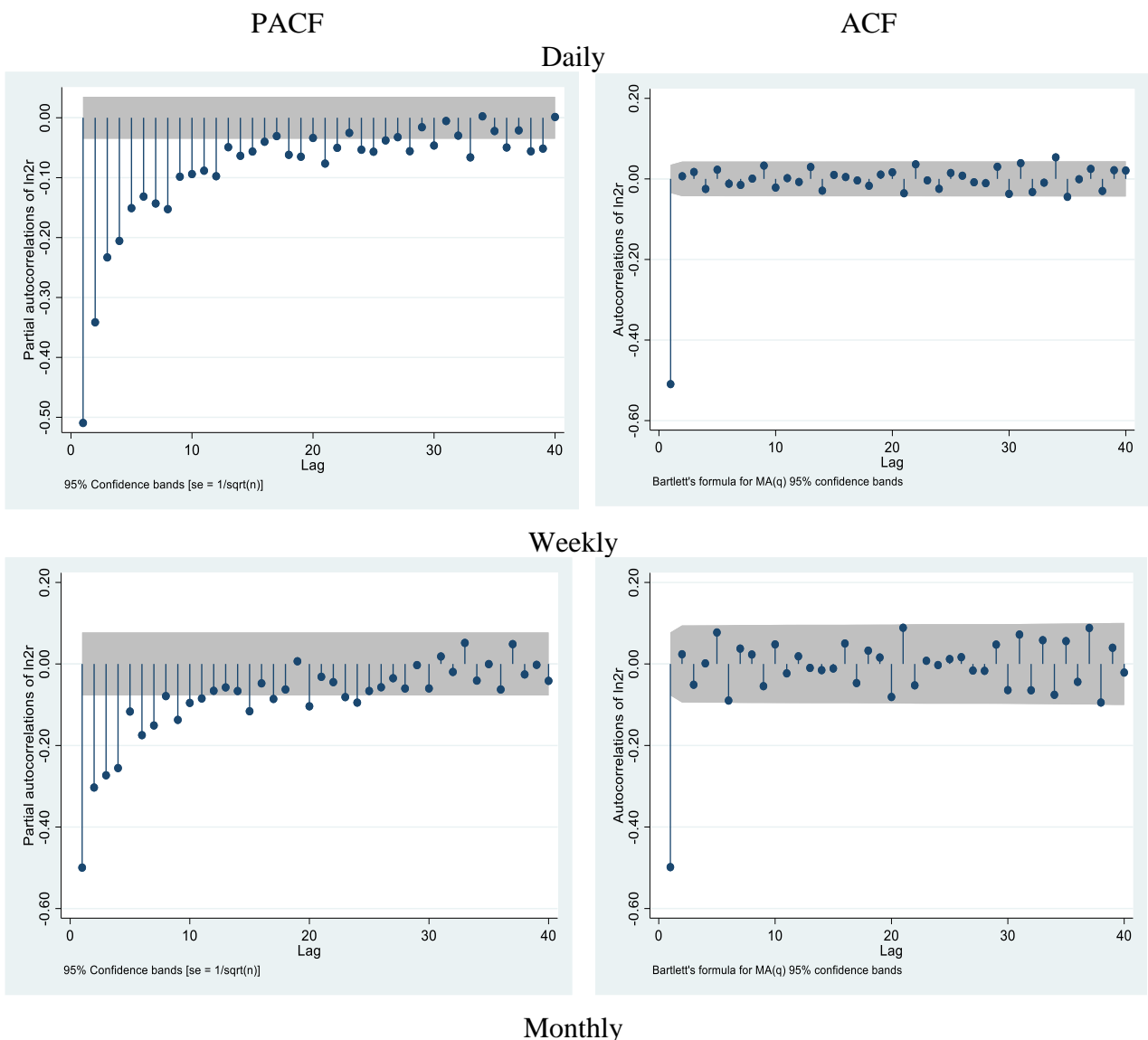
Autoregressive (AR) which accounts for the relationship between an observation and a number of lagged observations, integrated (I) which makes the time series stationary by differencing, and Moving Average (MA) that incorporates the dependency between an observation and a residual error from a moving average model applied to lagged observations. This model's efficacy in capturing autocorrelation within time series data ensures it can adeptly discern patterns in gold price fluctuations, rendering it a prime choice for such a study. Further, ARIMA's popularity in econometric analyses, such as in forecasting inflation rates and GDP growth [6], substantiates its reliability and precision in dealing with financial and economic datasets.

$$TS_t = \phi_0 + \sum_{i=1}^p \phi_i TS_{t-i} + a_t - \sum_{i=1}^q \theta_i a_{t-i} \quad (1)$$

3. Empirical Results

3.1. Order Identification and Residual Test

The following session is going to discuss the components of the ARIMA Model, particularly determining the order based on PACF, as well as ACF.



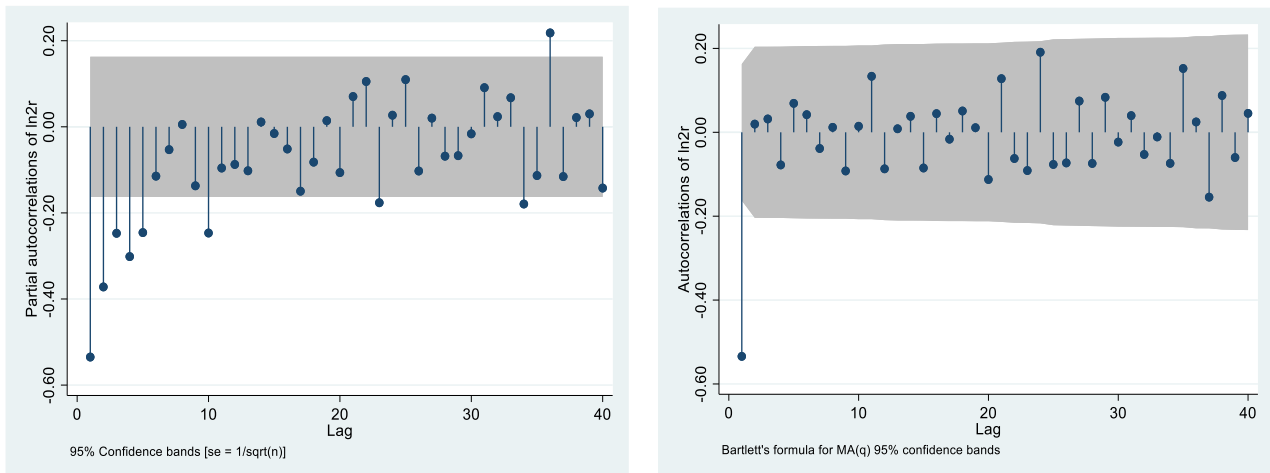


Figure 1. ARMA (p, q) identification.

Photo credit: Original.

For daily data, it can be observed that the length of the pillar has decreased significantly from lag 1 to 4. There is also a drastic decrease from lag 8 to 9 (Figure 1). Thus, it is a relatively proper justification to pick 10 as the lag order for AR.

For ACF, with reference to Figure 2, it is clear to see that the second order falls into the significance range for MA.

Therefore, for the daily data, the appropriate model to carry out is ARIMA (10, 2, and 1). The model's validity is tested through Residual test, whereby the Prob > chi2 is 0.8689, which means that the probability of the residual being white noise is as high as 86.89%, which is far higher than the required 10%.

For Weekly data, it is also rejected at the 1st difference. By carrying out second order, its PACF graph (Figure 1) suggests that order 10 could be an appropriate order to choose for AR, even further lag may deteriorate the precision of the model as the lag number is too large.

For ACF, like the daily data, lag 1 is the last lag that falls outside the significance range (Figure 1).

Thus, with the sufficiently high Prob > chi2 at 0.9821 from the Residual test, the model used for Weekly data is ARIMA (10, 2, 1).

Last but not least, the PACF monthly data present a similar trend of decreasing in bar length, leaving lag 5 as the result for p, the lag number of AR (Figure 1).

For ACF of monthly data, like the daily data, lag 1 is the last lag that falls outside the significance range (Figure 1).

Regarding Table 2, it is a collective result that display the level of appropriateness of different time period ARIMA Model. The indicators are Portmanteau (Q) statistic and Prob > chi2. Residual test aims to examine whether the residual series of each model is white noise. The null hypothesis is that the series is not self-correlated. Thus, from Table 2, with the validity of Prob > chi2 at 0.6554, the monthly model is proven to be predicted sufficiently by ARIMA (5, 2, 1). In general, monthly data has a wider significance range than weekly and daily data.

Table 2. Residual test.

Model	Portmanteau (Q) statistic	Prob > chi2
Daily-ARIMA (10,2,1)	30.2244	0.8689
Weekly-ARIMA (10,2,1)	23.5580	0.9821
Monthly-ARIMA (5,2,1)	35.8981	0.6554

3.2. Prediction Results and Rationale

This part is going to discuss the difference between the actual value of gold price and the fitted value, as well as some possible reasons behind it, in the sequence of daily, weekly, and monthly.

For daily data, it is relatively positive to affirm that the ARIMA model has successfully produced accurate fitted value (Figure 2). It has seen a general increase in gold price from the day of US adjustment to 15 days later. It shows that the public and market need time to digest the changes and no significant reaction yet.

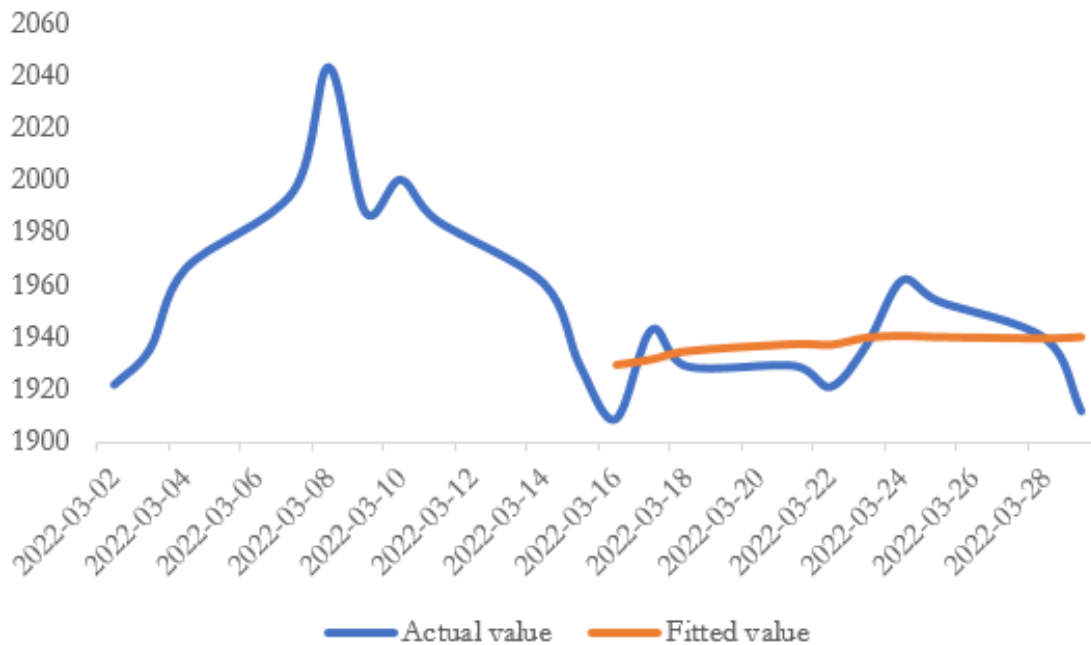


Figure 2. Actual value and fitted value, daily.

Photo credit: Original

For weekly data, the actual value has seen a drastic decrease at the beginning of May 2022, while the fitted value still produces a gentle increase trend. This suggests that some investors has panic and the demand for gold started to decrease (Figure 3).

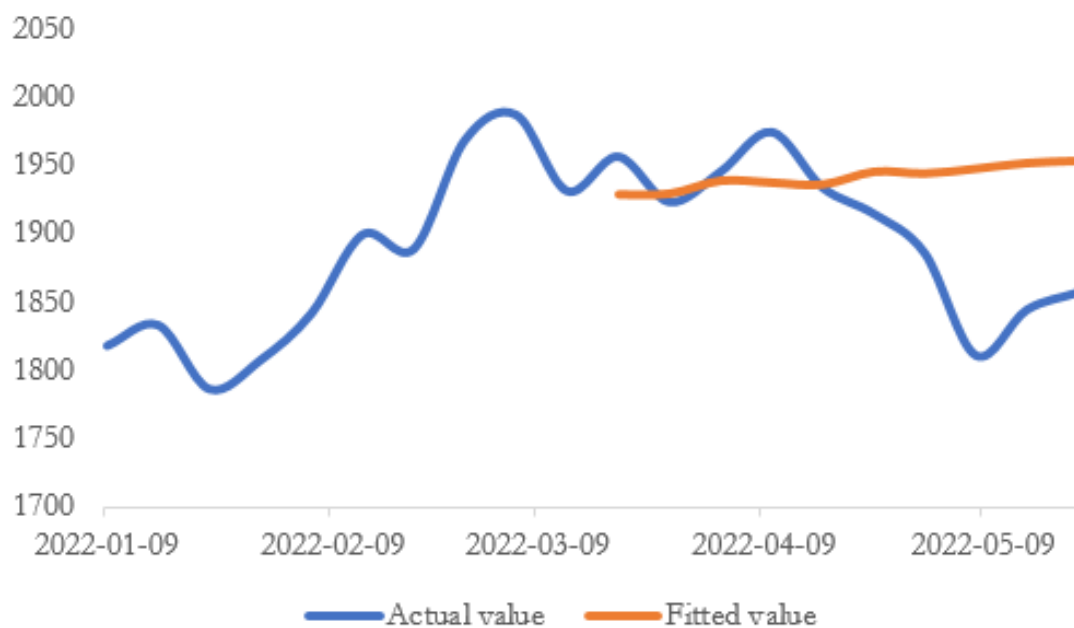


Figure 3. Actual value and fitted value, weekly.

Photo credit: Original

Looking at the monthly data, whereby the predicted date has reached 6 months later, there has been a great discrepancy between the fitted value and actual (Figure 4).

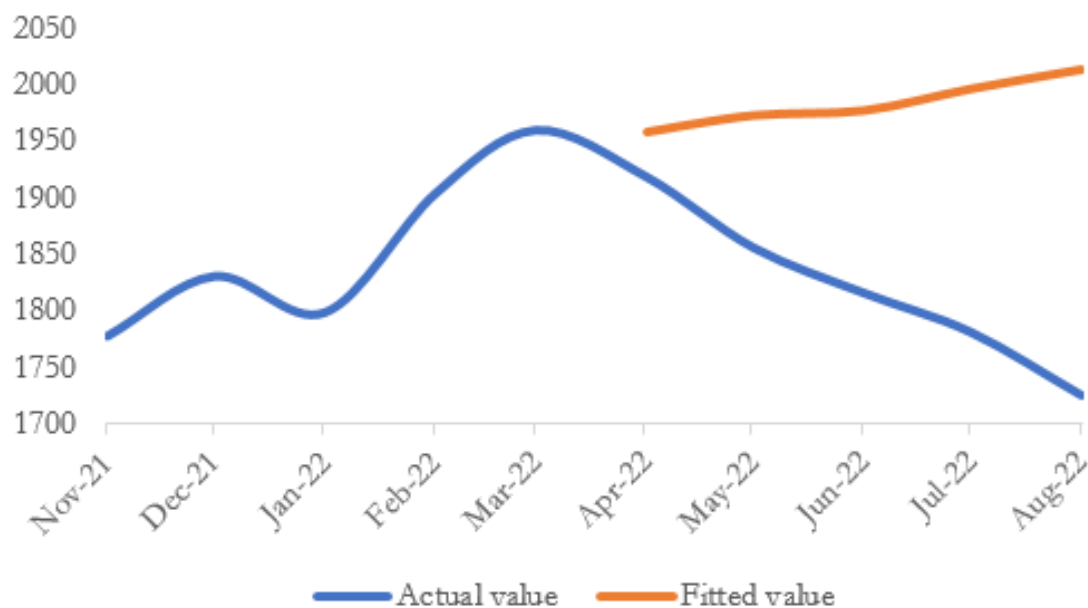


Figure 4. Actual value and fitted value, monthly.

Photo credit: Original.

Next, some possible reasons for the discrepancy are discussed.

First of all, model limitation may be an inevitable concern. ARIMA models, though robust, have their limitations in capturing sudden and unforeseen changes. According to the findings from the study on MDPI, the ARIMA model is mainly employed in the short term, indicating its limited capability to predict long-term trends or sudden market shifts [7]. The announcement of the Fed rate increase is an external event that could introduce sudden shifts in market behavior. A real-life example is how stock markets might react unpredictably to geopolitical events, such as surprise election results or sudden political upheavals, which might not be captured in historical stock price data. Given ARIMA's short-term predictive nature, it may not fully account for the sudden changes triggered by significant market events, leading to discrepancies between predicted and actual gold prices.

Secondly, the time lag may also be an issue. Markets can have lagging reactions to significant economic announcements [8]. While the search results don't directly reflect this, it's a common phenomenon in financial markets. A relevant real-life example is the time lag observed in policy implementation. When governments announce economic stimulus packages, there's often a delay before the actual funds are distributed and their effects are felt in the economy. Similarly, after an economic policy announcement, gold prices might not immediately reflect the change but may adjust over a period as market players process the information. Gold plays an important and special role of individual's consumption goods, commercial commodity, and national reserve. Thus, the impact of the time lag on price may be more dynamic. The market's delayed reaction to the rate hike announcement can contribute to discrepancies between the ARIMA model's predictions and the actual gold prices in the days or weeks following the event.

Moreover, the influence of Exogenous Variables should also be considered. It's well-understood in economic literature that changes in federal interest rates can influence investment decisions and, by extension, the demand for gold as an alternative investment. When facing dominant foreign policy shift, many investors may shift their financial assets from future markets to bond and debt markets. By reconstructing their investment portfolio, they put more emphasis from risky market to riskless market. For instance, during the 2008 financial crisis, central banks around the world slashed interest rates. This led to a surge in gold prices as investors sought safer assets. Such dramatic changes in external economic factors can render predictions based solely on historical gold prices inaccurate. However, The ARIMA model, focusing primarily on the historical prices of gold, might not account for the influence of external economic events [9]. When such events occur, like the change in the Fed rate, the model's predictions might deviate from actual prices.

Furthermore, the intensity of increase in interest may also affect the market. By considering these real-life scenarios, a clearer understanding is gained about the complexities involved in forecasting gold prices, especially in the context of significant economic changes.

4. Discussion

Gold is a hedge against inflation [10]. This essay draws an analogical conclusion to the rest of the literature.

Some aspects to consider can be prior education or signaling on the market. Investors are not always rational, and their decisions can be influenced by cognitive biases.

Behavioural Finance Insights can be altered through utilizing the insights from Prospect Theory and concepts like loss aversion to make informed decisions in the face of market anomalies.

However, the latest news on March 23, 2023, suggests that the gold price has also climbed slightly after the government announced the end of the interest rate hike approach. Thus, the investors should also conduct Dynamic Hedging. In efficient markets, gold price movements can be sudden and unpredictable. Dynamic hedging adjusts to these changes in real-time. To utilize gold derivatives like futures or options, adjusting positions in response to the Black-Scholes model's delta or the Greeks' other measures.

The policy setters should not solely rely on the monetary policy to maintain the internal and external financial balance. The reason why adjusting interest rate is effective is due to the key role of dollar as a “carry” currency and USA being the most powerful financial hub in the world. Based on such premises, can the US government attract foreign currency and assets in the economy cycle, even in times of difficulties? If the U.S. government continues to erode international trust by intervening in and endorsing actions perceived as inhumane, such as supporting Japan's decision to discharge contaminated nuclear wastewater into the ocean, there may come a time when its strategy to mitigate domestic inflation by harnessing global resources proves ineffective.

5. Conclusion

In the realm of financial economics, the longstanding inverse relationship between gold prices and the Federal Reserve's interest rate remains consistently apparent. Given gold's paramount importance as one of the world's primary traded commodities, one might conjecture that alterations in the Federal Reserve rate would be a predominant determinant of its price dynamics. However, a closer examination suggests that these rate shifts might only represent a fraction of the underpinnings behind the intricate fluctuations in gold prices. Factors such as the scale and frequency of interest rate modifications warrant further investigation in relation to their potential ripple effects on commodities.

Furthermore, the contemporary global economic milieu, characterized by its increasingly volatile nature, brings additional layers of complexity. Events of considerable magnitude, like the geopolitical tensions emanating from the Ukraine conflict or the environmental implications of the Japanese nuclear situation, have potential ramifications that extend beyond regional confines, threatening the very fabric of global security. Such unprecedented events pose a novel challenge for investors, necessitating the evolution of their analytical frameworks.

In this context, while quantitative methodologies, such as the ARIMA model, offer valuable insights into predictive scenarios, there is an escalating need to integrate more qualitative assessments into these analytical paradigms. These qualitative dimensions, encompassing geopolitical, environmental, and socio-economic considerations, can provide a more holistic understanding, thereby refining the decision-making process for astute investors.

References

- [1] Capie F, Mills T C, Wood G. Gold as a hedge against the dollar [J]. *Journal of International Financial Markets, Institutions and Money*, 2005, 15(4): 343–352.

- [2] Mccown J R, Zimmerman J R... Is gold a zero-beta asset? Analysis of the investment potential of precious metals [J]. SSRN Electronic Journal, 2006.
- [3] Baur D G, Mcdermott T K J... Is gold a safe haven? International evidence [J]. SSRN Electronic Journal, 2009.
- [4] Degshi A, Natalucci F, Qureshi M S. Commercial real estate sector faces risks as financial conditions tighten [EB/OL]. IMF, 2022-09-22. (2022-09-22)[2023-09-04]. <https://www.imf.org/en/Blogs/Articles/2022/09/21/commercial-real-estate-sector-faces-risks-as-financial-conditions-tighten>.
- [5] Cox J. Fed holds off on rate hike, but says two more are coming later this year [EB/OL]. CNBC, CNBC, 2023-06-14. (2023-06-14) [2023-09-04]. <https://www.cnbc.com/2023/06/14/fed-rate-decision-june-2023.html>.
- [6] Elsayir H A. An econometric time series GDP model analysis: Statistical Evidences and investigations [J]. Journal of Applied Mathematics and Physics, 2018, 06(12): 2635–2649.
- [7] Ospina R, Gondim J A, Leiva V et al. An overview of forecast analysis with Arima models during the COVID-19 pandemic: Methodology and case study in Brazil [J]. Mathematics, 2023, 11(14): 3069.
- [8] Dupor B... Examining long and variable lags in monetary policy [EB/OL]. Saint Louis Fed Eagle, Federal Reserve Bank of St. Louis, 2023-06-27. (2023-06-27)[2023-09-04]. <https://www.stlouisfed.org/publications/regional-economist/2023/may/examining-long-variable-lags-monetary-policy>.
- [9] Madziwa L, Pillalamarry M, Chatterjee S. Gold price forecasting using multivariate stochastic model [J]. Resources Policy, 2022, 76: 102544.
- [10] Barsky R, Epstein C, Lafont-Mueller A et al. What Drives Gold Prices? [EB/OL]. What drives gold prices? - Federal reserve bank of chicago, 2021-11. (2021-11)[2023-09-04]. <https://www.chicagofed.org/publications/chicago-fed-letter/2021/464>.