

Research on the Dynamic Linkage Relationship Between COMEX Gold Futures Prices and Macroeconomic Variables

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Abstract. As a core precious metal with dual commodity and financial attributes, gold price fluctuations are profoundly influenced by macroeconomic policies, monetary conditions, and market supply-demand dynamics. As the global benchmark for gold pricing, the COMEX gold futures market generates price signals that hold significant reference value for investors' asset allocation decisions, central banks' reserve management practices, and the stability of the global bulk commodity market. Against this backdrop, this study focuses on the dynamic linkage between COMEX gold futures prices and key macroeconomic variables, aiming to quantitatively analyze the short-term impact effects and long-term equilibrium relationships of the U.S. dollar exchange rate, real interest rates, and inflation rates on gold prices. Methodologically, the Vector Autoregression (VAR) model, this research uses monthly data of COMEX gold futures prices, U.S. Dollar Index (DXY), U.S. 10-year Treasury real yields, and U.S. core PCE inflation rate from 2015 to 2024 as the research sample.

Keywords: COMEX Gold Futures, Macroeconomic Variables, Foreign Exchange Rate, 10-Year Real Interest Rate, CPI, VAR Model

1. Introduction

The COMEX gold futures price reflects real-time supply and demand, as well as market expectations based on the US dollar, interest rate policies, and inflation levels. Current studies focus on single-factor macroeconomic variables, neglecting dynamic interaction effects among multiple variables. A systematic analysis of the combined influence of multiple macroeconomic variables is needed to understand gold futures prices. From an academic perspective, this study makes two distinct contributes to the existing literature. First, it enriches the theoretical framework of precious metal pricing by integrating the foreign exchange rates, 10-Year real interest rates, and consumer price index into a unified analytical framework, and uses the VAR model to avoid presupposing causal relationships between variables, thereby more accurately capturing the dynamic feedback mechanism between COMEX gold futures prices and macroeconomic variables. Second, it expands the empirical research sample by selecting monthly data from 2015 to 2024, which covers multiple economic cycles such as the 2015-2018 interest rate hike cycle, the 2020 pandemic-induced economic recession, and the 2022 aggressive interest rate hike cycle, making the research

conclusions more robust and generalizable. From a practical perspective, the research findings have important guiding significance for different market participants. For individual and institutional investors alike, a clear understanding of the dynamic linkages between macroeconomic variables and COMEX gold futures prices can facilitate the formulation of more targeted and risk-adjusted investment strategies, particularly in navigating volatile market conditions driven by macroeconomic shifts.

2. Literature review

The correlation between gold prices and macroeconomic variables has long been a focus of academic research. This chapter sorts out classic studies on the impact of foreign exchange rates, U.S. 10-Year Treasury real interest rates, and Consumer Price Index (CPI) on gold prices, and identifies gaps in existing literature to highlight the value of this study.

2.1. Research on foreign exchange rates and gold prices

Given that gold is predominantly priced in U.S. dollars globally, the U.S. dollar exchange rate—typically proxied by the U.S. Dollar Index (DXY)—exerts a direct influence on gold prices. Frankel was the first to systematically propose the "U.S. dollar pricing effect" systematically: a 1% increase in DXY leads to a 0.8% decrease in gold prices (significant at the 1% level), as a stronger U.S. dollar raises non-U.S. [1]. investors' purchase costs, curbing gold demand. Sjaastad and Scacciavillani further found that this negative correlation is more pronounced in the short term, especially during sharp U.S. dollar fluctuations [2]. They attributed this phenomenon to the "speculative demand effect," wherein short-term traders amplify the linkage between the DXY and gold prices through responsive trading strategies. Reboredo noted the correlation weakened during the 2008 financial crisis (both U.S. dollar and gold served as safe-havens) but re-strengthened post-crisis [3]. However, few studies have integrated foreign exchange rates with 10-Year real interest rates and CPI to analyze their joint impact on gold futures prices.

2.2. Research on 10-Year real interest rates and gold prices

Gold, a non-interest-bearing asset, has an opportunity cost tied to real interest rates, with the 10-Year Treasury real rate as a core benchmark. Barsky and Summers pioneered the "opportunity cost effect" framework, arguing that elevated 10-Year real interest rates incentivize investors to reallocate capital from gold to interest-bearing assets (e.g., Treasury bonds), thereby suppressing gold prices [4]. They cited the long-term decline in gold prices during the 1980s–1990s as empirical evidence, which coincided with the U.S. Federal Reserve's tight monetary policy to maintain high real interest rates. Hood and Hobson refined this research using 1990–2010 daily data: a 1-percentage-point increase in the 10-Year real rate leads to a 5%–7% monthly gold price drop, and rate hikes have a stronger inhibitory effect than rate cuts (due to investors' loss aversion) [5]. Existing studies, however, often use short-term real rates or mixed maturity indicators, lacking focus on the 10-Year rate's interaction with foreign exchange rates and CPI.

2.3. Research on CPI and gold prices

Gold's widely cited "inflation hedge" attribute is inherently linked to CPI, a key measure of consumer price inflation. Erb and Harvey tested this using 1975–2004 data from 15 economies, finding gold preserves purchasing power long-term (20-year cumulative returns outpace CPI) but

has a weak short-term effect—only significant when CPI exceeds 5% [6]. Baur and Lucey explained this via the "monetary substitution effect": rising CPI erodes fiat currency value, increasing gold demand [7]. Their 1979–1990 data showed the positive CPI-gold correlation is most pronounced when CPI exceeds 3%. Aye et al. confirmed gold's inflation hedge effect strengthened during 2020–2022 global high inflation, but few studies have combined CPI with the other two variables to analyze synergistic impacts on gold futures prices, especially for the 2015–2024 period [8].

2.4. Gaps in existing research

Three key gaps remain: first, most studies focus on single-factor impacts, ignoring dynamic interactions (e.g., 10-Year real rate hikes may strengthen the U.S. dollar, indirectly suppressing gold prices). Second, academic focus on spot gold prices is limited, while research on gold futures prices is scarce. Futures prices offer unique insights into price trends, but spot prices cannot fully reflect them. Third, sample periods rarely cover 2015–2024 (a period with distinct cycles like 2015–2018 rate hikes and 2022 high inflation), limiting conclusion timeliness. This notion is supported by Wang and Lee, who found that the hedging and diversification benefits of gold exhibit significant time-varying characteristics, and the 2015–2024 period in particular has unique features that differ from earlier samples [9]. This study addresses these gaps by integrating three variables, focusing on gold futures, and using 2015–2024 data.

3. Theoretical foundation and impact mechanism

This chapter clarifies gold's price-driving logic based on its dual attributes and constructs the theoretical mechanism of how foreign exchange rates, U.S. 10-Year Treasury real interest rates, and CPI influence COMEX gold futures prices.

3.1. Core driving logic of gold prices: dual attributes

Gold possesses both commodity and financial attributes, but the latter dominates price fluctuations. From the commodity perspective, gold is used in jewelry (50% of global demand), industry (10%), and central bank reserves (20%)—yet supply-demand is stable short-term: annual mining output grows only 2%–3%, and existing stocks (200,000 tons) far exceed new supply; demand is rigid (e.g., cultural factors keep jewelry demand stable despite price changes). Gold's price volatility is primarily due to its financial attributes. It acts as a "safe-haven asset" during market uncertainty, with demand surged during the COVID-19 pandemic. It's a zero-interest-bearing asset, with its opportunity cost tied to long-term real interest rates. As CPI growth reduces fiat currency purchasing power, investors increase gold holdings to safeguard wealth, driving up demand and prices. This financial dominance, particularly its role as a diversifier in multi-asset portfolios whose effectiveness is shaped by macroeconomic conditions, means COMEX gold futures prices are mainly shaped by the three macro variables studied [10].

3.2. Theoretical mechanism of variable linkage

Gold's global U.S. dollar pricing has a negative correlation with foreign exchange rates, with appreciation raising non-U.S. investors' purchase costs and depreciation making gold cheaper for non-U.S. investors. Cross-market arbitrage amplifies this. The 10-Year Treasury Real Interest Rates have a negative impact on gold's opportunity cost, with hikes increasing gold's opportunity cost and lower prices, and cuts reducing returns and increasing gold's attractiveness. The Consumer Price

Index (CPI) has a positive, lagged impact, with rising CPI eroding fiat currency purchasing power and falling CPI stabilizing currency value, weakening gold's hedge demand and lowering prices [11].

4. Model construction and data description

4.1. Quantitative model selection: Vector Autoregression (VAR) model

Given the bidirectional dynamic impacts between COMEX gold futures prices and the three macro variables (e.g., rising gold prices may amplify inflation expectations, affecting CPI), the VAR model is selected for its advantage of not presetting causal relationships—ideal for analyzing multi-variable linkage effects.

4.1.1. Model Expression Define core variables

G_t : COMEX gold futures price (monthly closing price of front-month contract),

EX_t : Foreign exchange rate (U.S. Dollar Index, DXY, monthly average),

R_{10t} : U.S. 10-Year Treasury real interest rate (monthly average)

CPI_t : U.S. CPI (monthly year-on-year data).

The VAR(p) model is constructed as:

$$\begin{bmatrix} G_t \\ EX_t \\ R_{10t} \\ CPI_t \end{bmatrix} = \Phi_0 + \Phi_1 \begin{bmatrix} G_{t-1} \\ EX_{t-1} \\ R_{10t-1} \\ CPI_{t-1} \end{bmatrix} + \dots + \Phi_p \begin{bmatrix} G_{t-p} \\ EX_{t-p} \\ R_{10t-p} \\ CPI_{t-p} \end{bmatrix} + \varepsilon_t \quad (1)$$

Φ_0 : Constant term vector,

$\Phi_1, \dots, \Phi_p$: Coefficient matrices (capturing lagged variable impacts on current values),

p : Lag order (determined by minimizing AIC/SC criteria, expected 2–4 for 2015–2024 monthly data),

ε_t : Random error term vector (white noise, mutually uncorrelated).

5. Empirical results

5.1. Linear regression

The linear regression has an R^2 of 0.8644, meaning the three macro variables well explain gold futures price changes.

Foreign Exchange Rates: Coefficient is 0.6368 , but P-value 0.885 is not significant, so no strong linear link.

REAINTRATREARATI0Y(10-Year real interest rate): Coefficient (-190.2232), P-value (9.40e - 11) is significant, showing a negative linear relationship (higher rates mean lower gold prices).

CPI: Coefficient (16.0811), P-value (< 2e - 16) is significant, showing a positive linear relationship (higher inflation means higher gold prices).

5.2. VAR model

Data Preprocessing Data is processed into `df_var`, with first differences to ensure stationarity for VAR. Optimal Lag and Estimation AIC criterion sets optimal lag to 1.

5.2.1. Equation results

Gold_price Equation: Lagged variables' coefficients aren't significant, but they interact in the VAR system.

Foreign_Exchange_Rates Equation: Lagged foreign exchange rates have a significant positive autocorrelation; lagged 10-Year real rates have a significant negative effect.

REAINTRATREARATIOY Equation: Lagged gold prices have a significant negative effect; lagged 10-Year real rates have significant positive autocorrelation.

CPI Equation: Lagged foreign exchange rates have a significant negative effect; lagged 10-Year real rates have a significant positive effect; lagged CPI has strong positive autocorrelation.

5.2.2. Impulse response & variance decomposition

Impulse response shows how shocks spread; variance decomposition (Figure 4, 5, 6) shows each variable contributes to gold price variation, matching the high (R^2) from linear regression.

5.3. Instrumental variable regression

The model has an R^2 of (0.8647).

Foreign Exchange Rates : Coefficient (6.029), P-value (0.236) not significant.

REAINTRATREARATIOY: Coefficient (-194.926), P-value ($9.33e - 10$) significant (negative relationship, same as linear regression).

CPI: Coefficient (15.955), P-value ($< 2e - 16$) significant (positive relationship, same as linear regression).

Diagnostic tests confirm strong instruments and justify using instrumental variables (due to endogeneity).

6. Summary of empirical results

The study uses a vector autoregression (VAR) model to analyze the correlation between COMEX gold futures prices, the US dollar index, the real interest rate of the 10-year US Treasury bond, and the consumer price index (CPI) from 2015 to 2024. The results show that the 10-year real interest rate is the primary factor influencing gold futures prices, with a negative correlation and a positive correlation with inflation. The model has a high goodness-of-fit, indicating strong explanatory power for gold price changes.

7. Conclusions and investment recommendations

Based on the above empirical results, this study offers the following recommendations for gold futures investors:

7.1. Place emphasis on the trend of real interest rates

Real interest rates are the most crucial factor influencing the gold price. Investors should closely monitor the monetary policy stance of the Federal Reserve, the yield curve of government bonds, and inflation expectations (such as the TIPS spread). When real interest rates are in a downward trend (such as when there is an increase in the expectation of an economic recession or a rapid rise in inflation), consider positioning a long position in gold futures at a low price; conversely, during the period of rapid increase in real interest rates (such as in the later stages of an interest rate hike cycle), be cautious in holding or consider reducing your position appropriately.

7.2. Tactical utilization of inflation data

The CPI data has a positive impact on gold prices but with a lag. Investors can adjust their positions based on the inflation trend: When the CPI consistently exceeds 3% and the actual interest rate does not rise simultaneously (i.e., a "negative real interest rate" environment), the inflation-protective nature of gold will become prominent, and more long positions can be increased; if the CPI peaks and falls while the actual interest rate remains high, it is necessary to be cautious of the risk of a gold price correction.

7.3. Indirect reference value of the US dollar index

Although the direct correlation between the US dollar and gold prices is not significant, the strength of the US dollar can indirectly affect the gold price by influencing real interest rates and global liquidity. It is recommended that investors use the US Dollar Index as an auxiliary indicator: when there is a deviation between the US Dollar Index and real interest rates (for example, the US dollar weakens but real interest rates rise), a comprehensive judgment should be made based on other signals; if the US dollar and real interest rates move in the same direction, the probability of gold prices being under pressure is higher.

7.4. Multi-factor dynamic configuration strategy

Investors should avoid relying on a single variable and establish a multi-dimensional decision-making framework based on actual interest rates, inflation, and the US dollar index. For instance, under the combination of "high inflation + low actual interest rates + weak US dollar", the upward momentum of gold futures is the strongest; while in the environment of "low inflation + high actual interest rates + strong US dollar", one should prioritize avoiding the risks of going long on gold.

7.5. Risk warning and timing selection

The price of gold futures is highly sensitive to the release of macroeconomic data (such as the non-farm employment report, CPI announcement). It is recommended that investors adopt an event-driven strategy, adjusting their positions based on the difference between market expectations after the data is released. At the same time, it is necessary to be cautious of the unconventional correlation where gold and the US dollar rise and fall together in extreme market conditions (such as a liquidity crisis).

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