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Article

US Dollar Exchange Rate Elasticity of Gold Returns at Different Federal Fund Rate Zones

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Abstract: We examine the relationship between gold prices and the U.S. dollar exchange rate, arguing that their interactions are state-dependent and asymmetric under different market conditions. State dependency hinges on different short-term interest rate zones. To prove this point, we determine three distinct levels or zones of the effective federal funds rate using SETAR(2,p) tests. Subsequently, we perform conditional least square estimations of log changes in gold prices as a function of log changes in the nominal broad U.S. dollar exchange rate index for each of the obtained zones. Their relationship is consistently inverse, suggesting that gold and the U.S. dollar are risk-hedging substitutes for normal market periods. This also implies that gold is a safe-haven asset against the U.S. dollar exchange rate risk against a broad range of currencies. The substitution is weaker in the low-interest rate zone, more robust in the intermediate zone, and very pronounced in the high zone. We also perform a Markov switching test on the double-log function of gold prices and the exchange rate. The tests show a pronounced inverse relationship, i.e., substitution between assets, at normal market conditions. The relationship becomes significantly positive during episodes of financial distress, indicating complementarity between gold and U.S. dollar assets.

Keywords: gold prices; exchange rates; effective federal funds rate; SETAR; Markov switching

JEL Classification: C58; F31; F37; G11; G15



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1. Introduction

We examine the relationship between gold returns and the U.S. dollar (USD) exchange rate in terms of state dependency, non-linearity, and asymmetry. This relationship is not believed to be uniform. It is inverse at most times, during tranquil global financial market conditions, as gold and USD are considered effective substitute instruments of market risk hedging. However, their relationship can also be positive during turbulent global financial market periods. Their non-linear, state-dependent relationship has been argued and empirically evaluated in several influential studies, including Capie et al. (2005), Baur and Lucey (2010), Aizenman and Inoue (2013), Reboredo (2013), Beckmann et al. (2015), Eichengreen et al. (2019), Zulaica (2020), and Azimli (2024), among others. There is a common consensus in the literature that gold is a safe-haven asset for the USD exchange rate risk against a broad range of currencies. We prescribe to the notion that interactions between gold returns and the USD exchange rate are state-dependent, non-linear, and asymmetric.

We contribute to the examination of a nexus between gold returns and USD exchange rates by arguing that the state dependency in the gold returns–exchange rate relationship strongly depends on the prevalent “level” or “zone” of short-term interest rates. We aim to prove this underlying hypothesis by investigating the responsiveness, i.e., the elasticity, of daily gold returns (log changes in gold prices) to log changes in the nominal broad U.S. dollar index (BRUSD) at three empirically determined zones of the effective federal funds rate.¹ In essence, we attempt to show that the exchange rate elasticity of gold returns

tends to be modest when the federal funds rate is low, but it becomes very pronounced at high fed fund levels. The key measurable objective of our paper is to demonstrate that the exchange rate elasticity of gold prices becomes more pronounced at higher levels of short-term interest rates.

In our empirical exercise, we estimate the low-, intermediate-, and high-interest rate zones by employing a self-exciting threshold autoregressive SETAR(2,p) model for the effective federal funds rate (FFR). Our daily data set covers the 4 January 2006–27 December 2023 sample period, with the starting point determined by the earliest availability of the BRUSD. The data are obtained from the Federal Reserve Economic Data (FRED) and CMX Gold and Silver Corp. (CMX) database. Subsequently, we estimate the exchange rate elasticity of gold returns using conditional least square estimations at each of the obtained FFR zones. As the last step in our empirical exercise, we estimate a two-state Markov switching multifractal MSM(2) model to show the asymmetric inverse vs. positive relationship between gold returns and exchange rate variations, obtaining discernible switches from negative to positive interactions in market crisis episodes.

Section 2 of our paper provides a review of the prior, pertinent literature. The data description and analysis are covered in Section 3. Section 4 shows and examines the SETAR(2,p) identification of low, intermediate, and high FFR zones. The nexus between gold returns and log changes in the BRUSD at each FFR zone is analyzed in Section 5. Section 6 examines asymmetric responses between both variables using MSM(2) tests. The concluding Section 7 contains a summary of key findings and additional remarks on the applications and extensions of this research.

2. Survey of Prior Literature

Gold has been a focal point in discussions about financial stability and risk management, particularly as a safe-haven asset. The status of gold as a strategic reserve has deep historical roots. From 1979 to 2010, central banks consistently maintained gold reserves and coordinated their sales, reflecting gold's role in global influence and historical power (Aizenman and Inoue 2013). This underscores gold's function as a safe-haven during periods of USD depreciation as well as the global financial market uncertainty.

The relationship between gold and the US dollar (USD) has been explored extensively. Similarly to the objectives of our study, Capie et al. (2005) use ARDL- and GARCH-type models to demonstrate a negative correlation between the USD exchange rate and gold prices, indicating that gold acts as a hedge against USD depreciation. This view is also supported by Reboredo (2013), who underscores gold's importance in risk management, particularly in its capacity to offset USD fluctuations.

The role of gold in stock markets is also significant. Building on Baur and Lucey (2010), Beckmann et al. (2015) employ a smooth transition regression model to show that gold can act both as a hedge and a safe haven for stocks. Their study finds that gold's role in financial markets is dynamic, serving as a hedge during stable periods and a haven during times of crisis.

Interactions between gold prices and the USD exchange rate are commonly accepted as complex and dependent on varied market conditions. There is a consensus in the prior literature that gold and USD generally act as substitutes, but they can become complementary during financial crises, both serving as safe havens. This relationship highlights the asymmetric nature of gold's role in financial markets (Baur and McDermott 2016). The market risk-hedging function of gold may also explain pervasive departures from the uncovered equity returns parity condition of exchange rate movements (Djeutem and Dunbar 2018; Orlowski et al. 2023).

Another widely accepted notion is that currency depreciation and gold prices commonly move in the opposite direction. Prior empirical studies including Chua and Woodward (1982), Ghosh et al. (2004), Capie et al. (2005), Wang et al. (2011), Beckmann et al. (2015), and Bampinas and Panagiotidis (2015) argue that gold is an effective hedge against inflation. This is because gold has been proven to preserve its value at periods of high inflation.

It is generally argued in the literature that the interactions between USD and gold prices are non-linear and not coincident. [Arfaoui and Rejeb \(2017\)](#) argue that there is a significant inverse relationship between changes in gold price affecting changes in the USD. The opposite causal inference from USD to gold price is shown by [Mo et al. \(2018\)](#). This causal reaction is non-linear and negative and particularly pronounced in the aftermath of financial crises.

Yet another approach to interactions between gold prices and exchange rates is examined by [Zulaica \(2020\)](#) who analyzes how gold serves as a hedge against interest rate fluctuations. Despite the increased risk of holding gold, it remains a critical component in portfolios, particularly those exposed to interest rate risks. This aligns with the consensus that gold serves multiple roles, including acting as a strategic reserve.

More recent studies focusing on the nexus between gold prices and exchange rates seem to point out their complementary risk-hedging role during extreme market risk conditions. A particularly strong interconnectedness among gold and currencies, as well as other asset classes, during the COVID-19 pandemic is reported by [Bouri et al. \(2021\)](#), as well as [Chiang \(2022\)](#) and [Kunkler \(2022\)](#). A varied, state-dependent relationship between gold and currencies during the COVID-19 pandemic is presented by [Akhtaruzzaman et al. \(2021\)](#). In closer proximity to our study, [Madani and Ftiti \(2022\)](#) examine the role of gold as a hedge and a safe-haven asset for the exchange rate risk of the USD against the currencies of developed countries during average and extreme movements in exchange rates. Their results imply that gold can act as a hedge and safe-haven asset against the exchange rate risk of the USD and reduce the portfolio risk.

The literature consistently shows that gold serves as both a hedge and a safe haven, depending on market conditions and economic environments. Gold's significance becomes particularly evident during high uncertainty, providing a buffer against currency and market risks. Future research could further explore the evolving role of gold, especially in the context of digital currencies and emerging financial technologies.

3. The Data

As we focus on interactions between gold and USD exchange rate returns, we choose data for gold prices obtained from the CMX Gold and Silver Corp. database, the Federal Reserve's Nominal Broad USD Index, and the effective federal funds rate obtained from the FRED. The daily data cover a sample period from 4 January 2006 to 27 December 2023 (4691 observations).

Before devising the analytical model and conducting its empirical tests, we intend to provide deeper insights into understanding the data by analyzing their key descriptive statistics shown in Table 1. The examined variables include the log changes in GOLDP, the log changes in the BRUSD, and the FFR at its level.

Table 1. The data—descriptive statistics.

Statistics:	$\Delta \log$ GOLDP	$\Delta \log$ BRUSD	FFR
Mean	0.0003	0.0001	1.4061
Median	0.0004	0.0000	0.2300
Maximum	0.1039	0.0189	5.4100
Minimum	−0.0888	−0.0256	0.0000
Std. Deviation	0.0110	0.0034	1.8136
Skewness	−0.3159	−0.0491	1.1940
Kurtosis	8.9295	7.9016	2.9109
Jarque–Bera	6950.1 ***	4697.9 ***	1116.1 ***
Probability	0.0000	0.0000	0.0000

Table 1. Cont.

Statistics:	$\Delta \log$ GOLDP	$\Delta \log$ BRUSD	FFR
Observations	4691	4691	4691
ADF	−69.030 ***	−66.372 ***	0.1915
ADF Breakpoint	−69.931 ***	−66.827 ***	−3.0487
PP	−69.057 ***	−66.407 ***	0.0029

Notes: Daily data for the 4 January 2006–27 December 2023 sample period (4691 observations). ADF represents the Augmented Dickey–Fuller test statistics, ADF Breakpoint is the Augmented Dickey–Fuller Breakpoint unit root test, PP is the Phillips–Perron test, and *** denotes significance at 1%. Source: authors’ own estimation based on FRED and CMX data.

As shown in Table 1, the distributions of gold and USD returns are both leptokurtic, as implied by kurtosis considerably exceeding 3.0. Such high-peak and heavy-tail distribution suggests greater potential for extremely low or high returns. It implies that variations in GOLDP and the BRUSD are confined around the mean at normal market periods, but they tend to explode at times of financial distress. The distributions of both variables are also left-skewed, suggesting the prevalence of negative over positive deviations. In contrast, the distribution of the FFR series is slightly platykurtic. It is right-skewed, implying the prevalence of positive over negative shocks.

It is worth noting that the Dickey–Fuller, Dickey–Fuller Breakpoint, and Phillips–Perron unit root tests confirm that log changes in the BRUSD and GOLDP are stationary, even when accounting for breaks in the data series. The distribution of the FFR at its level is non-stationary, which is acceptable for our SETAR testing of thresholds and zones of short-term interest rates that we identify in the next section.

4. Identification of Low, Intermediate, and High Federal Funds Rate Zones

As indicated before, we employ the SETAR(2,p) test to identify three discernible zones of the FFR: low, intermediate, and high. We use the SETAR model because this methodological approach helps quantify quite precisely the distinctive zones of changeable interactions between the tested variables. Our SETAR testing is rooted in the generalized two-regime, one-threshold SETAR(1,p) model originally proposed by Tong and Lim (1980) that is specified as follows:

$$X_t = \begin{cases} \alpha_{10} + \alpha_{11}X_{t-1} + \varepsilon_t & \text{if } X_{t-p} < r \\ \alpha_{20} + \alpha_{21}X_{t-1} + \varepsilon_t & \text{if } X_{t-p} \geq r \end{cases} \quad (1)$$

where α_n is a real constant.

The self-exciting component, the SE of the SETAR, is a lagged value of the dependent variable X_{t-p} driven by the threshold “ r ”.

Our extension of Tong’s original methodology (Tong and Lim 1980; Tong 2011) aims to identify three interest rate zones proxied by the FFR, and our SETAR model is reflected by the following:

$$FFR_t = \begin{cases} \alpha_{10} & \text{if } FFR_{t-p} < r_1 \\ \alpha_{20} & \text{if } r_1 \leq FFR_{t-p} < r_2 \\ \alpha_{30} & \text{if } FFR_{t-p} \geq r_3 \end{cases} + \alpha_{k1}FFR_{t-1} + \alpha_{k2}FFR_{t-2} + \alpha_{k3}FFR_{t-3} + \varepsilon_k \quad (2)$$

As implied by Equation (2), our SETAR(2,3) model specification is optimized by using two thresholds and three lagged terms. To make the test functional for interpretive purposes, we use two thresholds to identify three interest rate zones and the FFR time displacement parameter of -2 . The optimization of lagged terms is based on minimizing the Akaike and, consistently, the Schwartz information criteria. The intercept or starting point in each zone is the switching variable, while the three FFR lags are included as non-switching explanatory variables. The empirical testing results of Equation (2) are shown in Table 2.

Table 2. Zones of effective federal funds rates—estimated with SETAR(2,p).

Estimated Variable →	Effective Federal Funds Rate (FFR) at Level
Lags of Dependent Variable	2
Threshold Variables Considered	FFR (−1) to (−10)
Threshold Variables Chosen	FFR (−2)
Low FFR Zone:	FFR (−2) < 0.659
Constant term	0.0015 *** (2.62)
No. of observations	2684
Intermediate FFR Zone:	0.659 ≤ FFR (−2) < 3.039
Constant term	0.0137 *** (2.81)
No. of observations	1772
High FFR Zone:	FFR (−2) ≥ 3.039
Constant term	0.040 *** (3.11)
No. of observations	1023
Non-Threshold Variables:	
FFR (−1)	0.957 *** (53.76)
FFR (−2)	−0.134 *** (−5.47)
FFR (−3)	0.169 *** (9.61)
Diagnostic Statistics:	
R-squared	0.998
Log-Likelihood	7093.58
AIC	−2.587
Mean	1.483
Durbin–Watson	2.054

Notes: AIC is Akaike information criterion, and *** denotes significance at 1%. Source: as in Table 1.

The SETAR(2,3) estimation of Equation (2) identifies the following FFR thresholds and zones:

- Low FFR zone, for $\text{FFR} < 0.659$ (2684 observations).
- Intermediate FFR zone, $0.659 \leq \text{FFR} < 3.039$ (1772 observations).
- High FFR zone, for $\text{FFR} \geq 3.039$ (1023 observations).

It is worth noting that the specification of the obtained thresholds and zones is robust and statistically significant at all levels. Moreover, the included three lagged FFRs as non-threshold variables and the switching constants are all statistically significant at 1 percent.

5. The Conditional Least Squares Estimation of the Exchange Rate Elasticity of Gold Returns at Different FFR Zones

Considering the obtained FFR zones, we proceed with the conditional least square (CLS) regression estimations of the relationships between gold and exchange rate returns within these ranges. For this purpose, we propose a simple bivariate elasticity model specified as follows:

$$\Delta \log(\text{GOLPD})_t = \beta_0 + \beta_1 \Delta \log(e)_{t+\tau} + \mu_t \quad (3)$$

where GOLPD is the daily gold price, $e_{t+\tau}$ is the BRUSD forwarded or moved back by the displacement parameter τ , and μ_t is a residual. In this double-log specification, β_1 is the coefficient of the exchange rate elasticity of gold returns. If the estimated β_1 coefficient is negative, gold prices and the USD exchange rate move in opposite directions, implying that gold and USD are substitute assets for hedging financial market risk by investors. If the coefficient is positive, both assets are complementary as they move in the same direction.²

The estimation representations of Equation (3) are shown in Table 3. The estimated β_1 coefficient is negative in all four cases (entire sample, low FFR zone, intermediate FFR zone, and high FFR zone). Its lowest absolute value (of -0.897) is obtained in the low FFR zone, suggesting a somewhat inelastic relationship between gold and USD. The elasticity

between both assets is higher in the intermediate zone ($\beta_1 = -1.368$) and the most robust in the high zone ($\beta_1 = -1.425$). Evidently, gold and USD display a low substitution in the environment of a very low FFR, i.e., ultra-easy monetary policy. It becomes more pronounced with a higher FFR, under tighter monetary policy conditions. This finding underscores the critical point of our study, which is that substitution between gold and USD as risk-hedging assets becomes more robust in the environment of higher short-term interest rates.

As shown in Table 3, the obtained estimations are robust and significant, as proven by the high log-likelihood ratios, high F-statistics, t-statistics, and negative Akaike and Schwartz information criteria. The estimated series has no discernible autocorrelation, as the Durbin–Watson statistics are close to two in all four cases.

The obtained CLS estimations lead us to argue that gold and USD are substitute assets. However, in the next section, we aim to find whether there is any degree of asymmetry in the substitution vs. complementarity relationships. We delve deeper into this problem to ascertain whether these two assets could be complementary under specific market conditions.

Table 3. Exchange rate elasticity of gold returns at different FFR zones. Conditional OLS estimations of Equation (3). *Dependent variable:* $\Delta \log(\text{GOLDP})_t$.

	Entire Sample 4 January 2006–27 December 2023	Low FFR Zone FFR < 0.659	Intermediate FFR Zone $0.659 \leq \text{FFR} < 3.039$	High FFR Zone FFR ≥ 3.039
τ parameter	0	0	0	0
β_0	0.0003 ** (2.13)	0.0003 (1.35)	0.002 (0.85)	0.0005 (1.54)
β_1	−1.053 *** (−23.72)	−0.879 *** (−15.75)	−1.368 *** (−15.70)	−1.425 *** (−11.03)
Included Observations #	4691	2684	1131	876
Diagnostic Statistics:				
Log-Likelihood	14,763	8386	3681	2725
F-statistics	562.86	248.14	246.54	121.70
AIC	−6.293	−6.247	−6.506	−6.219
SIC	−6.291	−6.243	−6.498	−6.208
DW	2.084	2.059	1.973	2.213

Notes: t-statistics are in parentheses, AIC = Akaike information criterion, SIC = Schwartz information criterion, DW = Durbin–Watson statistics, *** denotes significance at 1%, and ** denotes significance at 5%. Source: as in Table 1.

6. Asymmetry in Exchange Rate Elasticity of Gold Returns—Two-State Markov Switching

To examine asymmetry and time-varying state dependency in the relationship between gold returns and log changes in the BRUSD exchange rate, we employ the two-state Markov switching process for the entire sample period. As suggested in the prior literature, particularly in Mo et al. (2018) and Madani and Ftiti (2022), state dependency and regime switching in the relationship between gold prices and other financial market variables, including exchange rates, can be reasonably expected. We therefore choose the Markov process to verify our initial assumptions. The two states in the Markov process are specified as follows.

State 1:

$$\Delta \log(\text{GOLDP})_t |_{ST=1} = c_1 + \gamma_1 \Delta \log(e)_{t+\tau} + \varepsilon_{t1} \quad (4)$$

State 2:

$$\Delta \log(\text{GOLDP})_t |_{ST=2} = c_2 + \gamma_2 \Delta \log(e)_{t+\tau} + \varepsilon_{t2} \quad (5)$$

The estimation representations of MSM(2) as prescribed by Equations (4) and (5) are shown in Table 4. The estimated elasticity coefficient $\gamma_1 = +1.554$ in State 1 implies that both GOLDP and USD move in the same direction, suggesting complementarity between gold and USD. Specifically, the estimated positive coefficient indicates that there

are episodes of increasing GOLDP coupled with USD appreciation. In a less realistic scenario, it also suggests that declining GOLDP would be coupled with the depreciation of the USD.

In contrast, the negative relationship between GOLDP and USD in State 2 as reflected by $\gamma_2 = -1.422$ suggests that GOLDP and USD move in opposite directions. Their reverse co-movement indicates substitution between gold and USD in their role as risk-hedging assets.

Table 4. Exchange rate elasticity of gold returns—two-state Markov switching process. Estimation of Equations (4) and (5).

State 1	$c_1 = 0.004$ *** (4.44) $\gamma_1 = +1.554$ *** (6.26)
State 2	$c_2 = -0.001$ (−0.22) $\gamma_2 = -1.422$ *** (−24.36)
Common term: Log sigma	−4.629 *** (−413.57)
Diagnostic statistics:	Log-Likelihood = 14,879.46 Akaike Info. Criterion = −6.341 Schwartz Info. Criterion = −6.331 Durbin–Watson stats. = 2.097
Constant Transition Probabilities, Probability of Staying (Switching):	
State 1	0.72 (0.28)
State 2	0.97 (0.03)
Constant Expected Durations:	
State 1	3.6 days
State 2	39.8 days

Notes: z-statistics are in parentheses, and *** denotes significance at 1%. Source: as in Table 1.

The constant transition probabilities and the expected durations for States 1 and 2 shown in Table 4 indicate that the obtained State 2 clearly dominates the Markov process. The probability of remaining in State 2 on any given day is 97 percent, which is considerably higher than the probability of remaining in the subordinate State 1 of 72 percent. In addition, the constant expected duration of the dominant State 2 is 39.8 days, which is significantly longer than the 3.6-day duration for State 1. Arguably, the MSM(2) tests indicate that the substitution between gold and USD as risk-hedging assets prevails over their sporadic complementarity.

Deeper insights into specific times and episodes of the inverse vs. direct co-movements between GOLDP and USD are provided by the time pattern of the filtered regime probabilities of the dominant State 2 shown in Figure 1. The probabilities close to the unity reflect the times of the inverse interactions between GOLDP and USD. The sporadic episodes of the probability falling to zero point to the episodes of switches from State 2 to State 1, i.e., to the incidences of a positive co-movement between both tested variables.

In conformity with our initial assumptions, the filtered regime probabilities in Figure 1 indicate the prevalence of State 2, i.e., substitution between gold and USD. As could be reasonably expected, the switching episodes to their positive interactions are consistent with the outbreaks of financial crises and systemic risk (see also Herley et al. 2023). We identify these episodes in Figure 1 showing the occurrence of State 1 under stressful market conditions, including the following:

- A. The global financial crisis of 2008 and 2009.
- B. The ‘Flash Crash’ of 6 May 2010.
- C. The peak of the European sovereign debt crisis, highlighted by a discernible global market shock on 2 September 2011.
- D. The Brexit vote of 23 June 2016.
- E. The apex of the COVID-19 pandemic in March/April 2020.
- F. Russia’s invasion of Ukraine on 24 February 2022.
- G. The U.S. Banking Crisis following the Silicon Valley Bank collapse on 10 March 2023.

In sum, our MSM(2) exercise shows that GOLDP and USD move in opposite directions during normal, tranquil market periods. However, they tend to move in tandem in turbulent markets, matching the global market crisis outbreaks.

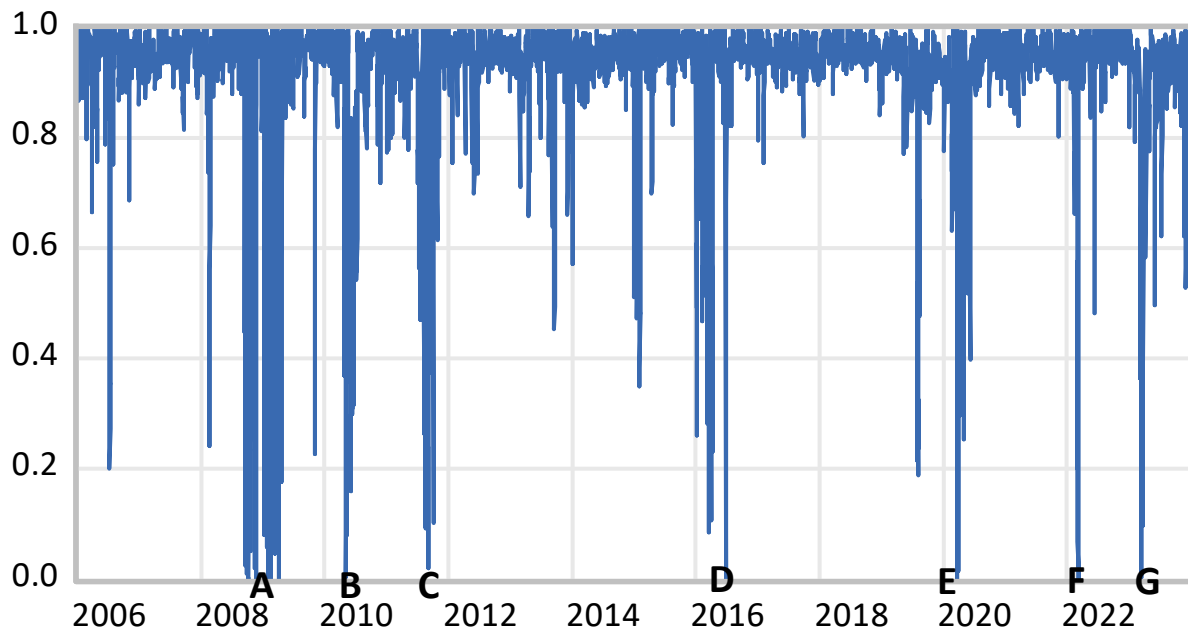


Figure 1. Markov switching filtered regime probabilities for dominant State 2. Notes: A = global financial crisis of 2008 and 2009. B = Flash Crash (6 May 2010). C = European sovereign debt crisis (discernible shock on 2 September 2011). D = Brexit vote (23 June 2016). E = peak of COVID-19 pandemic (March/April 2020). F = Russia's invasion of Ukraine (24 February 2022). G = Banking Crisis in U.S. triggered by Silicon Valley Bank collapse (market shock on 15 March 2023). Source: as in Table 1.

7. Summary and Concluding Remarks

Our study examines interactions between gold prices and the U.S. dollar exchange rate (proxied by the nominal broad U.S. dollar index) under different market conditions. It was inspired by the widely accepted observation that both gold and U.S. dollar assets are alternative substitutes in risk-hedging strategies by investors, central banks, and other financial institutions (Reboredo 2013; Gopalakrishnan and Mohapatra 2017; Arslanalp et al. 2023; Azimli 2024).

We argue that the relationship between gold returns (log changes in gold prices) and log changes in the U.S. dollar index is state-dependent and asymmetric. We show that interactions between the two variables are predominantly inverse, indicating the prevalence of their role as risk-hedging substitutes. These interactions are different across varied zones of short-term interest rates. We perform SETAR(2,p) tests on the effective federal funds rate to discern these zones. The tests identify the low-interest rate zone when the federal funds rate is below 0.659 percent. In the intermediate zone, the rate is within the range of 0.659–3.039 percent. The rate exceeds 3.039 percent in the high-interest rate zone.

We subsequently conduct conditional least square regression tests on the relationship between dynamic changes in gold prices and the exchange rate at each of the obtained interest rate zones. Their inverse reactions are weaker in the low-interest rate zone, stronger in the intermediate zone, and very pronounced in the high-interest rate zone. The tests indicate that substitution between gold and the U.S. dollar becomes stronger in high-interest rate environments.

We also find asymmetry in interactions between gold returns and log changes in the exchange rate by performing two-state Markov switching tests. The Markov switching estimations and the derived filtered regime probabilities show predominantly inverse interactions between gold and USD returns at normal market periods. Their interactions are positive under

stressful market conditions, suggesting an occurrence of complementarity between both assets as they become alternative safe havens for investors at times of financial distress.

We believe our analysis can be extended in the future as the state dependency of gold prices and the exchange rate on interest rates may alter with the ongoing digitalization of gold that contributes to the enormous increase in the trading volume (Frömmel 2022). Indeed, their interactions may become more dependent on proliferation or risks stemming from inflation expectations, economic policy uncertainty, and other factors influencing global financial markets, including macroprudential policy.

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Conflicts of Interest: The authors declare no conflicts of interest.

Notes

- ¹ In preliminary testing, we also examined the relationship between gold returns and the USD exchange rates at varied levels of market risk proxied by CBOE VIX and separately at different discernible levels of the economic policy uncertainty for the United States. These tests have produced far less robust results than the exercise on the gold–exchange rate dependency at varied levels of the federal funds rate. In addition, we used different USD exchange rates, leading us to employ the nominal broad USD index as the most statistically significant.
- ² Prior to testing Equation (3), we performed the Ramsey RESET test for possible specification errors in the bivariate relationship between log changes in gold prices and the log changes in the BRUSD. The test shows t-statistics of 1.457, F-statistics of 2.125, and a likelihood ratio of 2.126, with a probability of 0.145 for each of these measures. The 14.6 percent probability exceeding a 10-percent threshold indicates no specification errors in our model.

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