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Will Gold Prices Continue to Rise? A Time-Varying Analysis of the Dollar-Gold Nexus under Geopolitical and Economic Uncertainty

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Abstract: This study examines the dynamic interplay between the US Dollar Index (USDI) and gold prices (GP) to assess the sustainability of gold price trends. Employing a rolling window bootstrapping causality test methodology across full and sub-samples, the findings of this study challenge the conventional assumption of a stable long-term inverse correlation between USDI and GP, thereby validating the hypothesis that their relationship is nonlinear and time-dependent. During periods of heightened geopolitical and economic volatility, both the US dollar and gold function as safe-haven assets, with USDI fluctuations exerting a positive influence on GP. Conversely, under stable market conditions, the US dollar serves as the currency in which gold is denominated, resulting in a negative impact of USDI on GP. Notably, GP also demonstrates bidirectional causality, exhibiting both positive and negative effects on USDI. The analysis reveals that while a general inverse correlation persists between gold and the US dollar, this relationship transitions to positive during surges in global political and economic instability. In light of contemporary developments—including escalating geopolitical rivalries, tepid post-pandemic economic recovery, and elevated US interest rates driven by inflationary pressures—this study posit that the upward trajectory of gold prices retains a robust empirical foundation.

Keywords: Gold prices (GP); The Dollar Index (USDI); Bootstrap method; Causal relationship; Time-varying

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1. Introduction

The main purpose of this paper is to assess the sustainability of the gold price rising trend since 2023 through a bootstrap subsample rolling window causality test of gold prices(GP) and the US Dollar Index (USDI). London spot gold prices reached a record high of $2,789.99 per ounce on October 30 as the Federal Reserve cut interest rates by 50 basis points for the first time in three years on September 19, 2024. On February 14th, 2025, it even surpassed the mark of $2900 per ounce. So, whether this upward trend in gold prices can be maintained has become a hot issue that people care about. The answer to this question requires a deep analysis of the causal relationship between gold and the dollar.

Typically, there is a negative relationship between gold prices and the US dollar. This causal relationship between gold prices and the exchange rate of the US dollar has been investigated and verified by numerous scholars for a long time [1–3]. This relationship has certain theoretical logic. Gold has both precious metal and monetary properties, and is a "hard currency" that has both reserve and investment functions [4]. It is considered by investors to be the safest investment target and one of the most important commodities [5]. As the main international trade settlement currency and reserve currency, most international commodity transactions are denominated in US dollars [6]. There is a close interplay between the fluctuations of the US dollar exchange rate and gold prices [7, 8]. According to the law of one price, when the dollar appreciates, the price of gold denominated in dollars falls. Conversely, when the dollar depreciates, gold prices rise [9]. In fact, most of the time there is a negative correlation between the gold price and the US dollar index

But the relationship between gold prices and the dollar is not always negative, there are instances where it exhibits a positive correlation. Nevertheless, this positive correlation is short-lived and has been previously observed by experts in the field too [10–12]. Moreover, this relationship is not always stable [13]. When financial markets are running smoothly, gold and the dollar tend to rise and fall each other; However, when there is a local political crisis or economic crisis in the world, it shows a positive correlation [14]. In 2015 and 2016, the US dollar index had a fairly clear positive correlation with gold prices [15]. In the early stages of the COVID-19 pandemic from August 2019 to January 2020, the US dollar index moved in the same direction as the international gold price [16]. However, during the COVID-19 pandemic, this phenomenon no longer exists [17].

It can thus be seen that the relationship between the gold price and the US dollar is not a simple linear one, but rather a complex causal one that varies over time [18]. However, the existing literature lacks in-depth studies on this matter. This paper endeavors to make up for this deficiency.

There are several marginal contributions of this article. Firstly, the current literature mainly focuses on the one-way relationship between gold prices and the US dollar, whereas this study investigate the two-way causal relationship between them. Secondly, the existing literature mainly employs the entire sample for empirical tests, while, here, sub-samples are adopted to study the causal relationship between the two. Thirdly, the current literature reaches a general qualitative conclusion regarding the relationship between the two, while in this study, the causal relationship between them that varies with time is examined. Finally, the precise conclusions about the direction and degree of influence of the relationship between the two over time is obtained.

2. Literature review

In terms of research content, the existing literature is primarily concentrated on the aspect of long-term causal relationship testing. Lucey [19], Joy [20], and Apergis [13] et al.'s studies have shown that there exists a relatively strong and stable correlation between them. Usually, the fluctuation of the US dollar exchange rate has a negative causal relationship with the price of gold, which the devaluation of the US dollar has resulted in an enhanced demand for gold [21–23]. Beckers *et al.* [1], as well as Sjaastad *et al.* [2] had noticed this phenomenon early on. Zhou as well as Qin *et al.* came to different conclusions that show a positive causal relationship between the two under certain circumstances, especially in the face of global political and economic uncertainty [24, 25]. Jia *et al.* analyze the causal relationship between gold and the US dollar exchange rate from the perspective of short-term investments [4].

In the perspective of research methodology, most studies have adopted an empirical testing approach.

Sugihara *et al.* explore the causal relationship between complex nonlinear systems from a dynamic perspective, measuring the causal relationship between gold and the US dollar [26]. Massimiliano *et al.* [27] and Apergis [13] obtain the time-varying causality between gold and the US dollar by using error correction models, standard binary GARCH models, and an extension of the structural BEKK model. Xie *et al.* use impulse response function and Granger causality test to construct vector autoregressive (VAR) model and analyze the relationship between international gold price and US dollar index, which shows that there is a long-run negative causal relationship between the two [28]. Suraya uses the Quantitative Clear Technique utilizing auxiliary information from finance yippee, list mundi, BPS, and IDX for the years 2013–2022 [29].

Scholars have conducted numerous beneficial explorations on the causal relationship between gold prices and the US dollar. The findings show that there is both a long-term negative causal relationship and a short-term one between them. This precisely indicates that the causal relationship between them is complex and may be time-varying. However, most existing studies have focused on the unidirectional causal relationship between the US dollar and gold price, while there is less research on the causal relationship between gold price and the US dollar, and even fewer studies on the bidirectional causal relationship between the two.

Therefore, this paper conducts an in-depth exploration of the two-way dynamic causal relationship between them from an interactive perspective, focusing on whether there is a synchronization effect in the long-term. This helps to provide a more comprehensive understanding of the mechanisms of their interactions, reveal the possible economic logic behind them, and assess the sustainability of the trend of gold price rising. To achieve this goal, this paper employs the method of bootstrap rolling window causality test. This not only effectively captures the nonlinear and time-varying features of the time series, but also dynamically tests the mutual influence between them at different time periods.

3. Theoretical analysis and research hypothesis

3.1. GP-USDI interaction mechanisms (Hypothesis H1)

H1: The interaction between gold prices and the US Dollar Index exhibits structural breaks and regime-dependent behavior, manifesting as a non-linear dynamic relationship rather than a stable linear association. This time-varying correlation is contingent upon macroeconomic regimes, monetary policy cycles, and global risk appetite fluctuations.

Theoretical Framework and Hypothesis Development Within the Bretton Woods system's fixed exchange rate regime, gold and the US dollar maintained a parity relationship characterized by mutual convertibility. The system's collapse in 1971 fundamentally altered this equilibrium, resulting in an emergent inverse correlation that has since dominated financial market observations. However, empirical evidence reveals notable exceptions where concurrent appreciation or depreciation of both assets occurs, challenging conventional assumptions of persistent negative correlation. This paradox underscores the necessity of adopting a dynamic analytical framework to examine their evolving relationship, particularly given the increasing financialization of gold markets and the dollar's evolving role in global reserve systems. These observations motivate our primary research hypothesis.

3.2. Transmission mechanisms of USDI on GP (Hypothesis H2)

H2: The US Dollar Index non-linearly impacts gold prices through regime-dependent transmission mechanisms, exhibiting time-varying characteristics in directional influence, operational pathways, and effect magnitude across different market states.

As the benchmark pricing currency in international gold markets (World Gold Council, 2022), fluctuations in the US dollar exchange rate mechanically influence gold price dynamics through dual transmission channels. When the dollar appreciates, it simultaneously creates a substitution effect that suppresses USD-denominated gold demand while enhancing purchasing power for non-USD investors, ultimately exerting downward pressure on dollar-based gold valuations. Conversely, dollar depreciation triggers inverse mechanisms that amplify gold's affordability in non-USD markets, thereby elevating its dollar-denominated price (**Figure 1a**).

Notably, both assets demonstrate crisis-hedging synergy during market turmoil, wherein investors concurrently accumulate gold and dollar positions to preserve value, generating temporary price co-movement (**Figure 1b**). This paradoxical relationship dissolves upon market stabilization, as post-crisis capital rebalancing prompts synchronized declines. These observations reveal context-dependent interactions where the dollar's influence on gold manifests through:

(1) currency denomination effects

(2) safe-haven competition dynamics, with transmission intensity varying non-proportionally to macroeconomic conditions.

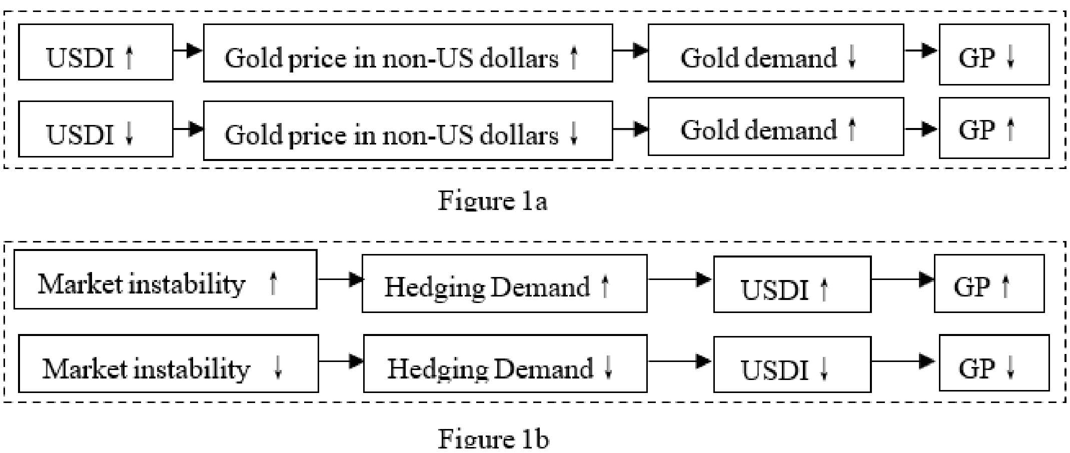

Figure 1. The transmission mechanism of USDI on GP

3.3. Transmission mechanism of GP on USDI (Hypothesis H3)

H3: Gold prices exhibit asymmetric spillover effects on USDI through dual transmission channels (commodity flow vs. risk sentiment), with directionality, intensity, and persistence demonstrating regime-dependent nonlinearities and measurable time-varying features.

Gold's dual role as both a physical commodity and safe-haven asset creates bidirectional price transmission mechanisms with USDI. Commodity market dynamics reveal an inverse relationship: rising gold prices suppress bullion demand through price elasticity effects, thereby reducing USD transactions in gold markets and exerting downward pressure on the dollar (**Figure 2a**). Conversely, gold price declines stimulate physical demand, expanding dollar-based settlement volumes that mechanically strengthen the currency.

Paradoxically, during market turmoil (VIX > 30), their safe-haven attributes dominate, establishing a competitive substitution relationship. Investors' flight-to-safety triggers simultaneous capital reallocations to both assets, creating positive price co-movement (**Figure 2b**). This crisis-driven correlation dissolves post-shock through mean reversion processes as portfolio rebalancing restores conventional price dynamics.

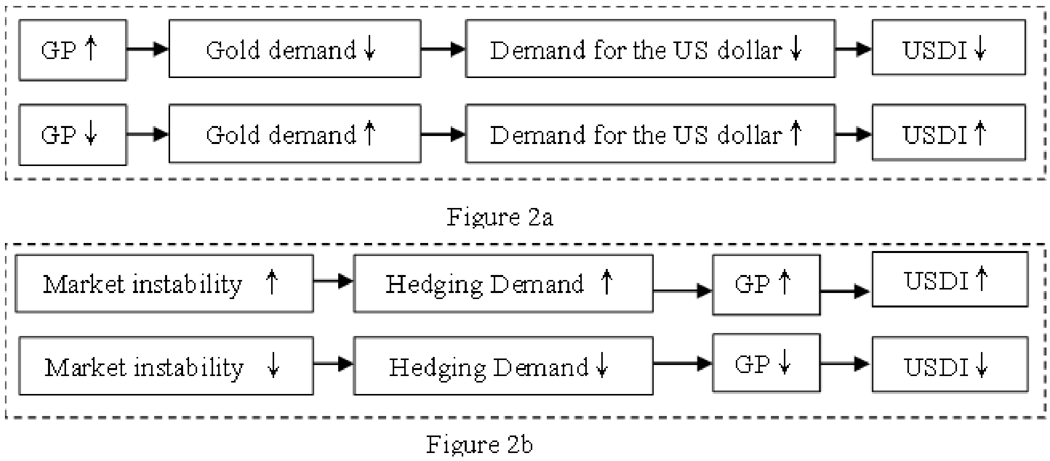

Figure 2. The transmission mechanism of GP on USDI

4. Methodology

4.1. Bootstrap full-sample causality test

Conventional Granger causality tests employing vector autoregression (VAR) frameworks exhibit deviations from standard asymptotic distributions, particularly in finite-sample conditions. To address this limitation and enhance test reliability, Shukur *et al.* pioneered residual-based bootstrapping (RB) techniques that generate empirical critical values through Monte Carlo simulations, effectively mitigating size distortions in small-sample scenarios while maintaining asymptotic validity [30]. Subsequent refinements by the same researchers introduced likelihood ratio (LR) test variants optimized through bootstrap adjustments, achieving superior power-size tradeoffs across distributional assumptions [31].

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \ldots\ldots + \alpha_p Y_{t-p} + \upsilon_t \qquad t=1, 2, \ldots\ldots, T \tag{1}$$

The optimal lag structure (p) is determined through rigorous application of the Schwarz Information Criterion (SIC), which balances model fit against complexity to achieve optimal model parsimony. This bivariate VAR(p) system, specifically configured with the US Dollar Index (USDI) and Gold Price (GP) as endogenous variables, can be reformulated in compact matrix notation as follows:

$$\begin{bmatrix} \mathrm{TWDI}_t \\ \mathrm{GP}_t \end{bmatrix} = \begin{bmatrix} \alpha_{10} \\ \alpha_{20} \end{bmatrix} + \begin{bmatrix} \alpha_{11}(L) & \alpha_{12}(L) \\ \alpha_{21}(L) & \alpha_{22}(L) \end{bmatrix} \begin{bmatrix} \mathrm{USDI}_t \\ \mathrm{GP}_t \end{bmatrix} + \begin{bmatrix} \upsilon_{1t} \\ \upsilon_{2t} \end{bmatrix} \tag{2}$$

Where $\upsilon_t = (\upsilon_{1t}, \upsilon_{t})$ is a white-noise process with zero mean and covariance matrix. The coefficients $\alpha_{ij}(L) = \sum_{k=1}^{p} \alpha_{ij,k} L^k$, i, j=1, 2 and L is a lag operator, with $L^k Y_t = Y_{t-k}$.

The null hypothesis that GP has no effects on USDI (i.e., $\alpha_{12,k}$=0 for k=1, 2, ..., p) can be tested based on the Equation (2). If this null hypothesis is rejected, it indicates USDI is a Granger cause of GP. Similarly, the inverse null hypothesis that USDI has no effects on BP(i.e., $\alpha_{12,k}$=0 for k=1, 2, ..., p) can be rejected in the same way.

4.2. Parameter stability test

Traditional bootstrap full-sample causality tests presume time-invariant parameters in VAR specifications, an assumption frequently violated in financial time series analysis. When parameters exhibit temporal variation, full-sample approaches risk generating biased inferences through structural break neglect. To rigorously diagnose parameter instability, the triple testing framework of Andrews [32] and Andrews *et al.* [33] was implemented:

(1) Sup-F test: Detects abrupt structural breaks

(2) Ave-F test: Identifies gradual parameter shifts

(3) Exp-F test: Captures smooth parameter transitions

Complementarily, the L_c statistic evaluates martingale-driven parameter evolution through nonparametric variance ratio analysis [34, 35]. Rejection of stability across any test dimension indicates potential regime-dependent USDI-GP linkages, necessitating supplementary time-varying analysis.

4.3. Bootstrap sub-sample rolling-window causality test

The method is developed by Balcilar *et al*., which involves dividing the entire time series into sub-samples using the rolling-window approach [36]. The sub-samples are then moved sequentially from the start to the end of the whole sample. The procedure works as follows: Let the total length of the time series be *T* and the rolling-window width be *l*. The last observation in each sub-sample is *l*, *l*+1, ... , *T* , resulting in *T*-*l*+1 sub-samples. Each sub-sample can then be analyzed using the RB-based modified-LR test to obtain Granger causality results.

The final results of the bootstrap sub-sample rolling-window test are derived by summarizing the p-values and LR statistics across all sub-samples in chronological order. The mean values of the parameters $N_b^{-1}\sum_{k=1}^{p}\hat{\alpha}^*_{12,k}$ and $N_b^{-1}\sum_{k=1}^{p}\hat{\alpha}^*_{21,k}$ represent the average effects of GP on USDI and USDI on GP, respectively, where

N_b is the number of bootstrap repetitions. The parameters $\hat{\alpha}^*_{12,k}$ and $\hat{\alpha}^*_{21,k}$ are the estimated coefficients from Equation (2). A 90% confidence interval is used, with the corresponding lower and upper bounds given by the 5th and 95th quantities of $\hat{\alpha}^*_{12,k}$ and $\hat{\alpha}^*_{21,k}$, respectively.

Choosing the appropriate rolling-window width is a complex decision. A smaller window may lead to less robust test results, while a larger window can improve the accuracy of the estimates but reduce the number of possible windows. Pesaran *et al.* suggest that the rolling-window width should not be less than 20 when parameter stability cannot be assumed [37].

5. Data

In this paper, monthly data spanning from March 1973 to July 2024 is used to examine the Granger causality between GP and USDI, with the aim of assessing the sustainability of the upward trend in GP. On August 15, 1971, the United States announced the cessation of fulfilling the obligation of exchanging US dollars for gold. On March 16, 1973, major countries in the European Community market implemented a floating exchange rate for the US dollar. As a result, the Bretton Woods system completely collapsed. Since then, GP has embarked on a spiral upward path, while USDI has fluctuated downward, as depicted in **Figure 3**.

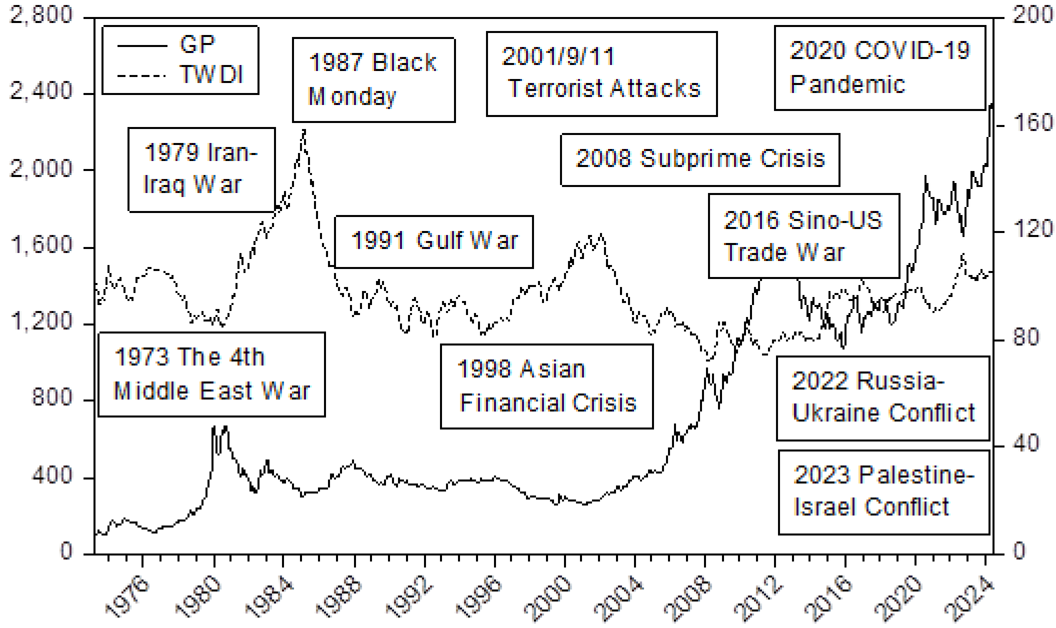

Figure 3. The trends of GP and USDI

GP have experienced three distinct cyclical patterns over the past half-century. The first major cycle commenced in March 1973 at 84.37 per ounce, entering a sustained upward trajectory that intensified with geopolitical tensions during the 1979 Iran-Iraq War. This bull market culminated in January 1980 when prices peaked at 675.31 per ounce - an extraordinary 800% appreciation within seven years. This historic high ushered in a 20-year bear market marked by gradual depreciation. Notably, even the 1987 Black Monday stock market collapse, which briefly drove prices to 486.24 per ounce in October of that year, failed to challenge the previous record. The second cycle emerged from its July 1999 low of 256.08 per ounce, gaining momentum during the 2008 global financial crisis. This surge propelled gold past the 1,000 milestone in October 2009, ultimately reaching 1,700 by 2012 before entering another corrective phase. The current cycle began in December 2013 at 1,221.51, with the COVID-19 pandemic in 2020 acting as a significant catalyst. Prices surpassed 1,900 in August 2020, broke through 2,000 in December 2023, and reached 2,398 by July 2024 while maintaining upward momentum.

Over this 51-year span, gold has delivered a 28.42-fold appreciation. Market corrections have shown a consistent pattern of contraction in both duration and magnitude: correction periods have shortened from 20 years in the first cycle to under two years in recent cycles, while price retracements have diminished from 62.1% to approximately 30% during the same timeframe.

USDI has demonstrated three distinct cyclical patterns since 1973. The inaugural cycle extended from March 1973 through August 1992, achieving its historical zenith at 158.4906 in February 1985 before commencing a prolonged depreciation phase. Subsequent market behavior manifested in the second cycle spanning September 1992 to April 2008, which attained its cyclical peak of 117.9548 in March 2002, ultimately transitioning into a phase characterized by heightened volatility and gradual decline. Currently in its third evolutionary stage commencing May 2008, the index has exhibited persistent upward volatility, culminating in an October 2022 high of 111.9375.

Observational data from **Figure 3** reveals a fundamental inverse correlation between GP and USDI dynamics.

Historically, appreciation in gold valuations has corresponded with dollar index depreciation, while gold price corrections have typically aligned with dollar strength. Notably, this relationship has demonstrated periodic synchronization, with transient intervals of concurrent directional movements. A significant deviation emerged post-September 2018, wherein both asset classes have exhibited a prolonged phase of simultaneous appreciation, challenging conventional market expectations.

This evolving interaction underscores the complex adaptive mechanisms governing GP-USDI dynamics, where macroeconomic variables, geopolitical developments, and monetary policy shifts collectively reshape traditional correlation patterns over temporal dimensions.

Table 1 summarizes key statistical characteristics of the dataset. The computed mean values for GP and USDI stand at 703.510 and 96.679, respectively. Both series exhibit positive skewness, with USDI demonstrating particularly pronounced kurtosis ($>$ 3), confirming its leptokurtic distribution pattern. Jarque-Bera test results decisively reject normality assumptions for both variables at the 1% significance level (JB statistics: GP=85.32, USDI=112.47), necessitating alternative analytical approaches.

Table 1. Descriptive statistics for GP and USDI

	GP	**USDI**
Observations	617	617
Mean	703.510	96.679
Median	404.760	95.115
Maximum	2398.200	158.490
Minimum	84.370	72.105
Standard Deviation	557.579	14.178
Skewness	1.0377	1.362
Kurtosis	2.772	5.821
Jarque-Bera	112.073^{***}	395.682^{***}

Note: *** denotes significance at the 1% level.

Given the identified non-normal distributions, the Residual-Based (RB) methodology is implemented to mitigate estimation bias. This investigation employs bootstrapped subsample rolling-window testing to capture time-dependent causality dynamics between these financial instruments.

Logarithmic conversion applied to GP/USDI series to stabilize variance First-differenced Bitcoin returns (ΔBP) incorporated as control variable Stationarity verification through augmented Dickey-Fuller testing.

6. Empirical results

6.1. The causal relationship test of the full sample for GP and USDI

Firstly, stationarity tests for both GP and USDI variables were conducted. Utilizing three methodologies— ADF, PP, and KPSS— unit root examinations were performed on both level data and first-differenced series. **Table 2** demonstrates that at the 1% significance level, the unit root hypothesis cannot be rejected for the original series, confirming their non-stationary nature. However, following first-order differencing, the null hypothesis becomes statistically rejectable at the same significance threshold, establishing stationarity. These diagnostic results collectively indicate that GP and USDI constitute first-order integrated time series.

Table 2. Unit boot tests

Series	Levels			First differences		
	ADF	PP	KPSS	ADF	PP	KPSS
GP	1.624399	2.858581	1.429996	-19.91648***	-19.81682***	-19.86323***
USDI	-2.417420***	-2.368128	-2.339115	-17.77002***	-7.830158***	-17.77002***

Note: *** denotes significance at the 1% level.

Then, on the basis of the first-order integrated sequence, a bivariate VAR model of the first-order differences of GP and USDI is established. Based on the Schwarz Information Criterion (SIC), the optimal lag order is determined to be 3. The modified LR causality test method based on RB is used to conduct the Granger causality test for the full sample. The results are shown in **Table 3**. According to the bootstrap *p*-values, it can be seen that in the full sample, GP is not the Granger cause of USDI, and USDI is not the Granger cause of GP. This indicates that there is no stable full sample causality relationship between the two.

Table 3. Full-sample Granger causality tests

Tests	H_0: GP does not Granger cause UDI		H_0: USDI does not Granger cause GP	
	Statistics	*p*-values	Statistics	*p*-values
Bootstrap *LR* test	0.722446	0.775200	2.634220	0.317300

Notes: To calculate *p*-values using 10,000 bootstrap repetitions.

6.2. The parametric stability test of GP and USDI

If there are structural changes in the time series, the assumptions of fixed parameters and causal relationships in the full-sample causality test are no longer reliable, and thus the results of the full-sample causality between GP and USDI estimated using the VAR model become meaningless. In view of this, the Sup-F, Mean-F, and Exp-F tests, as well as the Lc test, are employed to examine the parameter stability based on the two-variable VAR model. To ensure the accuracy of the tests, the critical values and probability values of the parameter stability tests are obtained through 10,000 bootstrap replications.

Table 4 presents the results of the short-term parameter stability tests. The Sup-F test result rejects the null hypothesis that the parameters are stable, indicating a significant one-time offset of the parameters over time. The Mean-F and Exp-F test results reject the null hypothesis that the parameters do not gradually evolve over time, suggesting that the parameters evolve over time. The Lc test result indicates that the parameters of the VAR model follow a random walk process, and the parameters are unstable during the full sample period. These results all suggest that the two-variable VAR model of GP and USDI is unstable in the short term. Since both GP and USDI are first-order integrated, this implies that when the cointegration relationship does not exist, the first-order difference VAR model of the two variables is not reasonable.

Table 4. The results of parameter stability test

Tests	GP		USDI		VAR system	
	Statistics	*p*-value	Statistics	*p*-value	Statistics	*p*-value
Sup-F	22.891	0.008	20.855	0.018	109.361	0.000
Ave-F	9.081	0.045	5.494	0.340	24.158	0.000
Exp-F	7.450	0.014	5.398	0.085	48.612	0.000
L_c					5.208	0.005

Notes: To calculate *p*-values using 10,000 bootstrap repetitions.

The Sup-F and Mean-F tests were employed to estimate the long-term parameter stability of the two variables, GP and USDI, and the Lc statistic was used to test the stability of the cointegration relationship. The results are shown in **Table 5**. Among them, the Lc test result rejects the null hypothesis of cointegration of the original sequence; the Sup-F test result rejects the null hypothesis, suggesting that there might be structural changes in the long term; the Mean-F test result accepts the null hypothesis that the sequence does not gradually evolve over time.

Table 5. The results of parameter stability test in long-run relationship

	Sup-F	Mean-F	Exp-F	Lc
GP=a + b × USDI	213.733	95.145	102.397	14.097
Bootstrap *p*-values	0.000	1.000	1.000	0.005

All these results suggest that a one-off transfer of parameters occurred in the long term, and the cointegration relationship between GP and USDI is not reliable. Thus, the results of the full-sample causality test might be biased and unable to precisely characterize the causal relationship between GP and USDI over the entire time series. It is indeed necessary to conduct causality tests for subsamples.

The results of **Tables 3**, **4**, and **5** above indicate that both GP and USDI possess structural break characteristics. There is no stable linear relationship between them but a nonlinear time-varying relationship. This validates the content of Hypothesis 1 in this study.

6.3. The causal relationship test of the sub-sample for GP and USDI

The unstable test results of the aforementioned parameters are largely in line with the actual circumstances of GP and USDI. Since the collapse of the Bretton Woods system in 1973, significant structural alterations have occurred in the relationship between GP and USDI. To investigate the causal relationship between two during this period, such structural changes must be taken into account. To this end, this paper employs the bootstrapped rolling window technique to more comprehensively reflect the characteristics of the subsamples as they evolve over time. Continuing to adopt a fixed subsample width of 24 months, a modified LR (likelihood ratio) causal test method is implemented to conduct rolling tests of the causal relationship among variables. The results of this process are presented in graphical form, specifically **Figure 4** to **Figure 7**, which visually showcase the detailed results of the rolling tests, facilitating in-depth analysis and comprehension of the dynamic changes in the causal relationship among variables.

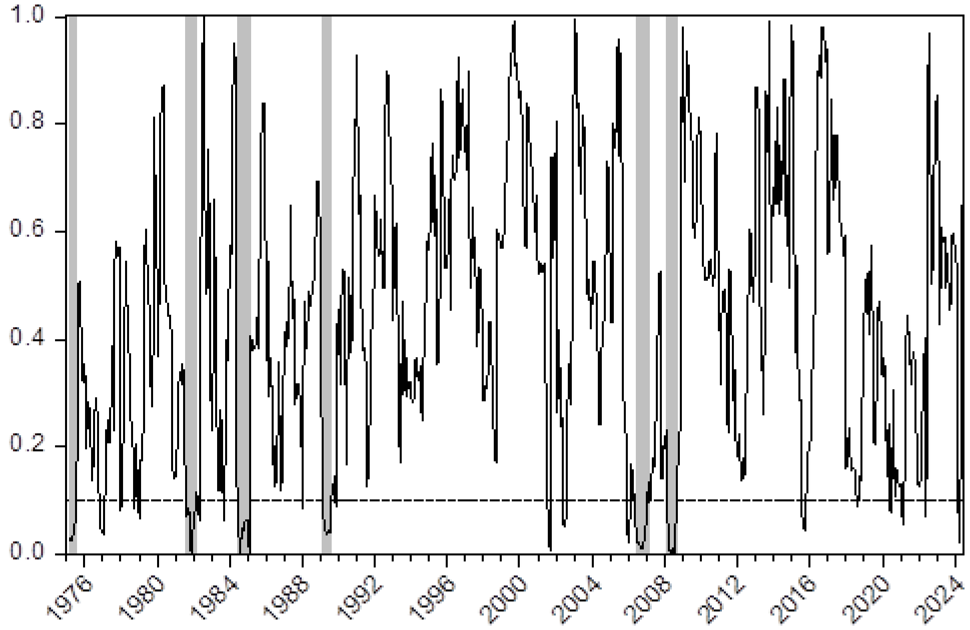

Figure 4. Bootstrap p-values of rolling test statistic testing the null hypothesis that USDI does not Granger cause GP

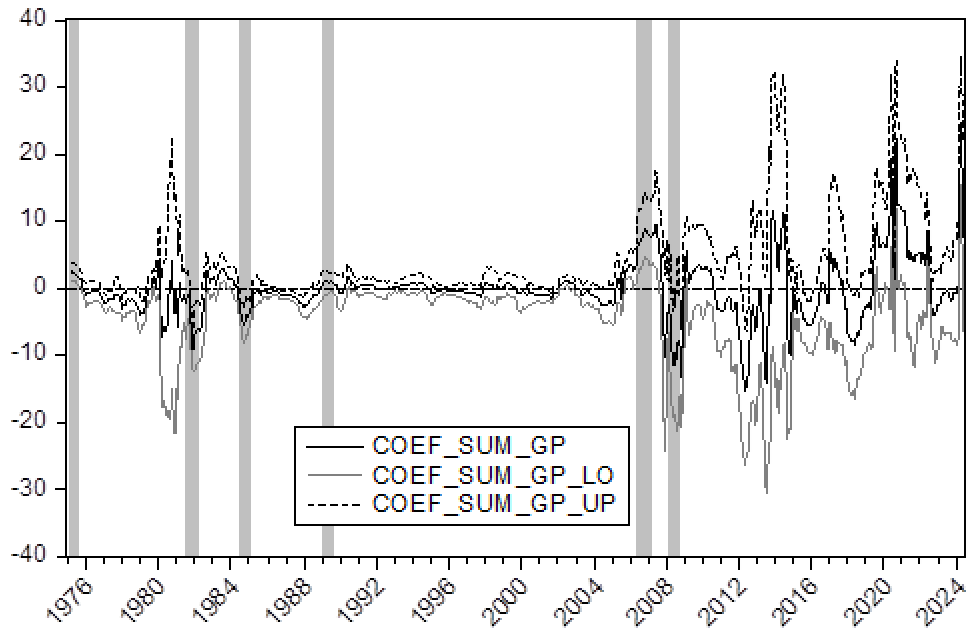

Figure 5. Bootstrap estimates of the sum of the rolling-window coefficients for the impact of USDI on GP

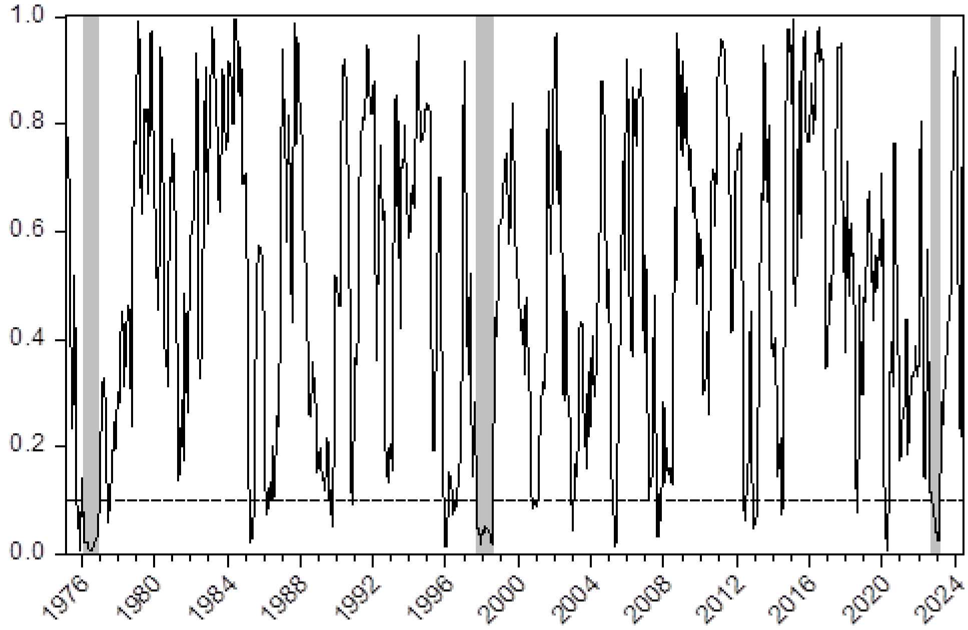

Figure 6. Bootstrap p-values of rolling test statistic testing the null hypothesis that GP does not Granger cause USDI

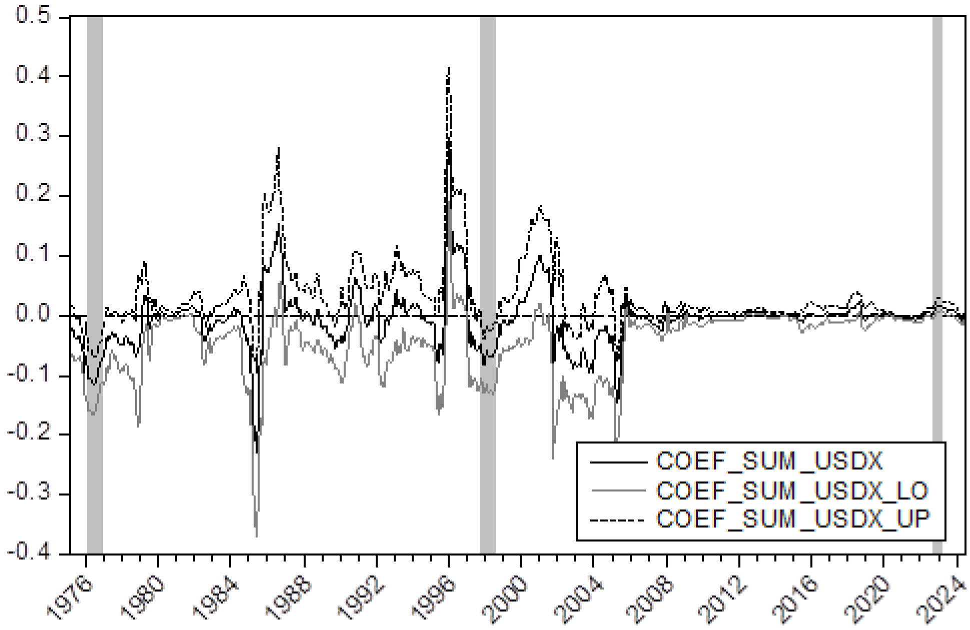

Figure 7. Bootstrap estimates of the sum of the rolling-window coefficients for the impact of GP on USDI

Figure 4 presents the bootstrapped p-value results for the USDI's lack of impact on GP. As shown in the shaded areas of the figure, the *p*-values are less than 0.1 during the periods of March-July 1975, August 1981-March 1982, July 1984-February 1985, February-August 1989, June 2006-March 2007, and March-September 2008. This indicates that at the 10% significance level, the null hypothesis that "USDI is not a Granger cause of GP" can be rejected, implying that USDI has a significant effect on GP during these periods.

Figure 5 further displays the average impact coefficients of USDI on GP, estimated using the subsample rolling window bootstrapping method, along with their upper and lower bounds. As shown in the figure, during the periods of March-July 1975, February-August 1989, and June 2006-March 2007, the average impact coefficients are greater than zero, indicating a positive relationship between USDI and GP. In contrast, during the periods of August 1981-March 1982, July 1984-February 1985, and March-September 2008, the average impact coefficients are less than zero, suggesting a negative relationship between USDI and GP.

When market uncertainty fluctuates significantly, both the U.S. dollar and gold serve as safe-haven assets, and changes in the value of the U.S. dollar generally have a positive effect on gold prices. Between March and July 1975, the U.S. dollar index declined, causing gold prices to retreat from historical highs. In October 1973, the outbreak of the Fourth Middle East War and the formal decoupling of the U.S. dollar from gold triggered a surge in gold prices, which rose from \$84.37 per ounce in March 1973 to \$183.78 per ounce in December 1974. However, after Egypt and Israel signed the first phase of the disengagement agreement in early 1975, easing tensions in the Middle East, market uncertainty significantly decreased, leading to a reduction in the demand for both the U.S. dollar and gold as safe-haven assets. From February to August 1989, the U.S. dollar index moved within a consolidation range, which led to a decline in gold prices and marked the beginning of a new downward cycle for both assets. Starting in February 1985, a negative correlation between the falling U.S. dollar index and rising gold prices emerged. However, in February 1989, following the Soviet Union's withdrawal from Afghanistan, international political risks significantly decreased, stabilizing the market environment. After a period of consolidation, the U.S. dollar index continued to decline, and gold prices entered a new downward phase. Between June 2006 and March 2007, the U.S. dollar index fluctuated at high levels, while gold prices continued to rise. In June 2006, the Federal Reserve concluded a two-year interest rate hike cycle, and market expectations of a potential shift toward more accommodative monetary policy led to the end of the U.S. dollar index's upward trajectory. Simultaneously, signs of a real estate bubble in the U.S. began to emerge, increasing economic uncertainty and driving up demand for gold as a safe-haven asset.

In contrast, when the market environment stabilizes, the value of the U.S. dollar, as the currency in which gold is priced, negatively affects gold prices. From August 1981 to March 1982, the U.S. dollar index surpassed 110, reaching a historical high, while gold prices continued to decline. The appreciation of the U.S. dollar attracted capital inflows, reducing the appeal of gold as an investment, which led to further declines in gold prices. This negative relationship between the U.S. dollar index and gold prices was also evident during the periods from July 1984 to February 1985 and from March 2008 to September 2008.

These results support the hypothesis H2 of this study, which asserts that USDI has a significant impact on GP, with the direction and magnitude of this influence exhibiting non-linear characteristics, strongly affected by fluctuations in the international political and economic environment. Specifically, when international political and economic uncertainty intensifies, changes in the value of the U.S. dollar have a positive effect on gold prices; when international political and economic conditions stabilize, changes in the value of the U.S. dollar exert a negative effect on gold prices. This conclusion highlights the importance of considering multiple factors, such as international political and economic uncertainty, when analyzing the relationship between the U.S. dollar and gold, as well as forecasting gold price movements.

Figure 6 presents the p-value results of the bootstrapping estimation of the no-effect of GP on USDI. During the periods of 1976M02-M12, 1997M10-1998M08, and 2022M10-2023M03, the p-values are less than 0.1, indicating that the null hypothesis that "GP is not the Granger cause of USDI" is rejected at the 10% significance level, meaning that GP has a significant impact on USDI.

Figure 7 further shows the mean values of the impact coefficients of GP on USDI obtained through bootstrapping estimation and their upper and lower limits. During the periods of 1976M02-M12 and 1997M10-1998M08, the mean values of the impact coefficients are less than 0, indicating a negative impact of GP on USDI. During the period of 2022M10-2023M03, the mean value of the impact coefficient is greater than 0, indicating a positive impact of GP on USDI.

During 1976M02-M12, the gold price dropped to a phased low point and the US dollar index rose to a phased high point. In 1976, global geopolitical conflicts eased, weakening the "safe haven" attribute of gold. The gold price dropped. The US economy gradually recovered from the stagflation predicament in the early 1970s, enhancing market confidence in US dollar investments, and the US dollar index strengthened accordingly. During 1997M10-1998M08, the relationship of the gold price falling and the US dollar index rising again occurred. This period coincided with the peak of the Asian financial crisis. On July 2, 1997, Thailand announced the abandonment of the fixed exchange rate system of pegging the baht to the US dollar, triggering a chain reaction, and the crisis spread rapidly. International investors sought safe assets. Although gold is usually regarded as a safe-haven asset, in a liquidity-constrained situation, investors may prefer to hold US dollars rather than physical gold. During 2022M10–2023M03, gold rose from a phased position and the US dollar dropped from a phased high point. Due to the continuous escalation of geopolitical tensions, such as the Ukraine crisis and other regional conflicts, market uncertainty increased, and the demand for gold as a safe haven increased. Gold prices rose. However, the continuous spread of the COVID-19 pandemic exacerbated investors' concerns about a US economic recession, leading to a lack of confidence in US dollar investments, and the US dollar index declined.

7. Conclusion

The primary objective of this paper is to investigate the dynamic relationship between the trade-weighted US dollar index (USDI) and gold prices (GP), aiming to provide a theoretical foundation for analyzing gold price trends.

First, a theoretical analysis is conducted. By examining the interaction mechanisms between the U.S. dollar index and gold prices, three hypotheses are proposed. The core argument posits that the relationship between the USDI and GP is bidirectional, involving either positive or negative influences, and is not static but rather time-varying.

Second, empirical validation is carried out using the rolling window bootstrapping causality test method to analyze both full-sample and sub-sample data. This approach effectively identifies structural breaks in the time series and reveals the time-varying nature of the relationship. Empirical results confirm the hypothesis of a time-varying relationship between the USDI and GP, challenging the traditional view of a stable long-term negative correlation. Specifically, during periods of heightened global political and economic uncertainty, both the US dollar and gold act as safe-haven assets, leading to a positive impact of USDI fluctuations on GP. Conversely, under stable political conditions and optimistic economic expectations, the US dollar's role as the pricing currency for gold drives a negative USDI-GP relationship. Additionally, bidirectional causality is observed, with GP also exerting both positive and negative feedback effects on the USDI.

The core point is simply one sentence. The study demonstrates that while gold and the US dollar typically exhibit a negative correlation, this relationship shifts to a positive correlation amid rising geopolitical and economic uncertainties.

Finally, policy implications are drawn. In the context of the current global political-economic landscape—characterized by intensifying major-power competition, a sluggish economic recovery, persistently high U.S. inflation, and elevated interest rates—the findings provide a plausible theoretical and practical basis for the continued upward momentum in gold prices. Investors analyzing gold price trends or engaging in gold-related investments should not only account for the time-varying USDI-GP relationship but also integrate broader considerations, including the evolving international political-economic environment and the underlying logic driving their interactions.

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