

# Analysing Interrelationship between Gold Prices in India and US Dollar Exchange Rate

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## Abstract

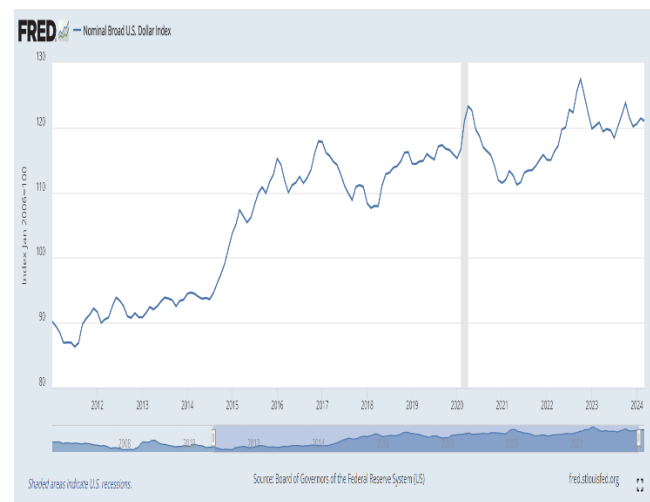
The study analysed the long-run equilibrium and lead-lag relationship between US dollar exchange rate and gold prices in India based on monthly observations spanning January 2011 to December 2022. Using Johansen cointegration test and Granger causality analysis, the study found that the variables considered have single cointegrating vector which confirms cointegration between Indian gold prices and US dollar. Further, it has been observed that a long-run unidirectional causality runs from US dollar towards Indian gold prices which clearly highlights the US dollar dominance towards gold prices in India. Hence, the study brings out the fact that the US dollar exchange rate is a significant driver that can influence the gold prices in India.

**Keywords:** US dollar, Indian gold prices, Cointegration, Causality.

## 1. Introduction

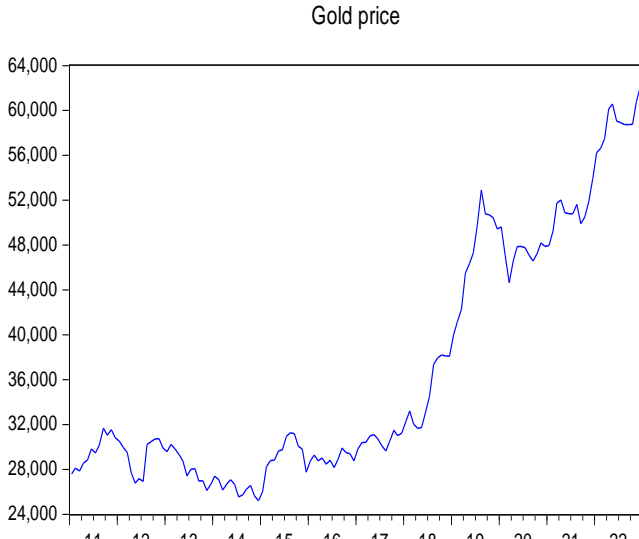
In India, gold is considered as one of the most precious metals not only from the perspective of ornaments but also from the point of view of investment assets in the form of financial securities and economic reserves. India is known for its position among the largest importers of gold in comparison to most of the emerging and advanced economies. US dollar is predominantly crucial for the settlement of economic and trade transactions including import and export of gold. The currency gained prominence as an international currency following first world war. Further, after the second world war, the Bretton Woods Agreement had replaced the British pound sterling with US dollar as the world's principal reserve currency. Till 1971, the Bretton Woods system prevailed in which US dollars were tied to a certain sum of gold and other countries' currencies were tied to US dollar. But the collapse of Bretton Woods agreement in 1973 led to suspension of the dollar's convertibility into gold and subsequently the countries were free to link their currencies to US dollar or other basket of major currencies. The value of US dollar is now based on demand and supply forces and is considered as an official currency for international trade.

Since 1973, US dollar hegemony is causing instability for all other economies in terms of currency valuation, inflation and other macroeconomic factors. Furthermore, the US is enjoying the undue authority of printing as many US dollar as it wants which deteriorates the monetary policy factors like interest rate and inflation in economies other than US and also gold price is no exception. This study attempts to foresee the impact of USD on gold prices in India. The intrinsic worth of the US dollar as an international currency influences the price of precious metals specifically gold of which India is one of the major consumers around the world. Moreover, the inverse relationship between the gold prices and US dollar is the subject of frequent discussion among the economic researches and currency market all around the globe. Considering this scenario, the study focuses on the ascertainment of the lead-lag relationship between the volatility of the US dollar exchange rate and the gold prices prevailing in Indian market.



Source: Federal Reserve Bank Database

Fig.1. Trends in US Dollar.



Source: RBI Database

Fig.2. Trends in Gold Prices in India.

## 2. Review of Literature

For evaluating the causal relationship between US dollar exchange rate and Indian gold prices, it is pertinent to review the existing literature based on similar studies. The relevant studies are outlined below in chronological order: Sjaastad (2008) examined the correlation between the spot and future gold prices and the major exchange rates such as US dollar, Japanese yen and euro using the forecasting error data technique. The author found that the major factor causing the volatility of gold prices was the evolution of floating exchange rates following the collapse of Bretton Woods system. The study further concluded that USD has remained the most prominent currency for the international transactions.

Sari et al. (2010) investigated the co-movements among the USD/euro exchange rate, oil prices and spot prices of four metals including gold, silver, palladium and platinum. The evidence of weak long-run equilibrium association but a strong short-term feedbacks has been witnessed in the study.

Chang et al. (2013) scrutinised the correlations of Taiwan's gold prices, international oil prices and New Taiwan (NT) dollar exchange rate vis-a-vis US dollar using daily data spanning September 2007 to December 2011. The results exhibit a significant level of independence between the NT exchange rate and the prices of gold and oil.

Jain and Ghosh (2013) examined the cointegration and causality among international oil prices, Indian rupee vis-a-vis US dollar exchange rate and prices of precious metals viz, gold, silver and platinum based on daily dataset covering a period from January 2, 2009 to December 30, 2011. The study observed a long-run equilibrium among considered data series when exchange rate and gold price were taken as dependent variables. Further, the Granger

causality results revealed that Indian rupee exchange rate causes other variables such as price of precious metals and crude oil prices.

Nair et al. (2015) studied the impact of global recession on Indian gold prices and USD exchange rate using Johansen cointegration and Granger causality approach during three separate phases i.e., pre financial crisis, during financial crisis and post financial crisis ranging from 2005 to 2013. The findings concluded that the value of US dollar exchange rate is predominantly affecting the gold prices of India in all the three phases.

Keeping in mind the review of earlier studies, the primary focus of the current study is to comprehend the long-term association and causal relationship between the gold prices of India and US dollar exchange rate.

## 3. Objectives of the Study

In the light of above discussion and analysis of earlier literature, the current study will primarily focus on following objectives:

1. To explore the cointegrating relationship between Indian gold prices and US dollar exchange rate.
2. To observe if there is any causality between Indian gold prices and US dollar exchange rate.

## 4. Data Description

The current paper uses secondary data based on monthly figures (with 144 observations) spanning January 2011 to December 2022. The Indian gold prices (GOLDP) are the monthly average gold prices per 10 grams which has been compiled from the website of Reserve Bank of India. The second variable used is United States' dollar (USD) which is the nominal board US dollar index, the data for which has been extracted from the website of Federal Reserve Bank of St. Louis. Both the series have been considered in its logarithmic form.

## 5. Research Methodology

### 5.1 Unit Root Tests

The verification regarding the stationary behaviour of considered datasets has been done using the ADF (Augmented Dickey and Fuller, 1979) and PP (Phillips-Perron, 1988) unit root tests. The analysis of stationarity of the series is based upon the following equations:

$$\Delta Y_t = \alpha_1 Y_{t-1} + \sum_{m=1}^n \beta_m \Delta Y_{t-m} + \mu_t \dots \dots \dots (1)$$

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{m=1}^n \beta_m \Delta Y_{t-m} + \mu_t \dots \dots \dots (2)$$

where,  $\Delta$  stands for first difference operator,  $\alpha_0$  is intercept or constant,  $Y_t$  is a time series,  $n$  denotes optimum lag length for dependent variables and  $\mu_t$  is error term which is pure white noise. Likewise, the following regression

models have been used to explain the Phillips-Perron (PP) test:

$$Y_t = \alpha + \beta Y_{t-1} + u_t \dots \dots \dots (3)$$

$$Y_t = \alpha + \beta Y_{t-1} + \gamma \left(t - \frac{n}{2}\right) + u_t \dots \dots \dots (4)$$

where,  $\alpha$  represents the constant term,  $Y_t$  represents the response variable,  $n$  denotes the number of observations,  $\gamma$  denotes the trend component coefficient and  $u_t$  denotes the white noise error term.

### 5.2 The Johansen-Juselius Cointegration Test

For analysing the existence of cointegration between Indian gold prices and US dollar exchange rate, the Johansen cointegration approach (Johansen & Juselius, 1990) has been used. The trace statistics ( $LR_{trace}$ ) and maximum eigenvalue statistics ( $LR_{max}$ ) provided by the Likelihood Ratio (LR) test have been used to verify the presence of cointegration. The trace statistic has been computed to assess the null hypothesis of  $r$  co-integrating vectors corresponding to alternative hypothesis of  $r+1$  co-integrating vectors and this relationship is stated as below in equations (5) and (6):

$$LR_{trace} \left(\frac{r}{k}\right) = -T \sum_{i=r+1}^k \log(1 - \lambda_i) \dots \dots \dots (5)$$

where,  $\lambda_{r+1}, \lambda_{r+2}, \dots, \lambda_k$  are the smallest squared canonical correlation or eigen value. Further, maximum eigen value statistic has also been estimated to determine number of cointegrating vectors ( $r$ ):

$$LR_{max}(r/r+1) = -T \log(1 - \lambda_{r+1}) \dots \dots \dots (6)$$

where,  $r = 0, 1, 2, \dots, k-1$  and  $\lambda_{r+1}$  is the  $(r+1)^{th}$  largest squared canonical correlation or eigenvalue. As discussed earlier, here again, the null hypothesis is  $r$  co-integrating vectors against alternative hypothesis of  $r+1$  co-integrating vectors.

### 5.3 Granger Causality Test

The pairwise causal relationship between the variables, that is, Indian gold prices and USD has been evaluated using Granger causality technique (Granger, 1969) which is based on the following hypotheses:

- (I)  $H_0$ : GOLDP (X) does not Granger cause USD (Y)  
 $H_1$ : GOLDP (X) Granger causes USD (Y)  
 $(X \rightarrow Y)$
- (II)  $H_0$ : USD (Y) does not Granger cause GOLDP (X)  
 $H_1$ : USD (Y) Granger causes GOLDP (X)  
 $(Y \rightarrow X)$

## 6. Results and Discussion

The results that have been obtained after testing the datasets through ADF and PP tests both at levels and first difference are being presented in Table 1 and 2, respectively.

**Table 1. Stationarity Tests through ADF unit Root Test**

Series	Model Used	Level	p-value	Result
GOLDP	Only Intercept	Levels	0.983	Non-Stat.
	Trend and Intercept	Levels	0.768	Non-Stat.
	Only Intercept	Ist Diff.	0.000***	Stat.
	Trend and Intercept	Ist Diff.	0.000***	Stat.
USD	Only Intercept	Levels	0.575	Non-Stat.
	Trend and Intercept	Levels	0.407	Non-Stat.
	Only Intercept	Ist Diff.	0.000***	Stat.
	Trend and Intercept	Ist Diff.	0.000***	Stat.

\*\*\*, \*\* and \* show 1%, 5% and 10% level of significance respectively.  
 Note: Stat. means Stationary.

Table 1 and 2 portray the findings of ADF and PP unit root test. It has been discovered that both the data series that is, Indian gold prices (GOLDP) and United States' dollar (USD) are non-stationary at levels and are integrated of order one, viz.,  $I(1)$ . Having confirmed the degree of integration of both the series, subsequently Johansen cointegration approach is being applied to further identify if cointegration exist between series taken into account.

For analysing the cointegration for the considered datasets, lag length of three has been fixed considering Akaike Information Criterion (AIC) method by means of VAR approach.

**Table 2. Stationarity Tests through PP unit Root Test**

Series	Model Used	Level	p-value	Result
GOLDP	Only Intercept	Levels	0.992	Non-Stat.
	Trend and Intercept	Levels	0.847	Non-Stat.
	Only Intercept	Ist Diff.	0.000***	Stat.
	Trend and Intercept	Ist Diff.	0.000***	Stat.
USD	Only Intercept	Levels	0.742	Non-Stat.
	Trend and Intercept	Levels	0.703	Non-Stat.
	Only Intercept	Ist Diff.	0.000***	Stat.
	Trend and Intercept	Ist Diff.	0.000***	Stat.

\*\*\*, \*\* and \* show 1%, 5% and 10% level of significance respectively.  
 Note: Stat. means Stationary.

**Table 3. Lag Length Appraisal Criterion using VAR**

Lag	LogL	LR	FPE	AIC	SC	HQ
0	147.30	NA	0.0004	-2.1369	-2.0940	-2.119
1	699.03	1079.1	1.28e-07	-10.191	-10.063	-10.13
2	714.47	29.737	1.09e-07	-10.359	-10.145*	-10.27*
3	719.62	9.7623*	1.07e-07*	<b>-10.376*</b>	-10.076	-10.25
4	721.80	4.0868	1.10e-07	-10.350	-9.9646	-10.19
5	723.45	3.0316	1.14e-07	-10.315	-9.8444	-10.12
6	724.13	1.2280	1.19e-07	-10.266	-9.7099	-10.04
7	728.74	8.2004	1.18e-07	-10.275	-9.6331	-10.01
8	732.82	7.1313	1.18e-07	-10.276	-9.5486	-9.980

Note: \* denotes lag order appraised by different criteria.

**Table 4. Johansen Cointegration Analysis**

Unrestricted Cointegration Rank Test (Trace)				
VAR Lag: 8				
Likelihood Ratio Tests	Null Hypothesis	T-Statistic	Critical Values at 0.05 level	p-value
Trace Test ( $\lambda_{\text{trace}}$ )	$H_0: r=0$	23.22	15.49	0.038**
	$H_0: r \leq 1$	0.064	3.841	0.799
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Likelihood Ratio Tests	Null Hypothesis	T-Statistic	Critical Values at 0.05 level	p-value
Maximum Eigenvalue Test ( $\lambda_{\text{max}}$ )	$H_0: r=0$	19.16	14.26	0.041**
	$H_0: r=1$	0.064	3.841	0.799

Note: r stands for no. of cointegrating vectors.

\*\*\*, \*\* and \* show 1%, 5% and 10% level of significance respectively.

The observations derived from cointegration analysis have been mentioned in Table 4 which is based on two hypotheses. The first hypothesis i.e., null hypothesis asserts that the variables under study are not cointegrated. The subsequent hypothesis (alternative hypothesis) maintains that cointegration exists in at most one case. On the basis of the findings, the null hypothesis is being rejected at 5% level of significance since the trace statistic value i.e., 23.22 exceeds the 5% critical value of 15.49. Likewise, the maximum eigen value i.e., 19.16 is more than 5% critical value of 14.26. It reflects that the model's variables have single cointegrating vector. Hence, it confirms cointegration between Indian gold prices and US dollar.

### 6.1 Granger Causality Analysis

Having confirmed the long-term association between two variables, the lead-lag relationship has been evaluated based on Granger causality test.

**Table 5. Granger Causality Test between Gold Prices and USD**

Null Hypothesis	Obs.	F-Statistic	p-value
USD does not Granger Cause GOLDP	142	1.321	0.027**
GOLDP does not Granger Cause USD		1.149	0.319

\*\* shows 5% level of significance.

Table 5 displays the findings of Granger causality analysis which highlight that a long-run unidirectional causality is running from US dollar to gold prices prevailing in India. However, no causality is running from gold prices towards US dollar. It implies that gold prices are passive and not influencing US dollar while US dollar have an active impact on Indian gold prices. It clearly brings out that US dollar lead the Indian gold prices.

### 7. Conclusion

The current study focused on scrutinising the cointegration and causal relationship between the gold prices prevailing in the Indian market (GOLDP) and the United States' dollar (USD) which is an international currency. The reason for considering these two factors is that US being India's principal trading partner over past few decades and at the same time, India continues to be among one of the world's largest importers of gold in comparison to other advanced and emerging nations and US dollar is an international currency for the conduct of international trade including import and export of gold. The analysis is based on 144 monthly observations of considered datasets spanning January 2011 to December 2022 using Johansen cointegration analysis and Granger causality approach.

The findings unveil that both the data series that is, Indian gold prices and US dollar are non-stationary at levels but stationary at first difference viz., I(1). Having confirmed the degree of integration, subsequently lag length of three has been fixed considering Akaike Information Criterion (AIC) by means of VAR approach. Further, Johansen cointegration approach has been applied which confirms the long-run association between Indian gold prices and US dollar. Besides, the observations of Granger causality test reveal a long-run unidirectional causality running from US dollar towards Indian gold prices. However, no causality is running from gold prices towards US dollar.

In nutshell, the findings of the study bring out the fact that the US dollar exchange rate is a significant driver that can influence the gold prices in India. In other words, the availability of US dollar plays a very crucial role in trade transactions of gold which eventually affects its prices at national and international level. The Indian government should emphasise on alternative measures for streamlining the regulations related to gold mining and refining in order

to expand its domestic supply and to minimise the country's reliance on gold imports.

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