

Gold As an Inflation Hedge in The Indian Economy: An Empirical Investigation Using Vector Error Correction Models (VECM)

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Abstract—This paper investigates whether gold functions as an effective hedge against inflation in the Indian economy over the period 1991–2023, a timeframe encompassing substantial monetary upheaval, structural reform, and recurring inflationary episodes. Using monthly data on domestic gold prices and the Consumer Price Index (CPI), we apply the Johansen cointegration framework and estimate a Vector Error Correction Model (VECM) to determine whether a stable long-run equilibrium relationship exists between the two variables. Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests confirm that both series are integrated of order one — $I(1)$ — satisfying the necessary precondition for cointegration analysis. Results reveal at least one cointegrating vector, consistent with the hypothesis that gold and the price level share a common stochastic trend over the long run. However, short-run dynamics tell a more complicated story: the adjustment coefficients suggest considerable deviations from equilibrium can persist for several months, and gold's hedging effectiveness varies noticeably across sub-periods. These findings carry practical implications for retail investors, institutional portfolio managers, and policymakers navigating India's inflation landscape.

Index Terms—Gold prices, Inflation hedging, Vector Error Correction Model, Johansen cointegration, Consumer Price Index, Indian financial markets, Commodity markets

I. INTRODUCTION

Gold occupies a peculiar place in the Indian imagination — it is at once ornament, inheritance, and insurance. Indian households collectively hold somewhere in the neighbourhood of 25,000 tonnes of the metal, more than the combined reserves of the top four central banks in the world (World Gold Council, 2023). Yet despite this cultural intimacy, the question of whether gold

actually does what people believe it does — that is, preserve purchasing power when inflation erodes the value of paper money — remains surprisingly contested in the empirical literature, particularly in the Indian context.

The theoretical case seems almost self-evident on the surface. Gold is a real asset; it cannot be printed, diluted, or defaulted upon. If fiat money loses value, gold, priced in that money, ought to rise. The Fisher hypothesis offers a more formal scaffold: if gold were to behave like any other good in an economy, its nominal price should rise proportionally with the general price level, leaving its real price broadly unchanged. But markets are messy, and the empirical record is mixed — sometimes gold does hedge, sometimes it does not, and often it hedges over some horizons but not others (Baur & McDermott, 2010; Beckmann & Czudaj, 2013).

India adds layers of complexity that make it a particularly interesting case study. The Indian gold market is segmented from global benchmarks by import duties that have fluctuated dramatically — most notably when the government imposed steep tariff hikes in 2013 in an attempt to curb the current account deficit. Exchange rate dynamics add a further complication: domestic gold prices are determined not just by international spot prices but also by the rupee-dollar exchange rate, meaning that currency depreciation — itself often correlated with inflation — can amplify gold returns in rupee terms. Add to this the seasonal demand patterns driven by weddings and festivals, and you have a market whose inflation-hedging properties may look quite different from those of, say, the U.S. or the U.K.

Against this backdrop, the present paper attempts a systematic empirical investigation of the long-run relationship between gold prices and inflation in India over the post-liberalisation period, 1991–2023. We employ the Johansen (1991) cointegration framework and estimate a Vector Error Correction Model (VECM), which allows us to distinguish between short-run dynamics — where deviations from equilibrium may be substantial — and long-run tendencies. To our knowledge, very few studies have applied this methodology using data spanning both the pre- and post-2013 tariff regime, a period that introduced significant structural breaks into the price relationship.

The remainder of the paper is structured as follows. Section 2 surveys the relevant literature. Section 3 describes the data and preliminary diagnostics. Section 4 sets out the econometric methodology. Section 5 presents and interprets the empirical results. Section 6 discusses the implications, and Section 7 concludes.

II. LITERATURE REVIEW

2.1. Gold as a Hedge: The Global Evidence

The claim that gold serves as an inflation hedge has a long intellectual pedigree, but the rigorous empirical literature is more recent and considerably more equivocal. Jastram (1977), in what remains a landmark historical study, documented that gold maintained its purchasing power over centuries in England and the United States, lending early credibility to the hedging hypothesis. More recent work, however, has been less sanguine about the short and medium run. Worthington and Pahlavani (2007) applied structural break-adjusted cointegration techniques to U.S. data and

found evidence of a long-run hedging relationship, but noted that it could break down for extended periods — sometimes a decade or more.

Baur and Lucey (2010) made an influential distinction between a 'hedge' (an asset negatively or uncorrelated with stocks and bonds on average) and a 'safe haven' (an asset that performs well specifically during market turmoil). Their findings suggested gold functions more reliably as the latter than the former, which has important implications for how investors ought to frame their gold allocations. Beckmann and Czudaj (2013) used a Markov-switching VECM and found that gold's hedging effectiveness is regime-dependent — it hedges robustly in high-inflation states but less so when inflation is subdued. This non-linearity, they argued, is one reason the unconditional literature produces such mixed results.

A meta-analysis by Gürgün and Ünalnış (2014) examined gold's inflation-hedging properties across a broad panel of developed and emerging economies and concluded that the relationship tends to be stronger and more stable in countries with structurally higher inflation — a finding that arguably bodes well for the India case, given the country's persistent inflationary tendencies.

2.2. Studies on the Indian Gold Market

Research specifically on India has grown considerably since 2010, partly in response to the government's anxious scrutiny of gold demand and its balance of payments consequences. Mishra et al. (2010) examined the relationship between gold prices and macroeconomic variables — including inflation, exchange rates, and stock returns — over the period 1990–2009 and found that gold did serve as a reasonable inflation hedge over the full sample, though the evidence was weaker when the sample was restricted to the post-2000 sub-period. The authors attributed this weakening to the increasing financialisation of gold demand, which had made prices more sensitive to global risk appetite than to domestic inflation dynamics.

Bhunia and Ganguly (2014) applied the Granger causality framework to monthly CPI and gold price data and found bidirectional causality — a result that is at least consistent with a long-run hedging relationship, though not necessarily probative of one. Patel (2013) employed a simple OLS regression of gold returns on inflation and concluded that gold was an effective hedge, but the study's econometric approach was limited by its failure to account for the non-stationarity of the underlying series.

More sophisticated analyses have followed. Kumar (2014) used the autoregressive distributed lag (ARDL) bounds testing approach and found evidence of cointegration between gold prices and the Wholesale Price Index (WPI), though the adjustment speed was slow, suggesting that deviations from equilibrium could persist for considerable periods. Sadorsky (2014) and, more recently, Nair et al. (2019) raised questions about the structural stability of these relationships, pointing to the 2013 tariff shock as a potentially important break in the gold price-inflation nexus.

What is notably absent from the Indian literature, however, is a comprehensive VECM analysis that explicitly models the short-run dynamics of adjustment while also accounting for potential structural breaks. This is the gap the present paper attempts to fill.

III. DATA AND PRELIMINARY ANALYSIS

3.1.Data Sources

The analysis uses monthly time series data spanning January 1991 to December 2023 — 396 observations in total. Domestic gold prices are measured in rupees per 10 grams, sourced from the Multi Commodity Exchange of India (MCX) and, for the earlier part of the sample, from the Reserve Bank of India's (RBI) Handbook of Statistics on the Indian Economy. Inflation is proxied by the Consumer Price Index (Combined), published by the Ministry of Statistics and Programme Implementation (MoSPI). The CPI Combined series, which blends urban and rural inflation and has been the headline measure since 2011, was spliced with the earlier CPI-Industrial Workers series using standard chain-linking procedures to produce a consistent long-run series.

All price series are converted to natural logarithms prior to analysis. This transformation reduces heteroskedasticity, renders the series more compatible with the assumption of log-normality that underlies many financial econometric models, and conveniently means that first differences correspond to continuously compounded growth rates — i.e., inflation rates and gold returns expressed in comparable units.

3.2.Descriptive Statistics

Table 1: Descriptive Statistics for Log Gold Prices and Log CPI (Monthly, 1991–2023)

Statistic	Log Gold Price	Log CPI
Mean	9.134	4.472
Median	9.062	4.483
Maximum	11.087	5.198
Minimum	7.218	3.601
Std. Deviation	0.982	0.462
Skewness	0.213	0.051
Kurtosis	1.891	1.762
Jarque-Bera	18.41**	21.03**
Observations	396	396

Note. ** denotes significance at the 5% level. Log values are natural logarithms.

Both series exhibit the expected upward trends over the sample period. Log gold prices grew at an average annual rate of approximately 12.3%, while log CPI grew at approximately 6.8% per annum — a differential that, *prima facie*, suggests gold delivered positive real returns over the full sample, though this masks considerable sub-period variation. The Jarque-Bera statistics indicate mild departures from normality in both series, primarily attributable to excess kurtosis rather than skewness; this is not unusual for financial time series and does not materially affect the validity of the cointegration tests employed.

3.3. Unit Root Tests

A precondition for the Johansen cointegration procedure is that all variables be integrated of the same order — in this case, $I(1)$. We apply both the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test to each series in levels and first differences. The ADF test controls for serial correlation in the error term by including lagged difference terms (the optimal lag length is chosen via the Akaike Information Criterion), while the PP test uses a non-parametric correction and is therefore more robust to heteroskedasticity.

Table 2: Unit Root Test Results

Variable	ADF (Level)	ADF (1st Diff)	PP (Level)	PP (1st Diff)	Conclusion
Log Gold	-1.842	-12.314***	-1.791	-13.027***	I(1)
Log CPI	-0.971	-10.883***	-0.834	-11.541***	I(1)

Note. Critical values at 1% (***) , 5% (**), and 10% (*) levels are -3.45 , -2.87 , and -2.57 , respectively.

Tests include a constant but no trend for levels; constant and trend for first differences. Lag selection by AIC.

The results are unambiguous. Neither log gold prices nor log CPI is stationary in levels under either test — the null of a unit root cannot be rejected at any conventional significance level. Both series become stationary upon first differencing, however, confirming $I(1)$ status. This outcome validates the use of cointegration techniques.

IV. ECONOMETRIC METHODOLOGY

4.1. The Johansen Cointegration Framework

When two or more $I(1)$ series are cointegrated, there exists at least one linear combination of them that is stationary — that is, the variables share a common stochastic trend and are bound together in the long run, even though each individually meanders without bound. The Johansen (1988, 1991) maximum likelihood approach is the method of choice here because it allows for the possibility of multiple cointegrating vectors (though with only two variables, there can be at most one) and it is more efficient than the single-equation Engle-Granger procedure.

The starting point is a vector autoregression (VAR) in levels of the form:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_k Y_{t-k} + \mu + \varepsilon_t$$

where $Y_t = (\text{lgold}_t, \text{lcpit}_t)'$ is the 2×1 vector of log prices, A_i are coefficient matrices, μ is a vector of intercepts, and ε_t is a vector of white noise disturbances. This VAR is re-parameterised into the VECM form:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \mu + \varepsilon_t$$

where $\Pi = \alpha\beta'$ is decomposed into the matrix of adjustment speeds α and the matrix of cointegrating vectors β . The rank of Π determines the number of cointegrating relationships: if $\text{rank}(\Pi) = 0$, no

cointegration exists; if $\text{rank}(\Pi) = 1$, there is exactly one cointegrating vector; and if $\text{rank}(\Pi) = 2$, the system would be stationary in levels, which our unit root tests have already ruled out.

Johansen proposes two test statistics for determining the cointegrating rank: the trace statistic and the maximum eigenvalue statistic. Both test the null of r cointegrating vectors against alternatives that are, respectively, unrestricted and $r+1$. We report both and use the Osterwald-Lenum (1992) critical values, which are adjusted for small-sample bias.

4.2. Optimal Lag Selection

The choice of lag length k in the underlying VAR is consequential: too few lags leave residual serial correlation that invalidates inference; too many consume degrees of freedom unnecessarily. We estimate VAR models for lags 1 through 12 and compare information criteria. The results point consistently to $k = 3$ as the optimal lag length — that is, three lags in the VAR, or equivalently two lagged difference terms in the VECM. This selection is confirmed by Ljung-Box Q-tests on the VAR residuals at $k = 3$, which show no evidence of serial correlation up to lag 12.

4.3. Structural Break Analysis

The period under study is long and encompasses several macroeconomic regime shifts — liberalisation in the early 1990s, the global financial crisis in 2008–09, the import duty hike in 2013, and the COVID-19 shock in 2020. Ignoring structural breaks can lead to spurious non-rejection of the null of no cointegration (Gregory & Hansen, 1996). We apply the Gregory-Hansen (1996) cointegration test with regime shifts, which allows for a level shift, a trend shift, and a full structural break in the cointegrating vector. The procedure identifies the most likely break point endogenously by searching over all possible dates in the middle 70% of the sample.

V. EMPIRICAL RESULTS

5.1. Cointegration Test Results

Table 3: Johansen Cointegration Test Results (Lag = 3, Unrestricted Intercept, No Trend)

Null Hypothesis	Trace Statistic	5% Critical Value	Max-Eigen Statistic	5% Critical Value
$r = 0$	28.74**	15.49	25.31**	14.26
$r \leq 1$	3.43	3.84	3.43	3.84

Note. ** denotes rejection of null at 5% significance level. Critical values from Osterwald-Lenum (1992).

The trace and maximum eigenvalue statistics both reject the null of no cointegration ($r = 0$) at the 5% level, while the null of at most one cointegrating vector ($r \leq 1$) cannot be rejected. This cleanly identifies one cointegrating relationship — exactly what one would expect when working with two $I(1)$ series that share a long-run equilibrium.

The normalised cointegrating vector, with log gold price on the left-hand side, is:

$$\text{lgoldt} = 1.842 \cdot \text{lc pit} - 3.714$$

The coefficient on log CPI (1.842) is statistically significant and greater than one, which is an important finding. A value of exactly 1.0 on the CPI coefficient would be consistent with gold fully tracking inflation in nominal terms — i.e., a perfect hedge. A coefficient greater than one implies that gold prices have, on average, risen faster than the price level over the long run, meaning gold has delivered not just an inflation hedge but a positive real return. This is consistent with Gürgün and Ünalımsı's (2014) finding that gold tends to over-hedge in high-inflation emerging economies.

5.2. VECM Estimates and Short-Run Dynamics

Table 4: VECM Coefficient Estimates

Equation	ECT (α)	Std. Error	t-Statistic	Significance
Δ gold (Gold Price Eq.)	-0.037	0.012	-3.082	***
Δ lcpı (CPI Eq.)	0.004	0.006	0.667	Not sig.

Note. ECT = Error Correction Term (lagged residual from the cointegrating equation). *** significant at 1%.

The error correction term (ECT) in the gold price equation carries a coefficient of -0.037 , significant at the 1% level. This tells us that when gold prices deviate from their long-run equilibrium with the CPI — say, because gold has risen much faster than inflation in the short term — the system corrects at a rate of approximately 3.7% per month. In practical terms, this implies a half-life of around 18 months for deviations to decay by half. That is not a particularly rapid correction; it confirms that short-run departures from equilibrium can persist for extended periods, which is one reason gold's inflation-hedging properties are often perceived as unreliable over shorter investment horizons.

The ECT in the CPI equation, by contrast, is not statistically significant. This is a reassuring result from a theoretical standpoint: it suggests that the causality runs from CPI (the common stochastic trend in the long run) to gold prices, not the other way around. In other words, gold adjusts toward CPI over time — consistent with the inflation-hedging interpretation — rather than gold price movements feeding back into the general price level in any systematic fashion.

5.3. Structural Break Results

The Gregory-Hansen test identifies the most statistically significant break at March 2013 — almost precisely coinciding with the government's decision to raise gold import duties from 4% to 6% (and subsequently to 8% and 10% within the same year). The test statistics under the regime-shift specification remain significant, suggesting that cointegration between gold prices and CPI is robust to this structural change in levels, though the cointegrating coefficient shifts somewhat across the two regimes.

Table 5: Sub-Period Cointegrating Coefficients (β on Log CPI)

Sub-Period	β Coefficient	Std. Error	Interpretation
1991:01 – 2013:02	2.104	0.241	Over-hedge (strong)
2013:03 – 2023:12	1.312	0.187	Over-hedge (moderate)

Note. Estimates from sub-sample OLS on the normalised cointegrating equation.

The decline in the cointegrating coefficient from 2.104 to 1.312 across the two sub-periods is worth pausing on. In the post-2013 period, the wedge between international and domestic gold prices introduced by higher import duties appears to have dampened the sensitivity of domestic gold prices to the domestic price level — even as both still move together over the long run. For investors, this suggests that the 2013 tariff changes meaningfully altered gold's hedging characteristics, at least in quantitative terms, even if the long-run relationship itself survived.

5.4. Variance Decomposition

To gauge the relative importance of gold price shocks versus CPI shocks in driving forecast error variance, we compute variance decompositions at horizons of 1, 6, 12, 24, and 36 months following a Cholesky decomposition with gold ordered first (reflecting the assumption that gold prices respond contemporaneously to CPI but not vice versa, consistent with the ECT results).

At the one-month horizon, virtually all of the variance in gold price forecasts (98.3%) is explained by gold price shocks themselves — CPI shocks play almost no role at that frequency. By 12 months, CPI shocks account for roughly 18% of gold price forecast variance, rising to 31% at 36 months. These results reinforce the picture of a long-run relationship that takes time to manifest: gold does respond to inflation, but the response is gradual and attenuated in the short run, which matters enormously for investors with shorter time horizons.

VI. DISCUSSION

6.1. Implications for Indian Investors

Taken together, the results suggest a nuanced answer to the question that motivates this study. Gold does appear to function as an inflation hedge in India — but only over the long run, which in this context means horizons of several years rather than months. The slow adjustment speed, combined with the substantial share of gold price variance unexplained by CPI movements even at 36-month horizons, implies that an investor who buys gold in response to a particular inflationary episode may face a long wait before the hedge pays off. Worse, short-term deviations from equilibrium can go in either direction: gold can undershoot or overshoot its long-run CPI-consistent level for extended periods.

This has practical implications for the way gold ought to be sized within an Indian household or institutional portfolio. Rather than treating gold as a tactical hedge to be deployed in response to short-term inflationary pressures, the evidence supports holding gold as a strategic, long-horizon allocation — part of the permanent rather than the tactical portfolio. This is, in a sense, consistent with the way most Indian households already hold gold: as long-term family wealth rather than a short-term financial instrument.

6.2. Exchange Rate and Import Duty Complications

One limitation of the present analysis, which should be acknowledged frankly, is that it does not explicitly model the exchange rate or import duty channels. As noted earlier, domestic gold prices in India are jointly determined by international prices (denominated in USD), the rupee-dollar exchange rate, and the tariff wedge. In periods of sharp rupee depreciation — as in 2013, 2018, and 2022 — domestic gold prices can rise substantially even in the absence of domestic inflationary pressure, and conversely, rupee appreciation can depress domestic gold prices even when inflation is running hot. This exchange rate channel may partly explain the coefficient above unity in the cointegrating relationship: gold in India has benefited not just from domestic inflation but also from secular rupee depreciation, both of which inflate the rupee price of gold.

Future work should attempt to decompose the domestic gold price into its international component, the exchange rate component, and a residual tariff component, and examine whether it is specifically the domestic-inflation-linked component that exhibits the hedging relationship documented here. A trivariate VECM incorporating the exchange rate would be a natural next step.

6.3. Gold versus Alternative Inflation Hedges

It is also worth situating gold within the broader landscape of inflation hedges available to Indian investors. Real estate is the traditional rival, and there is substantial anecdotal evidence that property prices in Indian cities have also broadly kept pace with — and often outrun — inflation over the past three decades. Government-linked instruments such as RBI Floating Rate Savings Bonds and, more recently, the Sovereign Gold Bond (SGB) scheme, which offers gold-price-linked returns alongside a fixed coupon, provide yet another angle. The SGB in particular is noteworthy because it effectively allows investors to access gold's long-run inflation-hedging properties while also earning a 2.5% annual coupon, potentially dominating physical gold on a risk-return basis — a question that our framework does not directly address but that deserves separate investigation.

VII. CONCLUSION

This paper has examined the inflation-hedging properties of gold in India over the post-liberalisation period using the Johansen cointegration framework and a Vector Error Correction Model. The main findings can be summarised as follows.

First, gold prices and the Consumer Price Index share a statistically robust long-run cointegrating relationship, confirming that gold functions as an inflation hedge over multi-year horizons. Second, the estimated cointegrating coefficient exceeds unity, implying that gold has historically delivered positive real returns in India — an over-hedge rather than merely a hedge. Third, short-run adjustment is slow: deviations from equilibrium have an estimated half-life of around 18 months, meaning that gold's hedging effectiveness is considerably more limited over shorter investment horizons. Fourth, structural break analysis identifies a significant change in the cointegrating relationship around March 2013, coinciding with the large increases in gold import duties; the relationship weakens in the post-2013 sub-period, though it remains statistically intact.

These findings have direct implications for Indian investors, portfolio managers, and policymakers. For investors, the results support a long-horizon strategic allocation to gold rather than a tactical deployment in response to short-term inflationary pressures. For policymakers, the finding that import duty increases can meaningfully alter the inflation-gold nexus is a reminder that trade policy has macroprudential spillovers that extend beyond the current account. And for researchers, the results underscore the importance of accounting for structural breaks and exchange rate dynamics when modelling gold's inflation-hedging properties in emerging market contexts. Several avenues for future research suggest themselves. A trivariate VECM incorporating the rupee-dollar exchange rate would sharpen the attribution of gold returns to domestic versus international drivers. Quantile regression or Markov-switching specifications could better capture the non-linear and regime-dependent nature of the hedge. And a comparative analysis across BRICS economies — all of which have large domestic gold markets and persistent inflationary tendencies — might yield generalisable insights beyond the India-specific context.

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