



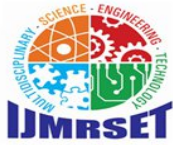
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Comparative Risk-Return, Liquidity, and Market Efficiency of Gold Investment Instruments in India: Evidence from Spot Gold, Gold ETFs, and Sovereign Gold Bonds

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ABSTRACT: Gold occupies a central place in Indian household portfolios and capital markets. Investors today can obtain gold exposure through three primary instruments, namely Spot Gold, Gold Exchange Traded Funds (ETFs), and Sovereign Gold Bonds (SGBs), which share a common underlying asset but differ materially in cost structure, liquidity, and tax treatment. This study provides a comparative empirical assessment of the three instruments using a balanced panel of 1,016 daily observations covering January 2020 to February 2026. Return characteristics, volatility dynamics (ARCH-LM and GARCH(1,1)), risk-adjusted performance (Sharpe and Sortino ratios), the effect of trading volume on ETF returns through OLS regression, weak-form market efficiency (Runs Test and Ljung-Box), and a composite efficiency index are examined. The return distributions of all three instruments are non-normal and stationary, and both one-way ANOVA and the Kruskal-Wallis test find no significant difference in mean daily returns. Every series exhibits significant volatility clustering, with SGB showing the highest GARCH persistence ($\alpha + \beta = 0.9727$) that is driven by thin secondary-market trading. Spot Gold delivers the best risk-adjusted performance, while ETF returns are not systematically explained by trading volume. Ljung-Box statistics reject weak-form efficiency across all three series. On the composite ranking, Spot Gold leads, followed by Gold ETF and SGB. The findings carry direct implications for portfolio construction, advisory practice, and regulatory design in India's gold investment market.

KEYWORDS: Gold ETF; Sovereign Gold Bond; GARCH; Weak-form efficiency; Sharpe ratio; Market microstructure; India.

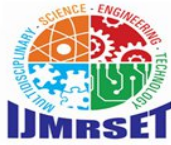
JEL Classification: G11, G14, G17, Q02.

I. INTRODUCTION

Gold has an unusual position in the Indian financial system. It functions simultaneously as a cultural asset tied to marriage, festivals, and wealth signalling, and as a financial hedge against inflation and currency depreciation. Annual Indian gold consumption ranges between 700 and 900 tonnes, which accounts for close to a quarter of global demand, and the World Gold Council estimates privately held household gold in India at over USD 1.5 trillion, the largest such concentration in any single country.

The institutional architecture for gold investment has changed substantially since 2007. Until then, physical gold in the form of jewellery, coins, and bars dominated retail participation. The introduction of Gold ETFs in 2007 and the Sovereign Gold Bond scheme in 2015 created regulated alternatives that deliver gold price exposure without physical custody. Gold ETFs trade on the NSE and BSE with intraday liquidity and total expense ratios between 0.59% and 0.79%. SGBs, until their suspension in February 2024, combined zero entry and holding costs, a fixed 2.50 to 2.75 percent annual coupon, and exemption from capital gains tax at maturity under Section 47(viic) of the Income Tax Act, 1961.

The period from January 2020 to February 2026 offers a rich window for comparative analysis. It encompasses the COVID-19 market dislocation of 2020, post-pandemic monetary easing and the 2021-22 inflationary surge, geopolitical shocks in Eastern Europe and West Asia, unprecedented central bank gold purchases, and the extraordinary 96.5 percent domestic price appreciation recorded in 2025-26. Most existing Indian comparative studies rely on annual data with small sample sizes, which precludes rigorous time-series econometric analysis. This paper addresses that



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limitation by working with 1,016 balanced daily observations and deploying GARCH(1,1), Sharpe and Sortino ratios, OLS regression, the Runs Test, the Ljung-Box test, and a composite efficiency index.

The specific objectives are (i) to compare daily return distributions across Spot Gold, Gold ETF, and SGB; (ii) to examine volatility clustering and conditional variance dynamics; (iii) to assess risk-adjusted performance using Sharpe and Sortino ratios; (iv) to test whether ETF trading volume explains daily ETF returns; (v) to evaluate weak-form market efficiency; and (vi) to construct a composite efficiency ranking that synthesises return, risk, and stability characteristics into a single score.

II. LITERATURE REVIEW

2.1 Gold as a financial asset

Baur and Lucey (2010) show that gold behaves as a hedge against equity risk and as a safe haven during extreme market downturns, though the safe-haven property is temporary and context-dependent. Hillier, Draper and Faff (2006) demonstrate that gold consistently improves portfolio Sharpe ratios, particularly during equity market stress, which supports its use as a Sharpe-enhancing component. Ghosh et al. (2004) confirm gold's long-run cointegration with inflation but note that short-run dynamics are driven by financial market forces rather than fundamentals, an observation also reported by Worthington and Pahlavani (2007) for Australia. Jain and Biswal (2016) show that INR-denominated gold prices in India are jointly shaped by global USD gold prices and the USD/INR exchange rate, so that rupee depreciation contributes to measured returns.

2.2 Theoretical and econometric foundations

The econometric treatment of financial volatility begins with Engle (1982), whose ARCH framework formalised time-varying conditional variance in financial returns. Bollerslev (1986) generalised this to GARCH, producing the parsimonious GARCH(1,1) model that underlies most empirical volatility work. The efficient market hypothesis of Fama (1970), especially its weak-form variant, frames the tests of return randomness applied in this paper. Portfolio theory (Markowitz, 1952) and the CAPM (Sharpe, 1964) provide the theoretical basis for the Sharpe and Sortino ratios used here. Kahneman and Tversky (1979) and Thaler (1980) supply the behavioural lens through which thin secondary-market trading and investor inertia in SGB markets can be understood.

2.3 Gold ETFs in India

Indian-specific studies of gold ETFs have focused largely on tracking efficiency and liquidity. Bansal and Sharma (2012) report that Indian Gold ETFs track spot gold closely, with small systematic tracking errors correlated with the total expense ratio. Sehgal and Jain (2011) find that Gold ETFs offer superior liquidity relative to physical gold markets, with tighter spreads and more continuous price adjustment. Rompotis (2009) documents that tracking errors scale with expense ratios and fund size, a finding consistent with the TER differentials observed across Nippon, SBI, and HDFC gold ETFs in the Indian market. Srivastava and Yadav (2022) show that Gold ETFs maintained continuous trading and close price tracking through the COVID-19 disruptions when physical gold markets were partially closed.

2.4 Sovereign Gold Bonds

Research on Sovereign Gold Bonds is comparatively thin. Kannan and Dhir (2017) describe the scheme's design and early adoption, noting structural superiority offset by distributional constraints. Mishra and Mohanty (2018) document SGB secondary market discounts of 3 to 7 percent relative to intrinsic value, which they attribute to the absence of formal market-making and low investor awareness. Chakraborty and Sarkar (2021) show that early SGB tranches delivered roughly 100 percent price appreciation by mid-2021 following the COVID-19 gold rally, with the fixed coupon providing an additional return stream.

2.5 Comparative work and research gaps

Comparative work on gold investment in India has produced mixed evidence. Dhankar and Singh (2018) find that Gold ETFs match physical gold on pre-tax returns while improving on liquidity and transaction costs. Gupta and Agarwal (2020) report higher cost-adjusted returns for financial instruments relative to physical gold but were unable to incorporate SGBs because of limited data availability at that time. Singh and Kumar (2023) and Sharma and Pillai (2023) analyse the effect of the Finance Act 2023 on ETF post-tax returns, an important contextual element of the current policy environment. Verma and Kapoor (2022) document that 68 percent of Indian retail investors continue to prefer physical gold despite being aware of financial alternatives, and only 12 percent of ETF investors can correctly state the TER of their own fund.



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Three gaps emerge from this review. First, most Indian comparative work uses annual data ($N \approx 8$ to 10 per instrument), which cannot support GARCH modelling or serial-correlation testing. Second, no prior Indian study has applied the full suite of Runs Test, ACF analysis, and Ljung-Box test simultaneously across all three instruments. Third, the 2020-2026 period, which spans the COVID dislocation, monetary expansion, and the 2025-26 gold price rally, has not been empirically covered in prior comparative work. This paper addresses these gaps.

III. DATA AND METHODOLOGY

3.1 Data sources and sample construction

Daily closing prices for Spot Gold (MCX and IBSA 24-karat benchmark, per 10 grams) were obtained from goldpriceindia.com. Gold ETF prices and trading volumes for Nippon Gold BeES (NSE ticker: GOLDBEES) were obtained from NSE historical archives, as were SGB daily closing prices for the most actively traded tranches during the sample period. All prices were standardised to a 10-gram gold equivalent basis. Spot Gold is already quoted per 10 grams; ETF units, each representing approximately 1 gram, were scaled by ten; SGB units, quoted per gram, were scaled accordingly.

The raw sample covered 1,529 observations between 1 January 2020 and 28 February 2026. Days on which SGB did not record a trade (513 observations) were excluded. These reflect genuine non-trading gaps in the thin SGB secondary market rather than data collection errors, and artificial interpolation would have introduced spurious returns. The balanced panel therefore contains 1,016 daily observations per instrument, which yields 1,015 daily log returns per series computed as $r_t = \ln(P_t / P_{t-1})$. The risk-free rate is proxied by the RBI repo rate at 6.5 percent per annum, translated to a daily equivalent of 0.000258 ($6.5 / 252$). All computations were performed in Python 3 using pandas, numpy, statsmodels, scipy, and the arch library.

3.2 Hypotheses Development

To provide a formal statistical framework for empirical testing, the study formulates the following null and alternative hypotheses corresponding to each analytical module.

3.2.1 Mean Return Comparison

The study examines whether there exists any statistically significant difference in the average daily returns across Spot Gold, Gold ETFs, and Sovereign Gold Bonds.

H0₁: There is no significant difference in mean daily returns across the three gold investment instruments.

H1₁: At least one instrument has a significantly different mean daily return.

This hypothesis is tested using one-way ANOVA and the non-parametric Kruskal-Wallis test to ensure robustness against non-normality.

3.2.2 Volatility Clustering

Financial time series are often characterized by volatility clustering, where periods of high volatility are followed by high volatility and vice versa. This study tests whether such effects are present in the return series.

H0₂: There is no volatility clustering (no ARCH effect) in the return series.

H1₂: Volatility clustering exists in the return series.

The hypothesis is examined using the ARCH Lagrange Multiplier (ARCH-LM) test, followed by GARCH(1,1) modelling to estimate the persistence of volatility.

3.2.3 Weak-Form Market Efficiency

The study evaluates whether past price information is reflected in current prices, implying randomness in returns.

H0₃: The return series follows a random walk and is weak-form efficient.

H1₃: The return series does not follow a random walk and is not weak-form efficient.

This hypothesis is tested using the Runs Test for randomness and the Ljung-Box Q-statistic for detecting serial correlation across multiple lags. These hypotheses provide a structured basis for interpreting statistical results and ensure alignment between theoretical expectations and empirical testing.

3.2.4 Risk-Adjusted Performance

The study evaluates whether there is a significant difference in risk-adjusted performance across the three instruments.

H0₄: There is no significant difference in risk-adjusted performance (Sharpe and Sortino ratios) across the three instruments.



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H1_a: There is a significant difference in risk-adjusted performance across the instruments.

3.2.5 Trading Volume and ETF Returns

The study examines whether trading volume has a significant impact on Gold ETF returns.

H0_b: Trading volume does not have a significant effect on Gold ETF returns.

H1_b: Trading volume has a significant effect on Gold ETF returns.

3.3 Empirical procedures

The empirical programme is organised into six modules. Module 1 tests stationarity using the Augmented Dickey-Fuller test, describes the return distributions, evaluates normality via the Jarque-Bera test, and compares means across instruments through one-way ANOVA and the non-parametric Kruskal-Wallis test. Module 2 applies the ARCH Lagrange multiplier test to detect volatility clustering and estimates GARCH(1,1) models for each series of the form

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2,$$

where the sum $\alpha + \beta$ measures volatility persistence, and values approaching unity indicate near-integrated volatility. Module 3 computes annualised Sharpe and Sortino ratios using the daily risk-free rate and scales by $\sqrt{252}$. A rolling 60-day Sharpe ratio is also plotted to track performance through time. Module 4 estimates an OLS regression of ETF daily log returns on the first difference of log trading volume ($\Delta \ln V$), after pre-testing the volume series for stationarity. Zero-volume days were removed before taking logarithms to preserve numerical stability. Module 5 tests weak-form efficiency through a two-sided Runs Test on return signs relative to the median and a Ljung-Box test at lag 10, supported by ACF plots with 95 percent Bartlett confidence bands. Module 6 constructs a composite efficiency index by min-max normalising five metrics, namely annualised return (positive), annualised volatility (negative), Sharpe ratio (positive), Sortino ratio (positive), and GARCH persistence (negative), and combining them as $\text{Efficiency} = \text{Norm}(\text{Return}) - \text{Norm}(\text{Volatility}) + \text{Norm}(\text{Sharpe}) + \text{Norm}(\text{Sortino}) - \text{Norm}(\text{Persistence})$.

Higher scores indicate greater combined efficiency. The primary significance level is $\alpha = 0.05$, with $\alpha = 0.10$ reported for borderline cases.

IV. EMPIRICAL RESULTS

4.1 Return characteristics

Mean daily log returns across the three instruments are nearly identical, namely 0.001403 for Spot Gold, 0.001272 for Gold ETF, and 0.001404 for SGB. All series are negatively skewed and leptokurtic, with SGB displaying the most extreme asymmetry and the heaviest tails (skewness -1.20, kurtosis 19.47). Annualised returns cluster between 32.06 percent (ETF) and 35.39 percent (SGB), and annualised volatilities stand at 21.06, 22.61 and 28.01 percent for ETF, Spot Gold, and SGB respectively (Table 1).

Table 1. Descriptive statistics and annualised moments (daily log returns).

Instrument	Mean	Std. Dev.	Skewness	Kurtosis	Ann. Ret.	Ann. Vol.
Spot Gold	0.001403	0.014246	-0.8406	7.88	35.34%	22.61%
Gold ETF	0.001272	0.013269	-0.6367	12.00	32.06%	21.06%
SGB	0.001404	0.017644	-1.2010	19.47	35.39%	28.01%

Note: N = 1,015 daily log returns per series. Source: Author's computation.

Jarque-Bera tests reject normality for all three series at the 1 percent level ($p < 0.0001$). Mean comparison through one-way ANOVA ($F = 0.025$, $p = 0.975$) and Kruskal-Wallis ($H = 0.906$, $p = 0.636$) fails to reject the null of equal means. Economically, the three instruments track the same underlying price. Statistical equivalence at daily frequency should not be interpreted as equivalence in compounded wealth over multi-year horizons, where differences in cost, tax, and coupon accumulate materially.



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The results of both ANOVA and Kruskal-Wallis tests fail to reject H_{01} at the 5 percent significance level, indicating no statistically significant difference in mean daily returns across the three instruments.

4.2 Volatility dynamics

ARCH-LM tests reject the no-ARCH null for all three series at the 1 percent level (Spot Gold LM = 50.75; ETF LM = 462.39; SGB LM = 78.09). Gold ETF shows the strongest clustering, which reflects the intraday exchange-based price discovery characteristic of equity-traded instruments. GARCH(1,1) estimates are reported in Table 2. The ARCH-LM test results lead to the rejection of H_{02} at the 1 percent significance level, confirming the presence of volatility clustering in all return series.

Table 2. GARCH(1,1) parameter estimates.

Instrument	ω	α	β	$\alpha+\beta$	Ann. Conditional Vol.
Spot Gold	0.1556	0.0962	0.8250	0.9212	22.61%
Gold ETF	0.0824	0.1215	0.8220	0.9435	21.06%
SGB	0.1405	0.1937	0.7790	0.9727	28.01%

Note: Returns scaled by 100 for numerical convergence. Source: Author's computation.

All three models are covariance-stationary, but SGB's near-integrated persistence (0.9727) indicates that shocks to conditional variance dissipate very slowly. Counter to the a priori expectation that a government-backed instrument with a fixed coupon would show the most stable volatility profile, SGB exhibits the highest annualised conditional volatility. This anomaly is attributable to market microstructure. Thin secondary-market trading produces discrete and sizeable price gaps between infrequent transactions, which statistical models interpret as high volatility even when the underlying gold exposure is identical across instruments.

4.3 Risk-adjusted performance

Spot Gold records the highest Sharpe ratio (1.2754) and Sortino ratio (1.6470), followed by Gold ETF (1.2135 and 1.5259) and SGB (1.0313 and 1.2738). The identical ranking across both measures confirms that the conclusion is robust to the choice of risk metric. The marginal return advantage of SGB over Spot Gold (35.39 percent against 35.34 percent) is more than offset by its substantially higher volatility, which leaves it in third place on every risk-adjusted measure (Table 3). The observed differences in Sharpe and Sortino ratios suggest variation in risk-adjusted performance across instruments; however, no formal hypothesis test is conducted, and therefore H_{04} is evaluated descriptively.

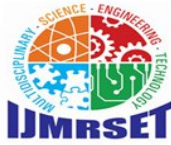
Table 3. Annualised Sharpe and Sortino ratios ($r_f = 6.5\%$ p.a.).

Instrument	Sharpe Ratio	Sortino Ratio	Rank
Spot Gold	1.2754	1.6470	1
Gold ETF	1.2135	1.5259	2
SGB	1.0313	1.2738	3

Source: Author's computation.

4.4 Trading volume and ETF returns

Regressing daily ETF log returns on $\Delta \ln V$ yields a statistically insignificant slope coefficient ($\beta_1 = 0.0015$, $t = 1.778$, $p = 0.076$) and an R^2 of 0.003. Domestic trading volume explains essentially none of the daily variation in ETF returns. This is consistent with the view that ETF prices are anchored by global gold prices rather than by domestic order flow. The residual diagnostics indicate non-normality and autocorrelation, so the reported standard errors should be interpreted with caution; however, the near-zero R^2 makes the directional conclusion unambiguous. The regression



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results fail to reject H_{05} at the 5 percent significance level, indicating that trading volume does not significantly explain ETF returns.

4.5 Weak-form market efficiency

Runs Test results are mixed. Spot Gold ($Z = 1.66$, $p = 0.096$) and Gold ETF ($Z = -1.48$, $p = 0.140$) are consistent with randomness at the 5 percent level, while SGB ($Z = 3.85$, $p = 0.0001$) rejects randomness strongly. Ljung-Box tests at lag 10 reject the no-autocorrelation null for all three series (Spot Gold LB = 26.02, $p = 0.0037$; ETF LB = 70.48, $p < 0.0001$; SGB LB = 80.57, $p < 0.0001$). Because the Ljung-Box test detects linear dependence across multiple lags and is generally more powerful for financial time series, greater weight attaches to its verdict. Indian gold markets therefore fail the weak-form efficiency test across all three instruments in the sample period (Table 4). The Ljung-Box test results lead to the rejection of H_{03} , indicating that all three return series violate weak-form market efficiency.

Table 4. Weak-form efficiency tests.

Instrument	Runs Z	Runs p	LB(10)	LB p	Efficient?
Spot Gold	1.66	0.096	26.02	0.0037	No
Gold ETF	-1.48	0.140	70.48	<0.0001	No
SGB	3.85	0.0001	80.57	<0.0001	No

Source: Author's computation.

4.6 Composite efficiency ranking

The composite index produces an unambiguous ranking. Spot Gold leads with a score of 2.7637, driven by the combination of high return, moderate volatility, and the best risk-adjusted measures. Gold ETF follows at 0.9882, reflecting the lowest volatility and strong tradability. SGB trails at -1.0000, penalised by its high measured volatility, near-integrated GARCH persistence, and poor risk-adjusted ratios (Table 5). The ranking, however, is best interpreted within the daily-market-data framework adopted here. For buy-and-hold SGB investors, the scheme's capital-gains tax exemption at maturity and fixed coupon add structural value that is not reflected in daily price movements.

Table 5. Composite efficiency ranking.

Rank	Instrument	Score	Profile
1	Spot Gold	2.7637	Best overall risk-return efficiency
2	Gold ETF	0.9882	Lowest volatility, strong liquidity
3	SGB	-1.0000	High measured volatility from microstructure

Source: Author's computation.

V. DISCUSSION AND IMPLICATIONS

The headline finding that SGB ranks last in a daily-data framework despite its structural tax and cost advantages reflects market microstructure rather than fundamental riskiness. Thin secondary-market trading produces discrete price jumps that inflate measured volatility and generate the serial correlation picked up by the Runs and Ljung-Box tests. A buy-and-hold investor who holds SGB to maturity does not experience this measured volatility in any economically meaningful sense. Advisers who apply daily-price risk metrics to long-dated instruments risk systematically misadvising their clients.

For retail investors, the appropriate instrument depends on horizon and constraints. Spot Gold offers the strongest risk-adjusted profile for those comfortable with physical custody and the 3 percent GST entry cost, particularly since its 20 percent LTCG rate is now more favourable than the slab-rate treatment applied to Gold ETFs post-Finance Act 2023.



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Gold ETFs, particularly low-TER funds such as HDFC Gold ETF at 0.59 percent, suit investors who value liquidity and demat-based holding. Secondary-market SGB remains attractive to long-horizon, tax-sensitive investors who are willing to accept limited liquidity, though they should note that secondary-market SGB units often trade at premiums of 1 to 7 percent over intrinsic value, which can erode the effective coupon.

For policymakers, the central implication is that SGB's poor market-data performance is a fixable design problem, not a fundamental limitation. Mandatory market-making on NSE and BSE for SGB series, analogous to the arrangements supporting the government securities market, would tighten bid-ask spreads, reduce measured volatility, and bring SGB closer to weak-form efficiency. The discontinuation of primary SGB issuance in February 2024 has left a policy gap. No primary instrument now combines nil costs, a fixed coupon, and capital gains tax exemption. A fiscally sustainable redesign, perhaps a partial CGT exemption or an inflation-indexed coupon, could preserve the welfare benefits for retail investors while addressing the sovereign's exposure to gold-price redemption risk. The Finance Act 2023 alignment of ETF LTCG with slab rates has made physical gold tax-preferred for high-bracket investors, a tilt that may redirect long-term savings into physical gold with adverse effects on the current account deficit.

VI. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Several limitations qualify the findings. First, the balanced-panel design excludes 513 observations on SGB non-trading days; while necessary for comparability, this exclusion may slightly inflate SGB's measured volatility because multi-day holding-period returns are treated as single-day observations. Second, the OLS regression in Module 4 does not fully satisfy the standard assumptions of normality and no-autocorrelation in residuals; a GARCH-in-Mean or HAC-corrected specification would yield more reliable standard errors. Third, GARCH(1,1) fits Spot Gold and ETF well but leaves residual autocorrelation in SGB, so regime-switching or higher-order specifications may be more appropriate. Fourth, only one Gold ETF (Nippon Gold BeES) proxies the category; extending the panel to Nippon, SBI, and HDFC simultaneously would deepen the analysis. Fifth, the composite efficiency index is a normative construct whose output depends on chosen metrics and weightings. Finally, the sample period reflects a strong gold bull market and may not generalise to prolonged bear phases.

Future research could extend the analysis to intraday data to isolate microstructure effects, apply GJR-GARCH or EGARCH to capture asymmetric volatility, conduct cointegration and price-discovery analyses across the three series, examine the post-February 2024 regime in which primary SGB issuance has ceased, and run cross-country comparisons with Turkey, China, and the UAE. Machine-learning approaches such as LSTM networks or gradient boosting could complement the historical econometric analysis with a forward-looking prediction framework.

VII. CONCLUSION

This study offers a methodologically comprehensive comparative analysis of Spot Gold, Gold ETF, and Sovereign Gold Bond in India using 1,016 balanced daily observations from January 2020 to February 2026. Mean daily returns are statistically indistinguishable across the three instruments, yet their volatility profiles, risk-adjusted performance, and efficiency characteristics diverge materially. Spot Gold emerges as the most efficient instrument on the composite daily-data index, with Gold ETF second and SGB third. Weak-form efficiency is rejected across all three series, and ETF returns are not explained by domestic trading volume.

The broader message is that the statistical picture of SGB is shaped by its secondary-market microstructure and not by fundamental riskiness. Policy attention to SGB secondary-market liquidity, combined with a fiscally sustainable redesign of the primary scheme, could meaningfully improve the gold investment landscape for Indian retail investors. The sample period, which includes the pandemic shock, monetary expansion, geopolitical turbulence, and an extraordinary 96.5 percent domestic gold price appreciation in 2025-26, demonstrates that all three instruments function as effective vehicles for capturing gold price exposure. What differs is the efficiency, transparency, and consistency with which each delivers that exposure to the end investor.

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