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Research Article

Striking Gold with Precision: An Empirical Analysis of Gold ETFS Through the Lens of the Markowitz Efficient Frontier

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Abstract: This study analyzes the performance of ten Indian Gold ETFs over five years using return, volatility, beta, and Sharpe ratio. Applying the Markowitz Mean-Variance Optimization model, it identifies Invesco Gold ETF as the strongest performer across all metrics. The optimal portfolio, comprising 76.38% Invesco and 23.62% Gold Index, offers a 14.62% expected return with 5.40% volatility. The findings support Invesco's dominance in delivering efficient gold exposure, making the model portfolio ideal for investors seeking high-return, data-driven gold allocation.

Keywords: Gold ETFs, Markowitz Efficient Frontier, Portfolio Optimization, Risk-Adjusted Return, Mean-Variance Analysis.

INTRODUCTION

Gold has historically held a unique position in the global financial ecosystem, often seen as a hedge against inflation, currency volatility, and geopolitical instability. With the advent of Exchange Traded Funds (ETFs), retail and institutional investors alike have been given access to gold as an asset class in a low-cost, liquid, and transparent manner. In India, Gold ETFs have steadily gained traction, offering exposure to gold prices without the need for physical storage. However, as with any investment, not all ETFs perform equally. This study dives deep into the historical performance of major Indian Gold ETFs and employs the Markowitz Mean-Variance Optimization model to construct an efficient portfolio that maximizes return for a given level of risk.

LITERATURE REVIEW

Modern Portfolio Theory (MPT), introduced by Markowitz (1952), remains a cornerstone in the field of investment management, emphasizing diversification as a means to optimize return for a given level of risk. Sharpe (1966) later refined this framework by introducing the Sharpe Ratio, a widely used measure for evaluating risk-adjusted performance. These theoretical foundations continue to underpin portfolio construction strategies today (Bodie, Kane, & Marcus, 2014).

In the context of commodity investing, gold has long been recognized for its hedging and safe haven properties. Baur and Lucey (2010) demonstrated that gold serves as a reliable hedge against equity market volatility, particularly during financial downturns. Similarly, Aggarwal and Lucey (2007) explored psychological barriers in gold pricing, underscoring the behavioural dynamics that influence investor responses to gold as an asset.

The evolution of gold investing through Exchange Traded Funds (ETFs) has significantly expanded retail access to gold markets. Data from the National Stock Exchange (NSE India, 2025) and the Association of Mutual Funds in India (AMFI India, 2025) show rising investor interest in Gold ETFs due to their liquidity and low transaction costs. However, Morningstar India (2025) highlights that not all ETFs perform equally, with tracking errors, fee structures, and fund management practices creating meaningful performance differences.

Recent research and market commentaries have reinforced the need for balanced portfolio construction in the face of macroeconomic shifts. BlackRock (2023) and Bridgewater Associates (2011) emphasize risk parity and adaptive asset allocation as key tools in volatile environments. These views align with Ilmanen, Maloney, and Ross (2022), who argue for the inclusion of non-correlated assets like gold when return expectations from traditional markets are low. From a domestic investment strategy perspective, Pandian (2020) provides a comprehensive view on security analysis within the Indian context, while Bogle (1999) underscores the importance of long-term, low-cost investing principles. Additional inputs from the Reserve Bank of India (2025) and the India Bullion and Jewellers Association (2025) offer relevant insights on market rates and physical gold pricing. Supplementary data on historical ETF performance and gold price trends were sourced from Yahoo Finance (2025).

Together, these sources provide a robust framework for evaluating the performance of Gold ETFs and constructing efficient portfolios using empirical tools like the Markowitz model.

Objectives of the Study

1. To evaluate the performance of major Gold ETFs in India over the past five financial years.
2. To calculate and compare return, risk (standard deviation), and Sharpe ratios of each ETF.
3. To construct an efficient portfolio using the Markowitz mean-variance model based on historical data.
4. To interpret the viability of the constructed portfolio in practical investment scenarios.

Scope of the Study

- The study covers **ten Gold ETFs** listed and traded in India, along with the **Gold Index** as a benchmark.
- The analysis is based on **five years of historical return data** from sources such as NSE India, AMFI, various AMC's and Investing.com.
- Only risk and return metrics (mean, standard deviation, Sharpe ratio) are considered; fundamental or qualitative parameters like AUM, tracking error, and fund house reputation are excluded.
- The Markowitz model is applied assuming no short-selling, and portfolios are long-only and fully invested.
- The analysis aims to support academic understanding and provide practical insights for retail investors, wealth managers, and finance students.

Data Analysis and Interpretation

TABLE 1: PERFORMANCE OF LEADING GOLD ETFS

	Average Daily return					Absolute return				
GOLD ETFS	2024-25	2023-24	2022-23	2021-22	2020-21	2024-25	2023-25	2022-25	2021-25	2020-25
UTI GETF	0.115	0.081	0.074	0.066	0.057	31.162	46.078	69.318	88.369	94.263
ICICI GETF	0.113	0.079	0.074	0.070	0.057	27.397	46.572	67.851	91.446	94.215
Kotak GETF	0.115	0.080	0.073	0.070	0.054	28.190	47.404	68.253	90.542	85.495
Nippon	0.113	0.079	0.073	0.070	0.057	27.160	45.984	66.390	89.668	93.933
Axis GETF	0.115	0.080	0.075	0.070	0.060	28.025	46.825	68.372	90.487	96.140
ABSL GETF	0.118	0.082	0.075	0.071	0.060	28.625	47.325	68.925	91.473	96.129
HDFC GETF	0.110	0.076	0.069	0.067	0.055	29.983	44.875	64.053	88.557	89.276
SBI GETF	0.111	0.076	0.070	0.067	0.053	29.749	44.958	64.316	88.582	83.009
Invesco GETF	0.116	0.081	0.078	0.073	0.061	27.432	47.353	69.068	91.511	100.24
Quantam GETF	0.115	0.080	0.073	0.070	0.057	28.009	46.821	67.261	90.762	94.261
GOLD prices	0.001	0.001	0.001	0.001	0.001	37.944	77.247	63.258	83.567	116.49

TABLE 2: STANDARD DEVIATION

STANDARD DEVIATION					
GOLD ETF	2024-25	2023-25	2022-25	2021-25	2020-25
UTIGETF	0.799	0.703	0.703	0.722	0.751
ICICIGETF	0.840	0.730	0.727	0.730	0.811
Kotak GETF	0.822	0.721	0.729	0.727	0.802
Nippon	0.841	0.728	0.728	0.731	0.800
AxisGETF	0.880	0.752	0.746	0.744	1.061
ABSLGETF	0.901	0.780	0.779	0.784	0.978
HDFCGETF	0.826	0.700	0.689	0.692	0.780
SBIGETF	0.806	0.703	0.704	0.712	0.826
InvescoGETF	0.914	0.811	0.856	0.891	0.963
Quantam GETF	0.813	0.705	0.711	0.717	0.781
Gold prices	0.800	0.700	0.699	0.720	0.749

TABLE 3: BETA

BETA					
GOLD ETF	2024-25	2023-25	2022-25	2021-25	2020-25
UTIGETF	0.849	0.430	0.435	0.497	0.523
ICICIGETF	0.959	0.486	0.481	0.543	0.608

Kotak GETF	0.950	0.487	0.486	0.544	0.603
Nippon	0.935	0.484	0.485	0.550	0.610
AxisGETF	0.890	0.465	0.468	0.532	0.562
ABSLGETF	0.935	0.459	0.444	0.514	0.586
HDFCGETF	0.050	0.007	0.014	0.026	0.107
SBIGETF	0.046	0.019	0.021	0.033	0.116
InvescoGETF	0.984	0.477	0.486	0.564	0.594
Quantam GETF	0.908	0.470	0.473	0.535	0.599

TABLE 4: SHARPE RATIO

SHARPE RATIO					
GOLD ETFS	**2024-25**	**2023-24**	**2022-23**	**2021-22**	**2020-21**
UTI GETF	-8.46	-9.78	-9.24	-8.11	0.68
ICICI GETF	-8.05	-9.41	-8.93	-8.02	0.69
Kotak GETF	-8.22	-9.53	-8.90	-8.06	0.68
Nippon	-8.04	-9.44	-8.92	-8.02	0.69
Axis GETF	-7.68	-9.13	-8.70	-7.87	0.70
ABSL GETF	-7.50	-8.81	-8.34	-7.47	0.74
HDFC GETF	-8.19	-9.82	-9.43	-8.47	0.65
SBI GETF	-8.40	-9.78	-9.23	-8.24	0.67
Invesco GETF	-7.40	-8.46	-7.58	-6.57	0.84
Quantam GETF	-8.31	-9.75	-9.13	-8.16	0.67
Gold prices	-8.45	-9.82	-9.29	-8.15	0.68

The data represented in above tables from Table No 1-4 represents the **Gold ETF Performance (2020–2025)**

Data Dimensions:

- **Average Daily Return & Absolute Return** = Performance
- **Standard Deviation** = Volatility
- **Beta** = Sensitivity to Gold Price
- **Sharpe Ratio** = Risk-Adjusted Return

Return Performance

- Absolute Returns over 5 years are led by Invesco (100.24%), Axis (96.14%), and ABSL (96.13%), outperforming even gold prices (116.49%) quite closely.
- However, ICICI, UTI, Kotak, and Nippon also deliver solid long-term returns, mostly in the 85–95% range.
- Quantum and HDFC trail slightly but still show strong long-term accumulation.
- 1-year return (2024–25) is lower across all ETFs compared to prior years, but UTI, Invesco, and ABSL remain top performers.

Volatility (Standard Deviation)

- Volatility is highest in 1-year (2024–25) values.
- Invesco (0.914), ABSL (0.901), Axis (0.880) -high-risk funds.
- Over the 5-year horizon, Invesco remains the most volatile, while HDFC, UTI, and SBI maintain relatively low and stable volatility.
- Volatility has steadily risen post 2022–23, returning to pandemic era levels in recent data.

Risk-Adjusted Returns (Sharpe Ratio)

- Over 1–4 year periods, all ETFs show negative Sharpe ratios, meaning returns haven't compensated for risk, possibly due to market turbulence or rising volatility.
- Invesco consistently has the least negative Sharpe ratios, showing better relative risk-adjusted performance.
- Over 5 years, Invesco (0.84) leads with the best Sharpe Ratio, followed by ABSL (0.74) and Axis (0.70).
- UTI, HDFC, SBI, and Quantum stay around 0.65–0.68, showing more stability but lower efficiency in risk-adjusted terms.

Market Sensitivity (Beta)

- Over 5 years, Invesco (0.984) and ICICI/Kotak (0.95+) have high beta, meaning they move more closely and often more aggressively with the market.
- HDFC and SBI, with 5 year betas around 0.10 or lower, are almost market-insensitive, suggesting very conservative behaviour.
- Beta has surged across all ETFs in the last 1–2 years, indicating increased market alignment or strategy changes.

So, what investors should do-

Best for Aggressive Investors:

- Invesco, ABSL, and Axis are high-return, high-risk ETFs.
- Invesco stands out across all metrics: top in returns, beta, and Sharpe ratio—but also most volatile.

Best for Conservative Investors:

- HDFC, UTI, and SBI offer low beta, low volatility, and modest returns.
- Better suited for stability-focused portfolios.

Mid-Range, Balanced Performers:

- ICICI, Kotak, Nippon, and Quantum provide a balance good long-term returns with moderate beta and volatility.

The above data was on **Returns**, **Standard Deviation**, **Beta**, and **Sharpe Ratio** for 10 Gold ETFs and gold itself. Then the analysis further moved towards making an efficient portfolio using **Markowitz optimization model**, and the result was an **efficient portfolio** combining just **two components (GETF's)**:

- **Invesco Gold ETF: 76.38% and Gold Index: 23.62%**
- Now, here's how we interpret this in light of all the results of Efficient portfolio made via using Markowitz model, represented in Table 5.

TABLE 5: EFFICIENT PORTFOLIO

GOLD ETFS	Weightages
UTIGETF	0
ICICIGETF	0
Kotak GETF	0
Nippon	0
AxisGETF	0
ABSLGETF	0
HDFCGETF	0
SBIGETF	0
InvescoGETF	0.763829396
Quantam GETF	0
Gold Index	0.236170604
Total	1
Portfolio Return	14.6167075
Portfolio Variance	29.1200292
Portfolio SD	5.39629773

Portfolio Construction Overview:

- The portfolio is highly concentrated:
  - 76.38% in Invesco Gold ETF
  - 23.62% in the Gold Index
  - All other ETFs have 0% weight

This is essentially a two-asset portfolio, heavily skewed toward Invesco, which is the most volatile and aggressive ETF based on your previous data.

Portfolio Return – 14.62%

- This is the expected annual return of the portfolio.
- Given Invesco's high past returns (e.g., 100% over 5 years, ~20% CAGR), a 14.62% return is reasonable and attractive.

- The inclusion of the Gold Index helps slightly smooth out extreme return swings, but the return is clearly driven by Invesco's performance.

Portfolio Variance – 29.12

- Variance is a measure of risk (spread of returns) but not intuitive on its own.
- A variance of 29.12 is quite high, especially for a gold-oriented portfolio, confirming that this portfolio is not conservative.

Portfolio Standard Deviation – 5.40%

- This is the annualized volatility (the square root of variance).
- A 5.4% SD is relatively high, especially considering gold is often seen as a safe asset.
- It reflects the fact that the Invesco ETF is the most volatile fund, and it dominates the portfolio.

Overall Interpretation:

- This portfolio is built for high return at high risk.
- The concentration in Invesco means:
    - You're capturing its aggressive return potential,
    - But you're also exposed to sharp price swings.
- The Gold Index inclusion helps soften this slightly, but it's not enough to balance out the risk.
- This portfolio is not diversified, making it vulnerable to Invesco-specific risk.

Bottom Line:

- 14.6% return is attractive, but comes with high risk (5.4% SD).
- Suitable for aggressive investors who are comfortable with short-term volatility.
- If you want better diversification or lower risk, you'd need to spread weight across more ETFs—especially ones like HDFC, SBI, or UTI, which offer lower volatility.

FINDINGS AND CONCLUSION

Markowitz-efficient portfolio is worth investing in, assuming your investment goal is capital preservation, inflation protection, and reduced market correlation.

Why it makes sense:

1. **Optimized for return vs. risk**
    - A return of **14.62%** with a standard deviation of **5.40** is an excellent trade-off. You're getting higher-than-average returns for lower-than-average volatility.
2. **Focused exposure**
    - Instead of spreading thin across 8–10 gold ETFs (which often track similar indices), the model zeroes in on what historically worked best: **Invesco Gold ETF** (solid historical returns and risk metrics), **Gold Index** (pure commodity exposure, low correlation with equities).
3. **Low beta**
    - This portfolio will **not swing wildly with the stock market**, which is exactly what you want from gold-based assets.
4. **Backed by data**
    - The inputs—returns, standard deviation, Sharpe ratios—are all real, multi-year figures. The Markowitz model isn't running on theory alone; it's using actual asset behaviour over time.

To conclude with-

- **Invesco Gold ETF** emerges as the strongest across **all four metrics**: high return, tight gold tracking (high beta), reasonable volatility, and best risk-adjusted performance.
- **ABSL and Axis** are strong contenders if you want to slightly reduce volatility.
- **Avoid treating HDFC and SBI Gold ETFs as serious gold exposure tools**—they're low beta, and offer no real hedge.

This data makes it clear: if the **goal is to hedge, preserve value, or gain from gold movements**, **tracking accuracy + return efficiency = key**. Invesco nails both.

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