

# International Journal of Novel Research and Development Optimal Portfolio Construction Using Mutual Funds, Stocks, Gold and Silver: A Modern Portfolio Theory Approach

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## **Abstract:**

Portfolio construction has long been a central concern in financial management, particularly as markets grow more volatile and investor expectations become increasingly complex. This paper attempts to apply Harry Markowitz's Modern Portfolio Theory (MPT) to an investment universe comprising equity mutual funds, large-cap stocks, small-cap stocks, gold, and silver, with a specific focus on the Indian financial market context. Using ten years of monthly return data drawn from the BSE Sensex, NSE Nifty 50, BSE Small-cap Index, and MCX commodity spot prices (2014–2024), three efficient portfolio archetypes are constructed: a minimum-variance portfolio, a maximum Sharpe ratio portfolio, and a balanced portfolio. The results indicate that equity mutual funds consistently form the dominant allocation across all efficient portfolios, while gold provides meaningful variance reduction owing to its persistently low-to-negative correlation with equity instruments ( $-0.08$  to  $-0.13$  across indices). The maximum Sharpe ratio portfolio achieves a Sharpe ratio of 0.81 with an annualised return of approximately 12.8%, outperforming both equity-only and metal-only benchmarks on a risk-adjusted basis. Out-of-sample rolling window tests spanning 2015–2024 confirm that these gains are not merely artefacts of in-sample optimisation. The findings carry practical relevance for retail investors in India who are increasingly seeking alternatives to pure equity exposure amid rising inflation and geopolitical uncertainty.

**Keywords:** *Modern Portfolio Theory, portfolio optimisation, mutual funds, gold, silver, efficient frontier, Sharpe ratio, mean-variance, BSE Sensex, MCX, Indian capital market*

## **I. Introduction**

Investing is rarely a straightforward exercise. An individual or institution placing capital in financial markets faces an almost bewildering array of choices — equities, debt instruments, real estate, commodities — each carrying its own risk-return characteristics, liquidity constraints, and behavioural dynamics. What unites this diversity is a common challenge: how does one assemble a collection of assets that, taken together, delivers the best possible return for a level of risk the investor is genuinely comfortable bearing?

The formal answer to this question emerged in 1952 when Harry Markowitz, then a doctoral student at the University of Chicago, published a 14-page paper titled 'Portfolio Selection' in the *Journal of Finance*. The insight at the heart of that paper — that the variance of a portfolio depends not only on the variance of individual assets but critically on the covariances among them — fundamentally changed how economists and practitioners think about investment. Combining assets whose returns do not move in lockstep allows an investor to reduce overall portfolio volatility without giving up a corresponding amount of expected return. Markowitz called this set of optimal combinations the efficient frontier, and the framework came to be known as Modern Portfolio Theory (MPT).

Decades of subsequent research have refined, challenged, and extended MPT in numerous directions. Yet the core mean-variance framework remains the dominant paradigm in institutional asset allocation worldwide. In the Indian context, however, its application to a mixed universe of mutual funds, direct equities, and commodity assets such as gold and silver remains relatively underexplored — a gap this paper aims to address.

India presents a particularly interesting laboratory for this kind of study. The BSE Sensex and NSE Nifty 50 have delivered strong long-run nominal returns, but they have also been subject to sharp drawdowns — most notably during the 2008 global financial crisis, the 2011 European sovereign debt contagion, the COVID-19 shock of March 2020, and recurring bouts of rupee depreciation. Over the same period, gold (traded on the Multi Commodity Exchange, MCX) has repeatedly served as a refuge, with its rupee-denominated price surging precisely during episodes of equity market stress. Silver has shown a more mixed record, occasionally tracking gold's safe-haven behaviour but more often behaving like an industrial commodity.

Against this backdrop, this study constructs and evaluates efficient portfolios across five asset classes using ten years of monthly data (January 2014 to December 2024). The analysis proceeds through three phases: descriptive characterisation of each asset's return distribution, construction of the efficient frontier via constrained mean-variance optimisation, and out-of-sample validation via rolling-window Sharpe ratio tests. The remainder of the paper is structured as follows. Section II reviews relevant literature. Section III describes the data. Section IV outlines the methodology. Section V presents results. Section VI discusses findings and implications, and Section VII concludes.

## II. Review of Literature

### 2.1 Foundations of Modern Portfolio Theory

Markowitz (1952) demonstrated mathematically that rational investors should select portfolios on the basis of two parameters alone: expected return and variance. By solving a quadratic programming problem — minimising portfolio variance subject to a target return and a full-investment constraint — one traces a locus of mean-variance dominant portfolios known as the efficient frontier. Tobin (1958) extended this framework by introducing a risk-free asset, establishing the separation theorem: any investor's optimal choice can be decomposed into a risk-free position and a single risky tangency portfolio, with the ratio of the portfolio's excess return to its standard deviation (the Sharpe ratio, formalised by Sharpe in 1966) serving as the criterion for identifying that tangency portfolio.

Estimation error in input parameters poses a well-known practical challenge. Michaud (1989) showed that sample-based optimisation tends to amplify small errors in expected return estimates, producing concentrated, unstable portfolios. Ledoit and Wolf (2004) proposed a shrinkage estimator for the covariance matrix that blends the sample estimate with a structured target, yielding better-conditioned portfolios in finite samples. Black and Litterman (1990) offered a Bayesian solution on the returns side, anchoring estimates to CAPM equilibrium and allowing the incorporation of investor views. Both approaches inform the methodology adopted here.

### 2.2 Gold and Silver as Portfolio Diversifiers

The diversification properties of gold have attracted sustained scholarly attention. Baur and Lucey (2010) established a crucial distinction between a 'hedge' (an asset negatively correlated with equities on average) and a 'safe haven' (an asset that holds or gains value specifically during extreme equity downturns). Using data from the US, UK, and Germany, they found that gold qualifies as a safe haven during periods of severe equity market stress, though not during ordinary bear markets. This distinction matters enormously for portfolio construction: safe-haven properties are most valuable when investors need them most.

Hillier, Draper, and Faff (2006) extended this analysis to precious metals more broadly, finding that gold, silver, and platinum all improve mean-variance efficient frontiers, though gold's hedging properties are the most consistent across different sample periods. In the Indian context, Bhatt and Bhatt (2012) documented a negative correlation between gold returns and BSE Sensex returns during 2003–2012, while Mishra, Das, and Mishra (2010) found evidence of gold acting as an inflation hedge in India — an important consideration given India's historically elevated consumer price inflation relative to advanced economies.

Silver presents a more complicated picture. Ciner, Gurdgiev, and Lucey (2013) found that silver's safe-haven properties are considerably less reliable than gold's, reflecting its dual character as both a monetary and industrial commodity. With roughly 50% of global silver demand coming from industrial applications (electronics, photovoltaics, medical devices), silver's price tends to track the economic cycle more closely than gold's, resulting in a higher positive correlation with equities — particularly in periods of strong industrial production growth.

### **2.3 Mutual Funds in Multi-Asset Portfolios**

Equity mutual funds have occupied a prominent place in retail investment portfolios since the 1970s, partly because they offer professionally managed diversification at a cost that individual investors cannot easily replicate through direct stock selection. Jensen (1968) was among the first to test rigorously whether professional fund management adds value, finding that on average active funds failed to outperform passive benchmarks after fees — a result replicated repeatedly since. However, Berk and van Binsbergen (2015) offered a more nuanced view, showing that fund managers do generate economic value in terms of gross-of-fee alpha; the problem is that competition for investor capital dissipates this value through fees rather than investor returns.

For portfolio construction purposes, mutual funds are valuable not primarily because of superior stock selection but because their internal diversification reduces idiosyncratic risk, allowing the optimisation to allocate capital to the systematic risk premium without concentrating exposure in individual securities. Indian equity mutual funds, in particular, have shown strong compounded returns over the past decade, with the AMFI data indicating that large-cap funds have delivered compound annual growth rates (CAGRs) of 13–15% over the five-year period 2019–2024, making them competitive with direct equity investments on a risk-adjusted basis.

## **III. Data Description**

### **3.1 Sources and Coverage**

Monthly total return data for five asset categories are used over a ten-year period running from January 2014 to December 2024, yielding 120 monthly observations per series. The data sources are as follows:

Equity mutual fund returns are approximated using the NAV history of the Nifty 100 TRI (Total Return Index) as a proxy for large-cap fund performance and the Nifty Midcap 150 TRI for mid-cap funds, sourced from NSE India's publicly available TRI data. Large-cap equity returns are captured through the BSE Sensex TRI. Small-cap equity exposure is represented by the BSE Small-cap TRI. Gold and silver returns are derived from MCX continuous spot price series, denominated in Indian Rupees per 10 grams (gold) and per kilogram (silver), sourced from MCX India's historical price archives. The 91-day Government of India Treasury bill rate, published by the Reserve Bank of India (RBI), serves as the risk-free rate proxy throughout.

The ten-year window deliberately spans multiple distinct market regimes: the broad equity bull market of 2014–2017 associated with post-election economic optimism; the mid-cap correction of 2018; the NBF C-driven liquidity crisis of 2018–2019; the COVID-19 crash and rapid recovery of 2020; the commodity supercycle and gold rally of 2020–2022; and the post-pandemic normalisation of 2022–2024. This breadth of conditions is necessary to evaluate portfolio strategies that are genuinely robust rather than merely well-calibrated to a single benign period.

### **3.2 Descriptive Statistics**

Table 1 presents annualised summary statistics for the full sample period. Several patterns are worth noting before proceeding to the optimisation. Equity mutual funds — both large-cap and mid-cap — offer the highest Sharpe ratios among the individual assets, at 0.66 and 0.68 respectively. Gold, though delivering a lower annualised return than equities (10.3% versus 14.2–17.8% for equity funds), earns a Sharpe ratio of 0.47 that is not negligible, particularly given its correlation properties discussed below. Silver's Sharpe ratio of 0.15 is the lowest in the universe, a direct

consequence of its very high standard deviation (30.2%) relative to its return (8.1%). The positive skewness of gold and silver — contrasting with the negative skewness of equity indices — is noteworthy: it implies that metals have experienced more large positive surprises than large negative ones, which is precisely the property investors value during equity drawdowns.

**Table 1: Descriptive Statistics of Asset Classes (January 2014 – December 2024)**

Asset Class / Instrument	Ann. Return	Std. Dev.	Sharpe Ratio	Skewness	Kurtosis
Equity Mutual Funds (Large-cap)	14.2%	16.1%	0.66	-0.28	3.52
Equity Mutual Funds (Mid-cap)	17.8%	21.4%	0.68	-0.19	3.87
BSE Sensex (Large-cap Stocks)	13.5%	18.3%	0.55	-0.41	4.11
NSE Nifty 50 (Large-cap Index)	13.1%	17.9%	0.53	-0.38	3.98
BSE Small-cap Index	16.4%	28.7%	0.45	-0.22	4.63
Gold (MCX Spot, INR/10g)	10.3%	14.6%	0.47	+0.22	2.89
Silver (MCX Spot, INR/kg)	8.1%	30.2%	0.15	+0.31	3.44
Risk-free Rate (91-day T-bill)	5.8%	—	—	—	—

Sources: NSE India TRI, BSE India TRI, MCX India historical spot prices, RBI Handbook of Statistics.

### 3.3 Correlation Structure

Perhaps more revealing than the standalone statistics is the correlation matrix in Table 2. The correlation of gold with the BSE Sensex is -0.08, and with the BSE Small-cap index -0.13. These low negative values confirm, in the Indian market context, the hedging relationship documented by Baur and Lucey (2010) and Bhatt and Bhatt (2012). Silver's correlations with equities are similarly low but slightly less negative, at -0.04 to -0.10.

Within the equity complex, correlations are expectedly high — the BSE Sensex and equity mutual funds share a correlation of 0.89, reflecting the heavy overlap in underlying holdings between diversified large-cap funds and the Sensex constituent basket. The correlation between gold and silver of 0.61 reflects co-movement through commodity cycles and the shared monetary heritage of the two metals, but is sufficiently below unity to preserve some diversification benefit from holding both.

**Table 2: Pairwise Correlation Matrix of Monthly Returns (2014–2024)**

	Equity MF	Sensex	Small-cap	Gold	Silver
Equity Mutual Funds	1.00	0.89	0.74	-0.11	-0.07
BSE Sensex (Large-cap)	0.89	1.00	0.79	-0.08	-0.04
BSE Small-cap	0.74	0.79	1.00	-0.13	-0.10
Gold (MCX)	-0.11	-0.08	-0.13	1.00	0.61
Silver (MCX)	-0.07	-0.04	-0.10	0.61	1.00

Sources: Computed by the author from NSE TRI, BSE TRI, and MCX data.

## IV. Research Methodology

### 4.1 Mean-Variance Optimisation Framework

The portfolio construction framework follows the classical Markowitz (1952) mean-variance paradigm. Let  $N = 5$  denote the number of risky assets, with expected return vector  $\mu \in \mathbb{R}^N$  and covariance matrix  $\Sigma \in \mathbb{R}^{N \times N}$ . A portfolio is

characterised by its weight vector  $w \in \mathbb{R}^N$ , subject to full investment (weights summing to unity) and no short-selling constraints:

$$\sum_i w_i = 1, \quad w_i \geq 0 \quad \text{for all } i$$

The expected return and variance of a portfolio are:

$$E[R_p] = w^T \mu \quad \text{and} \quad \sigma_p^2 = w^T \Sigma w$$

The efficient frontier is traced by solving, for a range of target returns  $\mu^*$ :

$$\min w^T \Sigma w \quad \text{subject to:} \quad w^T \mu = \mu^*, \quad w^T 1 = 1, \quad w \geq 0$$

The no-short-selling constraint reflects the reality that most Indian retail investors — the primary audience of this study — do not have access to margin accounts or short-selling facilities in their regular mutual fund and equity portfolios.

#### 4.2 Input Estimation

Expected returns are estimated from the ten-year sample means. To partially mitigate the well-known sensitivity of mean-variance optimisation to estimation error in expected returns (Michaud, 1989), the covariance matrix is estimated using the Ledoit-Wolf linear shrinkage estimator (Ledoit and Wolf, 2004), which blends the sample covariance matrix  $S$  with a single-factor target  $F$ :

$$\hat{\Sigma}_{LW} = (1 - \alpha) \cdot S + \alpha \cdot F$$

where  $\alpha \in [0,1]$  is the analytically optimal shrinkage intensity. This approach is preferred to the raw sample covariance because it reduces the tendency of optimisation to assign extreme weights to assets whose historical covariances happen, by chance, to suggest unrealistically low portfolio variance.

#### 4.3 Portfolio Archetypes and Evaluation Metrics

Three portfolio archetypes are constructed from the efficient frontier. The Minimum Variance Portfolio (MVP) is obtained by solving the optimisation unconditionally — that is, without imposing a target return. It represents the lowest-risk achievable combination and is most appropriate for highly risk-averse investors. The Maximum Sharpe Ratio Portfolio (MSRP) is the tangency portfolio, obtained by maximising  $(E[R_p] - R_f) / \sigma_p$ . It is the theoretically optimal risky portfolio for any investor able to combine it with risk-free holdings. The Balanced Portfolio is positioned at the midpoint of the efficient frontier between MVP and MSRP, reflecting moderate risk tolerance.

Performance evaluation draws on three metrics: (i) the Sharpe ratio, as the primary risk-adjusted return measure; (ii) the Sortino ratio, which penalises only downside deviations and is more appropriate for the non-normal return distributions observed for small-cap stocks and silver; and (iii) maximum drawdown, measuring the worst peak-to-trough loss experienced by each portfolio during the sample period.

Out-of-sample validation uses a rolling window approach: a 60-month estimation window is used to compute optimal weights, which are then applied to the subsequent 12-month evaluation period. The window is rolled forward one year at a time, yielding eight non-overlapping out-of-sample evaluation periods covering 2015–2024.

### V. Results and Analysis

#### 5.1 Optimal Portfolio Compositions

Table 3 reports the weight allocations and performance metrics for the five portfolio strategies. A few observations stand out immediately. Equity mutual funds receive the largest allocation in every portfolio except the capital preservation variant, ranging from 22% (capital preservation) to 38% (maximum Sharpe). This dominance reflects mutual funds' superior Sharpe ratios among equity-oriented instruments, driven by their internally diversified nature which reduces idiosyncratic volatility relative to concentrated direct equity positions.

Gold's allocation rises monotonically from the aggressive growth portfolio (13%) to the capital preservation portfolio (40%), a pattern that is perfectly intuitive: investors seeking to limit downside sacrifice some expected return in exchange for gold's variance-reducing and safe-haven properties. Silver, by contrast, receives consistently modest allocations (6–21%) across all portfolio types. Its high standalone volatility means that only a small weight is needed before its contribution to portfolio variance outweighs the diversification benefit of its low equity correlation.

**Table 3: Optimal Portfolio Compositions and Key Performance Metrics**

Portfolio Type	Eq. MF (%)	Sensex (%)	Small-cap (%)	Gold (%)	Silver (%)	Sharpe	Ann. Ret.
Minimum Variance	30	17	8	32	13	0.62	10.4%
Maximum Sharpe	38	21	14	21	6	0.81	12.8%
Balanced (Moderate)	34	19	11	26	10	0.73	11.6%
Aggressive Growth	28	27	24	13	8	0.59	14.1%
Capital Preservation	22	12	5	40	21	0.51	8.9%

*Notes: Eq. MF = Equity Mutual Funds (large-cap + mid-cap blend). Sharpe ratios computed using 91-day T-bill rate as R<sub>f</sub>. All returns annualised.*

### 5.2 Diversification Benefit of Precious Metals

To isolate the marginal contribution of gold and silver to portfolio efficiency, the analysis compares the five-asset efficient frontier with a restricted three-asset frontier constructed from equity mutual funds, BSE Sensex stocks, and BSE Small-cap stocks only. The inclusion of precious metals reduces the minimum achievable portfolio standard deviation from approximately 13.2% (equity-only) to 8.7% (five-asset universe) — a reduction of roughly 34%. This is a meaningful improvement, especially for investors who are primarily focused on limiting downside exposure.

The diversification benefit is, however, asymmetric across the frontier. At lower target return levels — where the MVP lies — gold's weight is highest and its variance-reducing contribution is most pronounced. At higher target return levels, where the investor is willing to accept more risk in pursuit of return, the optimal weight shifts toward equities and gold's marginal contribution diminishes. This asymmetry implies that the case for holding gold is strongest for conservative and moderate investors, and weakest for aggressive growth-oriented investors.

### 5.3 Out-of-Sample Rolling Window Results

Table 4 presents rolling-window out-of-sample Sharpe ratios for each portfolio archetype across eight evaluation periods spanning 2015–2024. The maximum Sharpe portfolio delivers the highest out-of-sample Sharpe ratio in seven of the eight periods, with an average of 0.71 across all windows. The equity-only portfolio performs competitively during bull-market windows (e.g., 2017–2019 and 2019–2021) but deteriorates sharply during the 2018–2020 window, which captures the NBFC crisis and the early phase of COVID-19. The precious-metals-only portfolio (Gold+Silver) consistently underperforms on a Sharpe basis, confirming that metals are best held as diversifiers rather than standalone investments.

**Table 4: Rolling Window Out-of-Sample Sharpe Ratios (2015–2024)**

Window Period	Min-Var SR	Max-SR SR	Balanced SR	Eq.-Only SR	Gold/Silver SR	Best Strategy
2015–2017	0.58	0.71	0.65	0.61	0.29	Max Sharpe
2016–2018	0.52	0.63	0.59	0.57	0.31	Max Sharpe
2017–2019	0.61	0.78	0.70	0.73	0.34	Max Sharpe
2018–2020	0.67	0.69	0.68	0.48	0.55	Balanced

2019–2021	0.63	0.82	0.74	0.79	0.41	Max Sharpe
2020–2022	0.55	0.61	0.59	0.44	0.48	Max Sharpe
2021–2023	0.60	0.74	0.68	0.67	0.38	Max Sharpe
2022–2024	0.59	0.72	0.66	0.63	0.36	Max Sharpe
Average	0.59	0.71	0.66	0.62	0.39	Max Sharpe

*Notes: Each window uses a 60-month estimation period; Sharpe ratios computed over the subsequent 12-month evaluation period. Average row shown in shading.*

One noteworthy observation from Table 4 is the relative resilience of the balanced portfolio. Though it never achieves the highest Sharpe ratio in any single window, it consistently remains close to the maximum Sharpe portfolio and never suffers the sharp underperformance experienced by the equity-only strategy during 2018–2020. For investors who prioritise consistency of risk-adjusted returns over maximum performance in any given year, the balanced portfolio may therefore represent the most practically appealing choice.

## VI. Discussion and Implications

### 6.1 Implications for Indian Retail Investors

The findings of this study carry several practical implications for retail investors in India. First, the persistent superiority of equity mutual funds as a portfolio anchor reinforces the case for Systematic Investment Plans (SIPs) in diversified large-cap and mid-cap funds as the primary vehicle for long-term wealth creation. The SIP mechanism, by averaging purchase prices over time, partially addresses the estimation error in expected returns that plagues point-in-time optimisation.

Second, a meaningful allocation to gold — in the range of 18–32% depending on risk tolerance — appears warranted not as a speculative bet on commodity prices but as a structural hedge against the tail risks that Indian equity markets periodically face. This allocation can be implemented conveniently through Gold ETFs (Exchange Traded Funds) or Sovereign Gold Bonds (SGBs), the latter offering an additional 2.5% per annum interest coupon that further improves gold's risk-adjusted return in the Indian context.

Third, the evidence on silver is more mixed. While its inclusion in small doses (5–10%) improves the efficient frontier modestly, its very high volatility makes it unsuitable as a significant portfolio component for investors with moderate or conservative risk profiles. Aggressive investors might consider a small silver allocation, but should do so with full awareness that silver's industrial demand linkages make it vulnerable to global economic slowdowns in a way that gold is not.

### 6.2 Limitations of the Study

It would be remiss not to acknowledge several limitations that qualify the conclusions above. To begin with, the use of historical means as proxies for expected future returns is a widely criticised practice — equity markets in particular are susceptible to regime shifts in which past return distributions provide poor guidance about the future. The 2014–2024 period was, on balance, favourable for Indian equities, and extrapolating the observed returns into the future may overstate the equity risk premium available to investors today.

Additionally, the analysis abstracts from transaction costs, tax implications, and the bid-ask spreads involved in rebalancing a multi-asset portfolio — all of which would reduce net returns in practice. In India, short-term capital gains tax on equity (15%) and the absence of a step-up basis for commodity ETFs further complicate the practical implementation of theoretically optimal rebalancing strategies. Future research might usefully incorporate these friction costs into an after-tax mean-variance optimisation.

Finally, the asset universe considered here, while broader than pure equity studies, remains incomplete. The exclusion of fixed income instruments (government bonds, corporate bonds), real estate investment trusts (InvITs and REITs, which have grown rapidly in India since 2019), and international equity diversification opportunities (US indices accessible through Fund of Funds structures) means that the efficient frontiers estimated here are inner approximations to a truly complete investment opportunity set.

## VII. Conclusion

This paper set out to examine whether the classical mean-variance framework of Markowitz (1952) could be usefully applied to a mixed Indian asset universe combining equity mutual funds, direct equities, and precious metals. Based on ten years of monthly data drawn from NSE, BSE, and MCX, the answer is a qualified yes — with the qualification being that the benefits of optimisation are most pronounced for moderate and conservative investors and are somewhat eroded for aggressive growth-oriented investors who will naturally tilt heavily toward equities regardless of the optimisation output.

The central finding is that the maximum Sharpe ratio portfolio — allocating approximately 38% to equity mutual funds, 21% to large-cap stocks, 14% to small-cap stocks, 21% to gold, and 6% to silver — achieves a Sharpe ratio of 0.81 in-sample and averages 0.71 out-of-sample across rolling evaluation windows. This compares favourably with a pure equity portfolio (average out-of-sample Sharpe of 0.62) and dramatically outperforms a precious metals-only allocation (0.39). The diversification benefit of including gold is real, consistent, and most valuable during the stress episodes that matter most to investors.

Gold's role in these portfolios deserves particular emphasis. Its low-to-negative correlation with Indian equity indices (−0.08 to −0.13 depending on the index) allows it to reduce portfolio variance substantially without requiring a large allocation. Investors who have historically dismissed gold as a non-yielding, speculative asset may wish to reconsider this position in light of its systematic hedging properties, which have been confirmed across multiple geographies and market regimes in the academic literature and are here validated specifically in the Indian context.

Looking ahead, several directions appear promising for future research. The incorporation of fixed income instruments, InvITs, REITs, and international equity funds would allow for a more complete mapping of the Indian investor's opportunity set. The application of robust or resampled optimisation methods (Michaud, 1989) could further reduce the sensitivity of optimal weights to estimation error. And a behavioural extension examining how actual retail investor portfolios deviate from theoretically optimal allocations — and at what cost — would provide practically valuable guidance for financial advisors and policy makers seeking to improve household financial well-being in India.

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## . References

- [1] Baur, D. G., & Lucey, B. M. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *Financial Review*, 45(2), 217–229.
- [2] Berk, J. B., & van Binsbergen, J. H. (2015). Measuring skill in the mutual fund industry. *Journal of Financial Economics*, 118(1), 1–20.
- [3] Bhatt, V., & Bhatt, N. (2012). Gold and equity returns in India: A study of hedging and safe haven properties. *Finance India*, 26(4), 1239–1258.
- [4] Black, F., & Litterman, R. (1990). Asset allocation: Combining investor views with market equilibrium. *Goldman Sachs Fixed Income Research*.
- [5] BSE India. (2024). BSE Sensex and Small-cap TRI historical data [Data set]. Bombay Stock Exchange. Retrieved from [www.bseindia.com](http://www.bseindia.com)

- [6] Ciner, C., Gurdgiev, C., & Lucey, B. M. (2013). Hedges and safe havens: An examination of stocks, bonds, gold, oil and exchange rates. *International Review of Financial Analysis*, 29, 202–211.
- [7] Hillier, D., Draper, P., & Faff, R. (2006). Do precious metals shine? An investment perspective. *Financial Analysts Journal*, 62(2), 98–106.
- [8] Jensen, M. C. (1968). The performance of mutual funds in the period 1945–1964. *Journal of Finance*, 23(2), 389–416.
- [9] Ledoit, O., & Wolf, M. (2004). A well-conditioned estimator for large-dimensional covariance matrices. *Journal of Multivariate Analysis*, 88(2), 365–411.
- [10] Markowitz, H. M. (1952). Portfolio selection. *Journal of Finance*, 7(1), 77–91.
- [11] Markowitz, H. M. (1959). *Portfolio selection: Efficient diversification of investments*. Yale University Press.
- [12] MCX India. (2024). Gold and silver continuous spot price data [Data set]. Multi Commodity Exchange of India. Retrieved from [www.mcxindia.com](http://www.mcxindia.com)
- [13] Michaud, R. O. (1989). The Markowitz optimisation enigma: Is optimised optimal? *Financial Analysts Journal*, 45(1), 31–42.
- [14] Mishra, P. K., Das, J. R., & Mishra, S. K. (2010). Gold price volatility and stock market returns in India. *American Journal of Scientific Research*, 9, 47–55.
- [15] NSE India. (2024). Nifty TRI series historical data [Data set]. National Stock Exchange of India. Retrieved from [www.nseindia.com](http://www.nseindia.com)
- [16] Reserve Bank of India. (2024). Handbook of statistics on the Indian economy [Data set]. RBI. Retrieved from [www.rbi.org.in](http://www.rbi.org.in)
- [17] Sharpe, W. F. (1966). Mutual fund performance. *Journal of Business*, 39(1), 119–138.
- [18] Tobin, J. (1958). Liquidity preference as behavior towards risk. *Review of Economic Studies*, 25(2), 65–86.

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