Portfolio Management and Optimization: Summary Report (Week 3)

This report summarizes six days of research and analysis (Day 15–Day 20) on portfolio management and optimization. The focus was on diversification, statistical evaluation of strategies, backtesting mean-variance optimization, building multi-asset portfolios, and comparing risk-adjusted performance metrics.

D15: Role of Diversification

Day 15 established the foundation of **Modern Portfolio Theory (MPT)**, introduced by Harry Markowitz in 1952.

- **Risk–Return Trade-off**
  MPT formalizes the principle that investors aim to maximize expected returns while minimizing risk, typically measured as variance or standard deviation. The Efficient Frontier represents the set of optimal portfolios balancing this trade-off.

- **Portfolio Risk**
  Unlike expected return, portfolio risk is not a simple weighted average of individual risks. It depends on **covariances between assets**, making correlations central to portfolio construction.

- **Power of Diversification**
  If assets are less than perfectly correlated, diversification reduces overall volatility by eliminating **idiosyncratic risk** without lowering expected returns. This principle underpins the Efficient Frontier.

D16: Diversification Effect – Statistical Tests

Day 16 evaluated four portfolio strategies on Nifty50 constituents (3 years of daily data):

- **Equal-Weight (baseline)**

- **Minimum Variance (Min-Var)**
- **Maximum Sharpe (Max-Sharpe)**
- **Hierarchical Risk Parity (HRP)**

Methodology:
Quarterly returns and performance metrics (return, volatility, Sharpe ratio, max drawdown) were computed. Statistical significance was tested using Paired t-test, Wilcoxon Signed-Rank Test, Permutation Test, and Bootstrap Confidence Intervals.

Key Findings:

- **Max-Sharpe** delivered the strongest results: Sharpe ratio **1.70**, annual return **42.91%**, with statistically significant outperformance over Equal-Weight (p-values < 0.05).
- **Min-Var** reduced volatility but showed the weakest returns, with borderline significance (small effect size, Cohen's d = 0.292).
- **HRP** did not show significant improvement over Equal-Weight.

Conclusion:
Optimization, particularly the **Max-Sharpe strategy**, provided measurable and statistically significant advantages over naïve diversification.

D17: Mean-Variance Optimization (MVO) Backtest

Day 17 implemented **Mean-Variance Optimization (MVO)** using **CVXPY** and compared results with **PyPortfolioOpt**.

Implementation:

- Trained on 2019–2021 data.
- The Max-Sharpe portfolio was **highly concentrated** (e.g., INFY.NS 37.22%, ASIANPAINT.NS 30.11%).
- Training metrics: Annual Return **36.81%**, Sharpe **1.428**.

Forward Test (2022–2025):

- Performance collapsed: Sharpe ratio turned **negative (-0.131, -0.058)**.
- Equal-Weight benchmark outperformed (Sharpe **0.636**).
- Failure traced to **concentration risk**—high weights on stocks that reversed trends (e.g., ASIANPAINT.NS, BAJFINANCE.NS).

Insights & Solutions:

- Limit exposure to single assets/sectors.
- Incorporate **multi-asset diversification** (equities, debt, gold, international).
- Apply **dynamic rebalancing** to adapt to changing market conditions.

D18: Multi-Asset GMV and Tangency Portfolios

Day 18 expanded the universe to include Indian equities, Debt ETFs (EBBETF0430.NS, LTGILTBEES.NS), Gold ETFs (AXISGOLD.NS), and international equity (^GSPC).

Portfolios Constructed:

- **Global Minimum Variance (GMV):** Minimized volatility (**3.63%**), dominated by **EBBETF0430.NS (85.36%)**.
- **Tangency (Max Sharpe):** Maximized Sharpe ratio (**1.459**), still debt-heavy (EBBETF0430.NS 62.88%) but diversified with **AXISGOLD.NS (14.32%)**, equities (ICICIB22.NS, INFY.NS).

Takeaway:
Debt assets provided the stabilizing core, while gold and equities improved return potential.

D19 & D20: Sharpe vs Sortino Analysis

The final two days compared Sharpe (total volatility) with Sortino (downside risk).

Metric Distinction:

- **Sharpe Ratio** = Return / Total Volatility.
- **Sortino Ratio** = Return / Downside Volatility (ignores positive volatility).

Results:

- Defensive assets (EBBETF0430.NS, AXISGOLD.NS) ranked higher on **Sortino**, reflecting strong downside protection.
- **Sharpe Ranking:** Tangency Portfolio (0.0903) > GMV.
- **Sortino Ranking:** GMV Portfolio (0.1999) > Tangency (0.1864).

Strategic Insight:

- Tangency Portfolio excels in growth phases.
- GMV Portfolio is more resilient in risk-off or volatile environments.
- Adaptive strategies blending both approaches can optimize performance across cycles.

Overall Conclusions

1. **Diversification is essential**—it reduces unsystematic risk and builds the foundation for optimal portfolios.
2. **Max-Sharpe optimization works in-sample** but fails out-of-sample without robust controls against concentration.
3. **Multi-asset allocation** (equities, debt, gold, global) improves stability and resilience.
4. **Risk metrics matter**—Sharpe captures efficiency, Sortino captures downside resilience.
5. **Practical recommendation:** Adopt an **adaptive allocation framework**, shifting between Tangency (Sharpe-optimal) and GMV (Sortino-optimal) depending on market regime.