AI in Finance

Stress Testing a Markowitz Portfolio

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Project Objectives

Objective: To construct and stress-test a dynamic Minimum Variance Portfolio (MVP) using a data-driven approach.

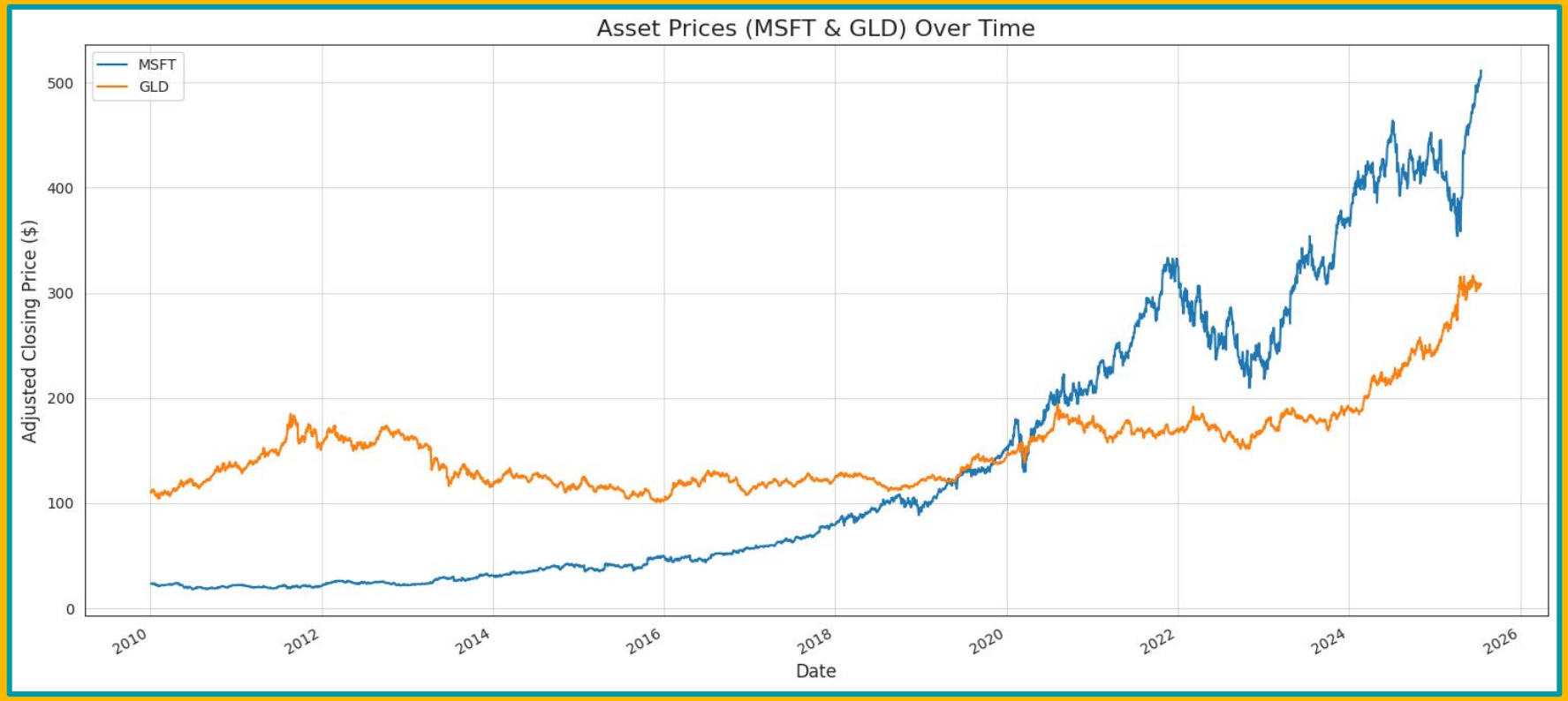
Key Focus Areas:

- Evaluating portfolio risk under normal and simulated stress conditions using Value at Risk (VaR) and Expected Shortfall (ES).
- Comparing MVP performance against traditional benchmarks (60/40 portfolio, S&P 500).

Dataset

Component	Details
Selected Assets	MSFT (Microsoft), GLD (SPDR Gold Shares)
Benchmark	S&P 500 (^GSPC)
Data Period	January 1, 2010 – July 19, 2025
Data Type	Daily Adjusted Closing Prices
Return Type	Daily Simple Returns
Training Set	2010-01-01 – 2023-12-31 (approx. 3,522 trading days)
Test Set	2024-01-01 – 2025-07-19 (approx. 384 trading days)

Dataset


Asset Prices (MSFT & GLD) Over Time
MSFT
GLD
Adjusted Closing Price ($)
0
100
200
300
400
500
2010
2012
2014
2016
2018
2020
2022
2024
2026
Date

Markowitz Portfolio Construction

Component	Details
Assets	MSFT (Microsoft), GLD (SPDR Gold Shares)
Covariance Estimation	Ledoit-Wolf shrinkage estimator over 180-day rolling window
Portfolio Goal	Minimize variance with diversification
Rebalancing Strategy	Every 21 trading days (~monthly) to adapt to market changes
Weight Constraints	Each asset weight between 30% and 70%
Transaction Costs	0.1% on turnover at each rebalancing step

Portfolio Strategy

[Rolling Window] → [Ledoit-Wolf Estimator] → [Covariance Matrix]

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[MVP Optimization]

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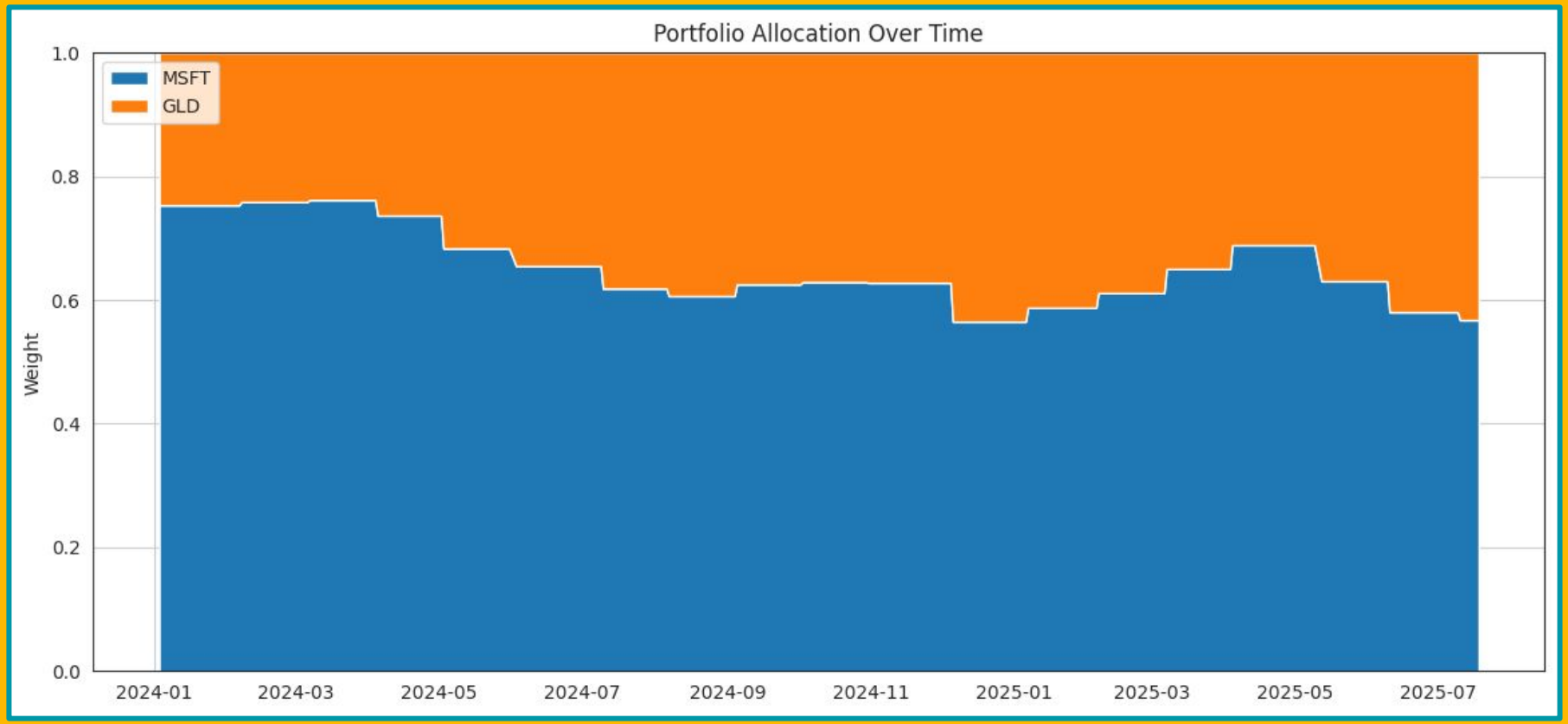
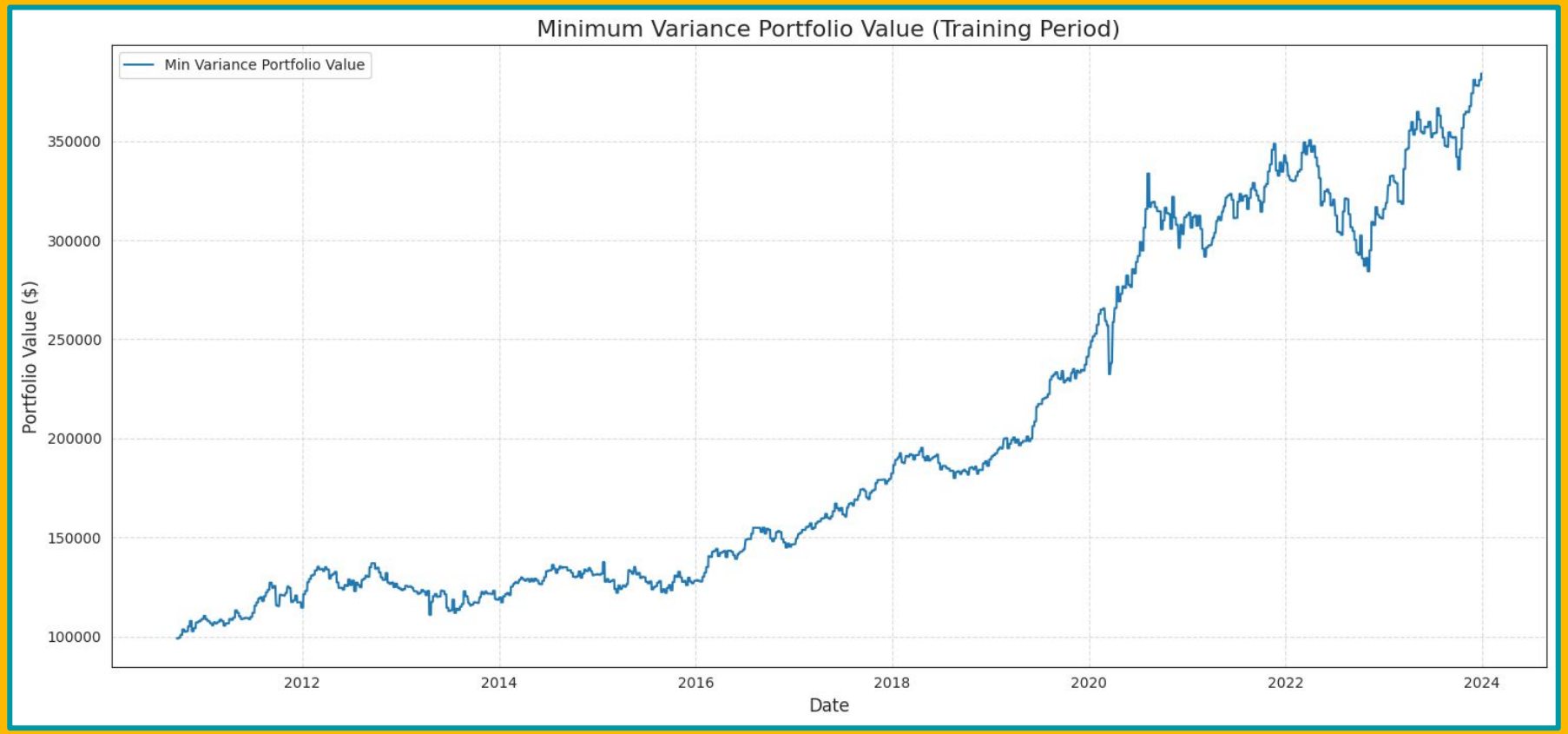
[Rebalancing every 21 days]

Dynamic Portfolio Allocation



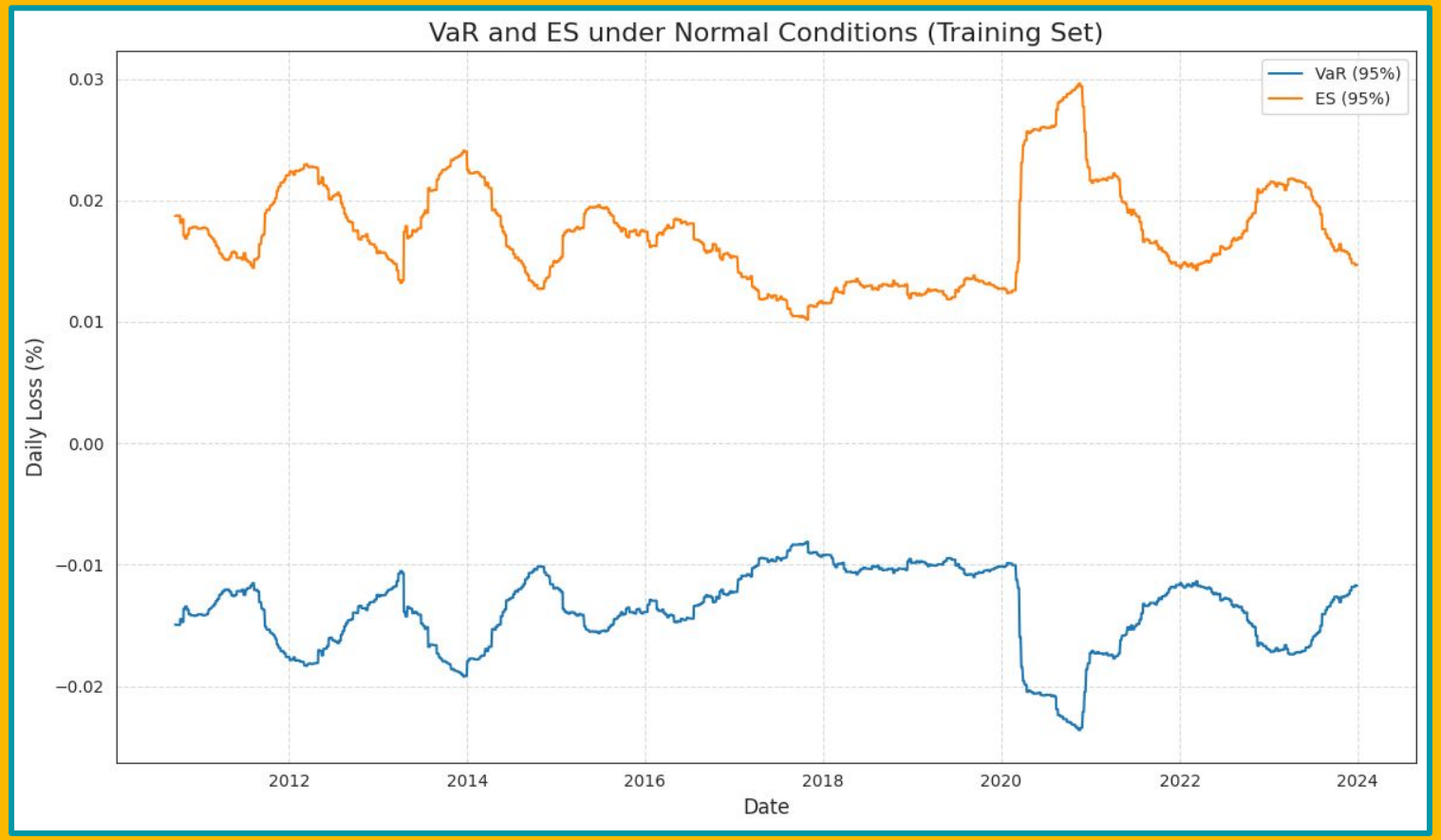
Portfolio Performance (Training Period)



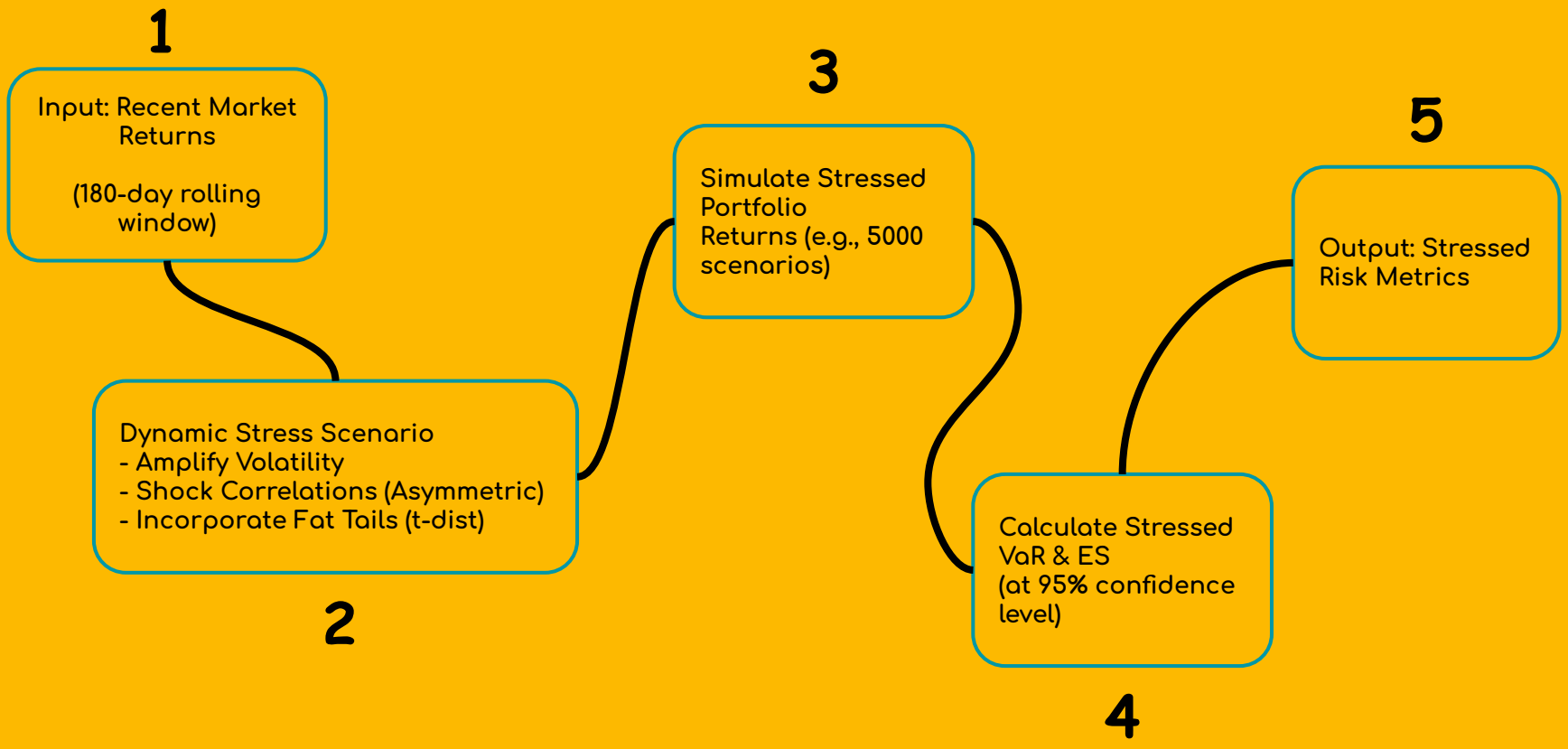
Risk Estimation under Normal Conditions

Component	Description
Goal	Dynamically compute Value at Risk (VaR) and Expected Shortfall (ES).
Confidence Level	95%
Assumption	Returns are normally distributed for baseline calculations.
Dynamic Approach	Recalculated daily using: • Estimated portfolio standard deviation • Current portfolio value • Reflects changing market volatility

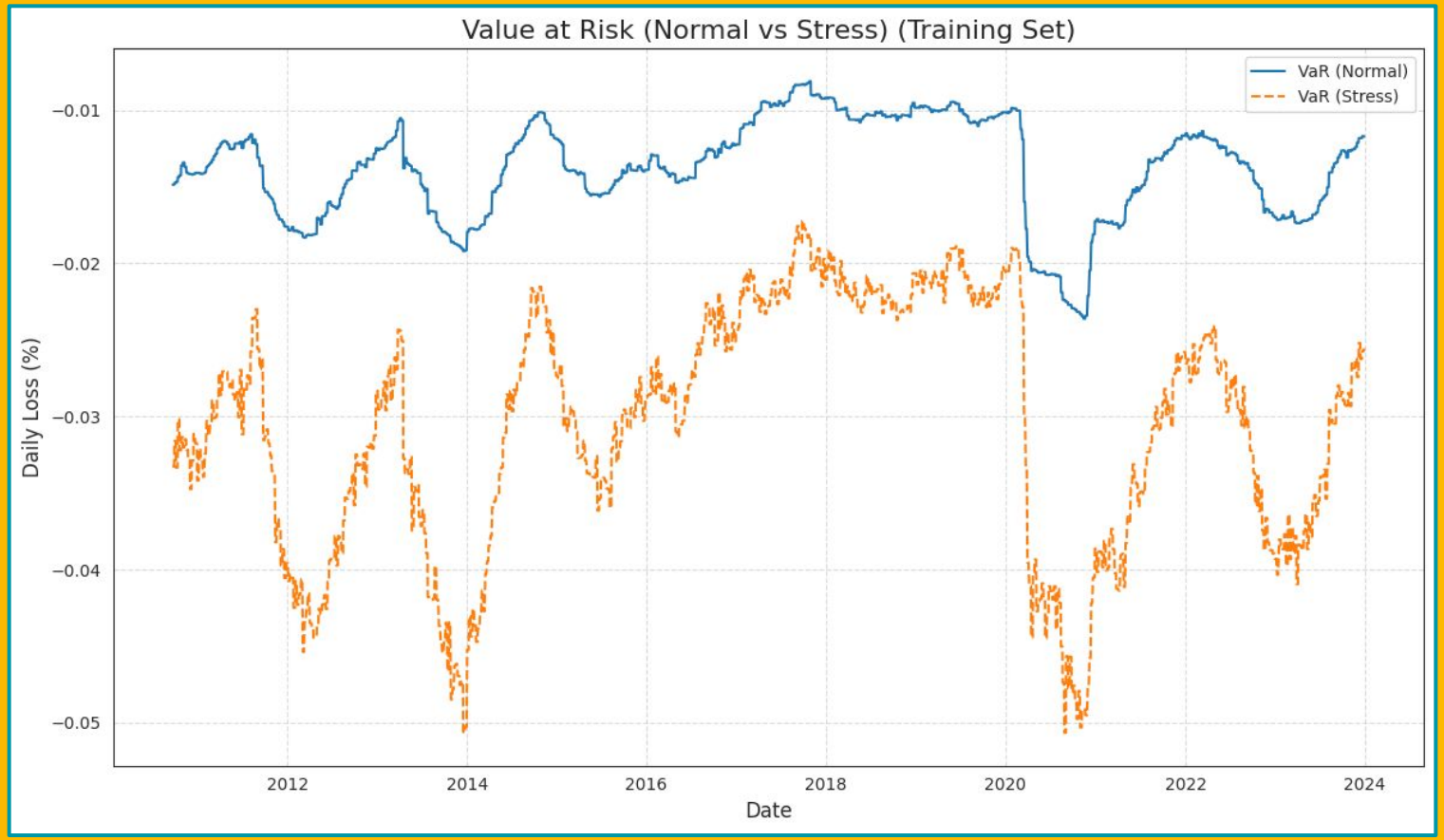
VaR and ES under Normal Conditions Training Set)



Stress Testing Framework

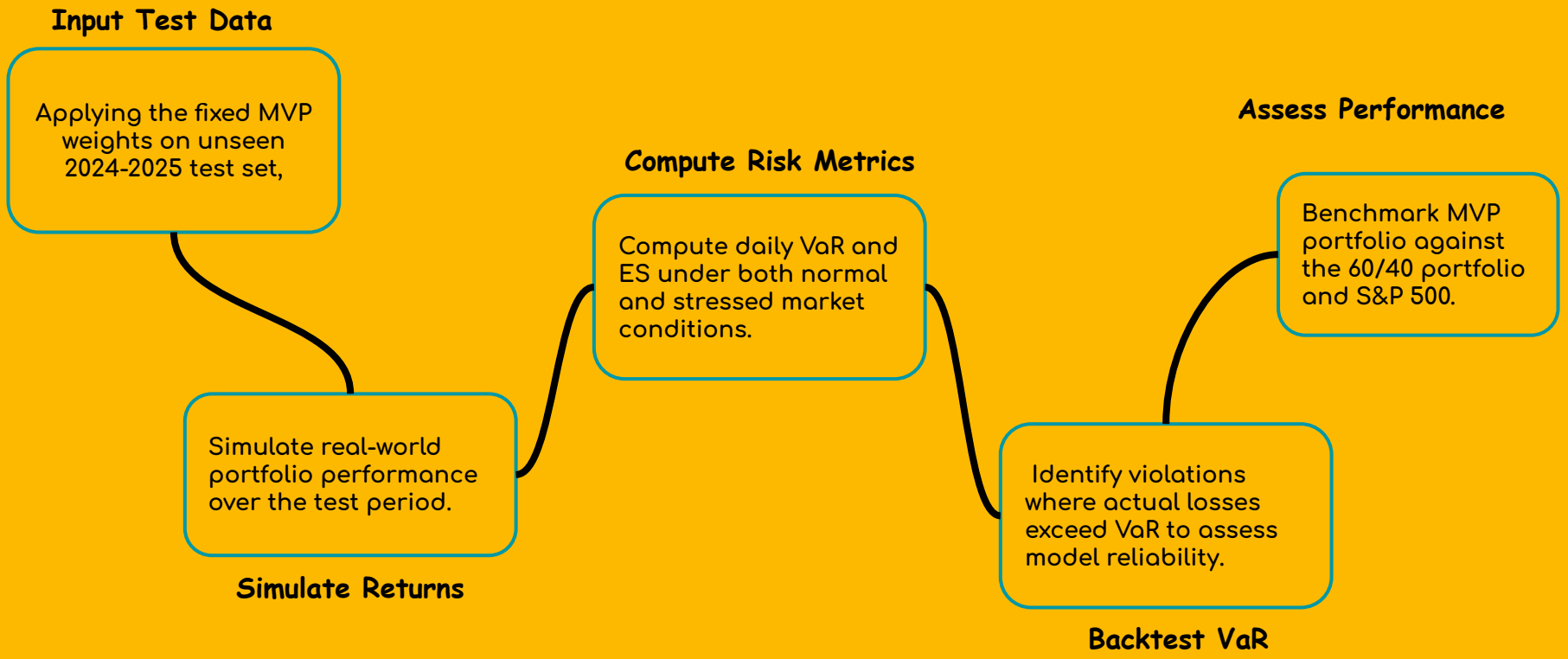


Impact of Stress Testing: VaR Comparison

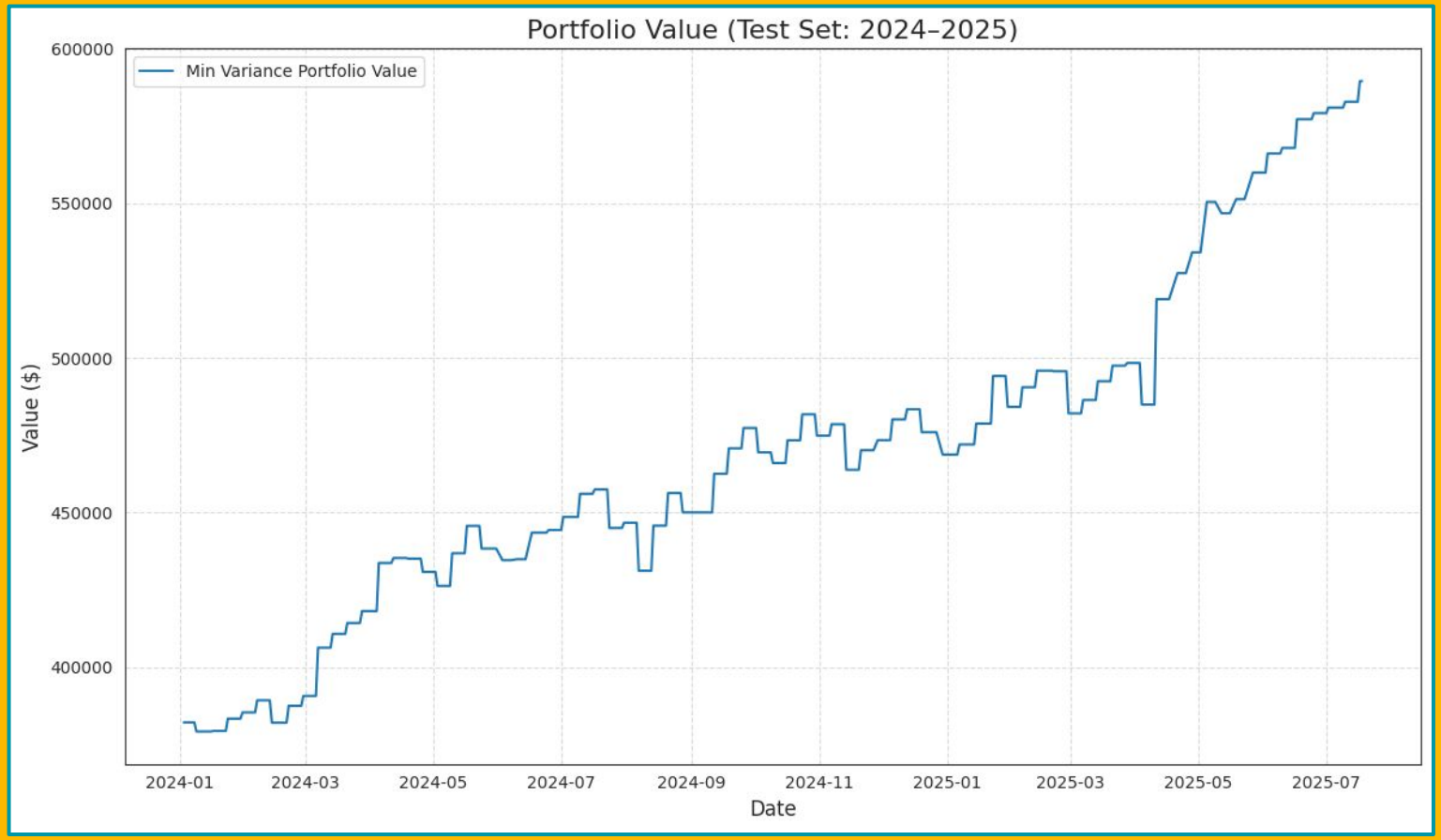


Impact of Stress Testing: Expected Shortfall Comparison

Model Evaluation and Backtesting Flowchart



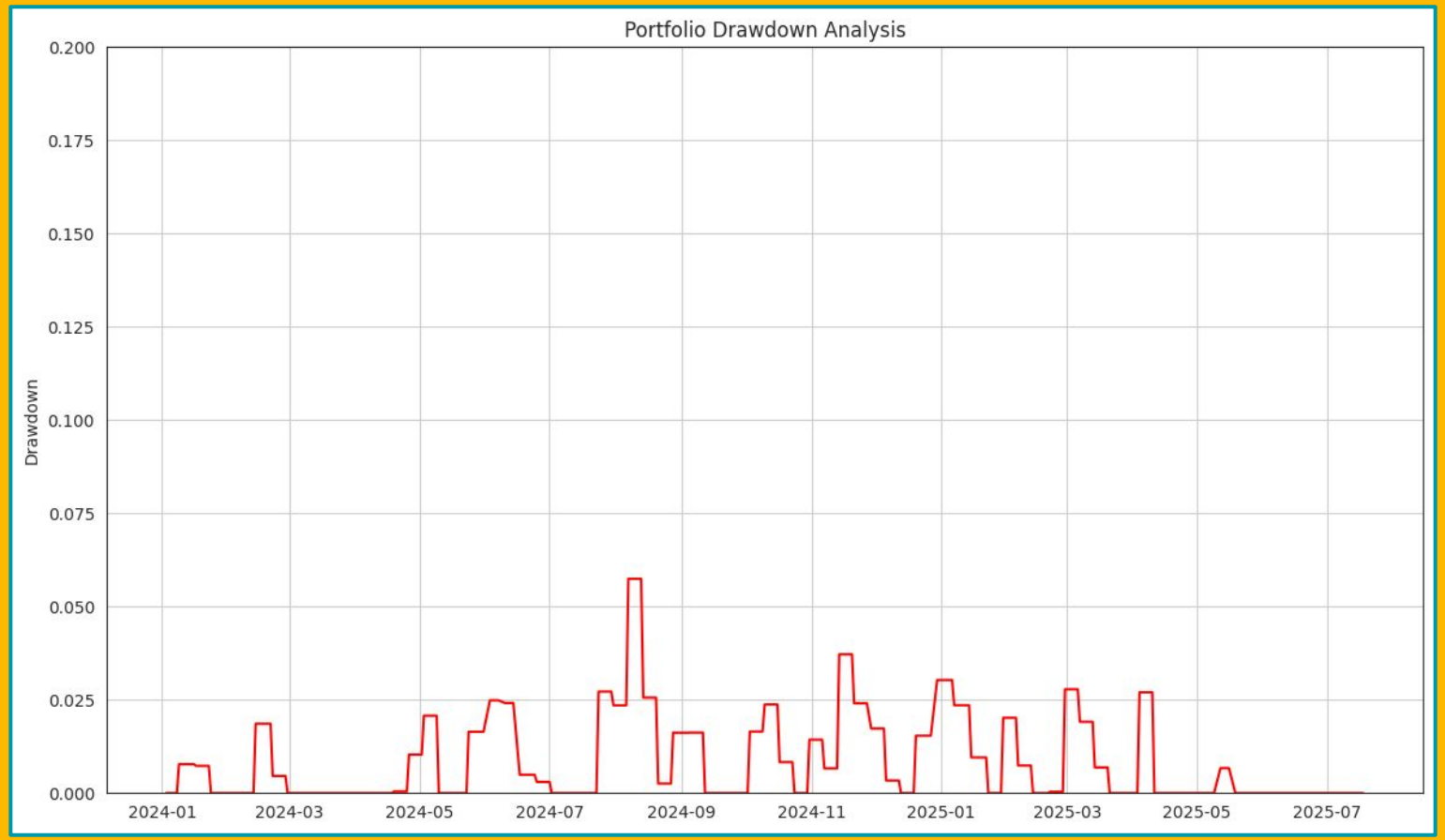
Portfolio Value (Test Set 2024-2025)



Performance Comparison (Normalized to $1)

Metric	Min Var Portfolio	60/40 Portfolio	S&P 500
Total Return	54.27%	54.68%	33.13%
Annualized Return	32.72%	32.94%	20.54%
Annualized Vol	12.85%	14.46%	16.97%
Sharpe Ratio	254.51%	227.77%	121.06%
Max Drawdown	5.75%	6.47%	18.90%

Portfolio Drawdown Analysis



Backtesting Results (VaR Violations)

Metric	Violations Rate	Expected Rate (at 95% Confidence)
Normal VaR Violations	13 (3.4%)	5.0%
Stressed VaR Violations	3 (0.8%)	5.0%

Conclusion & Key Takeaways

- The dynamic Minimum Variance Portfolio strategy delivered strong absolute and risk-adjusted returns.
- The implemented stress testing framework significantly enhanced risk awareness by providing more conservative VaR and ES estimates under simulated adverse conditions.
- The MVP demonstrated superior risk management capabilities (lower volatility, maximum drawdown) compared to traditional benchmarks, validating the Markowitz approach in practice.
- The low number of stressed VaR violations validates the robustness of the stress testing methodology in identifying potential tail risks.
- This project highlights how adaptive models for covariance estimation and scenario generation can enhance risk management in financial applications.
- **Further work:** Could explore other stress factors, advanced backtesting methods, or alternative portfolio optimization techniques (e.g., Black-Litterman model).