Maximizing Risk-Adjusted Returns: Through Predictive and Prescriptive Analytics

An analytical approach to portfolio optimization using the Sharpe Ratio for proper asset allocation.

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Introduction

Objective

To optimize a $10,000 initial portfolio using predictive and prescriptive analytics.

Overview

We'll explore how historical stock data and constraint-based optimization guide portfolio growth.

Key Question

How can a young investor build a portfolio that maximizes returns while minimizing risk?

Problem Formulation

Objective Function

Maximize the Sharpe Ratio over a 20-year investment horizon.

Sharpe Ratio = $(E(R_p) - Rf) / \sigma_p$

Decision Variables

Portfolio weights x_i for 40 stocks listed on the NYSE.

Each $x_i \in [0, 1]$ represents the portfolio weight of stock i.

Investment Goals

Balance expected returns against volatility with a risk-free baseline.

Optimize across multiple stocks for diversification.

Constraints

Total Capital Invested	$\Sigma x_i = 1$	Prevents idle capital, maximizing growth for a young investor
Non-negativity	$x_i \geq 0$ for all i	Prohibits short selling, aligning with long-term, risk-averse goals
Maximum Allocation	$x_i \leq 0.10$ for all i	Ensures selection of at least 10 stocks, promoting diversity
Initial Investment Cap	$\Sigma (x_i * 10{,}000) \leq 10{,}000$	Pairs with salary contributions to simulate gradual wealth building
Industry Diversification	$\Sigma x_i \leq 0.10$ for all i in industry	Limits exposure to sector-specific risks and market crashes

Dataset and Preprocessing

Data Source

Historical stock data from the NASDAQ website based on closing prices for 40 stocks over 5 years.

Period ending April 21, 2025.

Preprocessing

Market modifiers based on Monte-Carlo simulation of S&P 500 and portfolio returns.

- Inflation: 2.5%
- Wages: $85,000 with 3.60% annual increase
- Risk-free-rate: 4.90%
- Contribution: 15% of income

Prescriptive Model

Objective Definition

Maximize Sharpe Ratio = $(E(R_p) - Rf) / \sigma_p$

Balance risk and return for optimal long-term performance.

Constraint Implementation

Incorporated 10% sector cap and other key constraints.

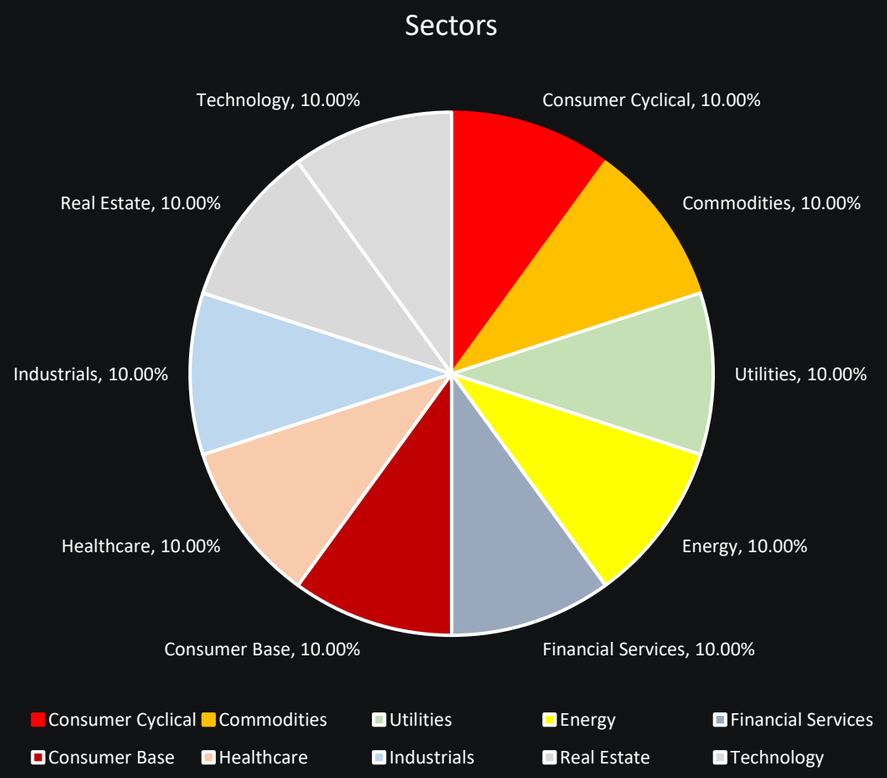
Ensures diversification while allowing for strategic allocation.

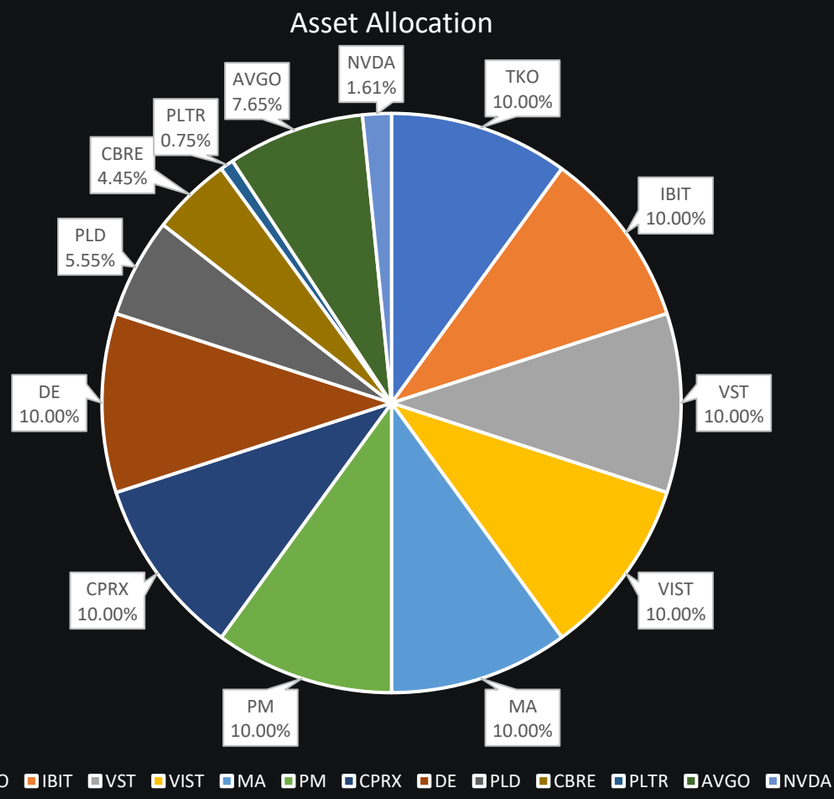
Computational Solution

Excel GRG Nonlinear solver optimizes weights across 40 NYSE stocks.

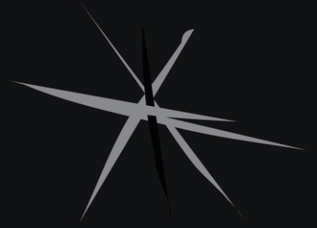
Iterative approach adjusts weights to balance risk-return profile.

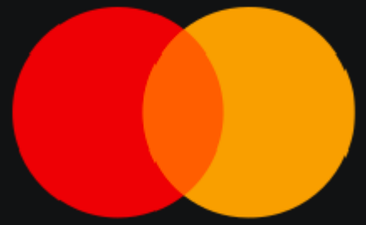
Optimal Solution





The optimal solution allocates the initial $10,000 across 13 carefully selected stocks. Maximum allocations of 10% are assigned to key performers while maintaining sector diversification.





Results

2.16

Sharpe Ratio

Ideal risk-adjusted performance

24.22%

Expected Return

Projected annual return over 20 years

13

Selected Equities

Optimally diversified portfolio

The optimization delivers a portfolio with potential to outperform the S&P 500. Statistical data supports the aggressive expected return forecast.

Sensitivity Analysis

Scenario 1

Aimed to test how the model reacted to slightly relaxed diversification Constraints.

Each sector is required to be 5%-15% of the total investments.

Scenario 2

Aimed to test how the model reacted to extremely relaxed diversification constraints.

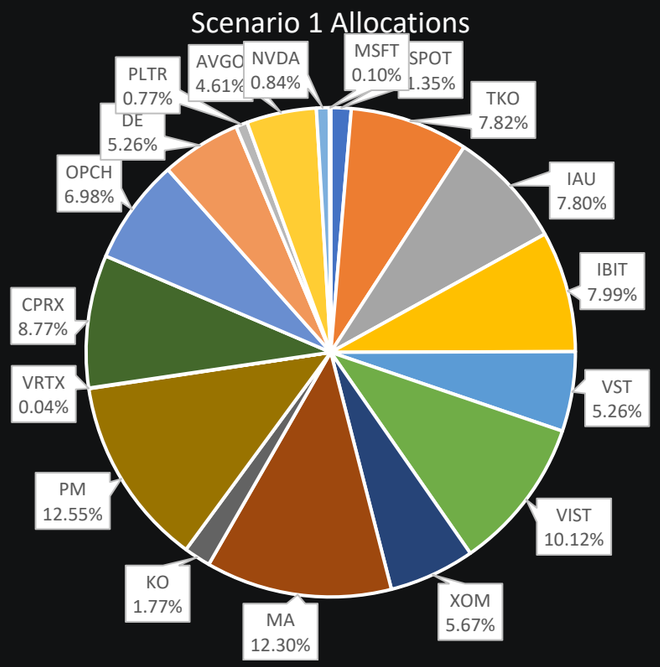
Each sector is required to be no more than 20% of the total investments

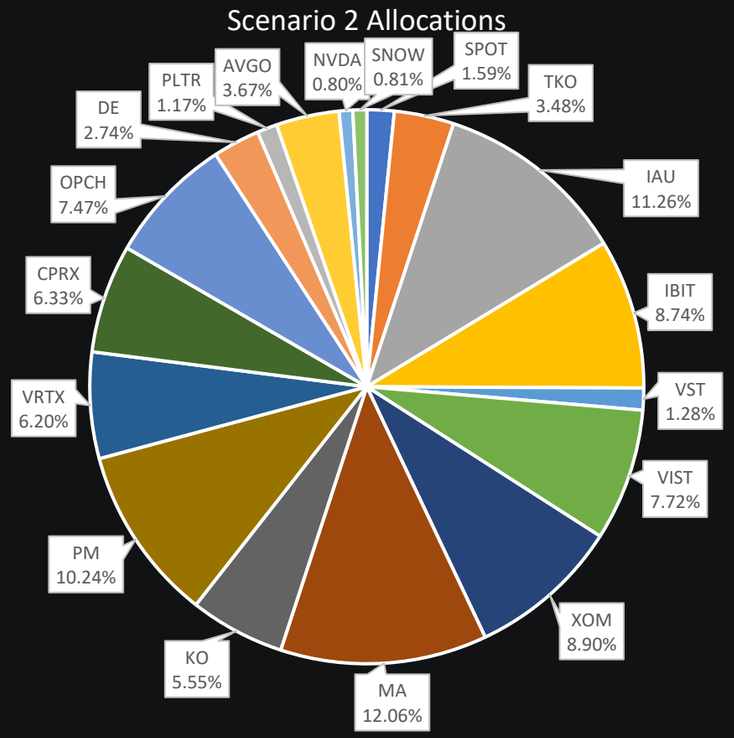
Scenario 3

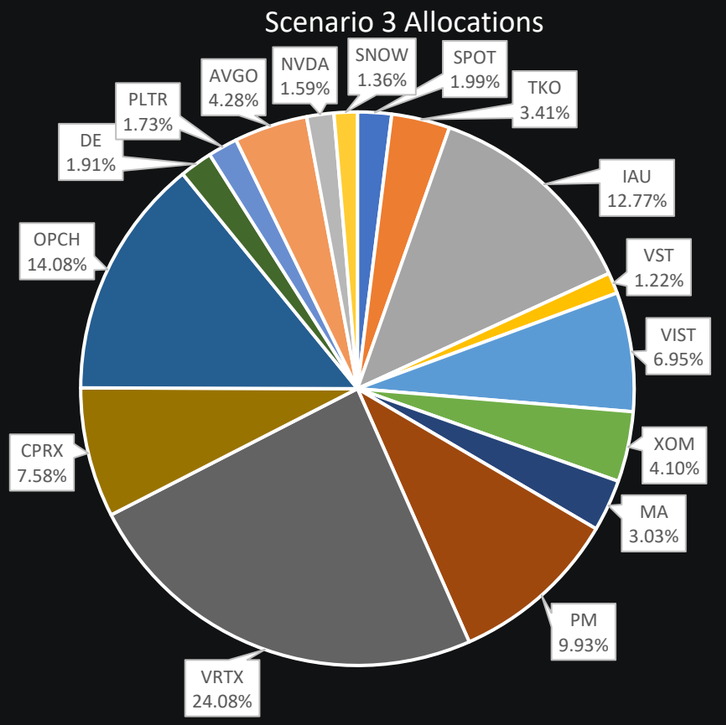
Aimed to test how the model reacted to no diversification constraints

Each sector required to be nonnegative.

GRG nonlinear solver was used in place of simplex LP due to standard deviation in our primary function.







Sensitivity Analysis (Scenario Comparison)

Scenario 1 Results

The easing of restrictions led to a noticeable increase in the Sharpe ratio.
Five sectors restricted by new constraints.

Scenario 2 Results

The Sharpe ratio is still increasing, but not as significantly as it was previously.
A 20% constraint binds two sectors, removing the real estate sector.

Scenario 3 Results

The Sharpe ratio increased similarly from S1 to S2.
Forty-five percent of the total is allocated to healthcare, while four sectors account for less than 5% each.

Trade-Off Analysis

Scenario	Diversification	Sectors	Companies	Return Rate	Sharpe Ratio
S0	l_i=10	10	13	24.2%	2.16
S1	5% ≤ l_i ≤ 15%	10	20	21.1%	2.58
S2	0% ≤ l_i ≤ 20%	9	18	16.6%	2.85
S3	0% ≤ l_i	9	16	19.7%	3.13

Maximizing Sharpe ratio weakens portfolio diversification. Initial model successfully balances diversification, return rates, and Sharpe ratio.

Finding the Right Balance

No single financial measure can determine investment desirability. Our model reveals crucial tradeoffs between optimization goals.

Higher Sharpe Ratio

Improves risk-adjusted performance but potentially reduces returns.

Return Rate

Can decrease as portfolio stability increases through diversification.

Sector Diversification

Protects against macro risks affecting entire industries.

Company Diversification

Enhances day-to-day stability across individual stocks.

The ideal portfolio balances safety with worthwhile returns. Our analysis demonstrates that maximizing any single metric creates imbalance elsewhere.

Predictive Analysis

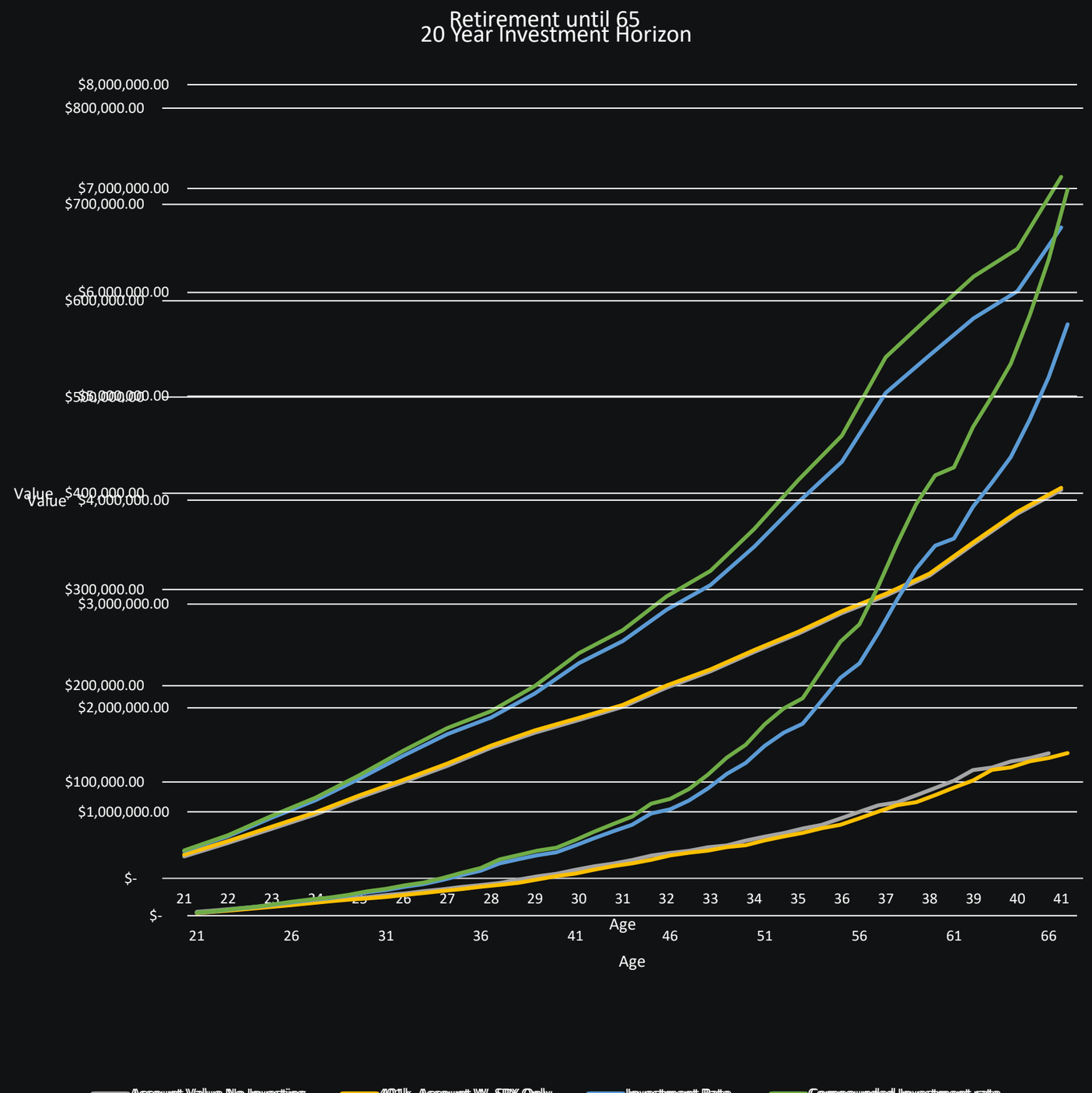
20 Year Horizon

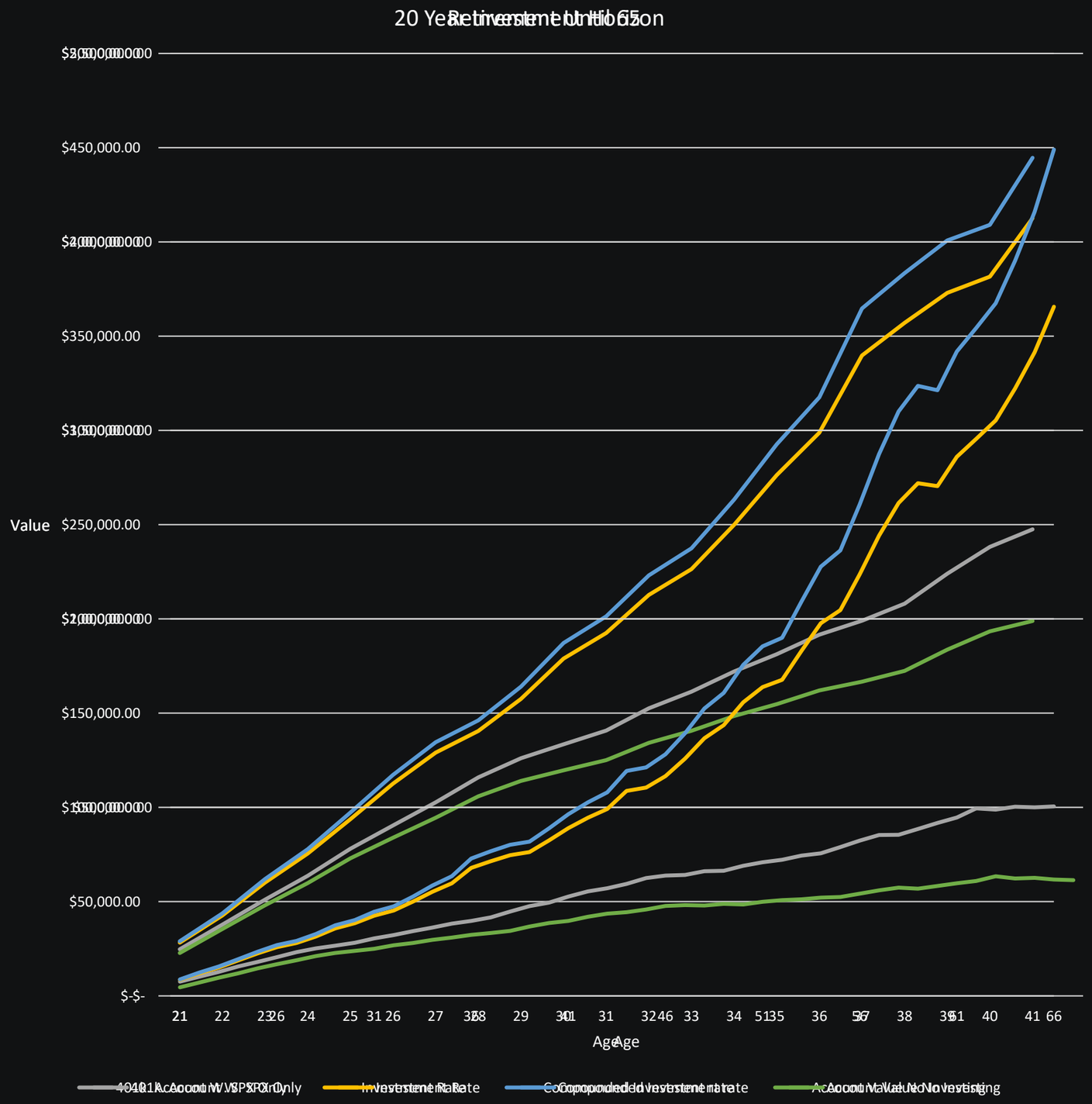
- No Investing: $403,490.34
- Just SPX: $405,595.21
- Non-Compounded: $676,144.71
- Compounded: $728,598.91

Full Retirement

- No Investing: $1,562,728.46
- Just SPX: $1,564,960.84
- Non-Compounded: $5,692,654.10
- Compounded: $6,990,597.98

Comparison between optimal portfolio returns and alternatives shows significant long-term advantages of our optimization approach.





Inflation-Adjusted Returns

$444,642

Optimized Portfolio

Inflation-adjusted value over 20 years

$247,523

S&P 500 Only

Conventional index investing

$198,901

No Investing

Base case comparison

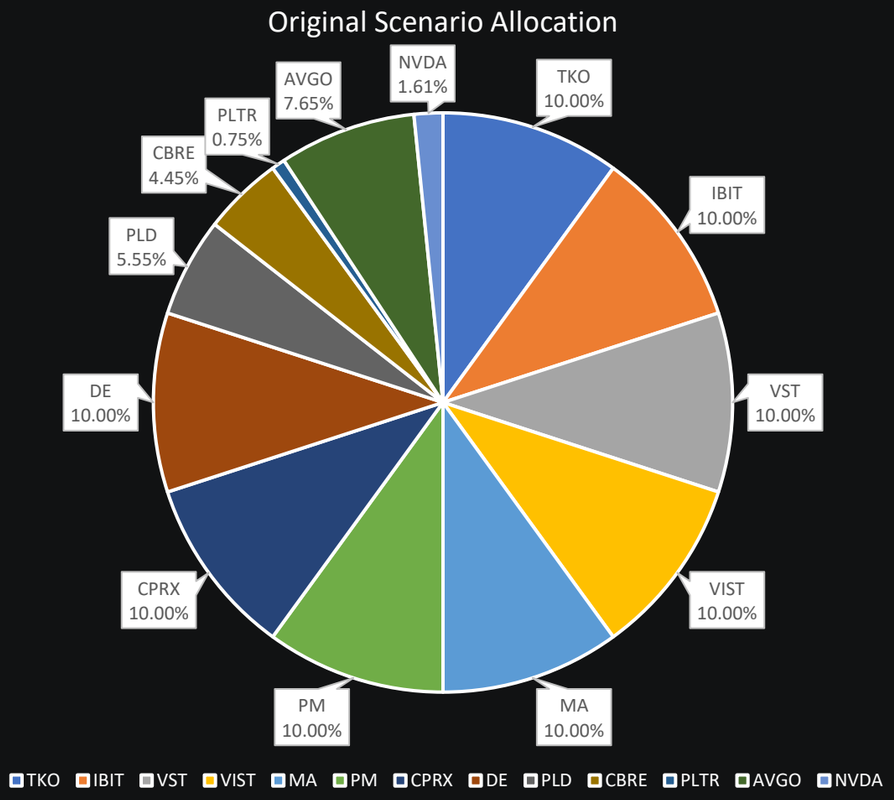
Full retirement returns show even greater differences: $2.24M for our compounded portfolio versus $502K for S&P 500 and $307K for no investing approach.

Results Interpretation

Sharpe Ratio Trends

Increased from 2.16 (S0) to 3.13 (S3) as diversification constraints relaxed.

Improved risk-adjusted return but lower forecasted returns: 24.2% (S0) to 19.7% (S3).



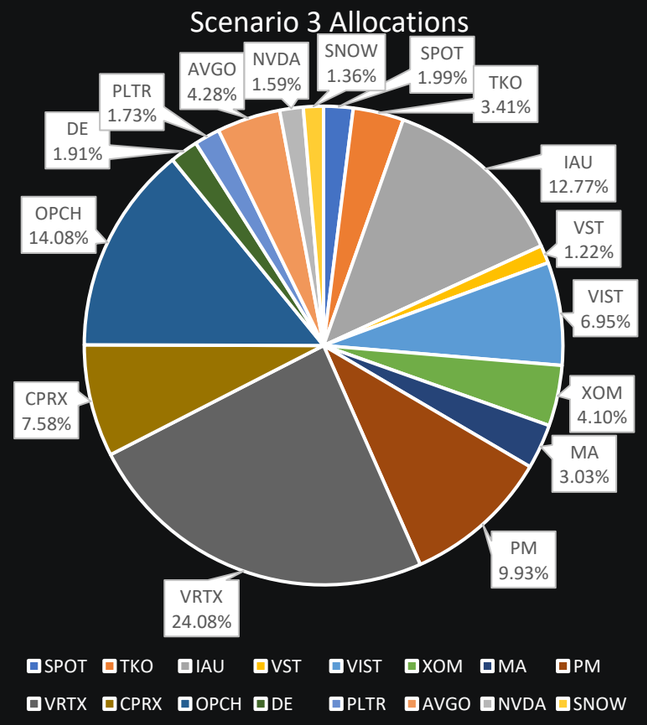
Diversification Trade-Offs

S0: 10 sectors, 13 companies selected.

S3: 9 sectors, 16 companies with 45.7% concentrated in healthcare.

Model shows sensitivity to constraint changes.

Less sector diversity increases specific risks.



Future Directions

Periodic Rebalancing

Simulate rebalancing to adapt to market changes. Improve risk management through moving average strategies.

Regular interval rebalancing enhances realism and performance.

Advanced Forecasting

Implement time-series forecasting and machine learning to predict future performance more accurately.

Python-based tools offer greater flexibility with more intricate scenarios.

Customizable Inputs

Enable users to customize inputs according to income, objectives, and risk tolerances.

Current model represents just one investor category with specific assumptions.

Summary

24.2%

Return

Optimal portfolio (S0)

2.16

Sharpe Ratio

Risk-adjusted performance

13

Companies

Across 10 sectors

1 **Sensitivity Analysis**

Relaxing constraints increases Sharpe Ratio yet reduces return and diversity.

2 **Insights**

Optimization balances risk, return, and diversification; sensitive to constraint changes.

3 **Future Directions**

Add rebalancing, machine learning, Python tools, and customizable inputs.

4 **Impact**

Empowers data-driven retirement planning with predictive and prescriptive analytics.

Thank you!

Questions

We welcome your inquiries about our methodology

Insights

Discuss implications for your investment strategy

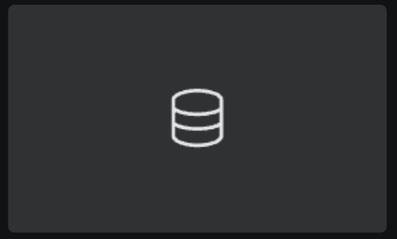
Analysis

Request additional data or scenario testing

Collaboration

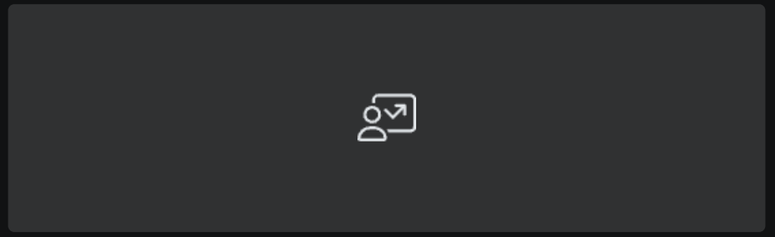
Explore potential applications to your portfolio

References



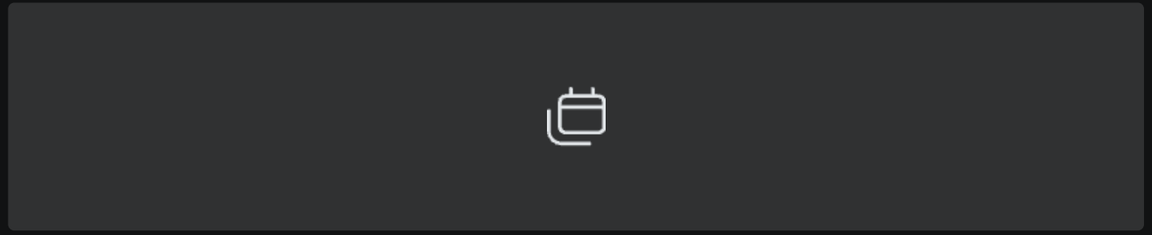
Data Sources

NASDAQ stock quotes & market activity



Stock Selection

40 diverse NYSE stocks analyzed



Time Period

Five years of historical data before April 2025

NASDAQ. (n.d.). Stock quotes & market activity. NASDAQ. Retrieved April 14, 2025, from https://www.nasdaq.com/

Data retrieved includes: TSLA, PLTR, XOM, KO, VST, GEV, AVGO, RKLB, JPM, GS, NVDA, OSCR, VIST, J, CBRE, HOOD, SOFI, BX, SNOW, MSFT, AAPL, KKR, RIVN, SPOT, CMG, CAVA, VRTX, IBIT, IONQ, MA, DE, PLD, IAU, CPRX, PM, OPCH, RIO, F, TKO, AMZN