Team 2

Non-Linear Optimization

Stock Portfolios

Warren Buffett

First Portfolio

- American Investor
- Berkshire Hathway
- Value investing
- Long term

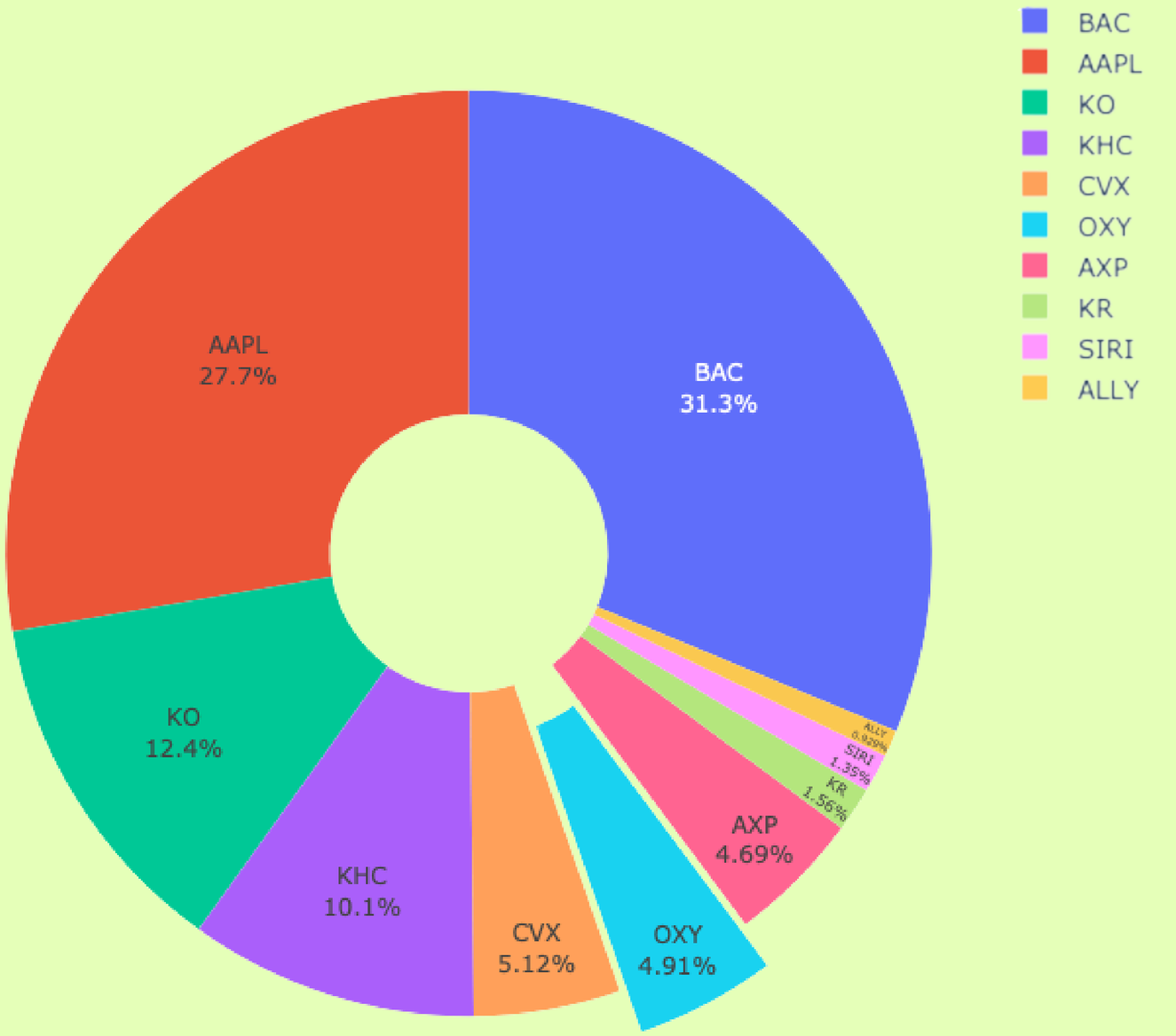
Buffett's Portfolio

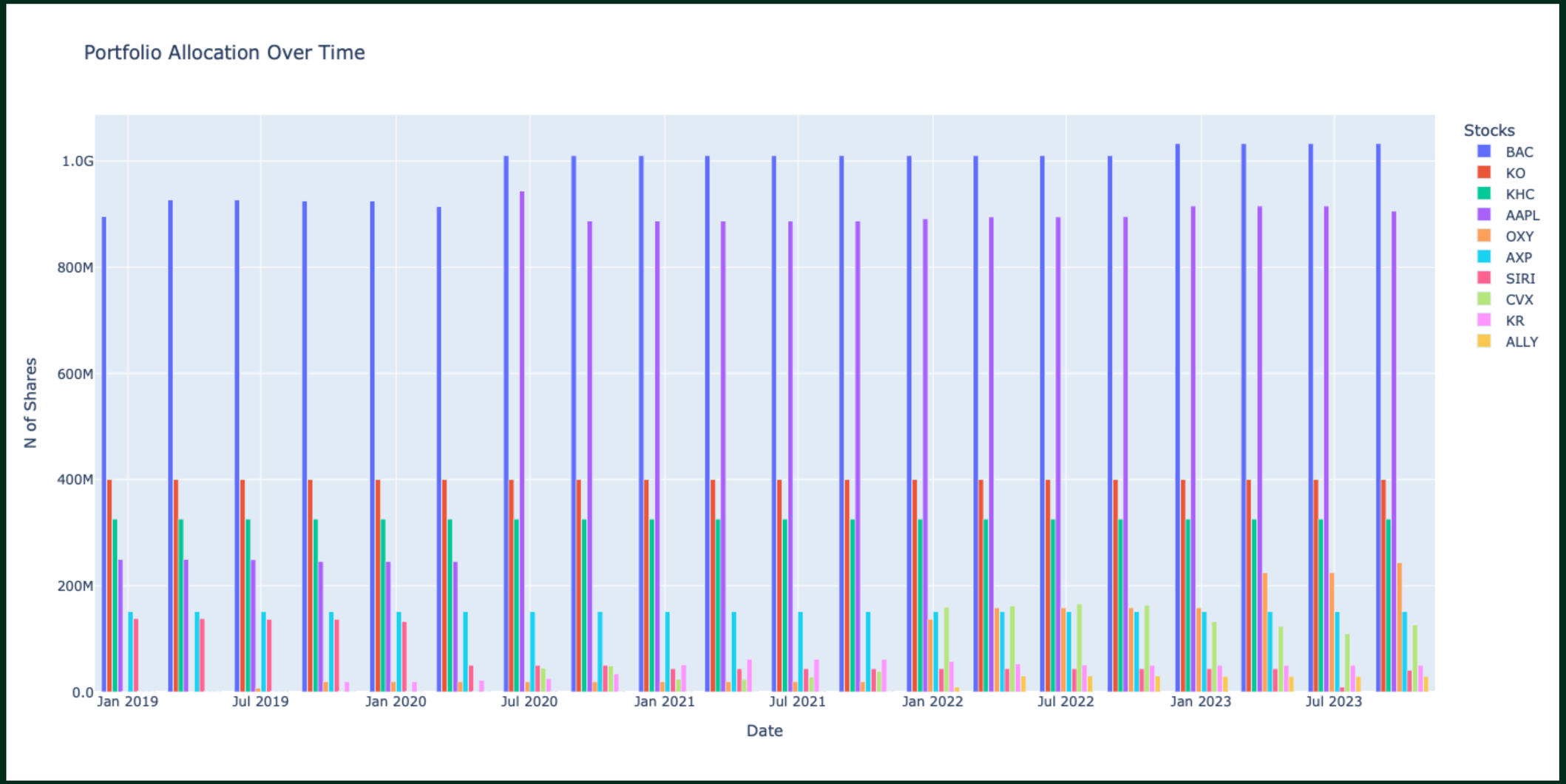
(Limited to 10 Stocks for Analysis)

- Bank of America (BAC)
- Coca-Cola (KO)
- Kraft Heinz (KHC)
- Apple (AAPL)
- Occidental Petroleum (OXY)
- American Express (AMX)
- SiriusXM (SIRI)
- Chevron (CVX)
- Kroger (KR)
- Ally (ALLY)

Portfolio Allocation

Q4 2023



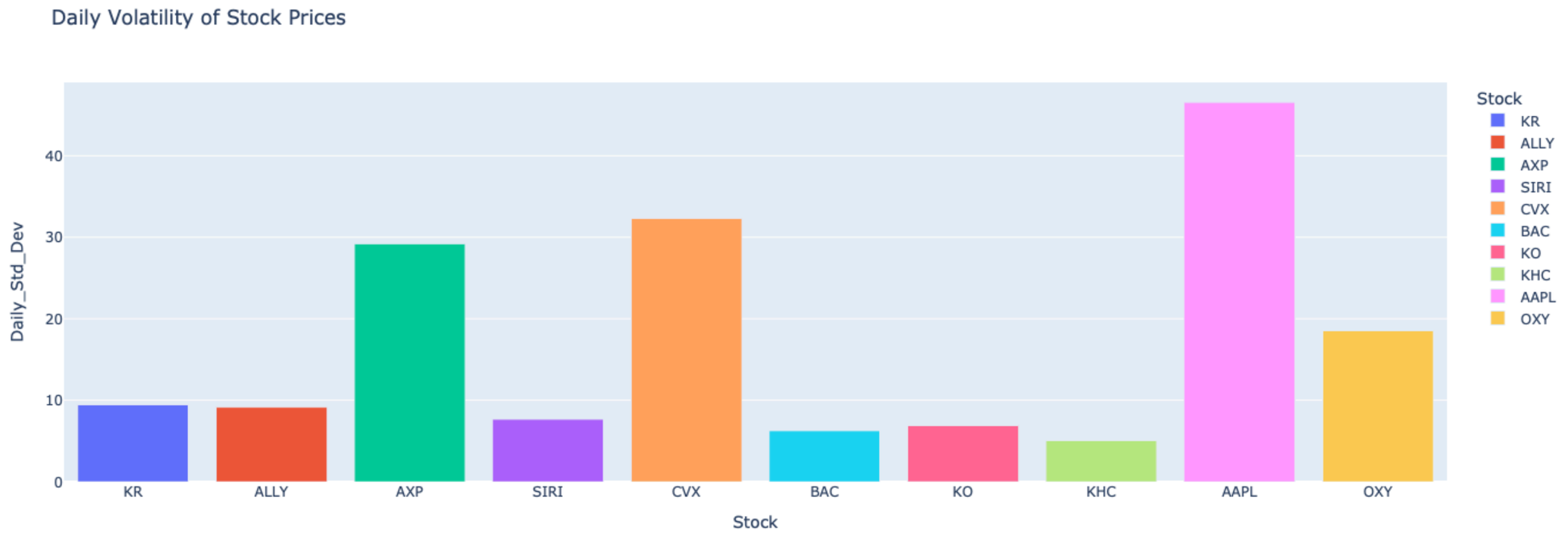

Portfolio Allocation Over Time
1.0G
800M
600M
400M
200M
0.0
N of Shares
Jan 2019
Jul 2019
Jan 2020
Jul 2020
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Date
Stocks
BAC
KO
KHC
AAPL
OXY
AXP
SIRI
CVX
KR
ALLY

Cumulative Returns

Daily

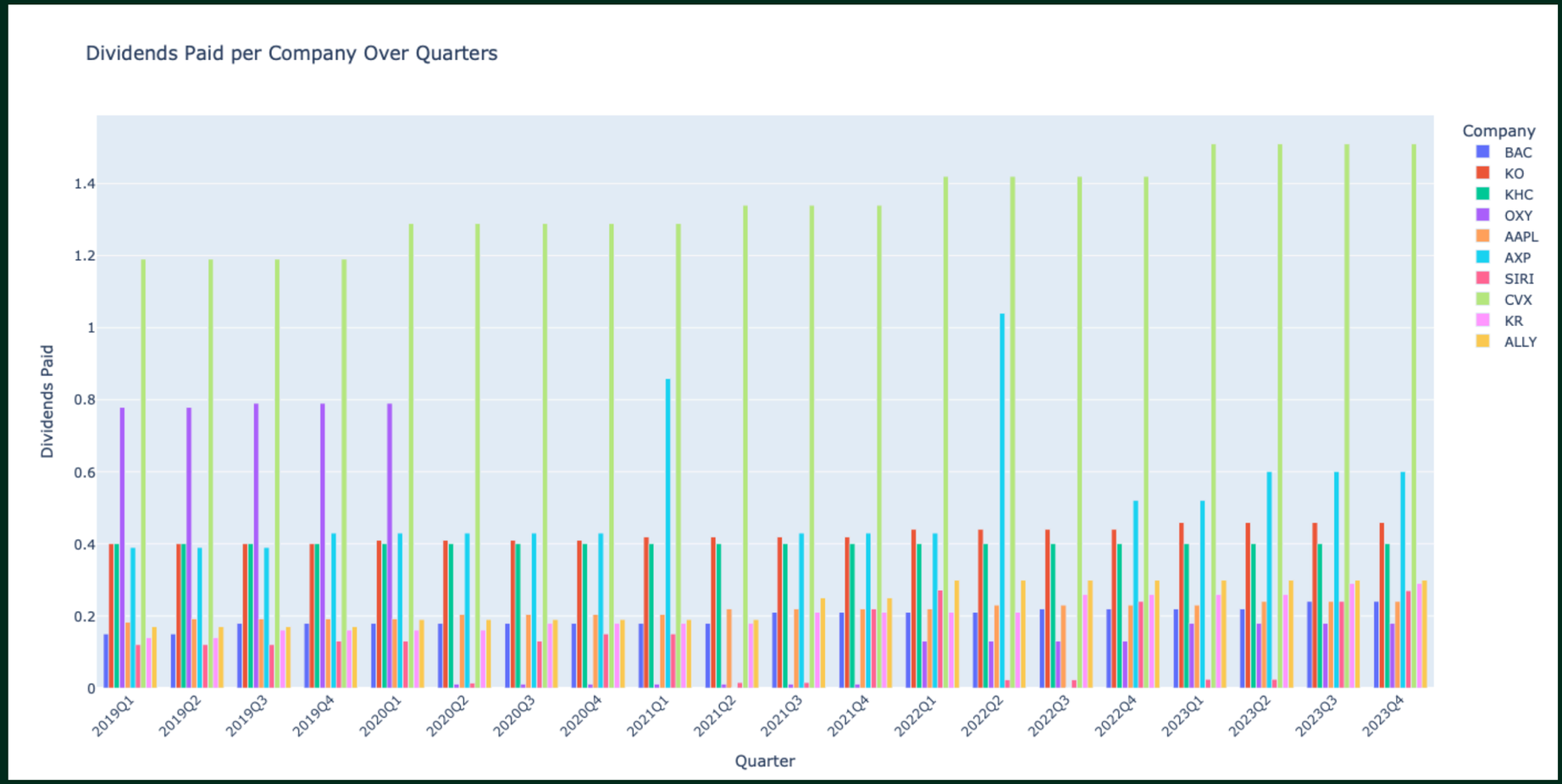
Stock Volatility

5 years



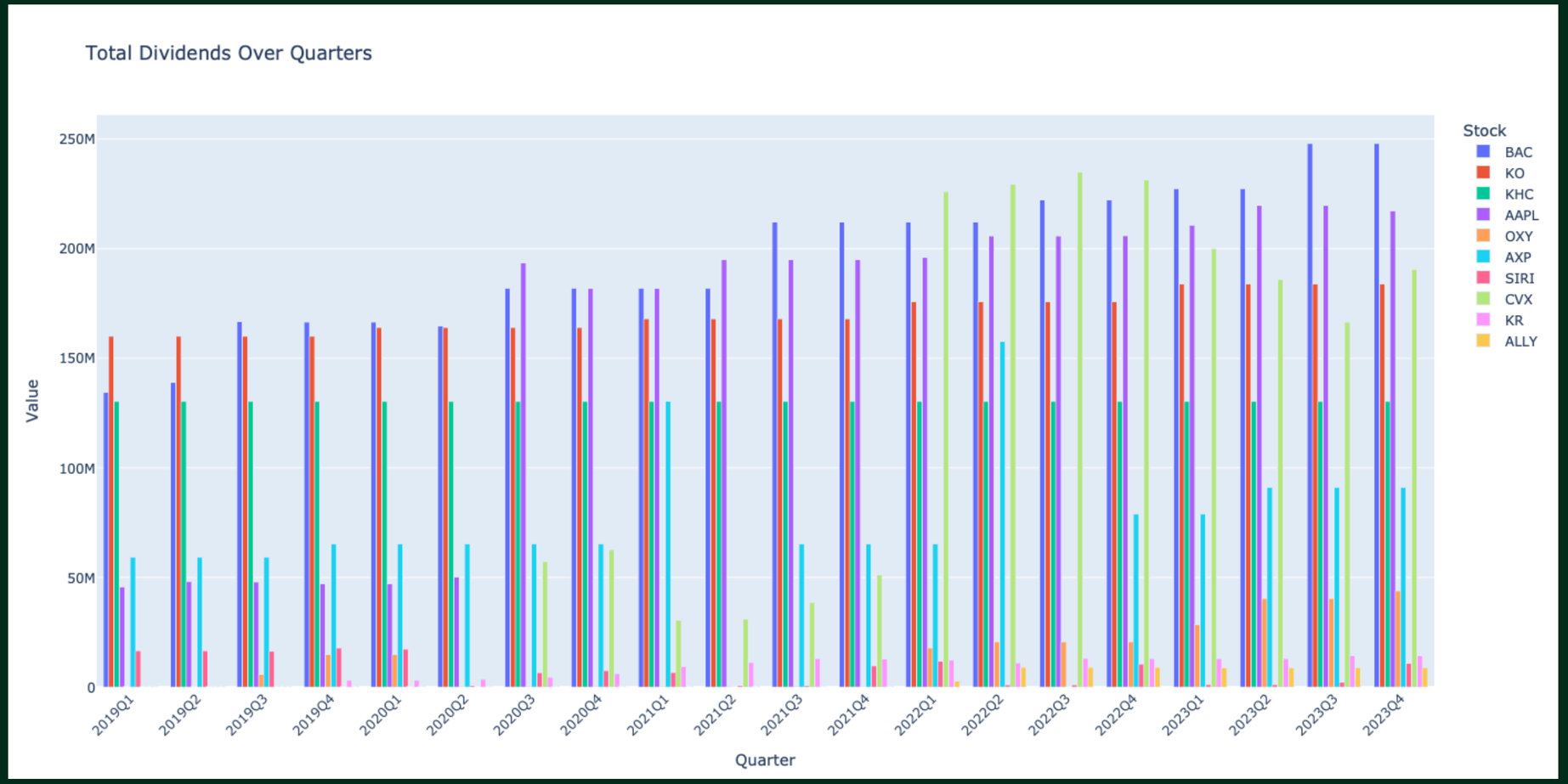
Dividends

Per Share



Dividends

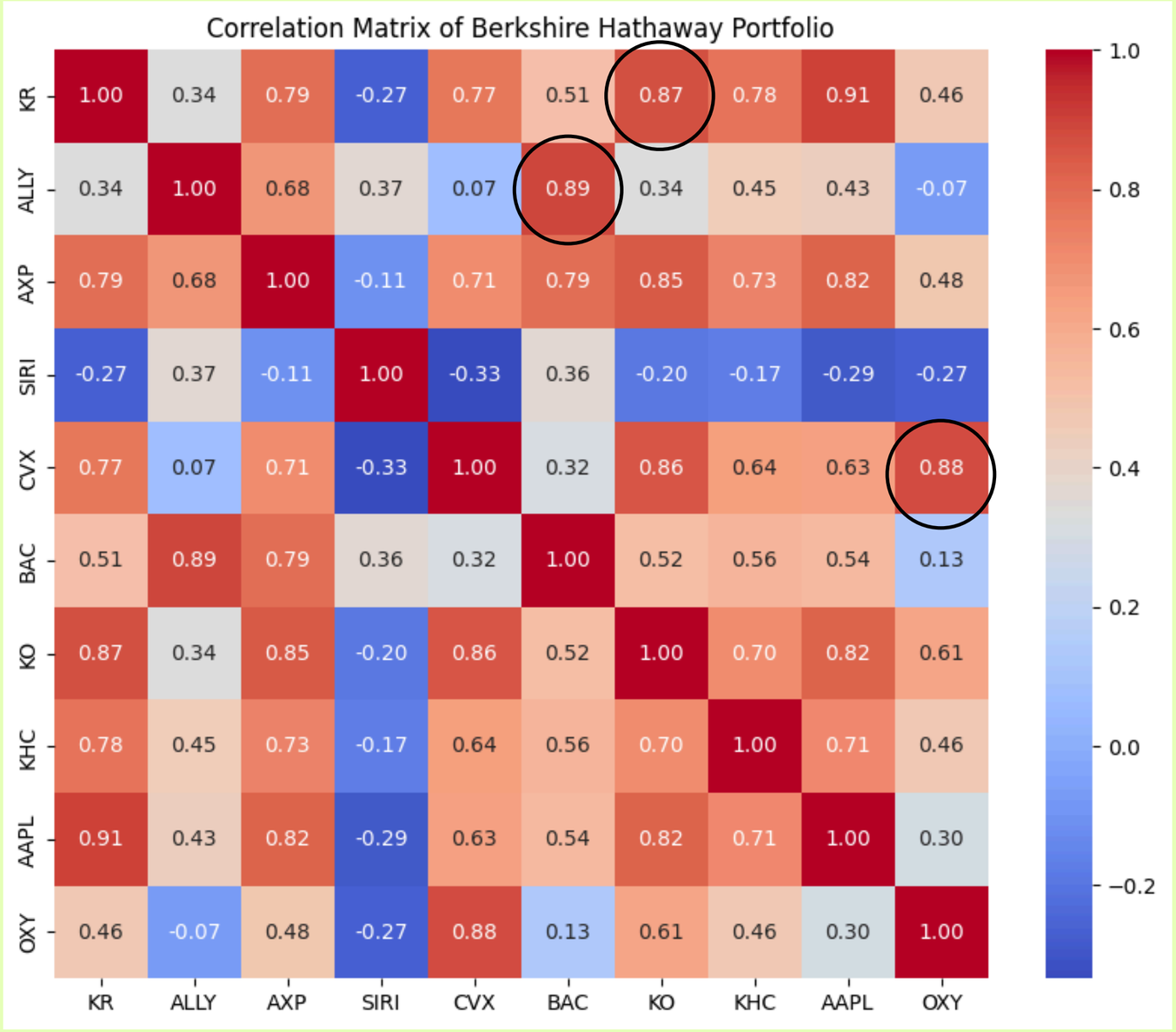
Total



Closing Prices

Correlation Matrix

10 stocks

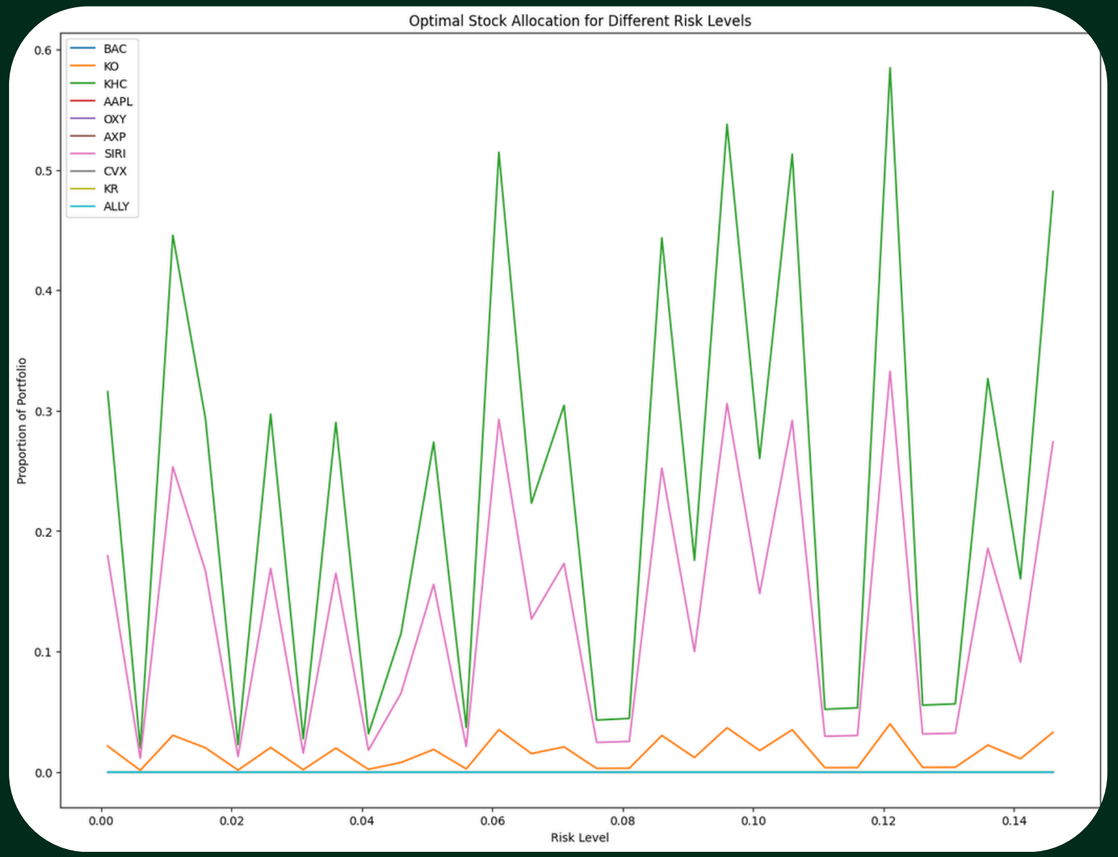


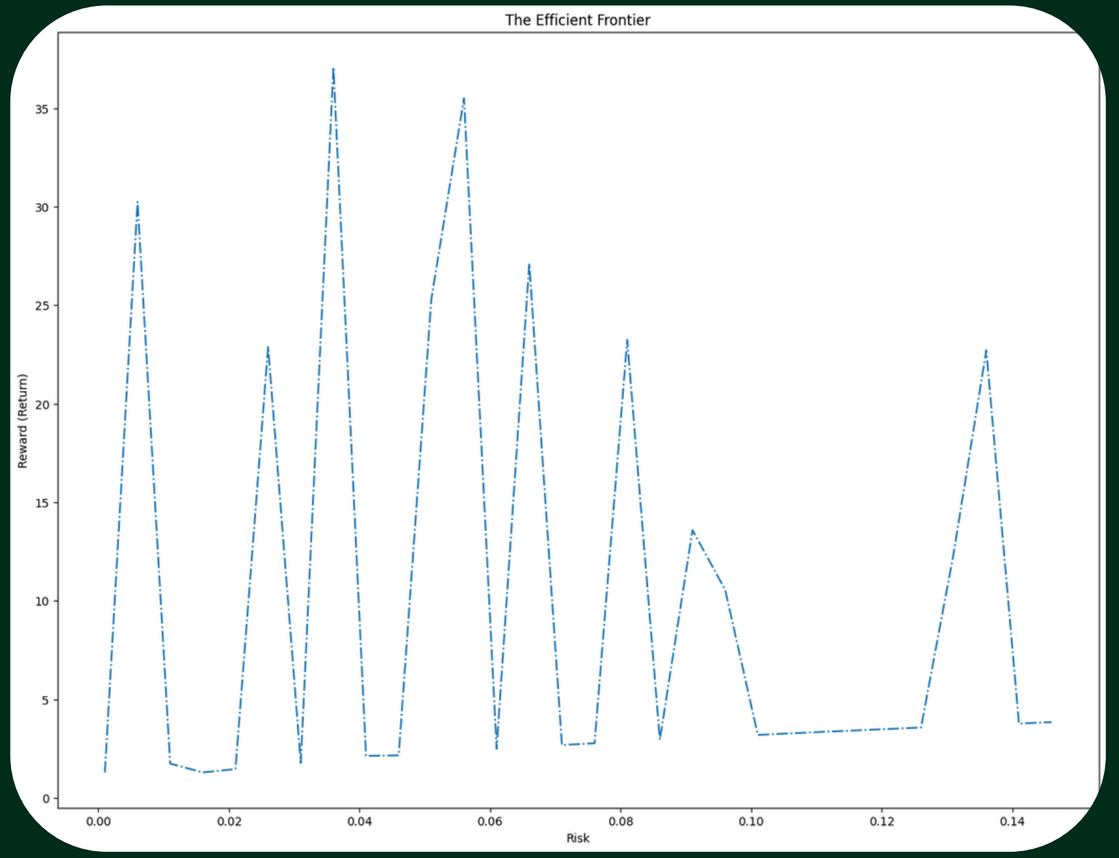
Modeling

Maximizing Returns Under Risk Constraints

Model 1

Lower Risk Tolerance Analysis - (max_risk = 0.15)





Model 1's strict risk constraint led to unstable stock allocations and an inefficient risk-return tradeoff

Stock Allocation

The allocation favored low-volatility stocks, as expected

KHC (Kraft Heinz Co.)

A defensive stock known for stable returns.

KO (Coca-Cola Co.)

Another low-volatility, dividend-paying stock.

SIRI (Sirius XM Holdings Inc.)

Though not as dominant, it frequently appeared in the allocation.

High-volatility stocks like AAPL (Apple), OXY (Occidental Petroleum), and CVX (Chevron) had minimal or no allocation due to their higher risk exceeding the strict constraint.

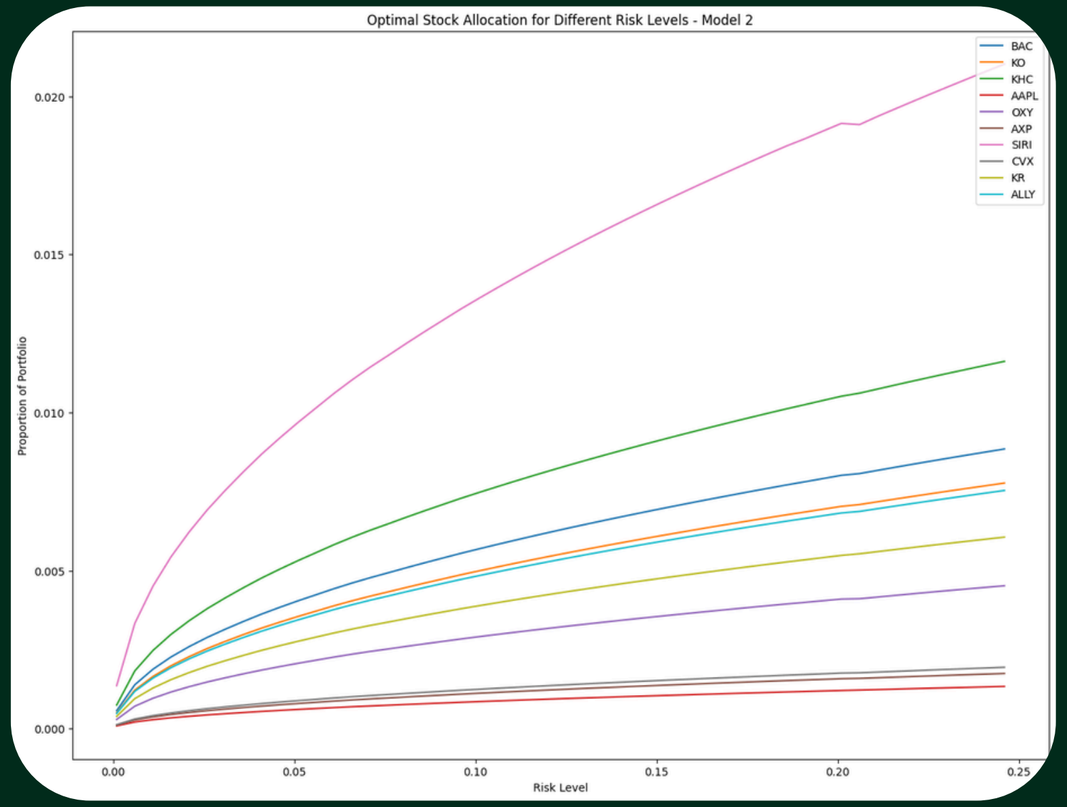
Parameter Analysis

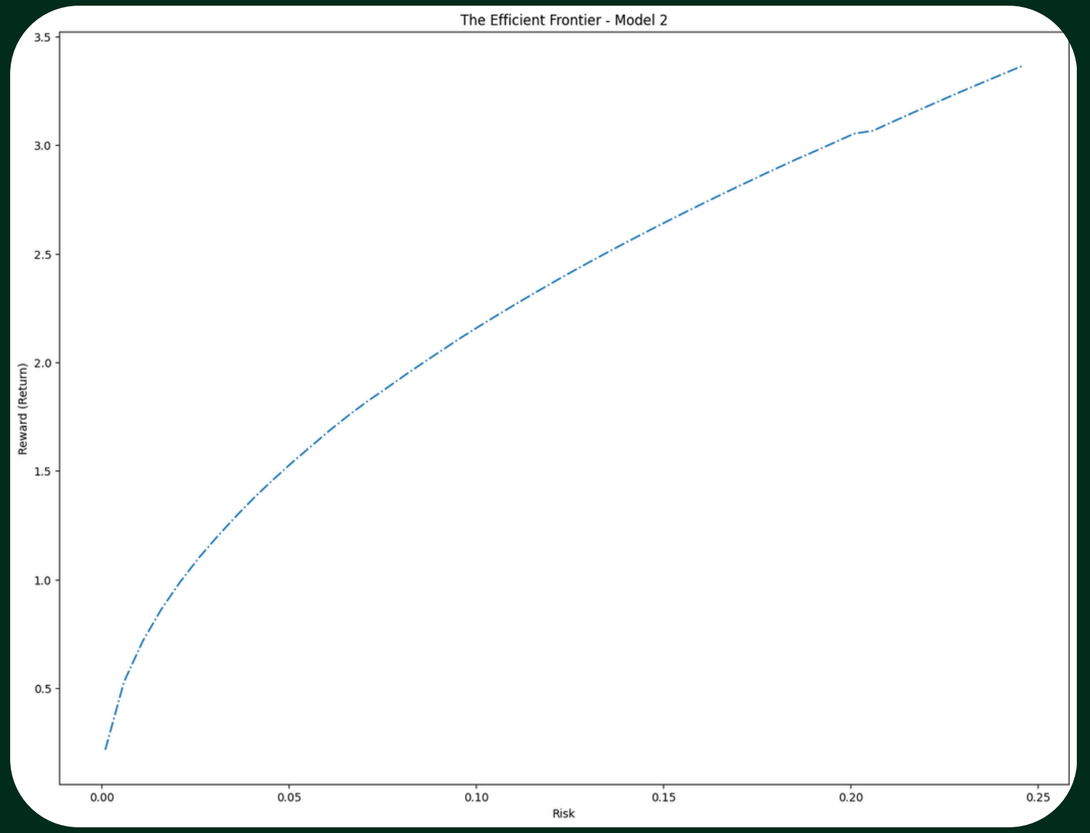
	BAC	KO	KHC	AAPL	OXY	AXP	SIRI	CVX	KR	ALLY
0.001	0.0	0.001364	0.019984	0.0	0.0	0.0	0.011368	0.0	0.0	0.0
0.006	0.0	0.032169	0.471248	0.0	0.0	0.0	0.268060	0.0	0.0	0.0
0.011	0.0	0.001842	0.026981	0.0	0.0	0.0	0.015347	0.0	0.0	0.0
0.016	0.0	0.001364	0.019984	0.0	0.0	0.0	0.011368	0.0	0.0	0.0
0.021	0.0	0.001546	0.022643	0.0	0.0	0.0	0.012880	0.0	0.0	0.0
0.026	0.0	0.024335	0.356478	0.0	0.0	0.0	0.202775	0.0	0.0	0.0
0.031	0.0	0.001878	0.027511	0.0	0.0	0.0	0.015649	0.0	0.0	0.0
0.036	0.0	0.039442	0.577793	0.0	0.0	0.0	0.328666	0.0	0.0	0.0
0.041	0.0	0.002258	0.033081	0.0	0.0	0.0	0.018817	0.0	0.0	0.0
0.046	0.0	0.002288	0.033512	0.0	0.0	0.0	0.019063	0.0	0.0	0.0

- Confirms the behavior of the model.
- At very low risk, majority of stocks had a zero allocation.
- Diversification was compromised

Model 2

Higher Exposure Analysis - (max_risk = 0.25)

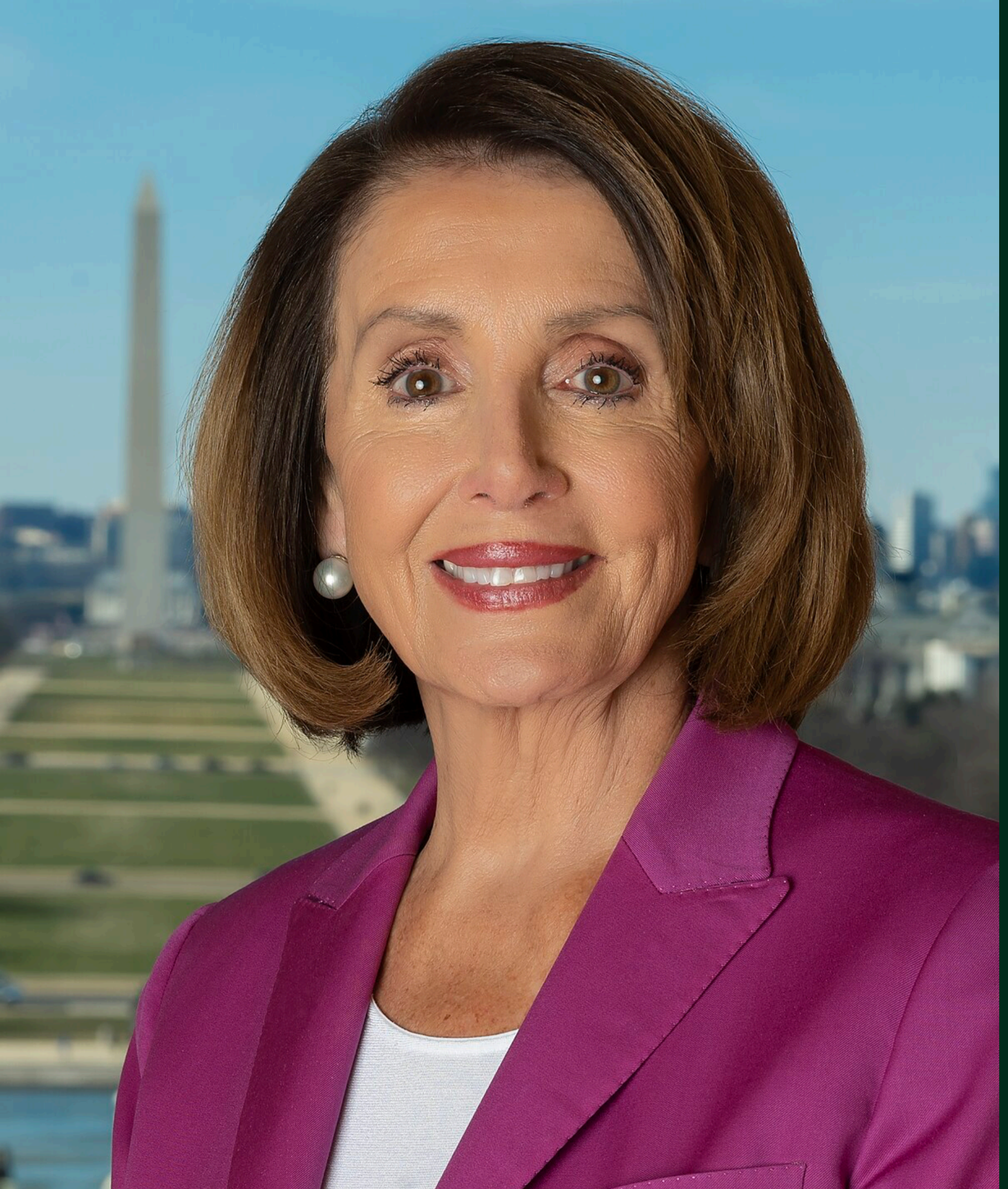




Unlike Model 1, this model allows for a more proportional stock distribution, leading to better diversification and performance

Which Model Works Best?

	Model 1: Low Risk (max_risk = 0.15)	Model 2: Higher Risk (max_risk = 0.25)
Diversification	Concentrated in a few low-volatility stocks	Balanced allocation across multiple stocks
Stock Allocation	Unstable fluctuations	Smooth, proportional increases
Risk-Return Tradeoff	Unstable, inefficient returns	Clear, logical upward trend
Solver Performance	Frequent infeasibility issues	No major solver problems
Practicality	Impractical due to poor diversification	More realistic for investment strategies



Nancy Pelosi

First Portfolio

- American Politician
- High-profile investor
- Strong focus on tech and growth stocks

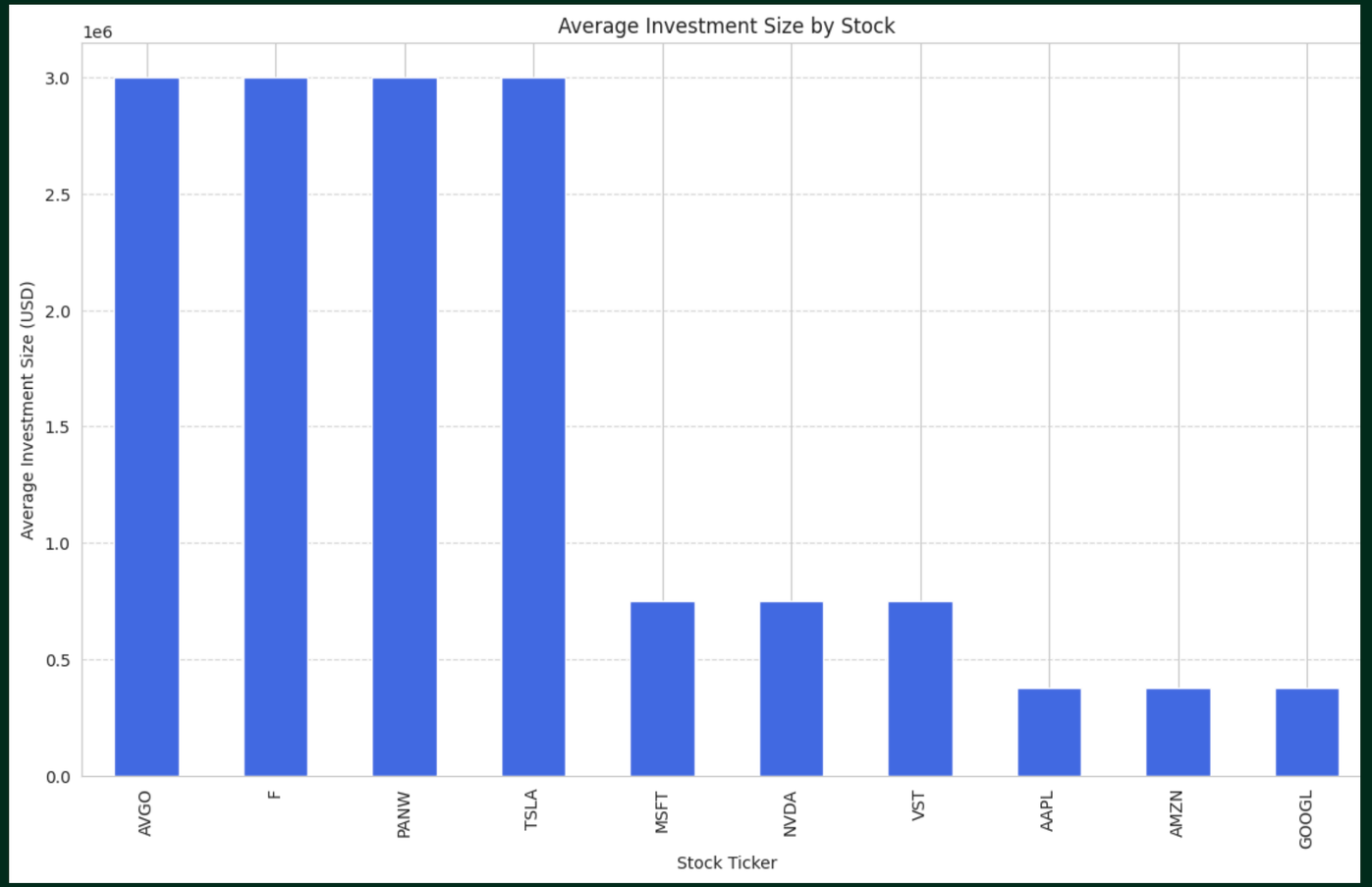
Nancy's Portfolio

Limited to the 10 picked stocks for the analysis

- Alphabet (GOOGL)
- Amazon (AMZN)
- Apple (AAPL)
- Nvidia (NVDA)
- Palo Alto Networks (PANW)
- Ford (F)
- Vistra Corp (VST)
- Microsoft (MSFT)
- Broadcom (AVGO)
- Tesla (TSLA)

Investment Size by Stock

- Biggest investments: TSLA, PANW, F, AVGO ($3M each)
- Smallest investments: GOOGL, AAPL, AMZN ($375K each)
- Tech dominates the portfolio.

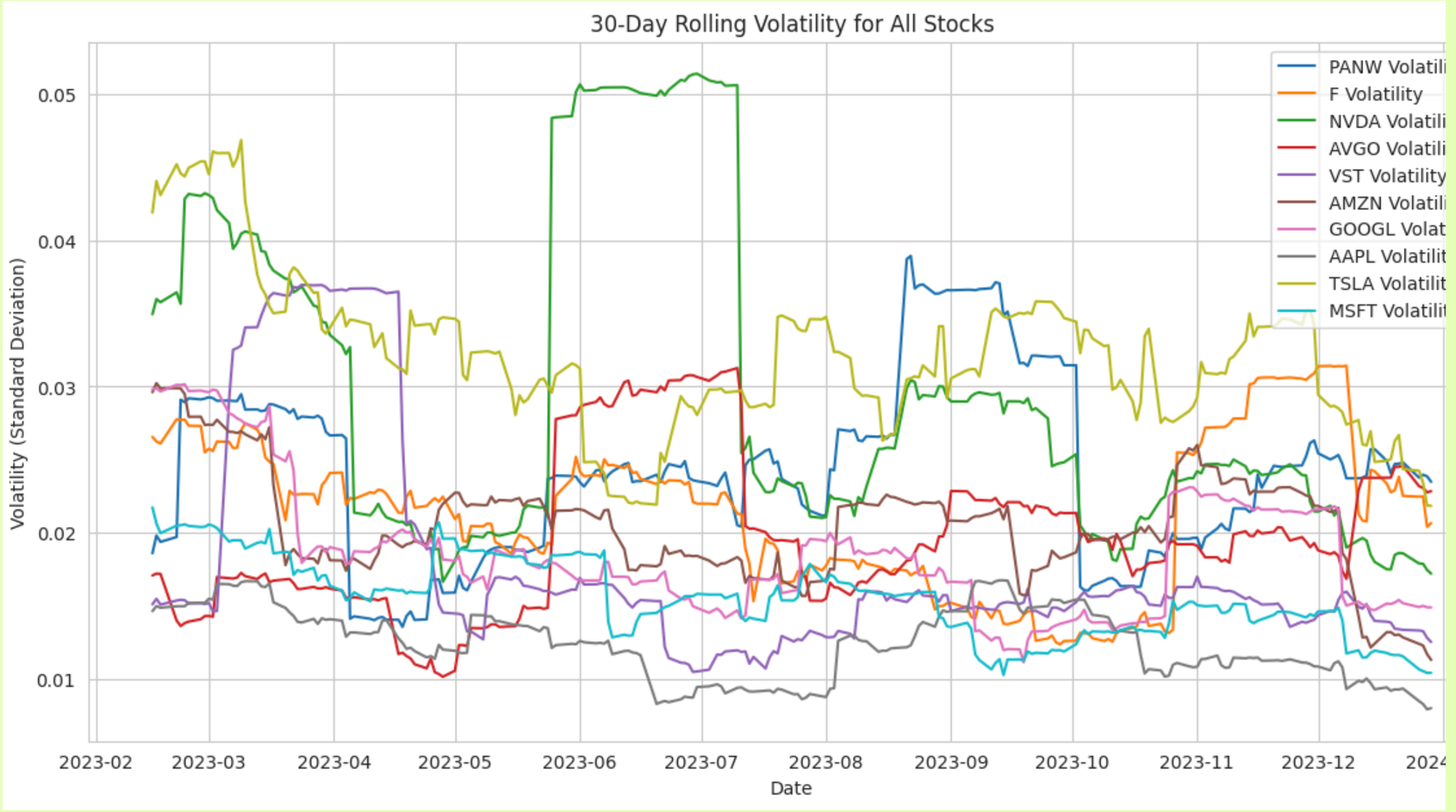


Stock Volatility

- **Highest volatility stocks:**
  NVDA, TSLA, F
  Strong price swings indicate high risk.

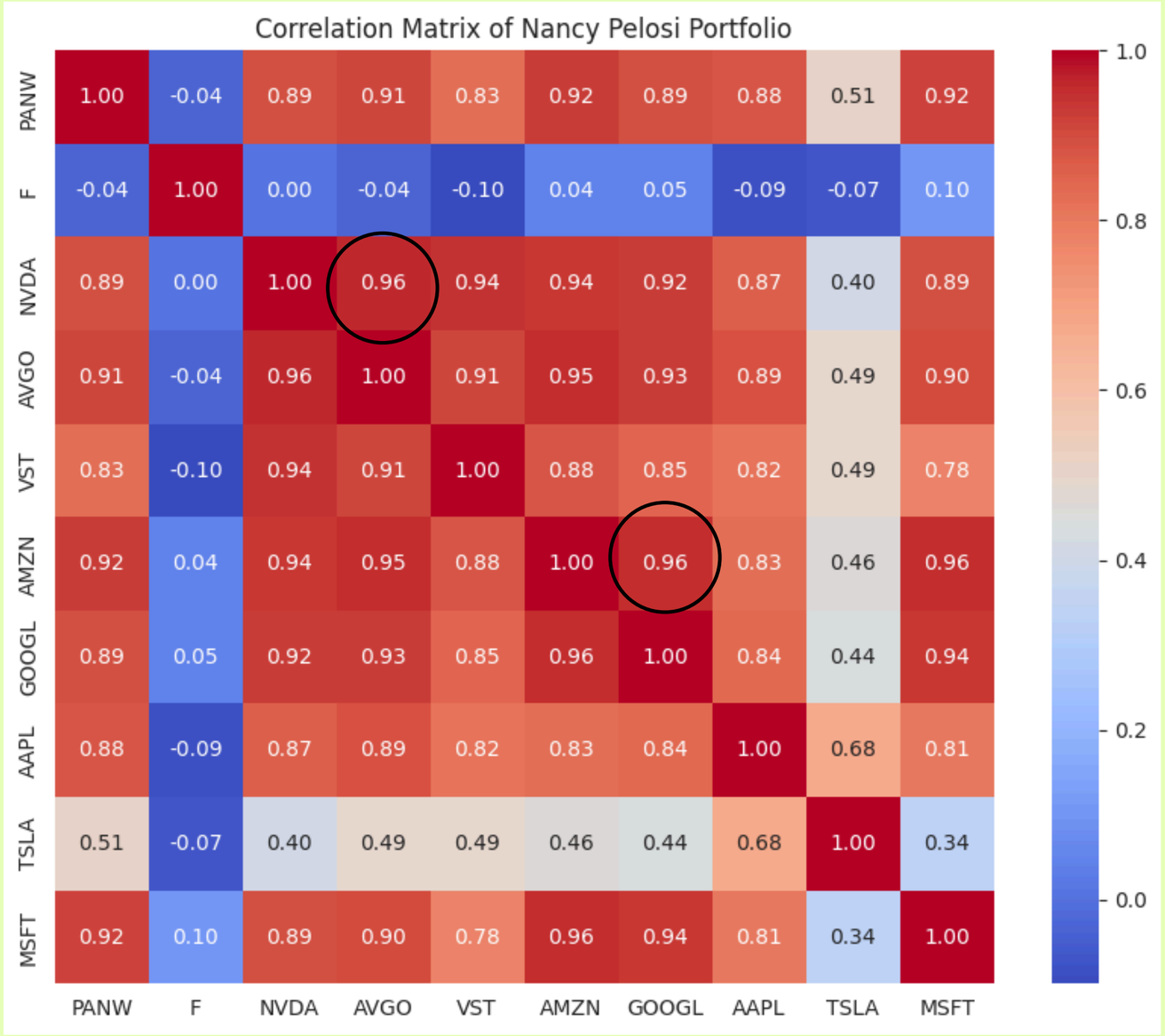
- **More stable stocks:**
  AAPL, MSFT, GOOGL
  Less volatility, meaning lower risk.

- Tech stocks experience periodic spikes, likely due to earnings reports or macroeconomic events.



Correlation Matrix

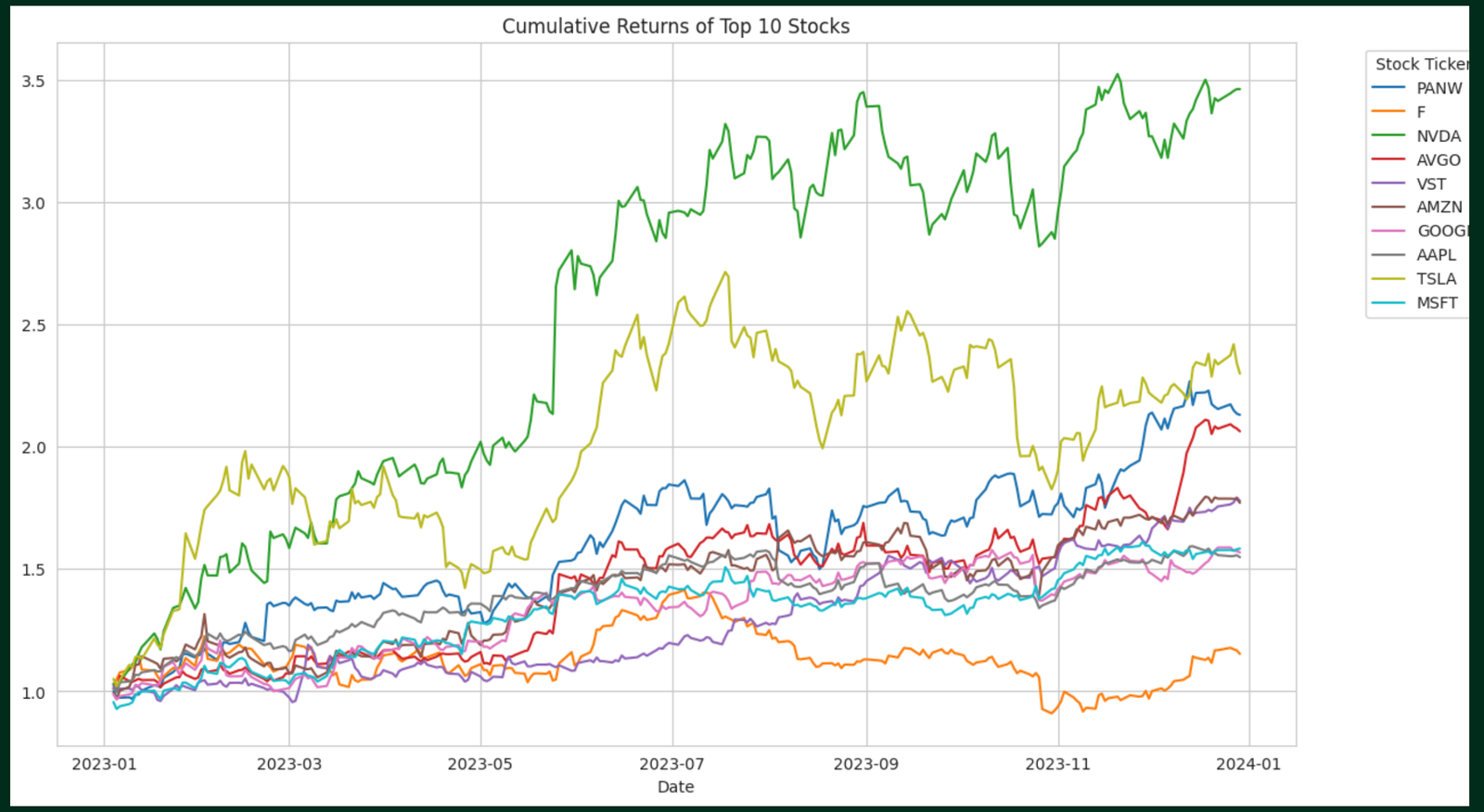
- Strongest correlations: AMZN & GOOGL (0.96), NVDA & AVGO (0.96)
- Tesla (TSLA) has weak correlations with most tech stocks, making it less dependent on typical tech market trends.
- Ford (F) has near-zero or negative correlations, making it the best diversification asset in the portfolio.



Closing Prices

Hypothesis

- High-growth tech stocks (TSLA, NVDA) generate higher returns over time but come with greater volatility.
- While traditional stocks are more stable but yield lower returns.



Modeling

Setting Up Parameters

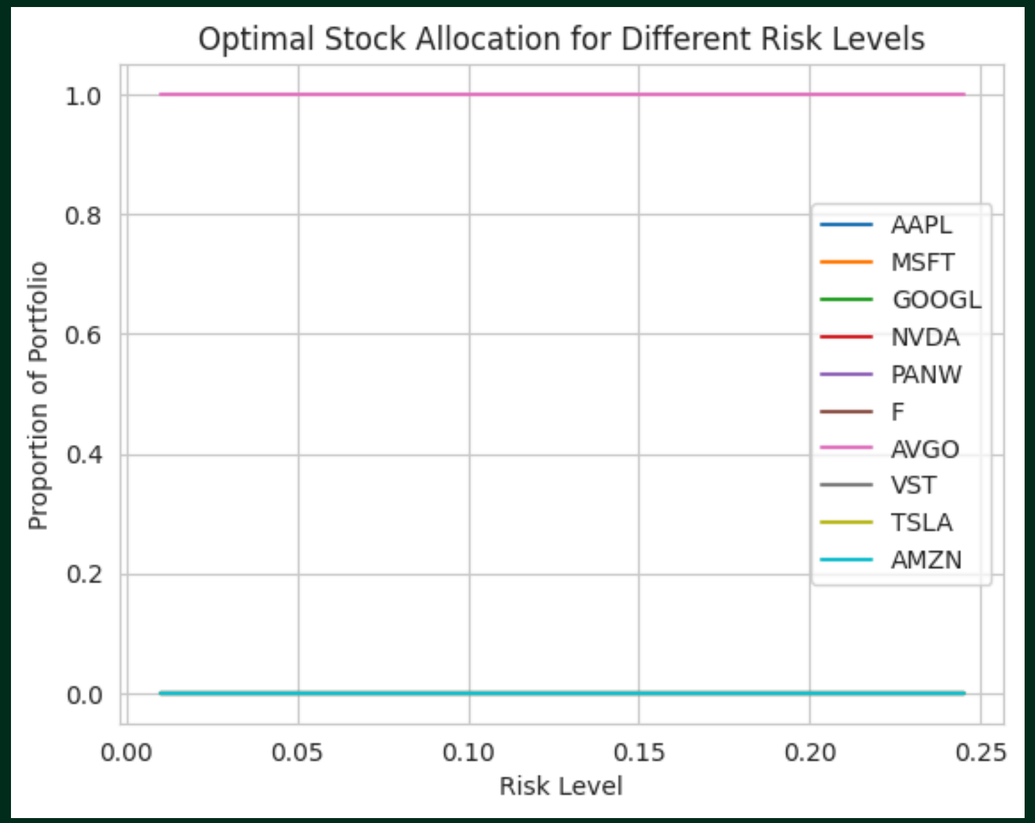
- Decision Variables
- Objective Functions
- Constraints

- max_risk = 0.25
- Portfolio must sum up to 1
- Minimum Return = 1%

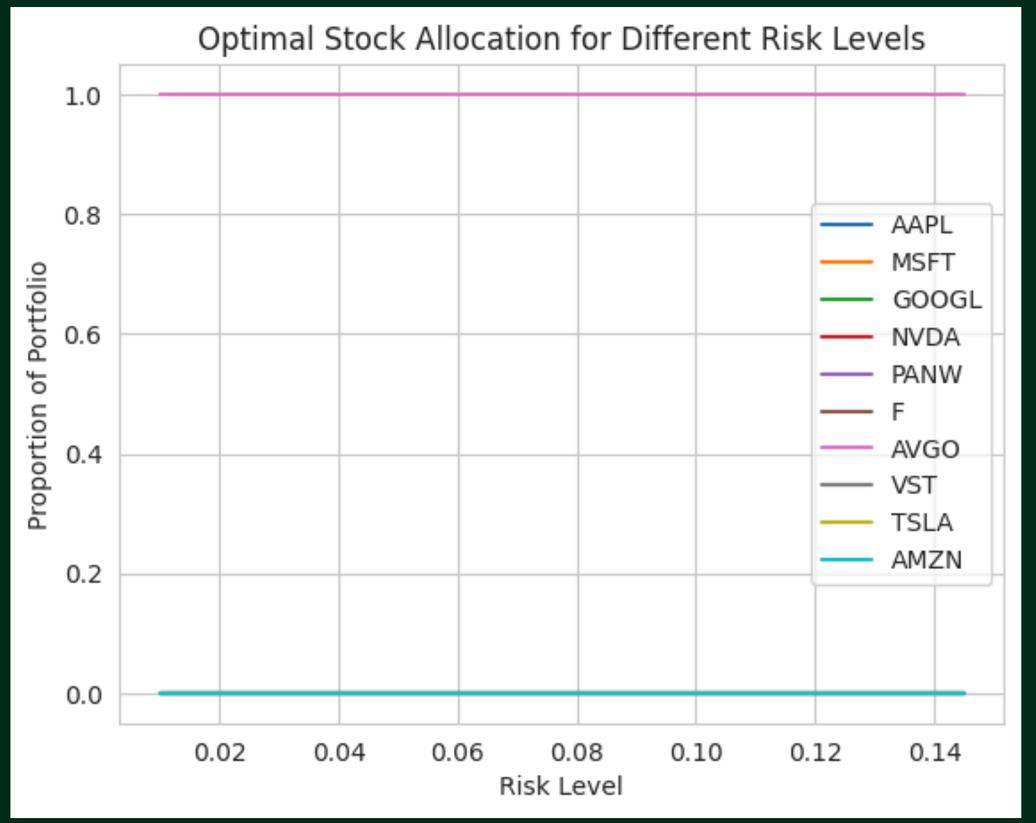
PANW	0.001835
F	0.002511
NVDA	0.003112
AVGO	0.000822
VST	0.001990
AMZN	0.001972
GOOGL	0.005442
AAPL	0.003326
TSLA	0.003893
MSFT	0.002482

Comparative Analysis

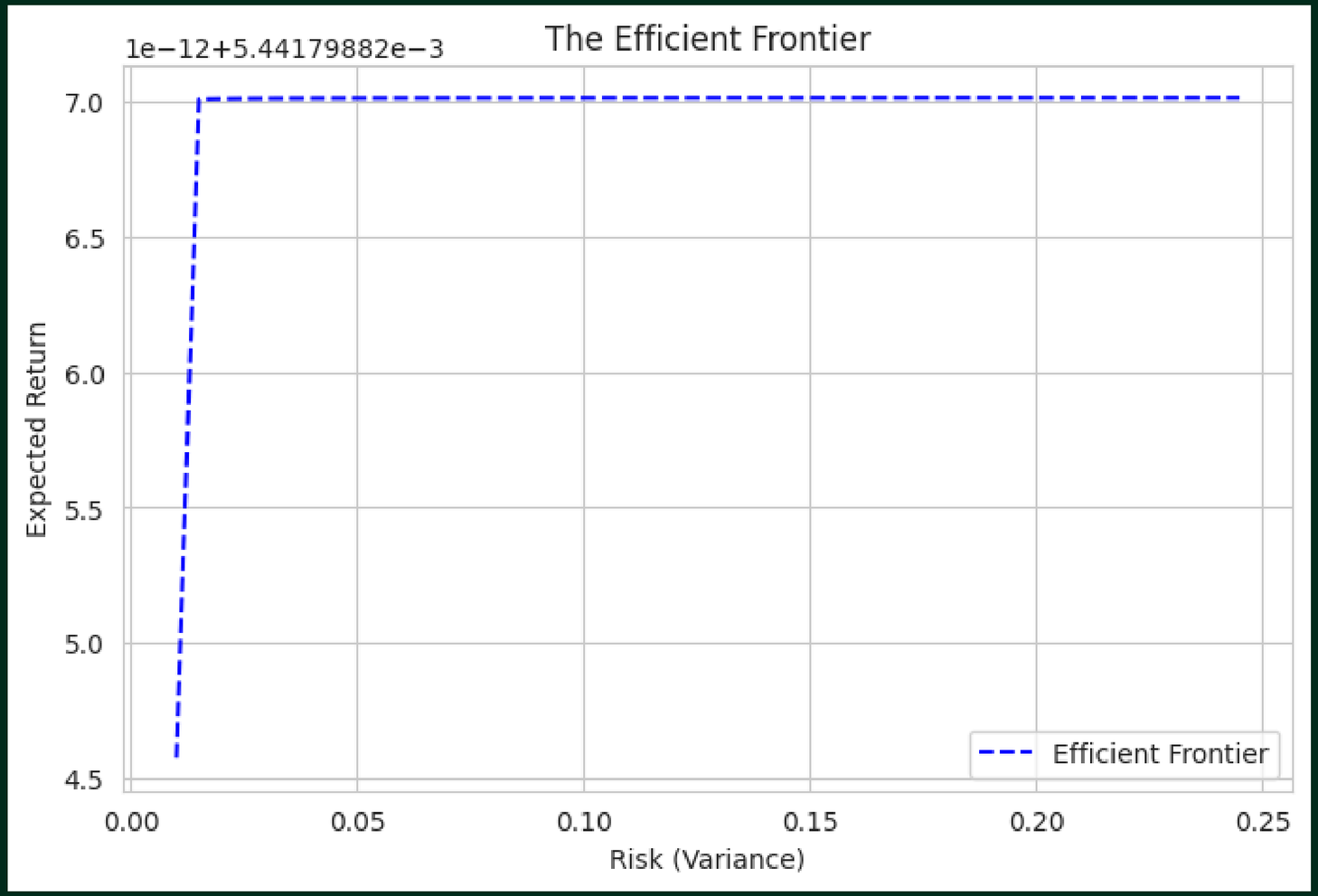
Model 1 - Risk level 25%



Model 2 - Risk level = 15%



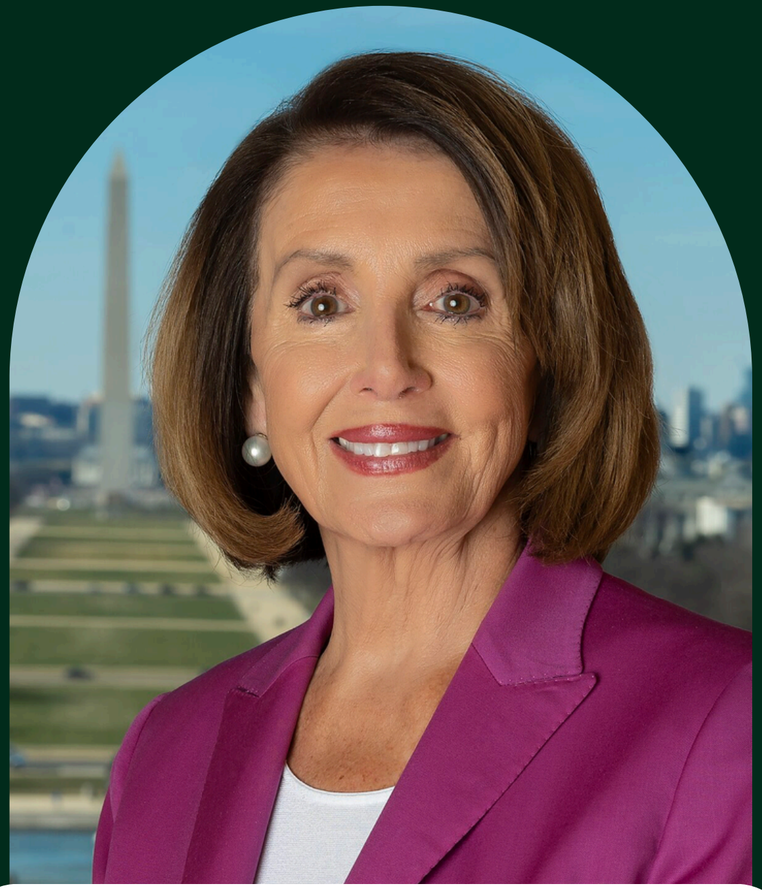
Efficient Frontier (Risk vs Return)



Conclusion

Buffet's Portfolio

Best Model: Model 2



Pelosi's Portfolio

Best Model: Model 1

Thank You!

Team 2