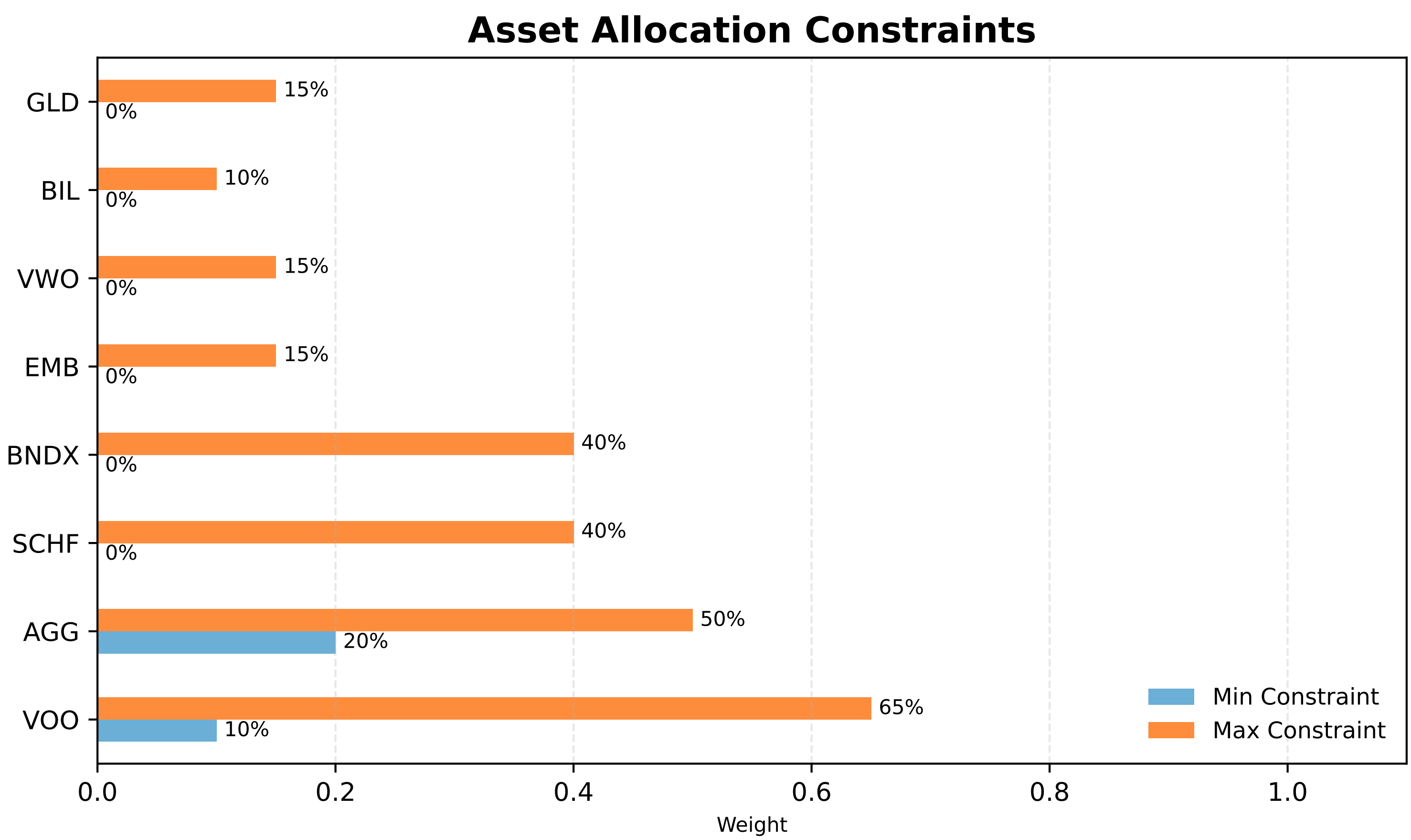
Portfolio Optimization Summary

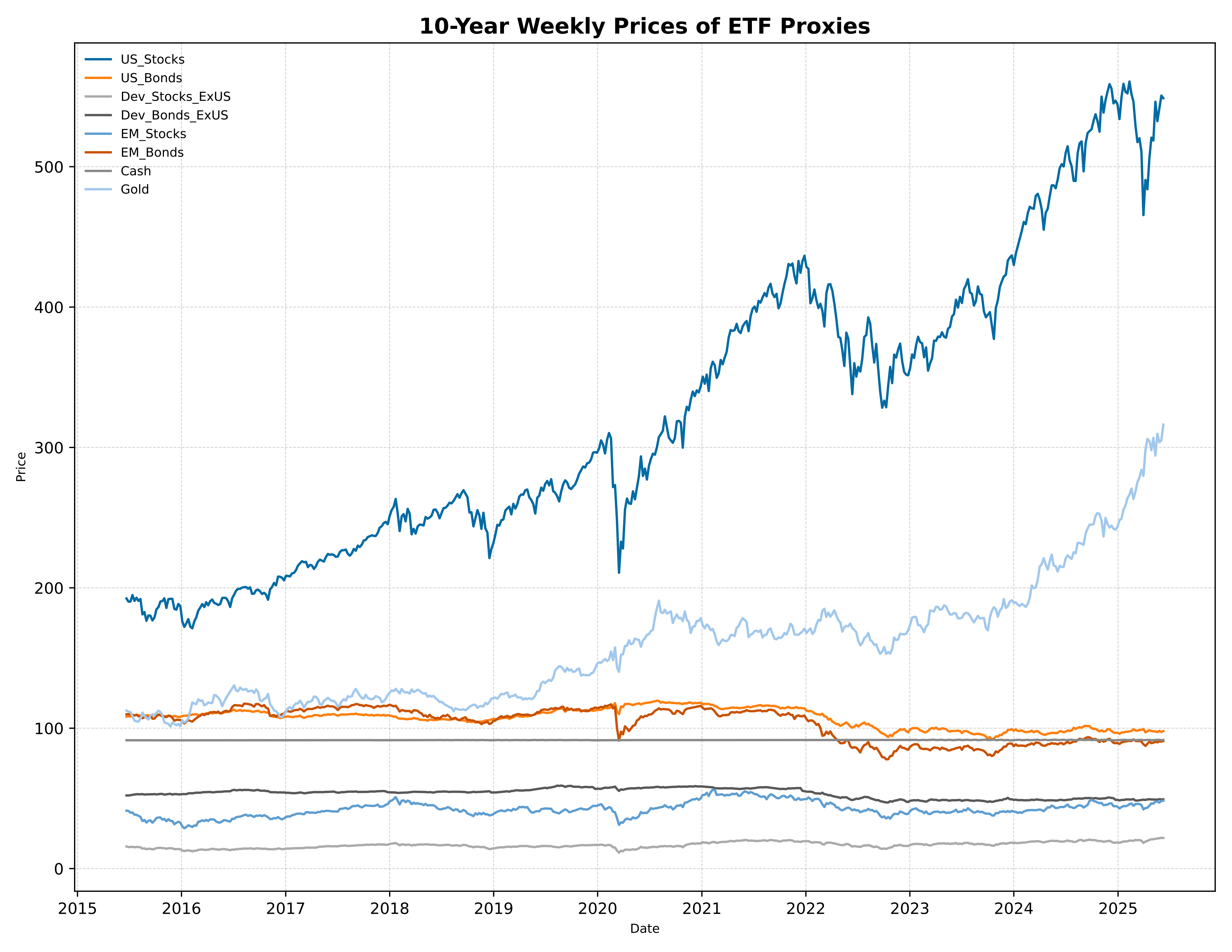
Basic Details and Constraints Overview

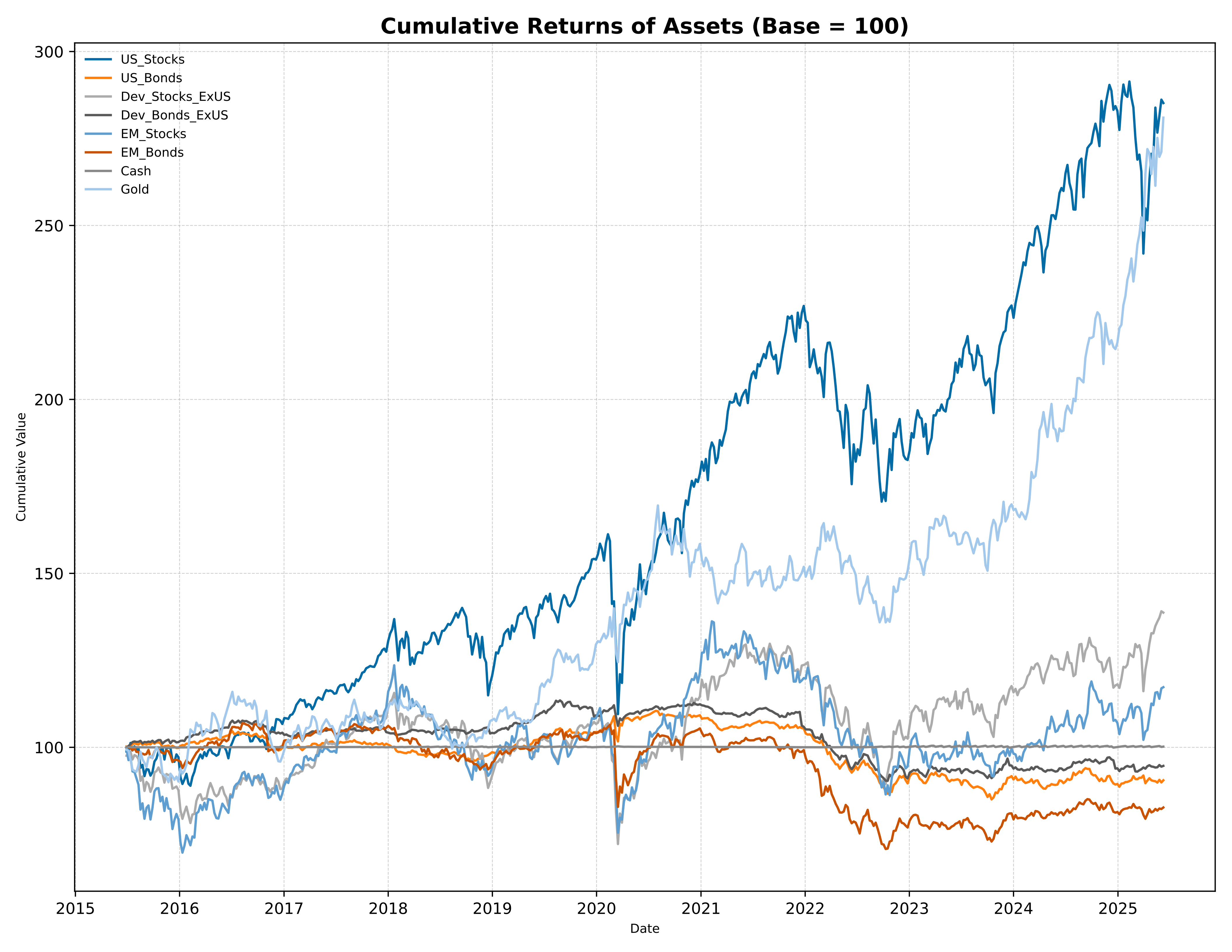
Item	Value
Risk-Free Rate	4.41%
Start Date	2015-06-26
End Date	2025-06-13
Assets Parsed	8

Asset Class	Ticker
US_Stocks	VOO
US_Bonds	AGG
Dev_Stocks_ExUS	SCHF
Dev_Bonds_ExUS	BNDX
EM_Stocks	VWO
EM_Bonds	EMB
Cash	BIL
Gold	GLD

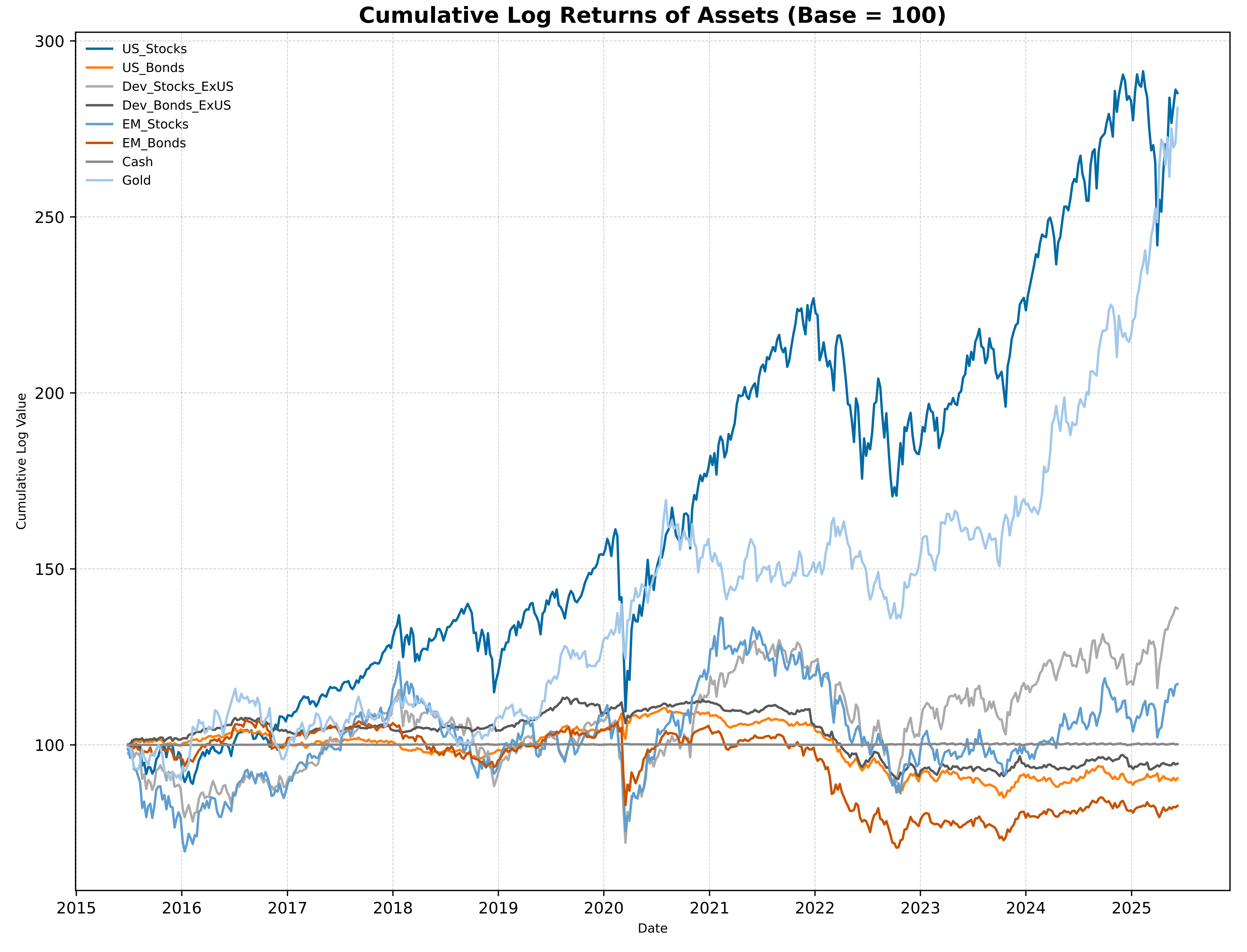


Note: All weights and constraints shown as decimal (0.10 = 10%)


10-Year Weekly Prices of ETF Proxies
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold
Price
Date
0
100
200
300
400
500
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

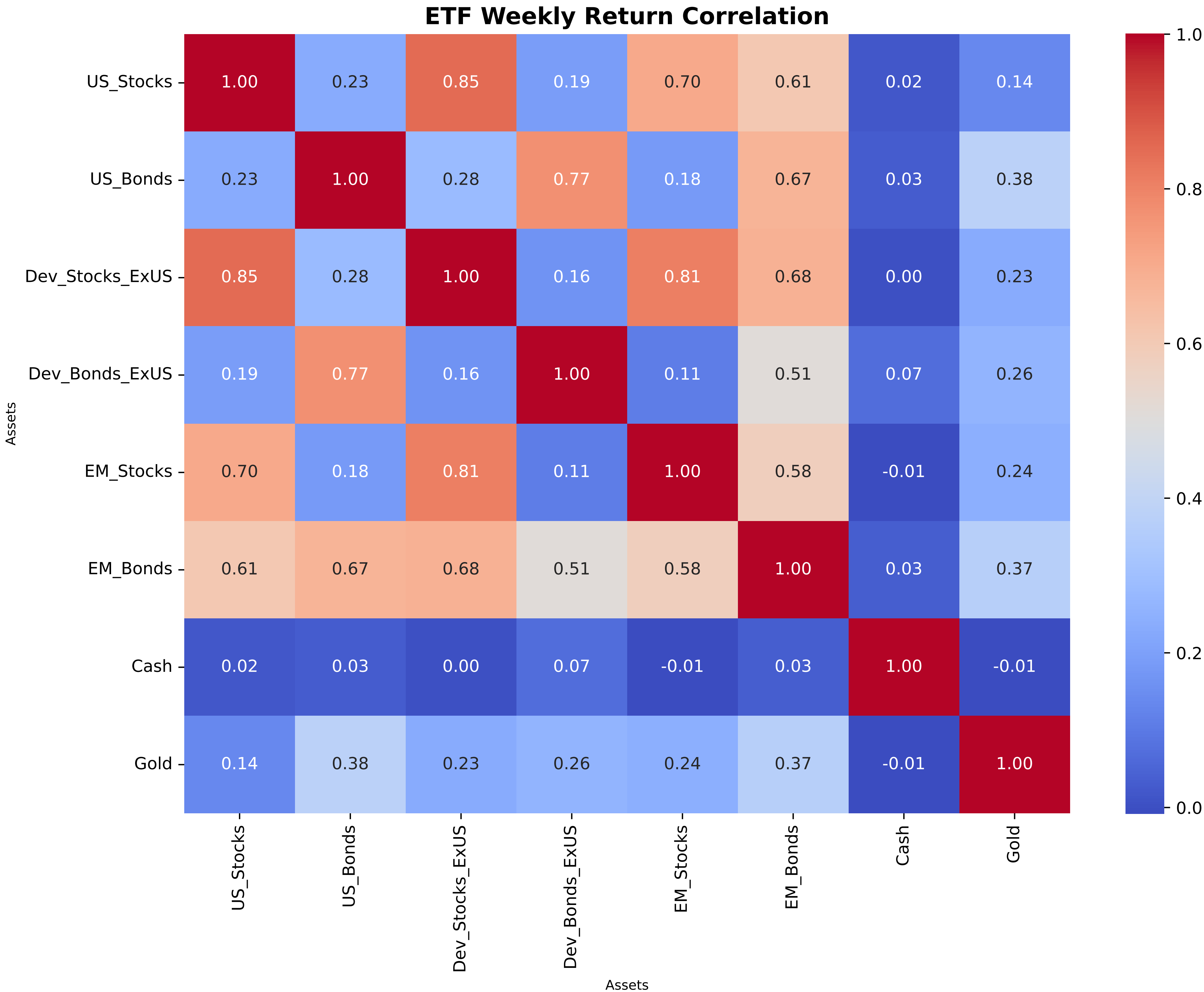


Cumulative Returns of Assets (Base = 100)
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold
Cumulative Value
300
250
200
150
100
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Date

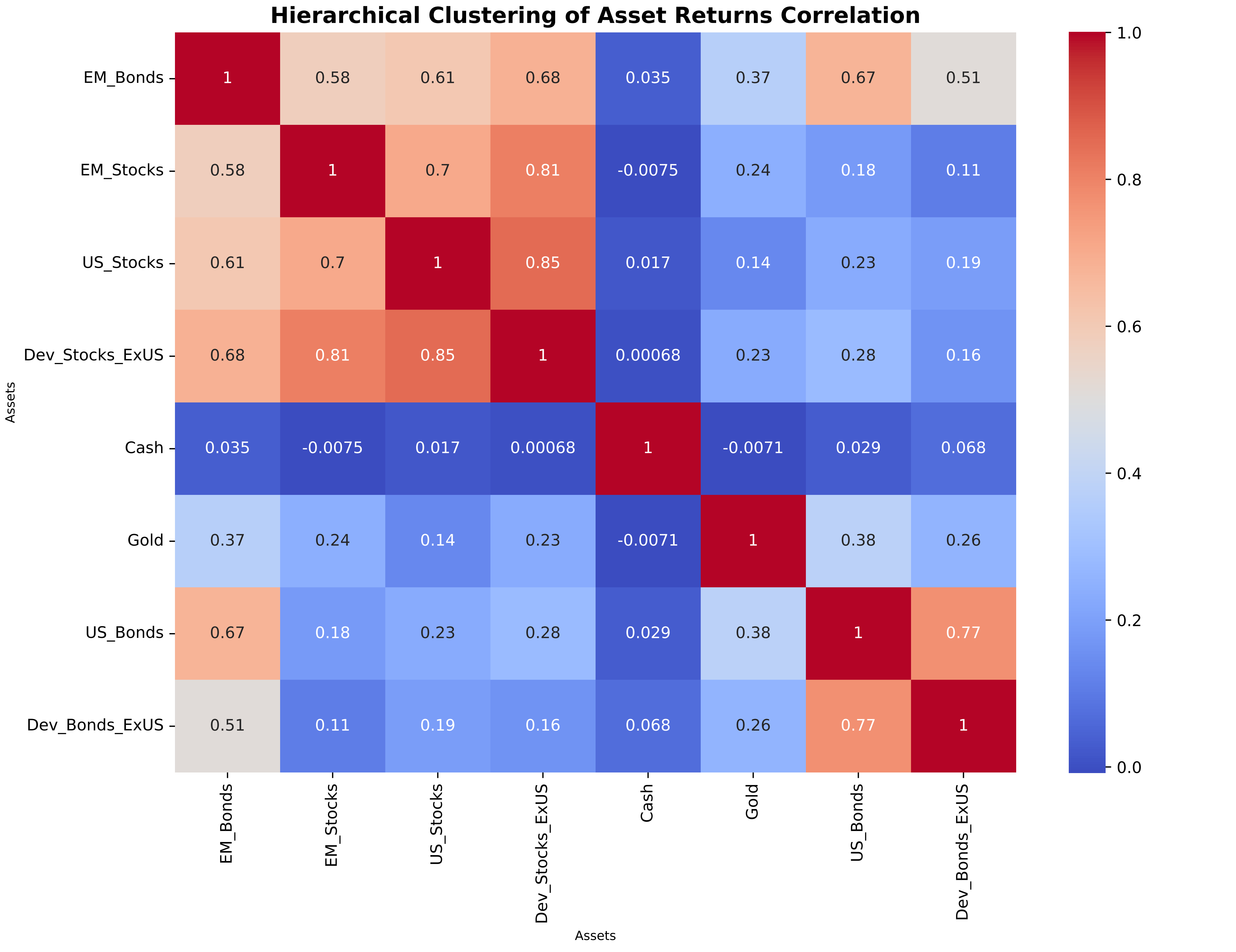

Cumulative Log Returns of Assets (Base = 100)
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold
300
250
200
150
100
Cumulative Log Value
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Date

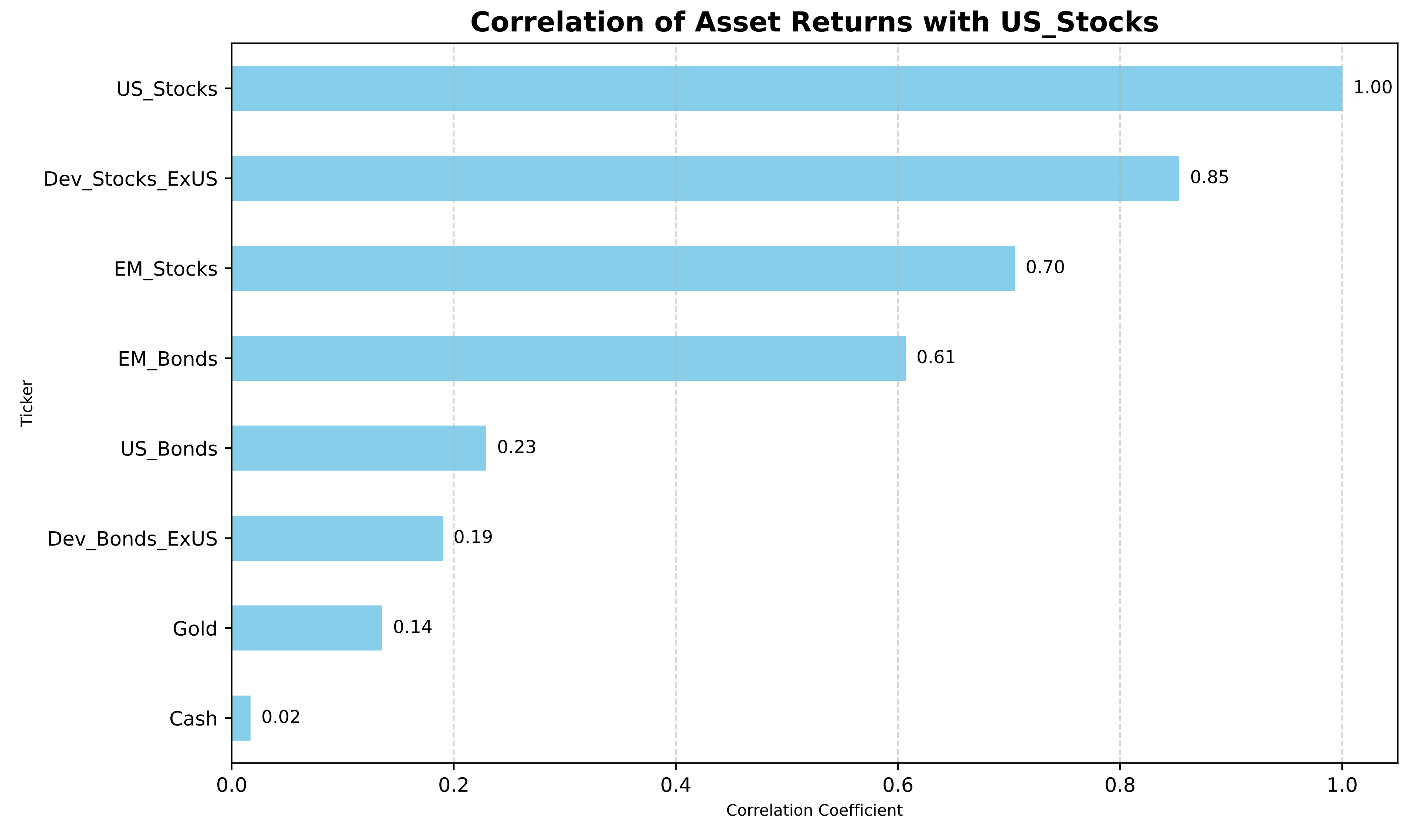
Descriptive Statistics of Weekly Returns
(Annualized Where Applicable)

Asset Class	Mean (Ann.)	Standard Deviation (Ann.)	Sharpe Ratio	Skewness	Kurtosis	Max Return	Min Return
Gold	11.36%	14.30%	0.49	0.03	1.77	8.66%	-9.06%
US_Stocks	12.01%	17.38%	0.44	-0.62	6.02	12.13%	-14.90%
Dev_Stocks_ExUS	4.76%	17.21%	0.02	-0.46	5.48	12.16%	-14.40%
EM_Stocks	3.34%	18.63%	-0.06	-0.40	2.06	9.40%	-13.31%
EM_Bonds	-1.39%	9.99%	-0.58	-1.94	20.76	7.09%	-13.22%
US_Bonds	-0.86%	5.19%	-1.02	-0.08	9.33	5.03%	-5.09%
Dev_Bonds_ExUS	-0.45%	4.44%	-1.09	-0.97	4.69	2.04%	-3.55%
Cash	0.02%	0.66%	-6.64	-2.10	4.99	0.15%	-0.36%



ETF Weekly Return Correlation
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold
Assets
1.00 0.23 0.85 0.19 0.70 0.61 0.02 0.14
0.23 1.00 0.28 0.77 0.18 0.67 0.03 0.38
0.85 0.28 1.00 0.16 0.81 0.68 0.00 0.23
0.19 0.77 0.16 1.00 0.11 0.51 0.07 0.26
0.70 0.18 0.81 0.11 1.00 0.58 -0.01 0.24
0.61 0.67 0.68 0.51 0.58 1.00 0.03 0.37
0.02 0.03 0.00 0.07 -0.01 0.03 1.00 -0.01
0.14 0.38 0.23 0.26 0.24 0.37 -0.01 1.00
1.0
0.8
0.6
0.4
0.2
0.0

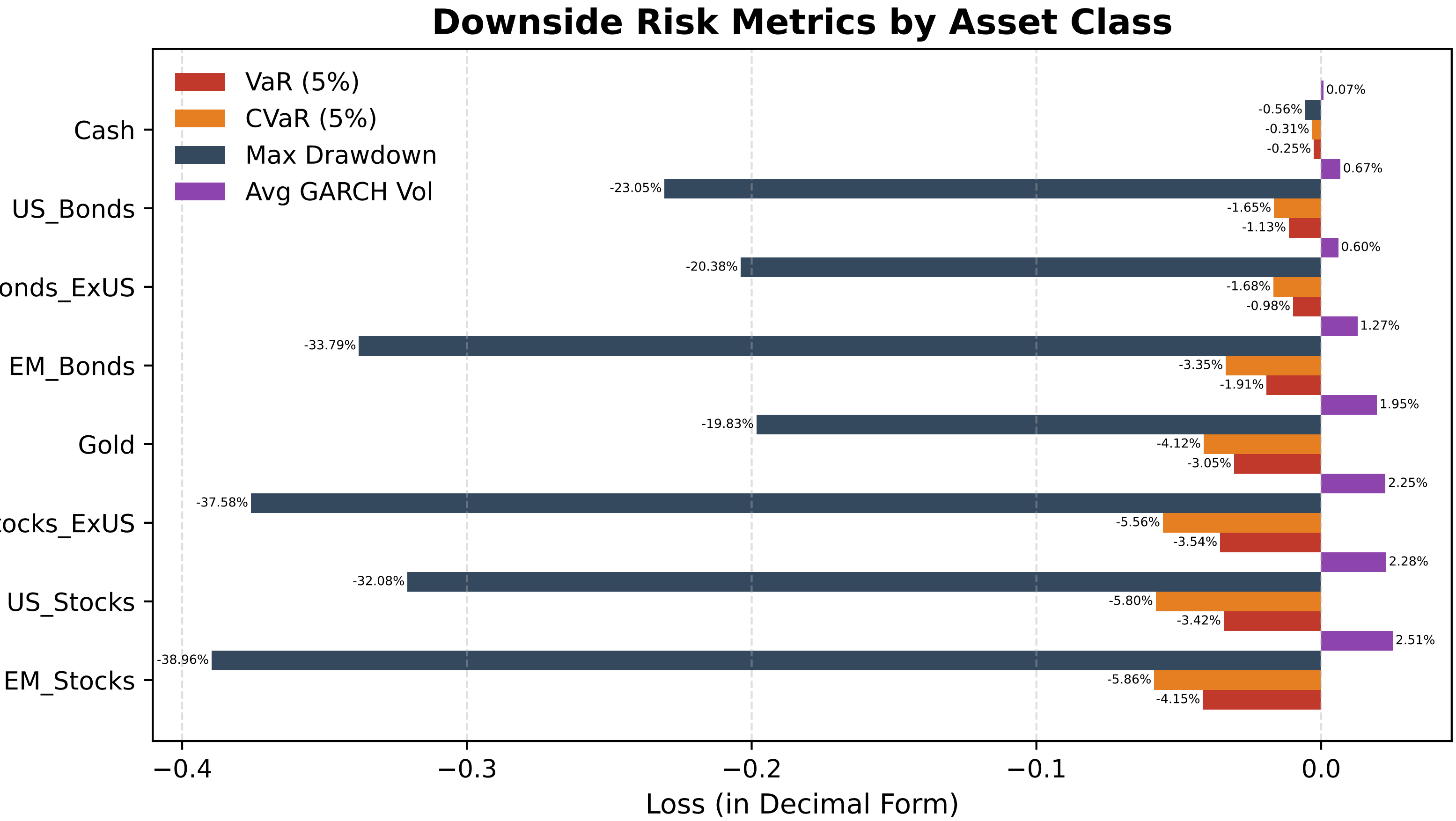

Hierarchical Clustering of Asset Returns Correlation
EM_Bonds
EM_Stocks
US_Stocks
Dev_Stocks_ExUS
Cash
Gold
US_Bonds
Dev_Bonds_ExUS
1 0.58 0.61 0.68 0.035 0.37 0.67 0.51
0.58 1 0.7 0.81 -0.0075 0.24 0.18 0.11
0.61 0.7 1 0.85 0.017 0.14 0.23 0.19
0.68 0.81 0.85 1 0.00068 0.23 0.28 0.16
0.035 -0.0075 0.017 0.00068 1 -0.0071 0.029 0.068
0.37 0.24 0.14 0.23 -0.0071 1 0.38 0.26
0.67 0.18 0.23 0.28 0.029 0.38 1 0.77
0.51 0.11 0.19 0.16 0.068 0.26 0.77 1
Assets
Assets
1.0
0.8
0.6
0.4
0.2
0.0



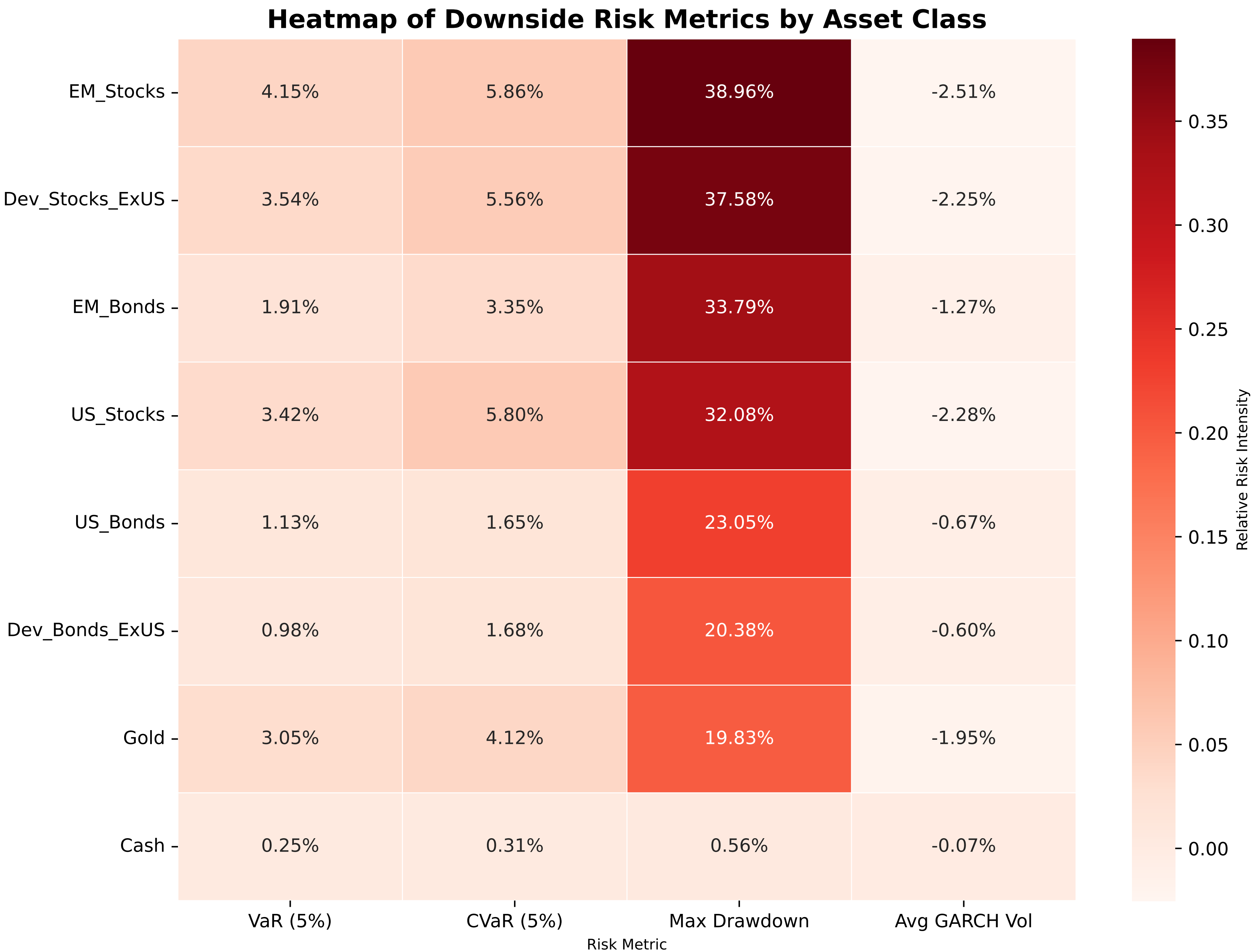
Correlation of Asset Returns with US_Stocks
US_Stocks
Dev_Stocks_ExUS
EM_Stocks
EM_Bonds
US_Bonds
Dev_Bonds_ExUS
Gold
Cash
1.00
0.85
0.70
0.61
0.23
0.19
0.14
0.02
0.0
0.2
0.4
0.6
0.8
1.0
Correlation Coefficient
Ticker

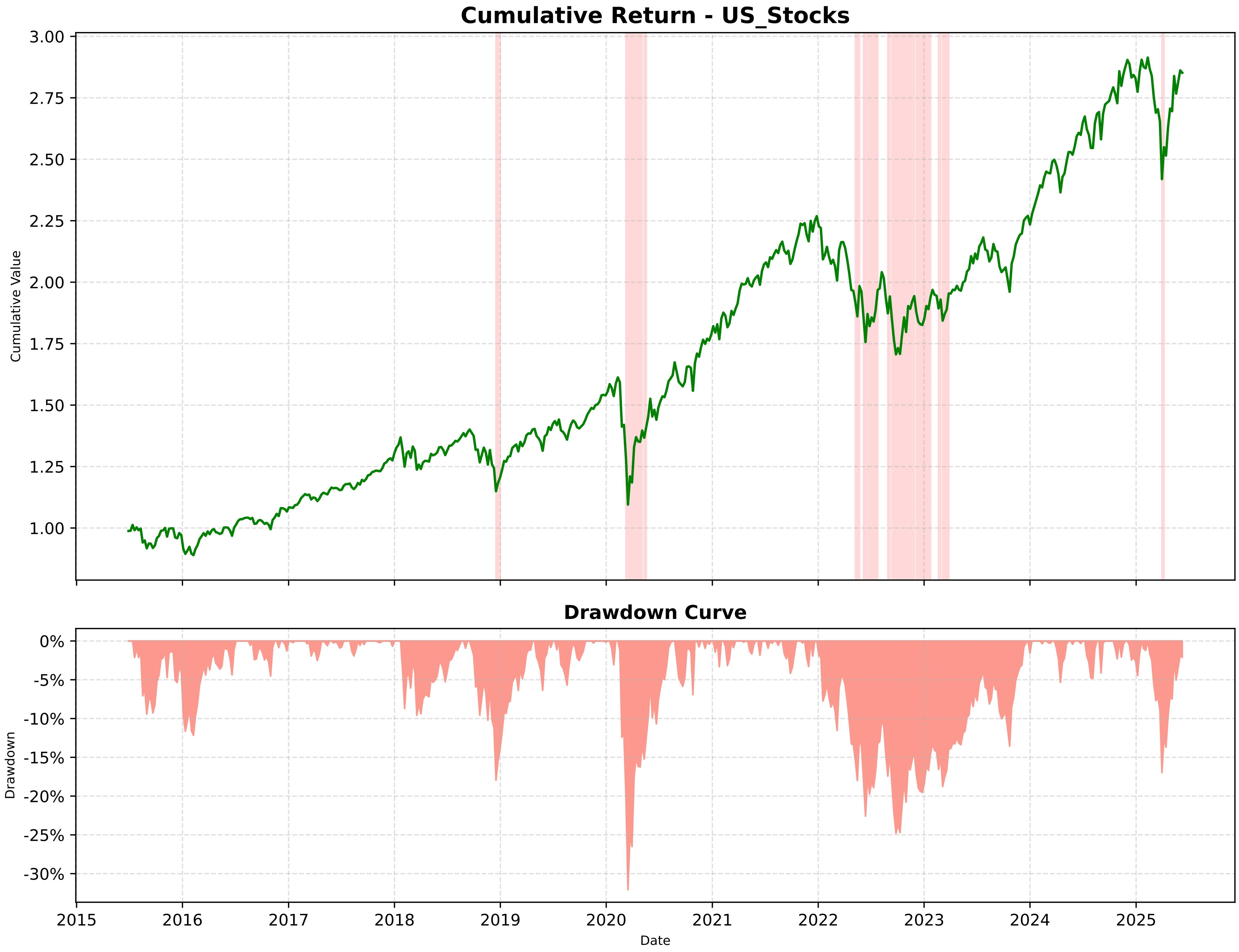
Downside and Tail Risk Statistics by Asset Class

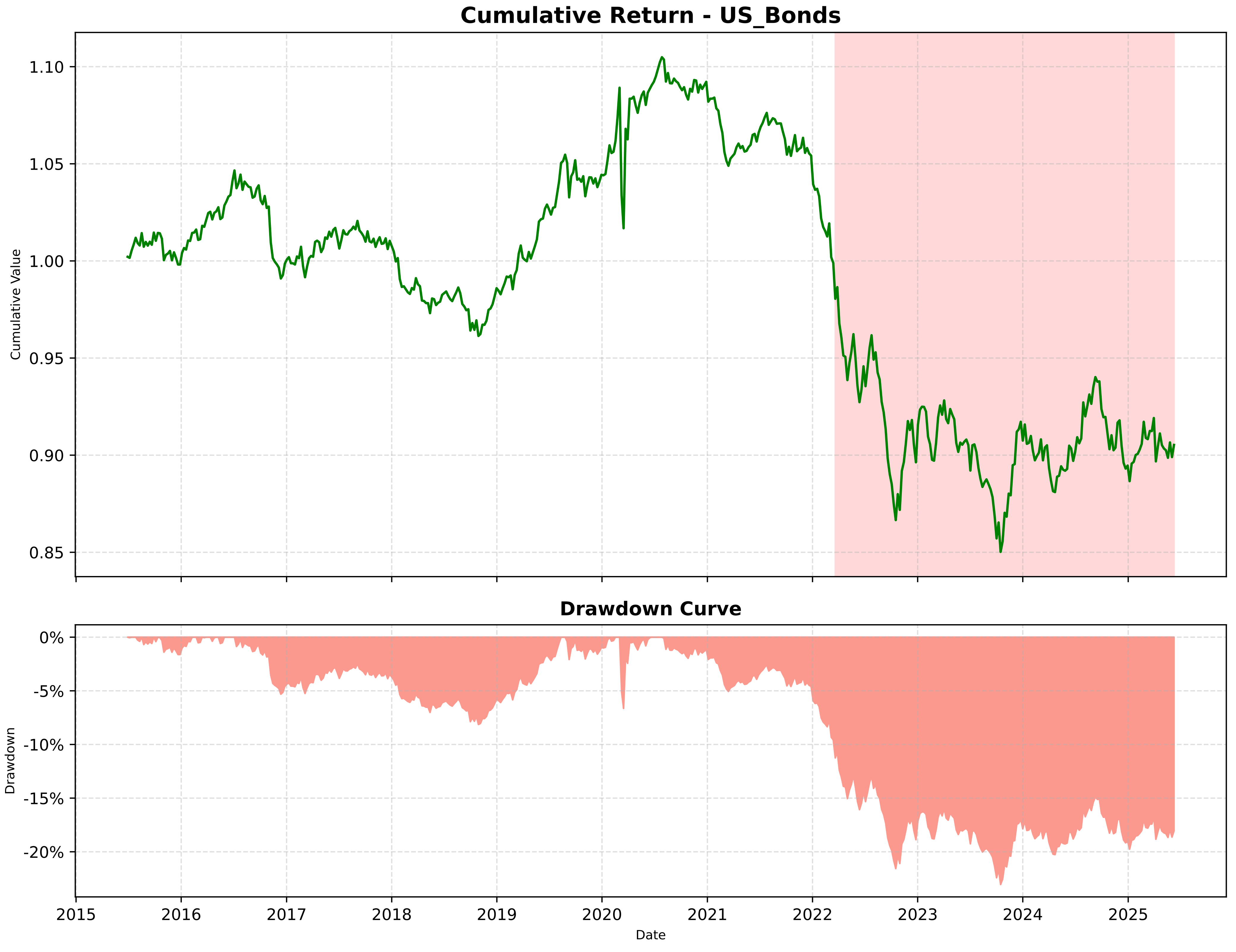
Asset Class	VaR (5%)	CVaR (5%)	Max Drawdown	Beta (vs US_Stocks)	Avg GARCH Vol
US_Stocks	-3.42%	-5.80%	-32.08%	1.00	2.28%
US_Bonds	-1.13%	-1.65%	-23.05%	0.07	0.67%
Dev_Stocks_ExUS	-3.54%	-5.56%	-37.58%	0.84	2.25%
Dev_Bonds_ExUS	-0.98%	-1.68%	-20.38%	0.05	0.60%
EM_Stocks	-4.15%	-5.86%	-38.96%	0.76	2.51%
EM_Bonds	-1.91%	-3.35%	-33.79%	0.35	1.27%
Cash	-0.25%	-0.31%	-0.56%	0.00	0.07%
Gold	-3.05%	-4.12%	-19.83%	0.11	1.95%



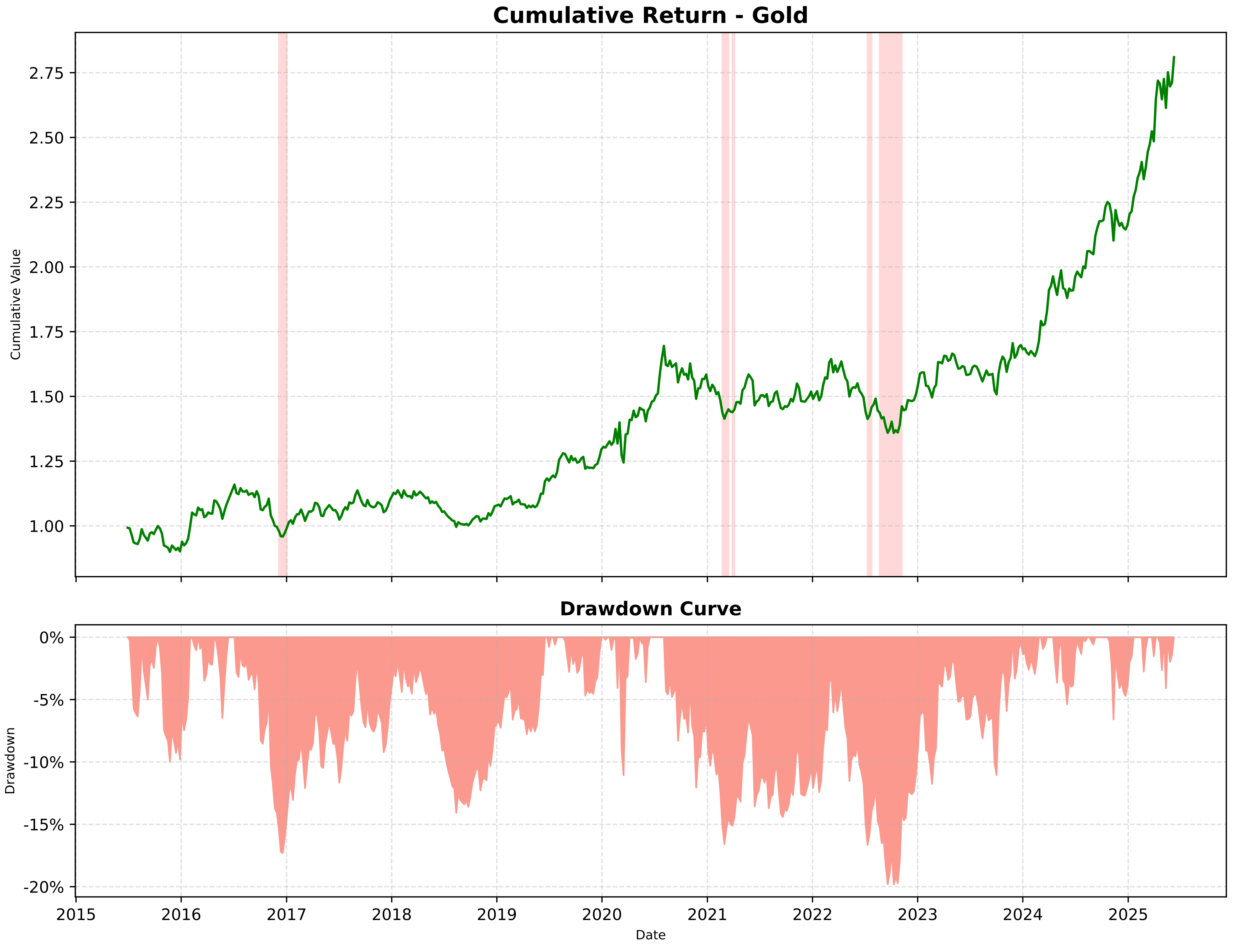
Asset Class	VaR (5%)	CVaR (5%)	Max Drawdown	Avg GARCH Vol
EM_Stocks	-4.15%	-5.86%	-38.96%	2.51%
US_Stocks	-3.42%	-5.80%	-32.08%	2.28%
Dev_Stocks_ExUS	-3.54%	-5.56%	-37.58%	2.25%
Gold	-3.05%	-4.12%	-19.83%	1.95%
EM_Bonds	-1.91%	-3.35%	-33.79%	1.27%
Dev_Bonds_ExUS	-0.98%	-1.68%	-20.38%	0.60%
US_Bonds	-1.13%	-1.65%	-23.05%	0.67%
Cash	-0.25%	-0.31%	-0.56%	0.07%


Heatmap of Downside Risk Metrics by Asset Class
EM_Stocks
Dev_Stocks_ExUS
EM_Bonds
US_Stocks
US_Bonds
Dev_Bonds_ExUS
Gold
Cash
VaR (5%)
CVaR (5%)
Max Drawdown
Avg GARCH Vol
Risk Metric
4.15%
5.86%
38.96%
-2.51%
3.54%
5.56%
37.58%
-2.25%
1.91%
3.35%
33.79%
-1.27%
3.42%
5.80%
32.08%
-2.28%
1.13%
1.65%
23.05%
-0.67%
0.98%
1.68%
20.38%
-0.60%
3.05%
4.12%
19.83%
-1.95%
0.25%
0.31%
0.56%
-0.07%
Relative Risk Intensity
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

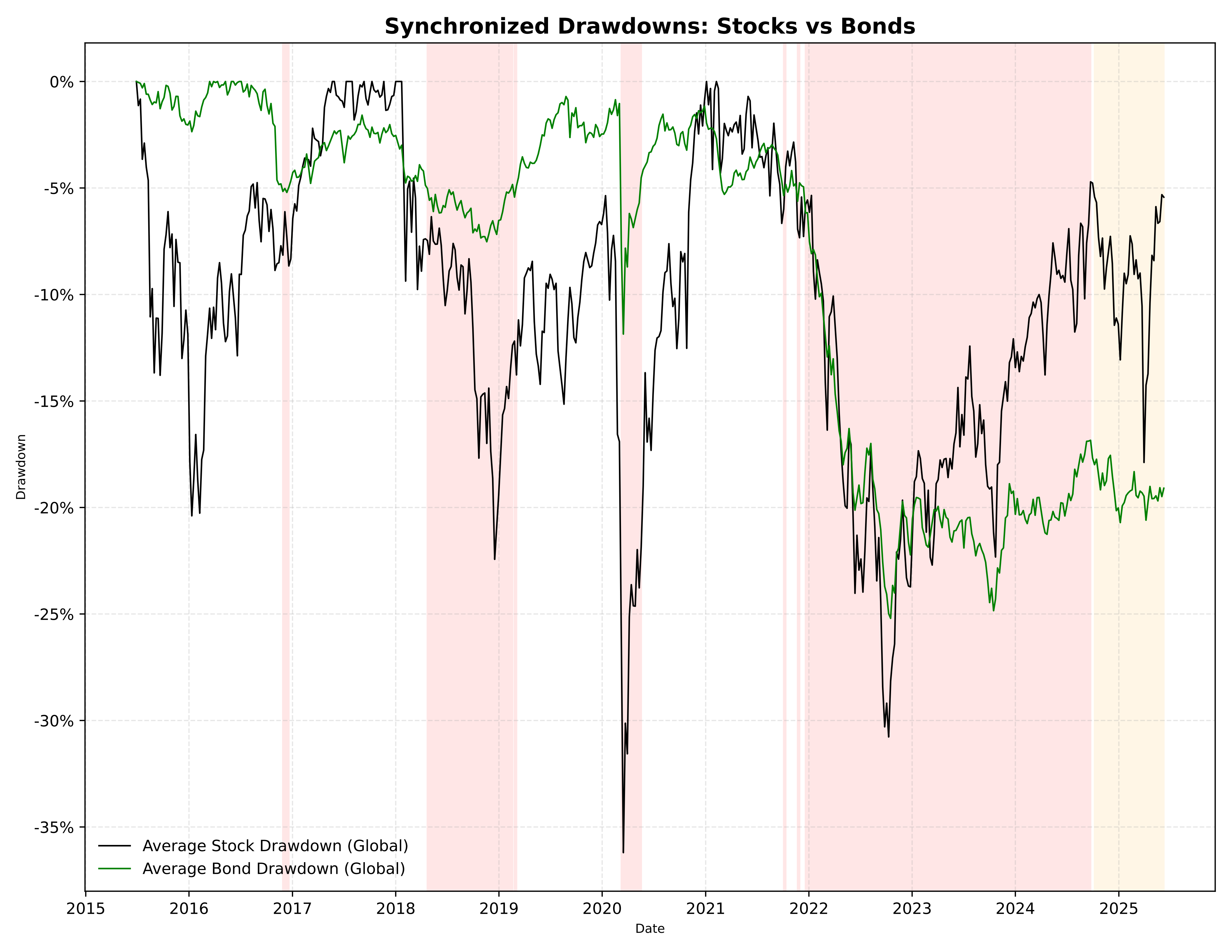

Cumulative Return - US_Stocks
Cumulative Value
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
Drawdown Curve
Drawdown
0%
-5%
-10%
-15%
-20%
-25%
-30%
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Date



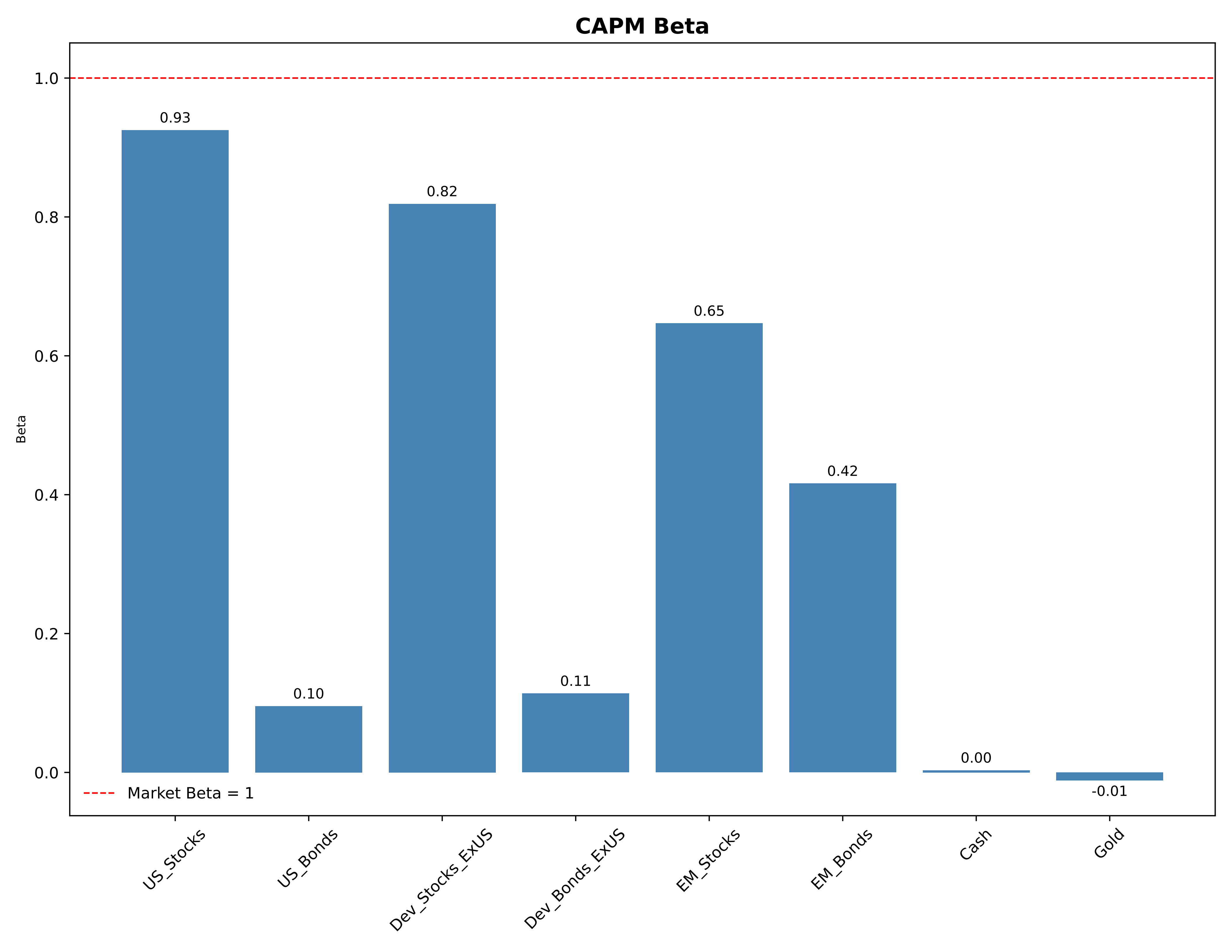
Cumulative Return - US_Bonds
Cumulative Value
1.10
1.05
1.00
0.95
0.90
0.85
Drawdown Curve
Drawdown
0%
-5%
-10%
-15%
-20%
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Date



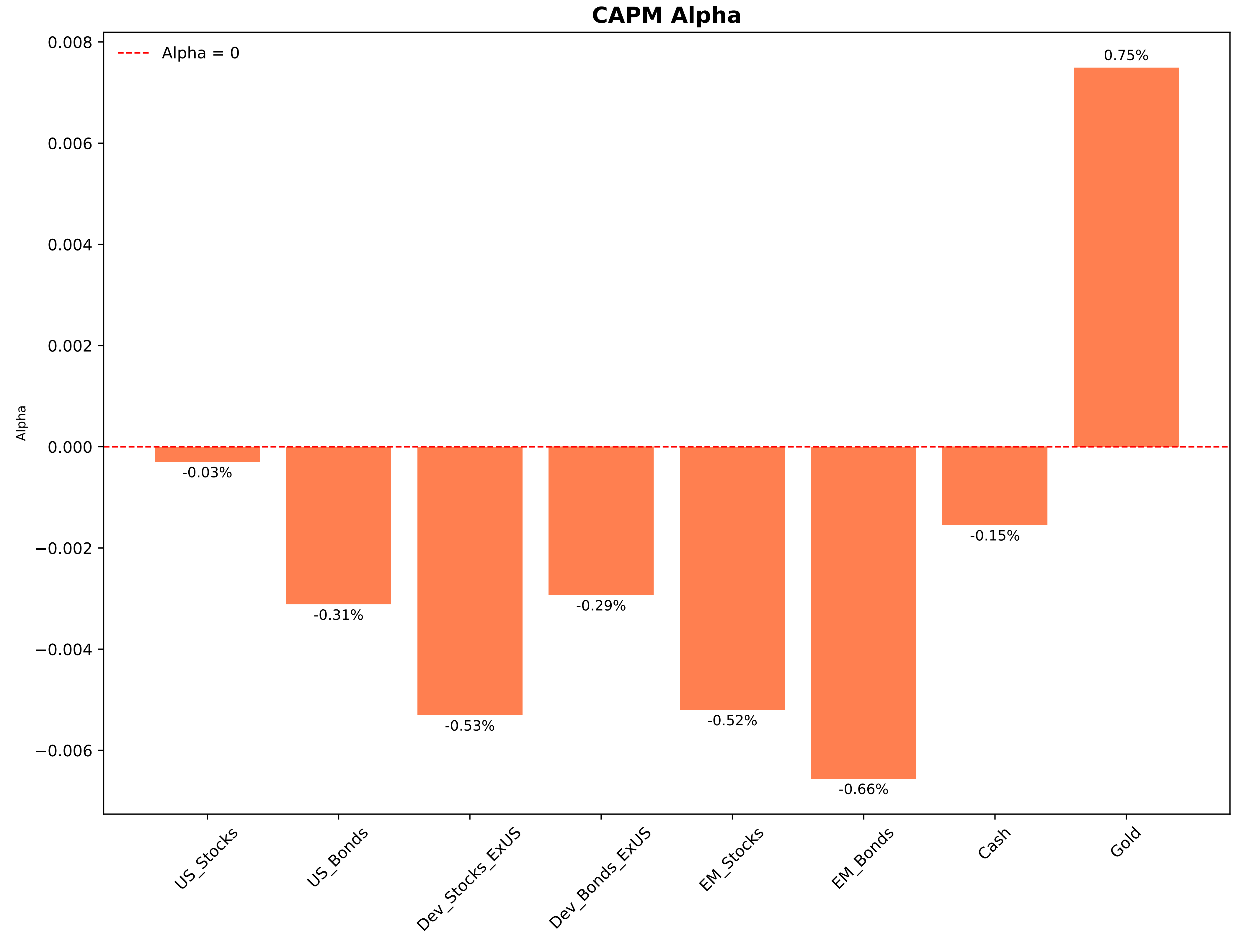
Cumulative Return - Gold
Cumulative Value
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
Drawdown Curve
Drawdown
0%
-5%
-10%
-15%
-20%
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Date



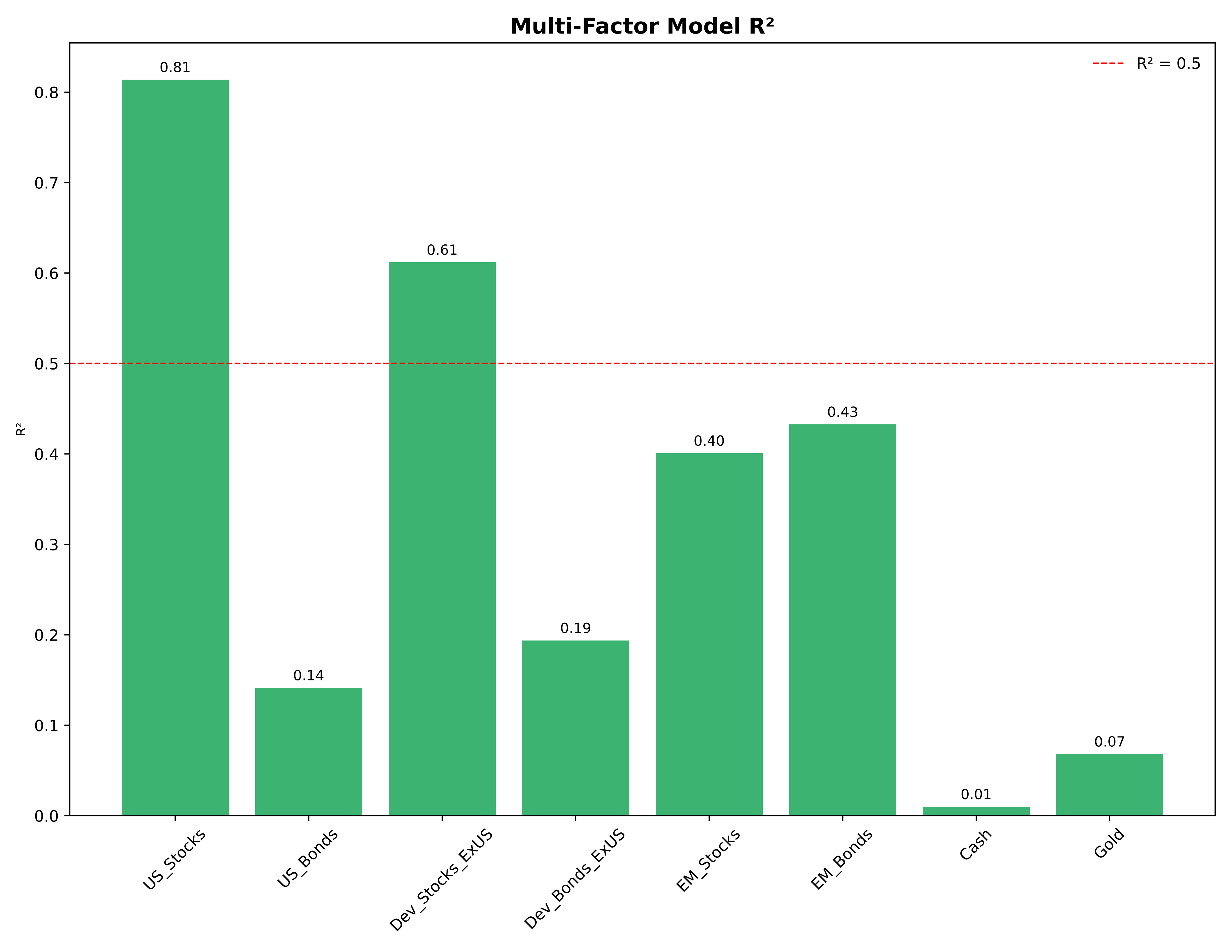
Synchronized Drawdowns: Stocks vs Bonds
0%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
Drawdown
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
Date
Average Stock Drawdown (Global)
Average Bond Drawdown (Global)



CAPM Beta
Beta
1.0
0.8
0.6
0.4
0.2
0.0
0.93
0.10
0.82
0.11
0.65
0.42
0.00
-0.01
Market Beta = 1
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold

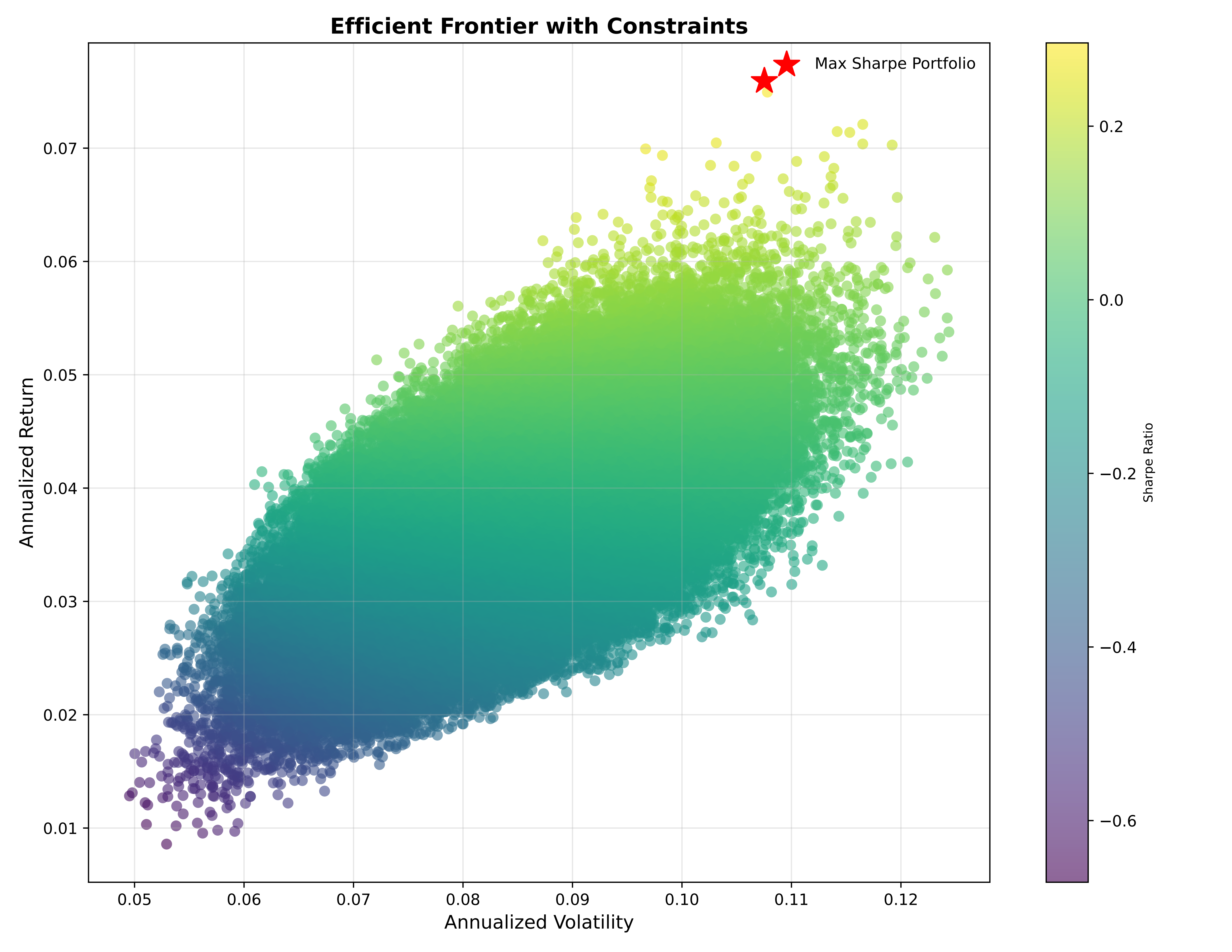


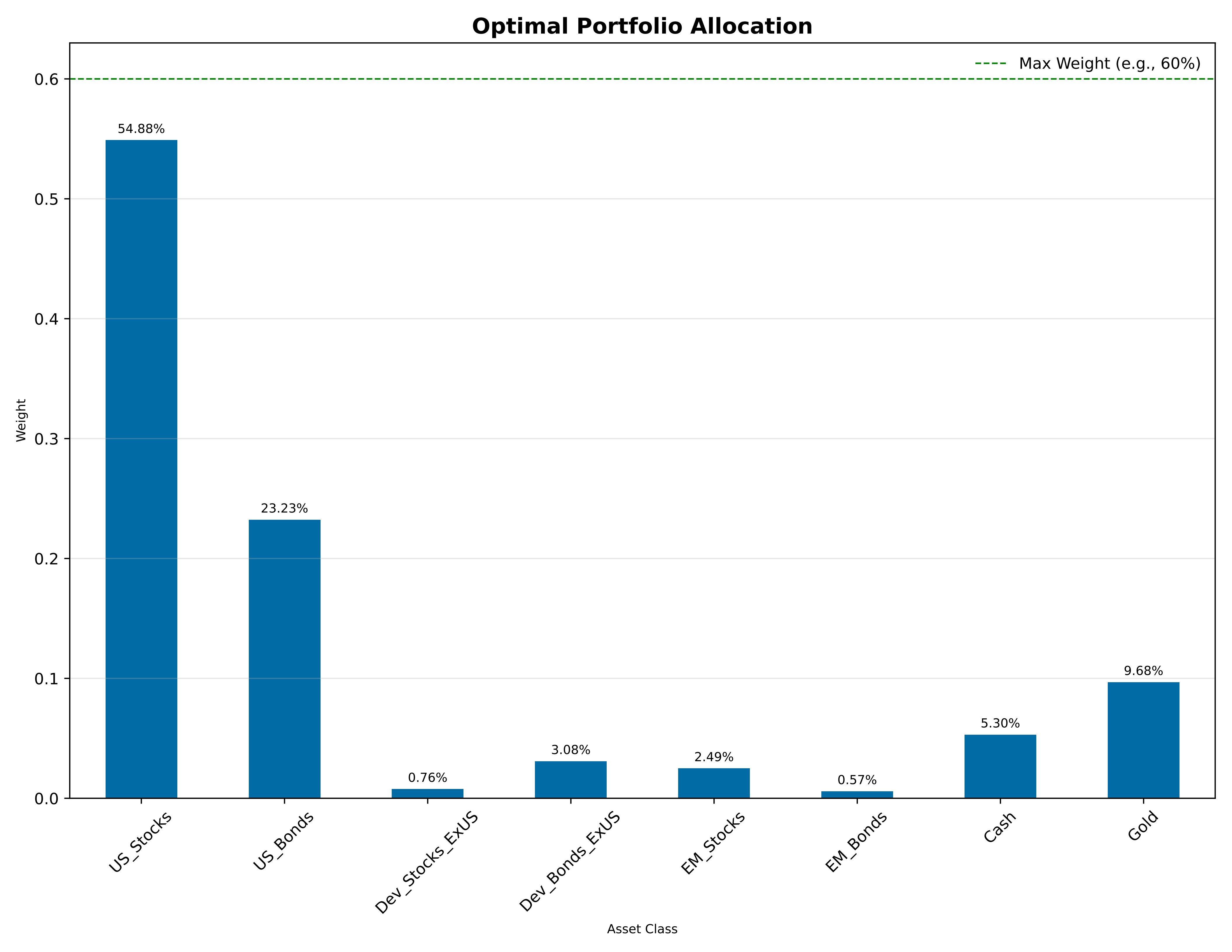
CAPM Alpha
Alpha = 0
Alpha
0.008
0.006
0.004
0.002
0.000
−0.002
−0.004
−0.006
0.75%
-0.03%
-0.31%
-0.53%
-0.29%
-0.52%
-0.66%
-0.15%
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold


Multi-Factor Model R²
R² = 0.5
R²
0.81
0.14
0.61
0.19
0.40
0.43
0.01
0.07
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold

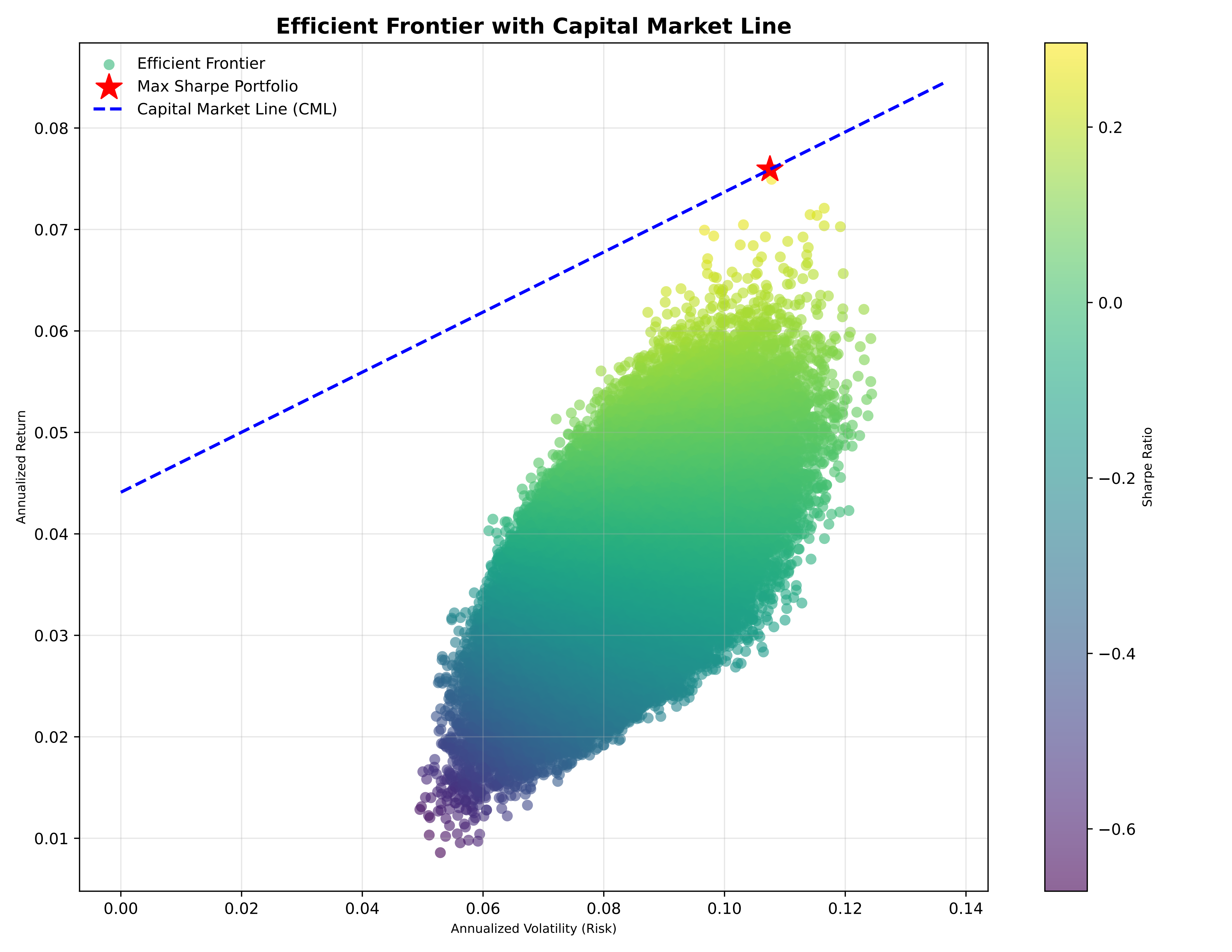
CAPM & Multi-Factor Regression Summary

Asset_Class	CAPM Beta	CAPM Alpha	MFC R²
US_Stocks	0.925	-0.0297%	0.814
US_Bonds	0.096	-0.3114%	0.141
Dev_Stocks_ExUS	0.819	-0.5303%	0.612
Dev_Bonds_ExUS	0.114	-0.2928%	0.194
EM_Stocks	0.647	-0.5199%	0.401
EM_Bonds	0.416	-0.6557%	0.433
Cash	0.003	-0.1546%	0.01
Gold	-0.012	0.7490%	0.068


Efficient Frontier with Constraints
Max Sharpe Portfolio
Annualized Return
Annualized Volatility
Sharpe Ratio
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.05
0.06
0.07
0.08
0.09
0.10
0.11
0.12
0.2
0.0
−0.2
−0.4
−0.6



Optimal Portfolio Allocation
Max Weight (e.g., 60%)
Weight
0.0
0.1
0.2
0.3
0.4
0.5
0.6
54.88%
23.23%
0.76%
3.08%
2.49%
0.57%
5.30%
9.68%
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold
Asset Class

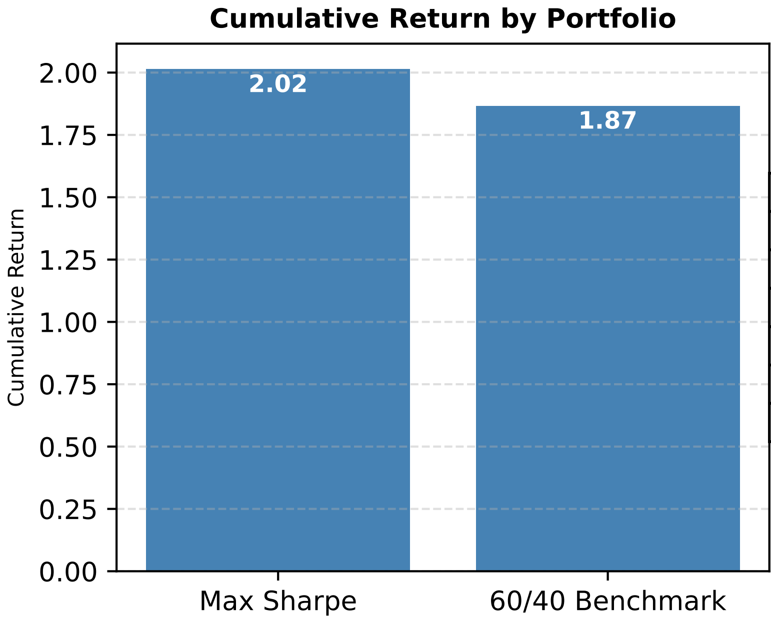

Efficient Frontier with Capital Market Line
Efficient Frontier
Max Sharpe Portfolio
Capital Market Line (CML)
Annualized Return
Annualized Volatility (Risk)
Sharpe Ratio
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.2
0.0
−0.2
−0.4
−0.6

Comparison of Optimal and Minimum Variance Portfolios
with Constraints

Asset Class	Weight	Return	Standard Deviation	Sharpe Ratio
US_Stocks	54.88%	12.01%	17.38%	0.44
US_Bonds	23.23%	-0.86%	5.19%	-1.02
Dev_Stocks_ExUS	0.76%	4.76%	17.21%	0.02
Dev_Bonds_ExUS	3.08%	-0.45%	4.44%	-1.09
EM_Stocks	2.49%	3.34%	18.63%	-0.06
EM_Bonds	0.57%	-1.39%	9.99%	-0.58
Cash	5.30%	0.02%	0.66%	-6.64
Gold	9.68%	11.36%	14.30%	0.49
Expected Optimal Portfolio	100.00%	7.59%	10.75%	0.30

Asset Class	Weight	Return	Standard Deviation	Sharpe Ratio
US_Stocks	14.22%	12.01%	17.38%	0.44
US_Bonds	31.45%	-0.86%	5.19%	-1.02
Dev_Stocks_ExUS	0.34%	4.76%	17.21%	0.02
Dev_Bonds_ExUS	38.03%	-0.45%	4.44%	-1.09
EM_Stocks	1.55%	3.34%	18.63%	-0.06
EM_Bonds	4.44%	-1.39%	9.99%	-0.58
Cash	9.89%	0.02%	0.66%	-6.64
Gold	0.08%	11.36%	14.30%	0.49
Expected Min Portfolio	100.00%	1.28%	4.95%	-0.63

Backtest Performance Summary



Metric	Max Sharpe	60/40 Benchmark
Cumulative Return	1.0152	0.8671
Annualized Return	0.0759	0.0686
Annualized Volatility	0.1075	0.1109
Sharpe Ratio	0.2959	0.2213
Sortino Ratio	0.3716	0.2775
Max Drawdown	-0.2103	-0.2152