

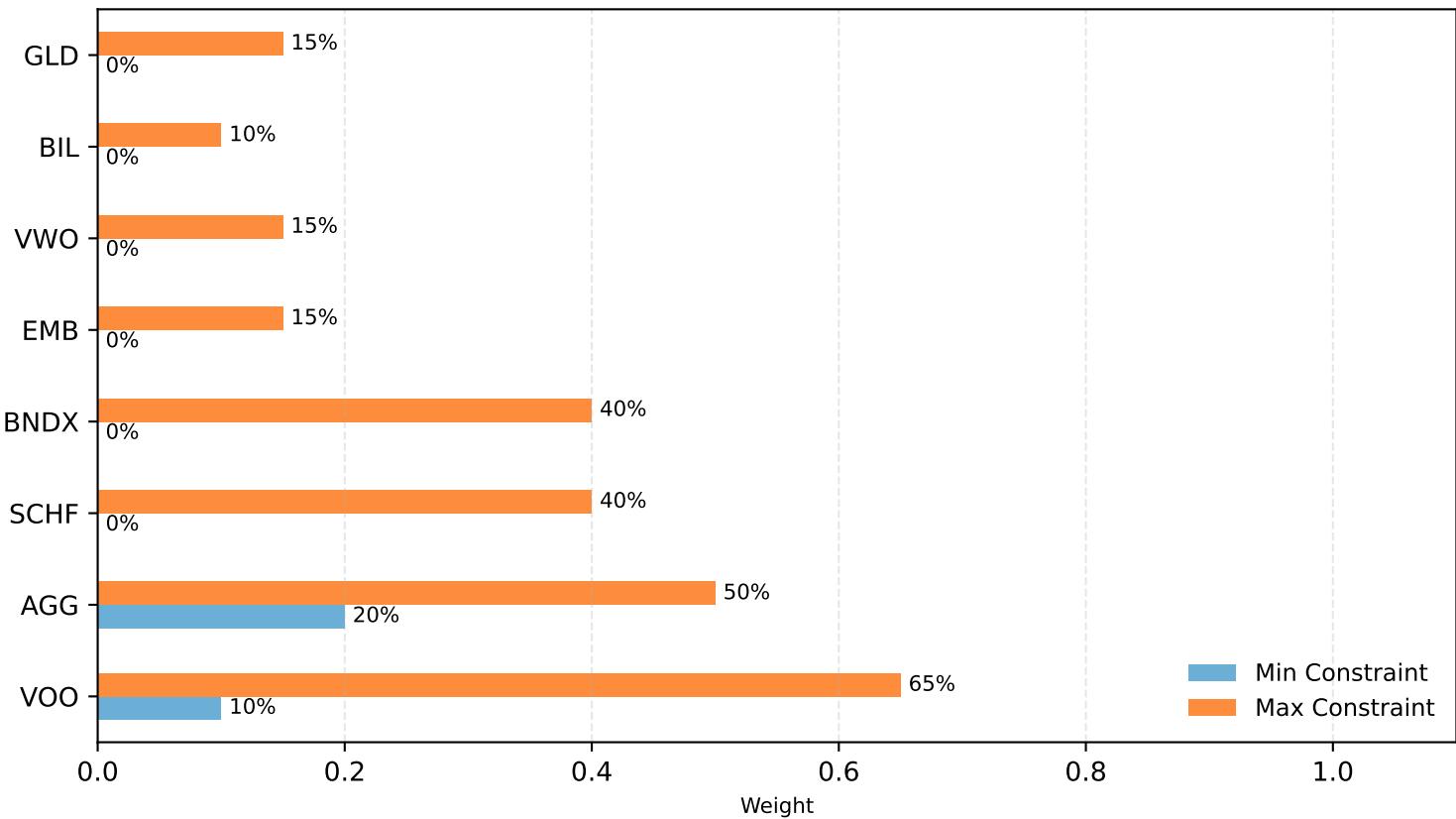
# Portfolio Optimization Summary

## 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

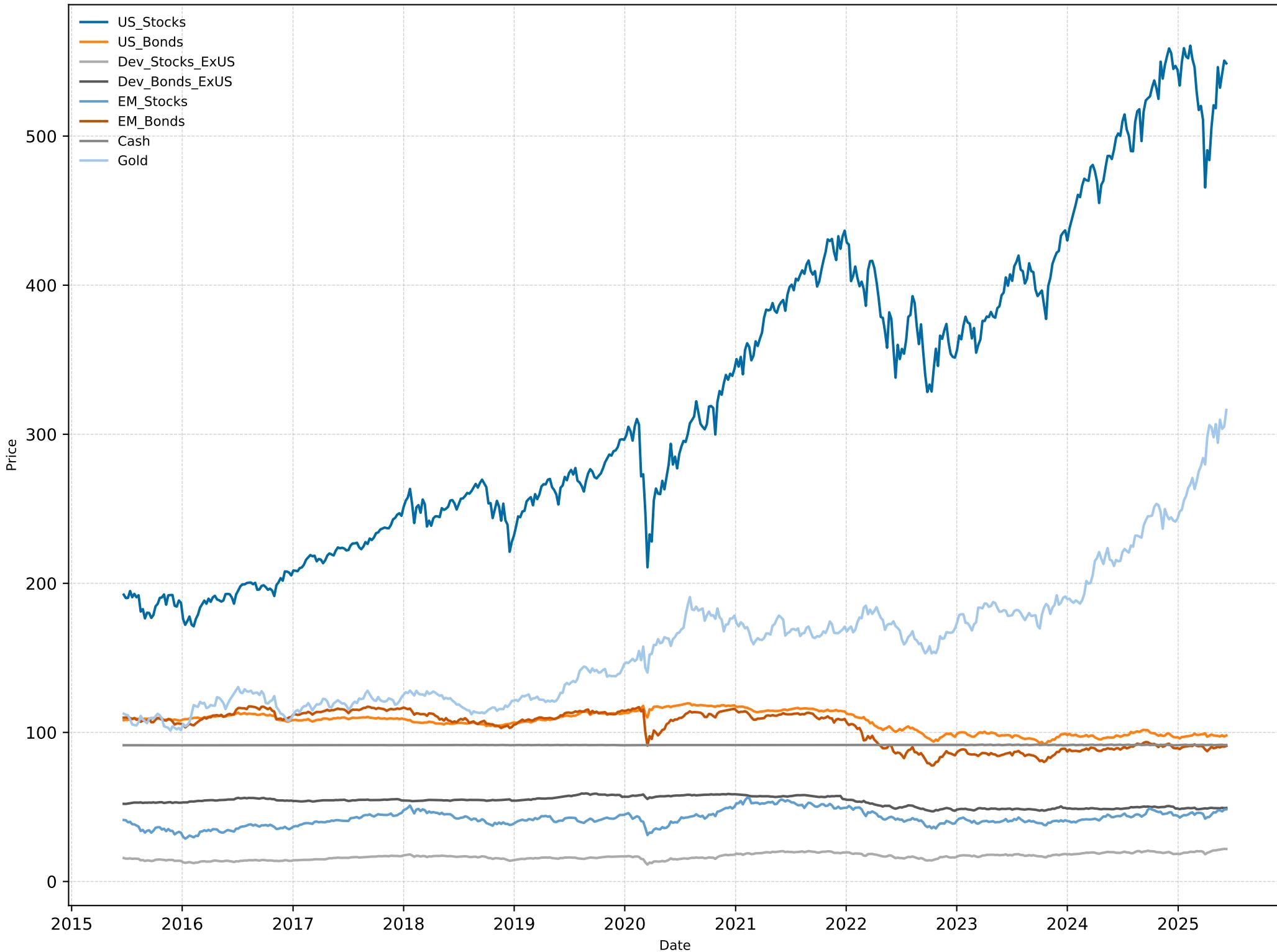
Asset Class	Ticker
US_Stocks	VOO
US_Bonds	AGG
Dev_Stocks_ExUS	SCHF
Dev_Bonds_ExUS	BNDX
EM_Stocks	VWO
EM_Bonds	EMB
Cash	BIL
Gold	GLD

## Asset Allocation Constraints

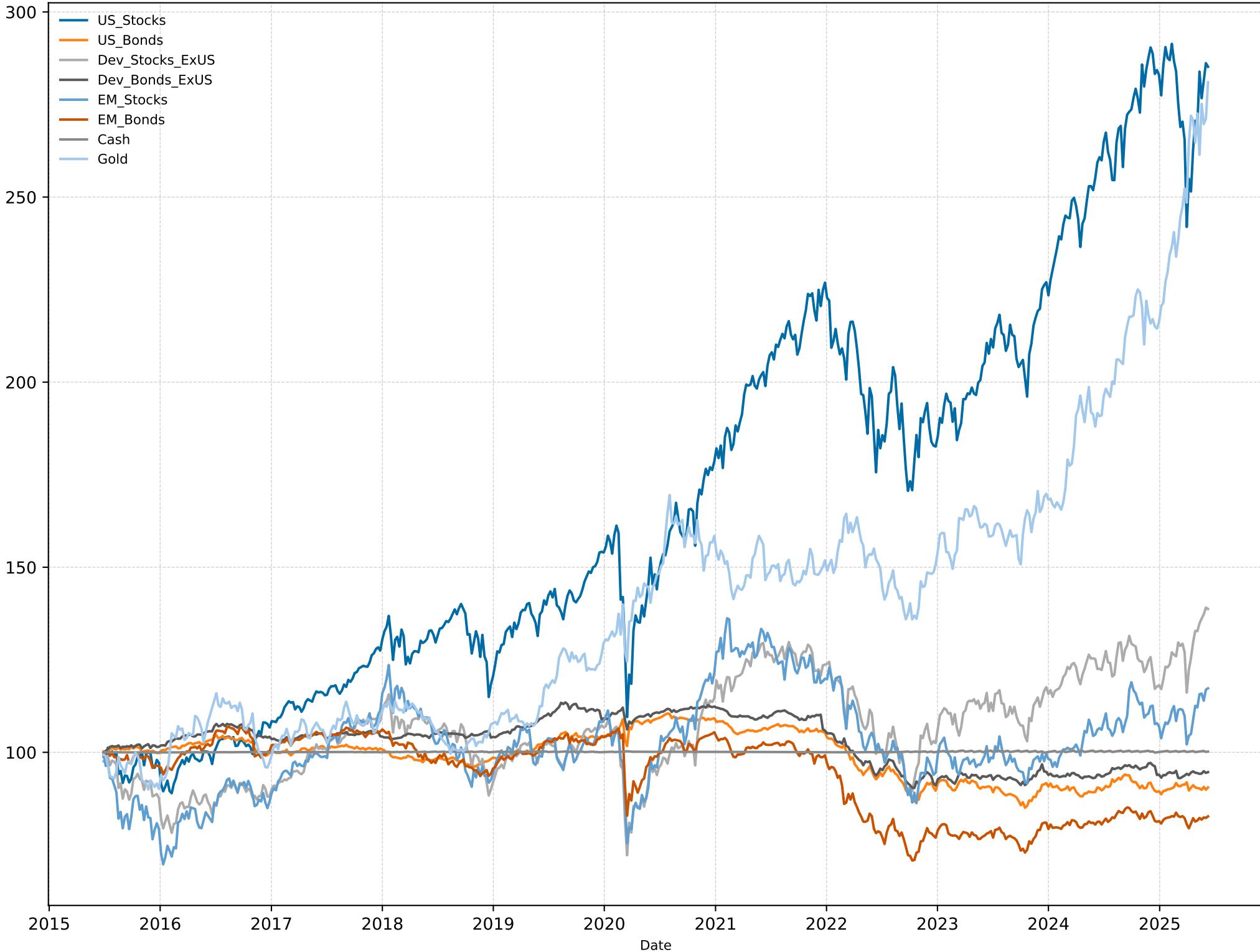


Note: All weights and constraints shown as decimal (0.10 = 10%)

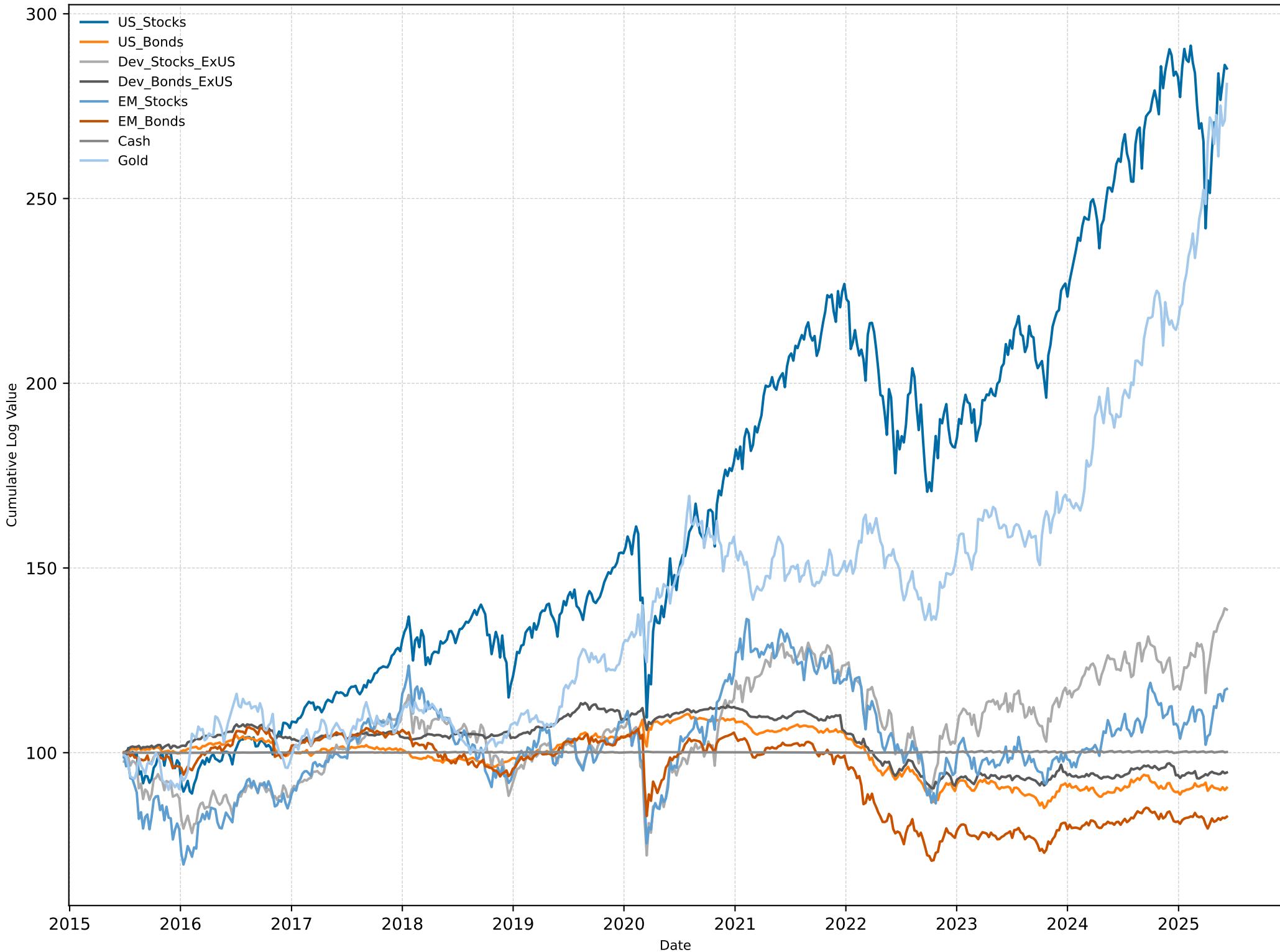
# 10-Year Weekly Prices of ETF Proxies



## Cumulative Returns of Assets (Base = 100)



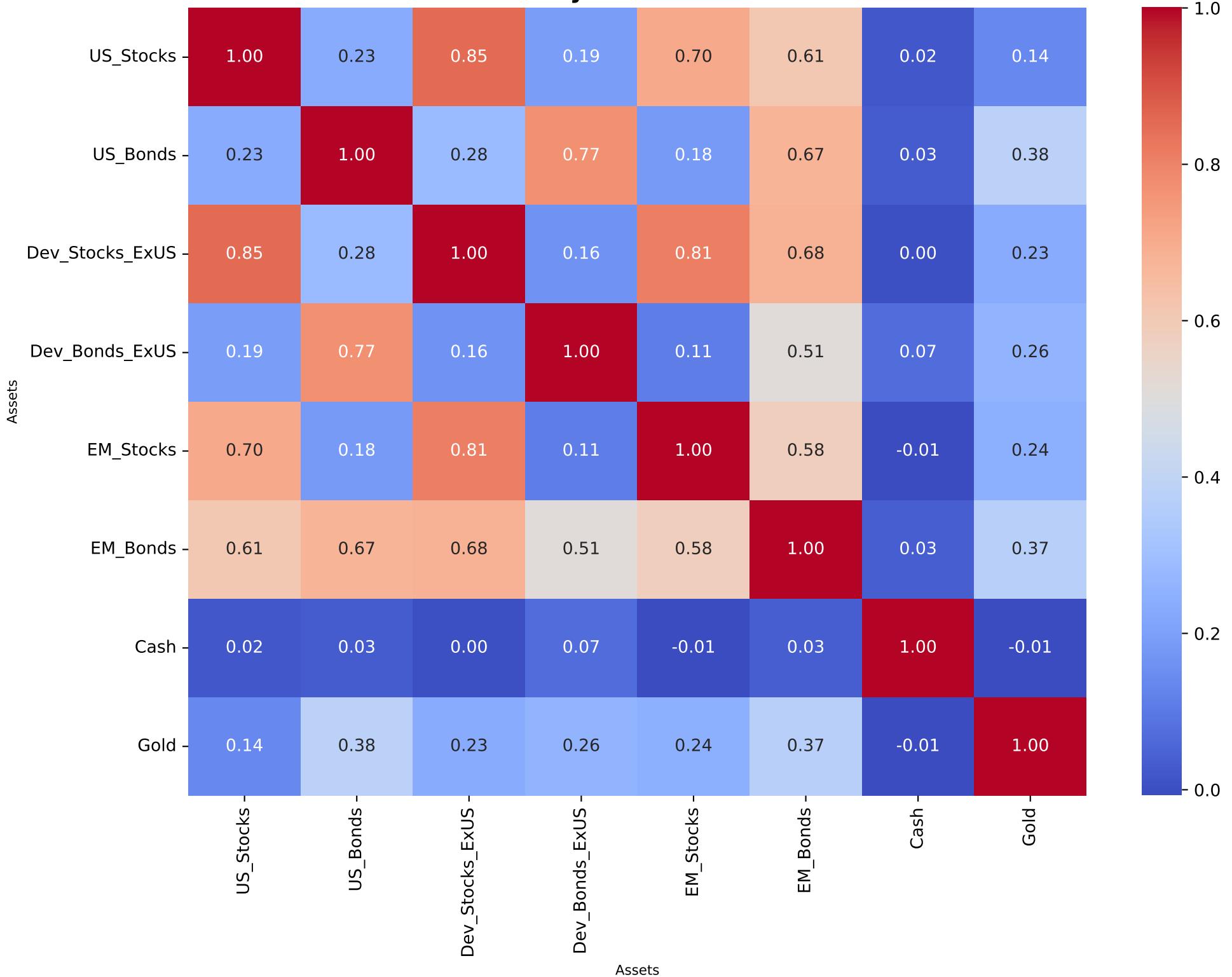
# Cumulative Log Returns of Assets (Base = 100)



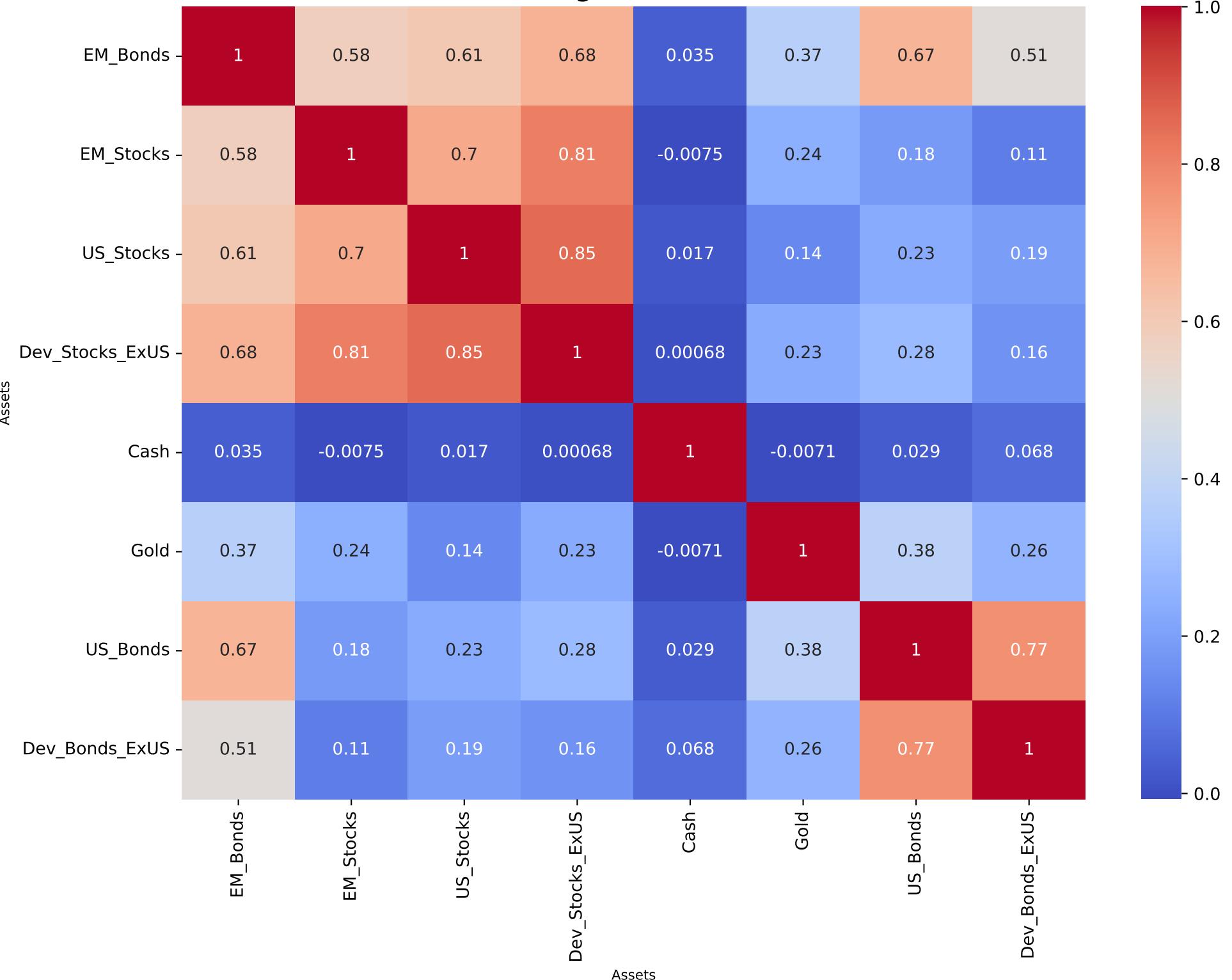
## Descriptive Statistics of Weekly Returns (Annualized Where Applicable)

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%

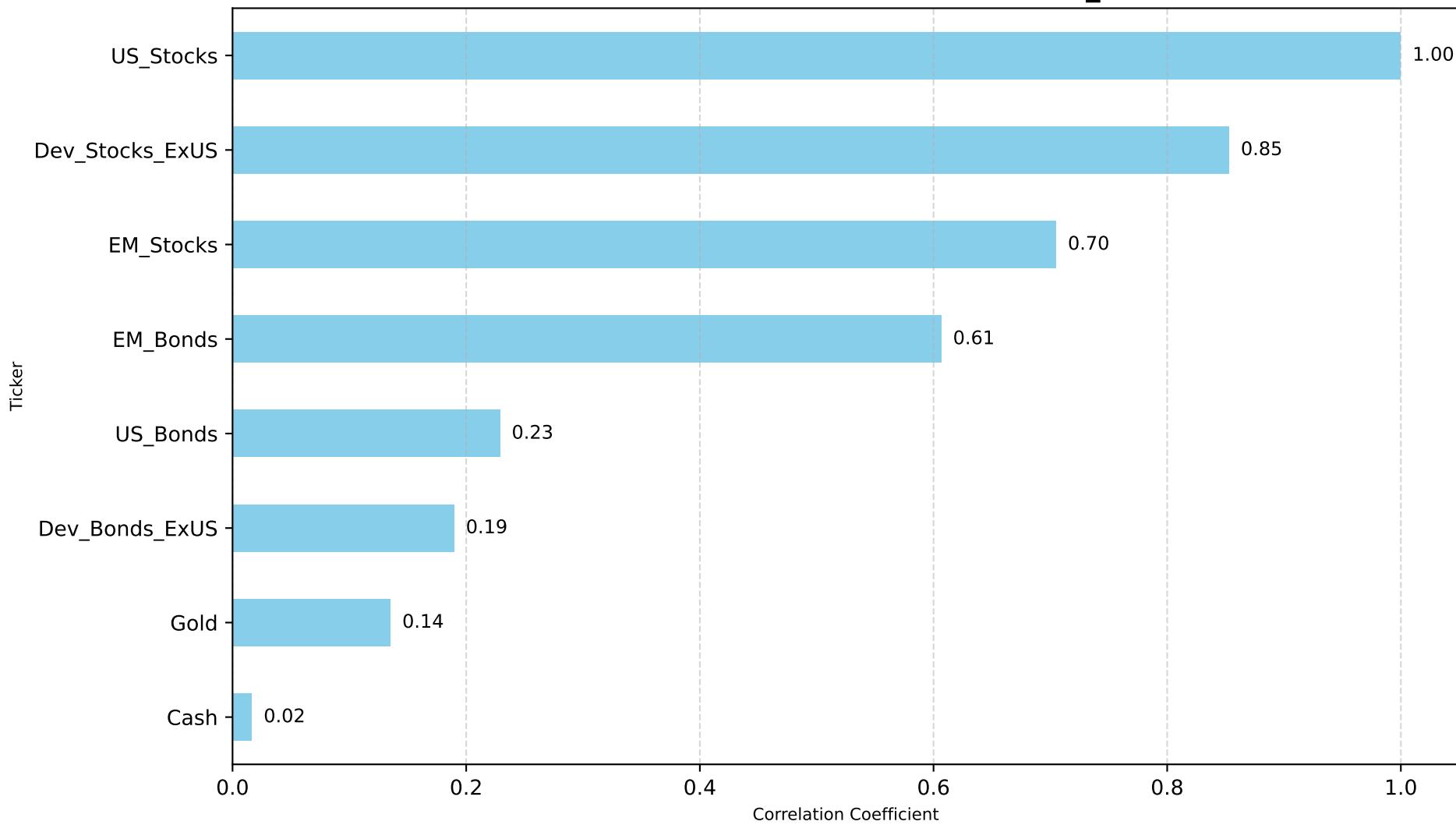
## ETF Weekly Return Correlation



## Hierarchical Clustering of Asset Returns Correlation



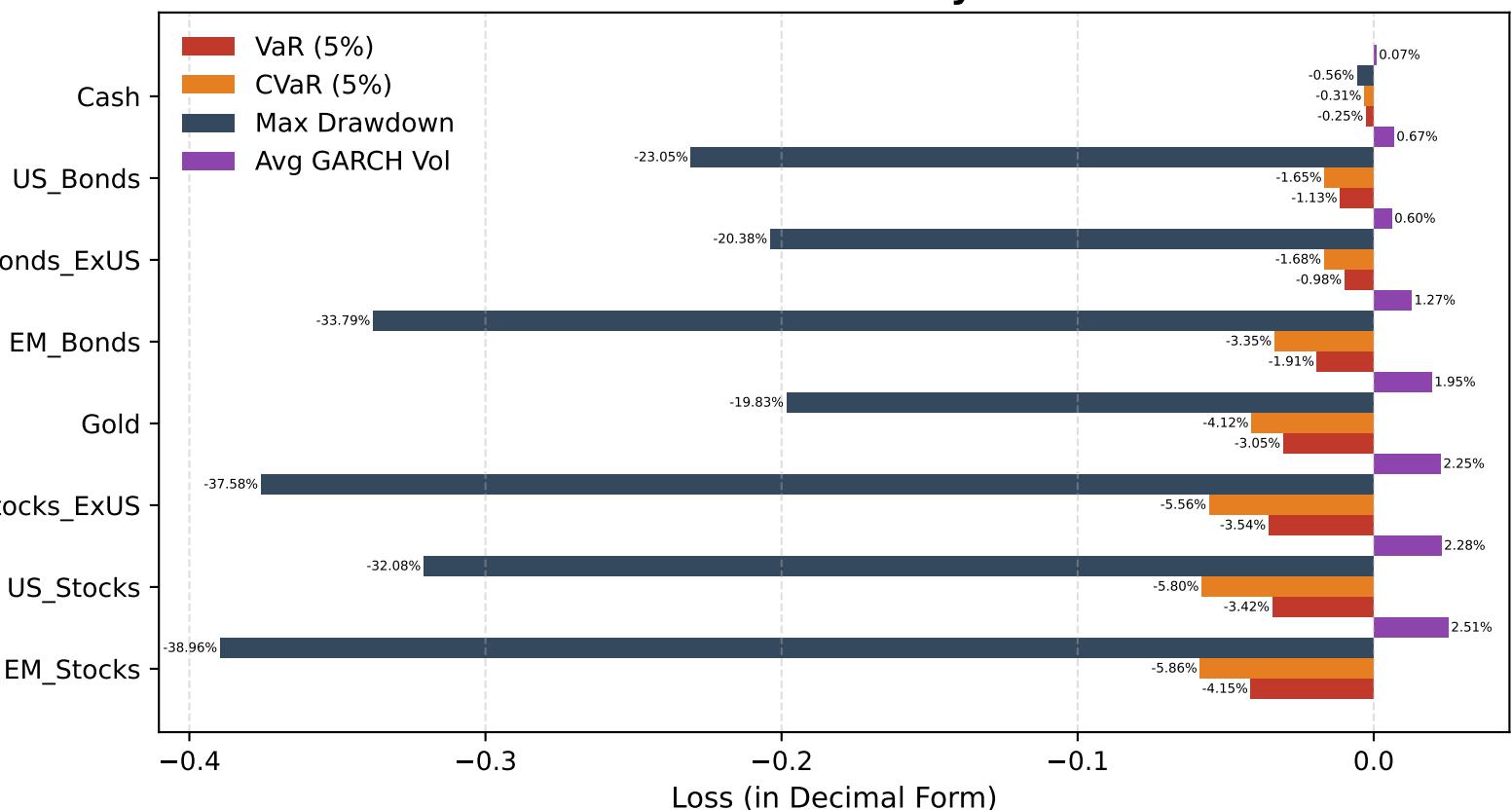
## Correlation of Asset Returns with US\_Stocks



## Downside and Tail Risk Statistics by Asset Class

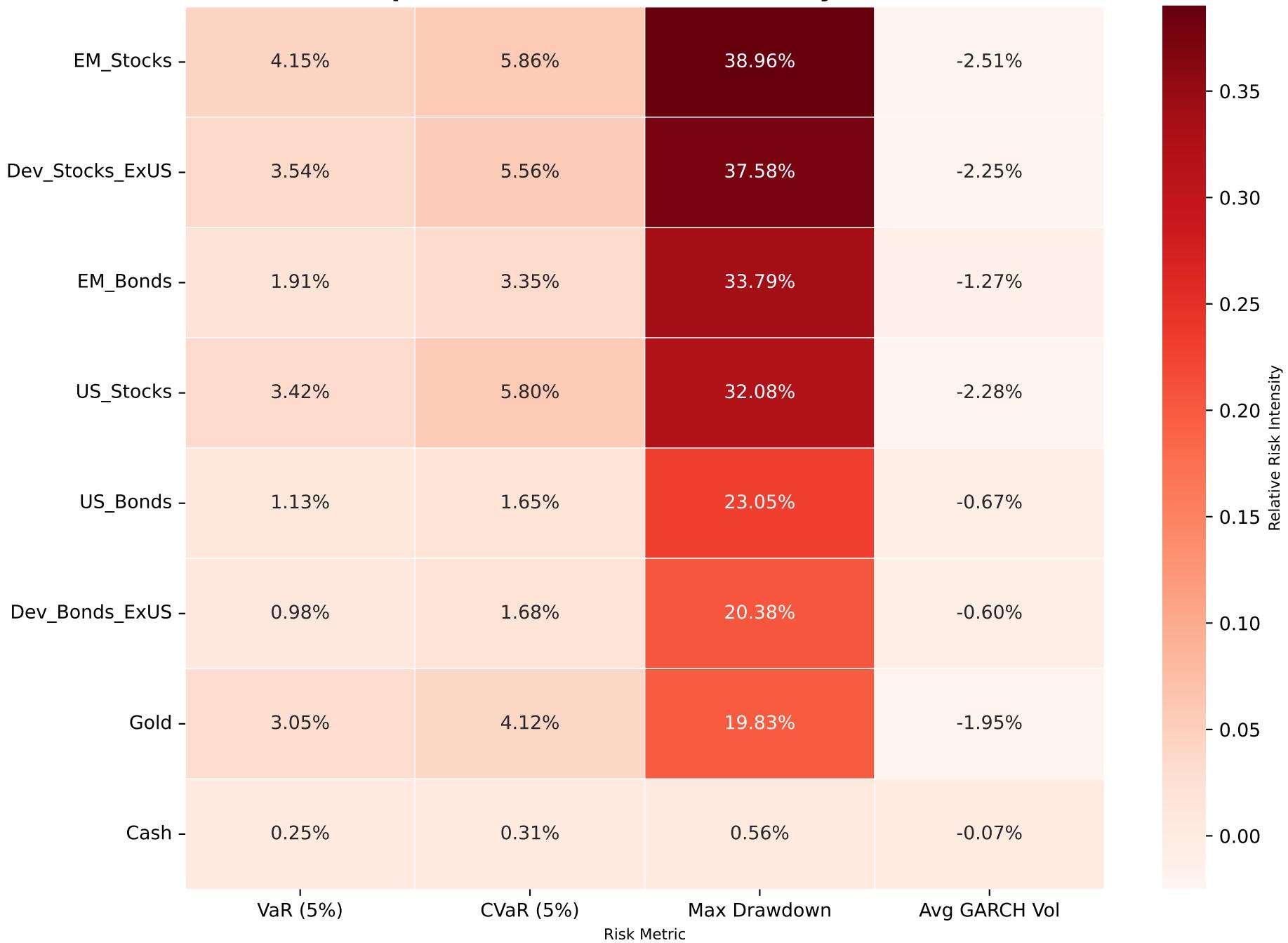
Asset Class	VaR (5%)	CVaR (5%)	Max Drawdown	Beta (vs US_Stocks)	Avg GARCH Vol
US_Stocks	-3.42%	-5.80%	-32.08%	1.00	2.28%
US_Bonds	-1.13%	-1.65%	-23.05%	0.07	0.67%
Dev_Stocks_ExUS	-3.54%	-5.56%	-37.58%	0.84	2.25%
Dev_Bonds_ExUS	-0.98%	-1.68%	-20.38%	0.05	0.60%
EM_Stocks	-4.15%	-5.86%	-38.96%	0.76	2.51%
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%

## Downside Risk Metrics by Asset Class



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



## Top Drawdowns by Asset Class

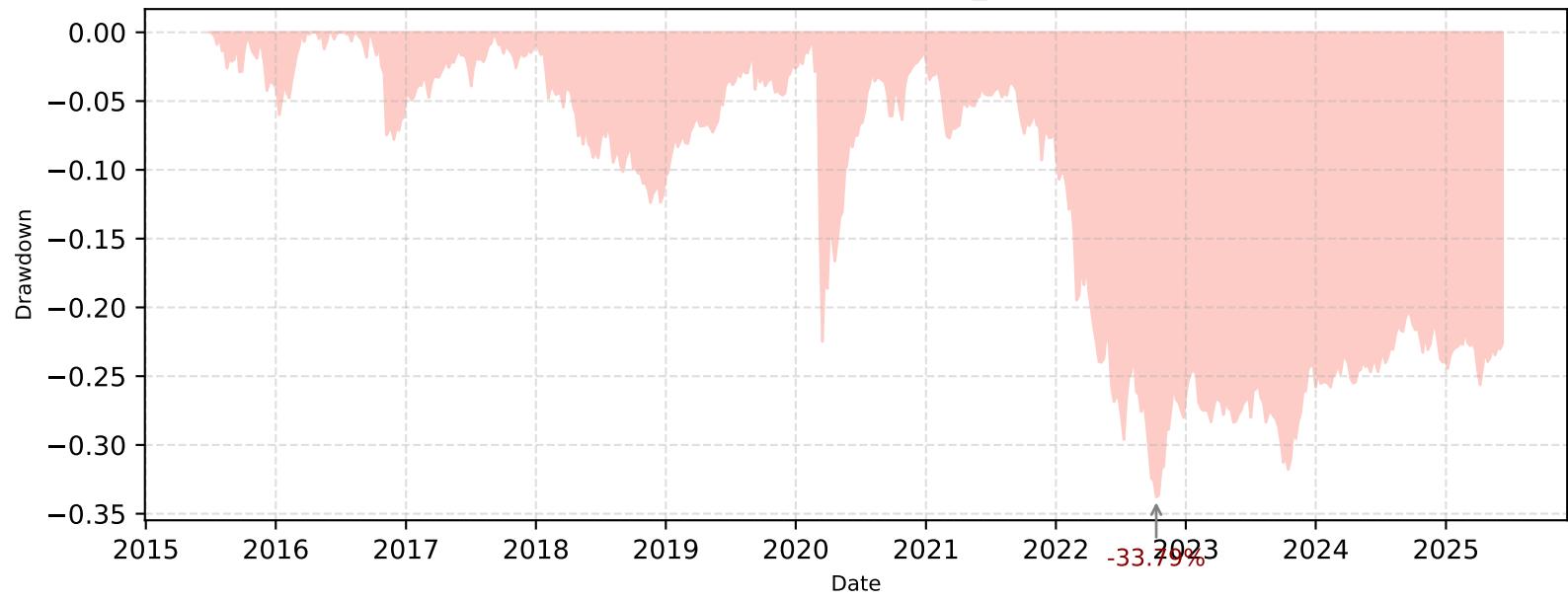
### Drawdown Curve: EM\_Stocks



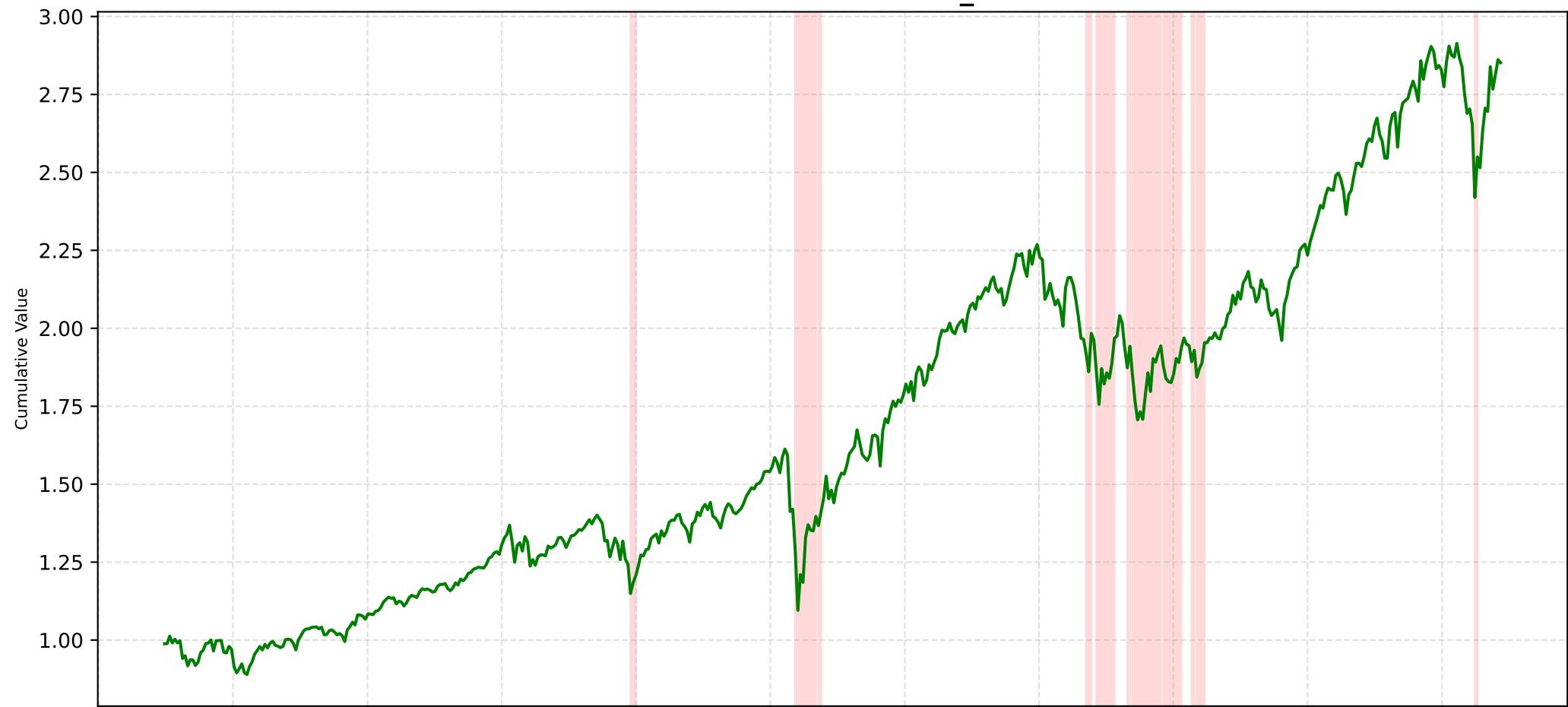
### Drawdown Curve: Dev\_Stocks\_ExUS



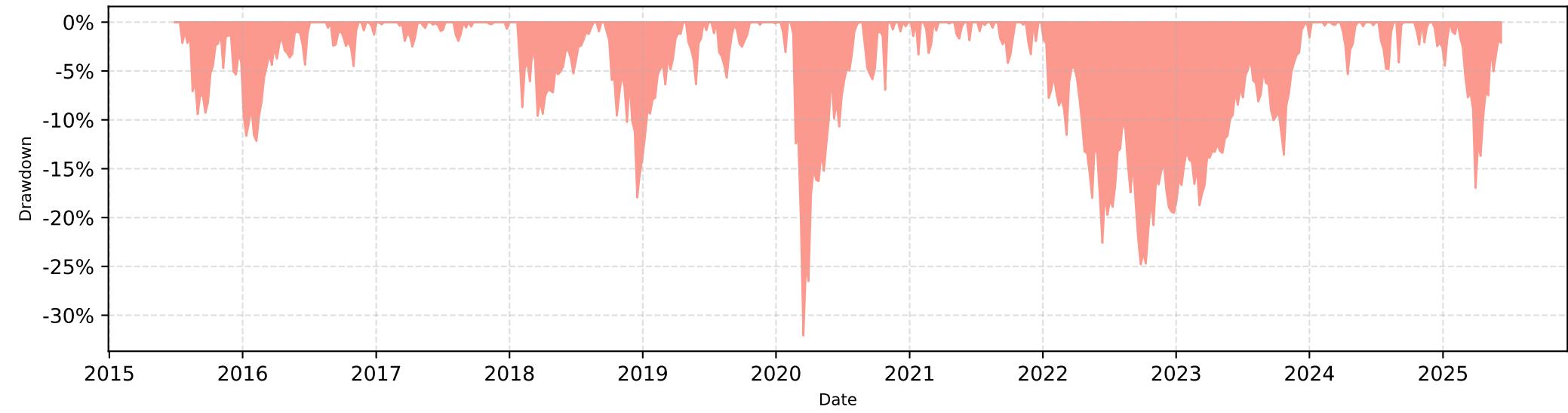
### Drawdown Curve: EM\_Bonds



## Cumulative Return - US\_Stocks



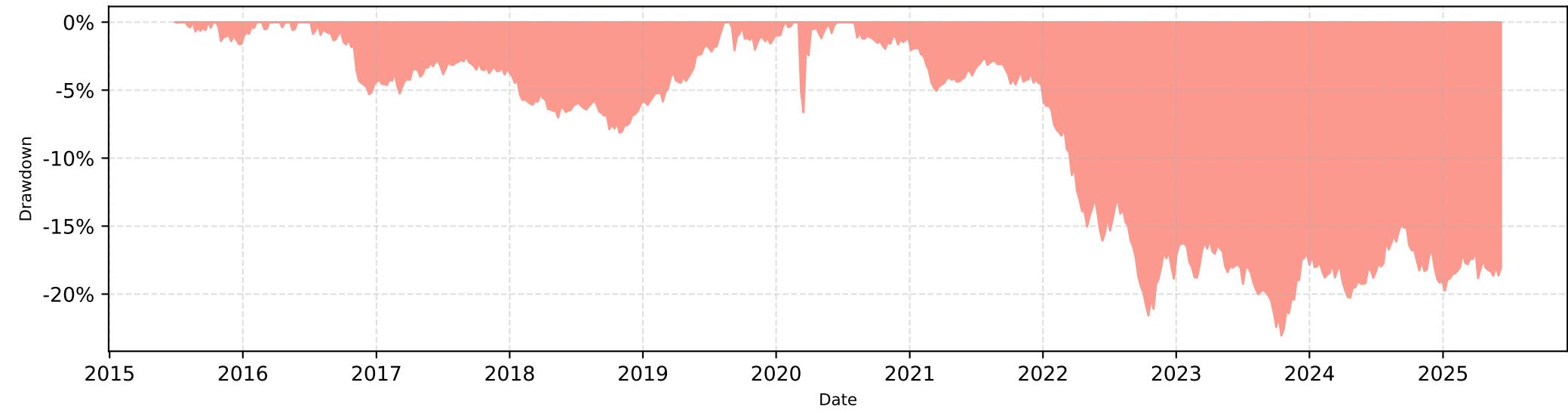
## Drawdown Curve



## Cumulative Return - US\_Bonds



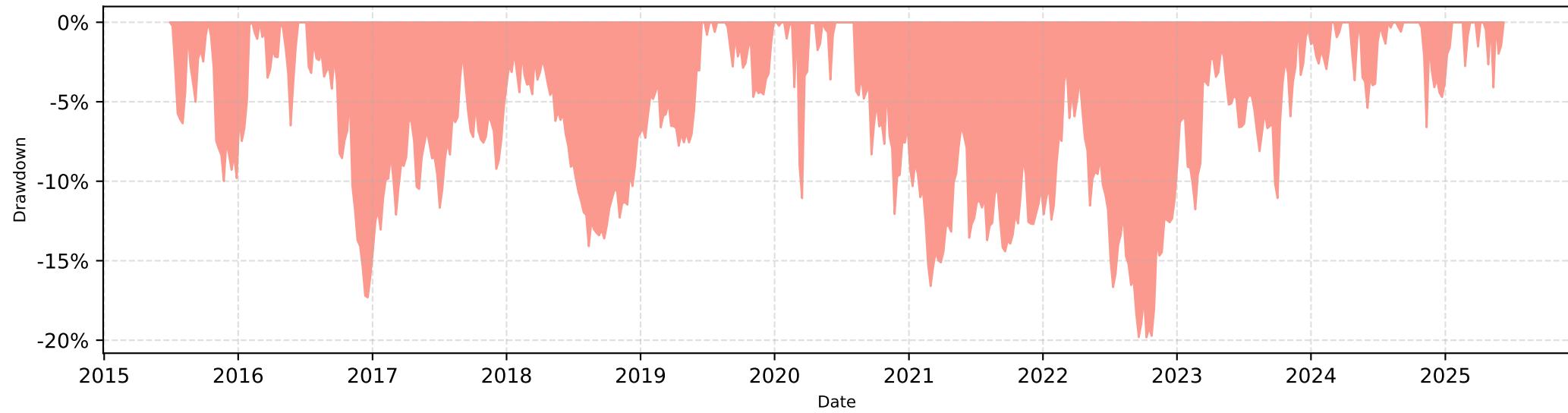
## Drawdown Curve



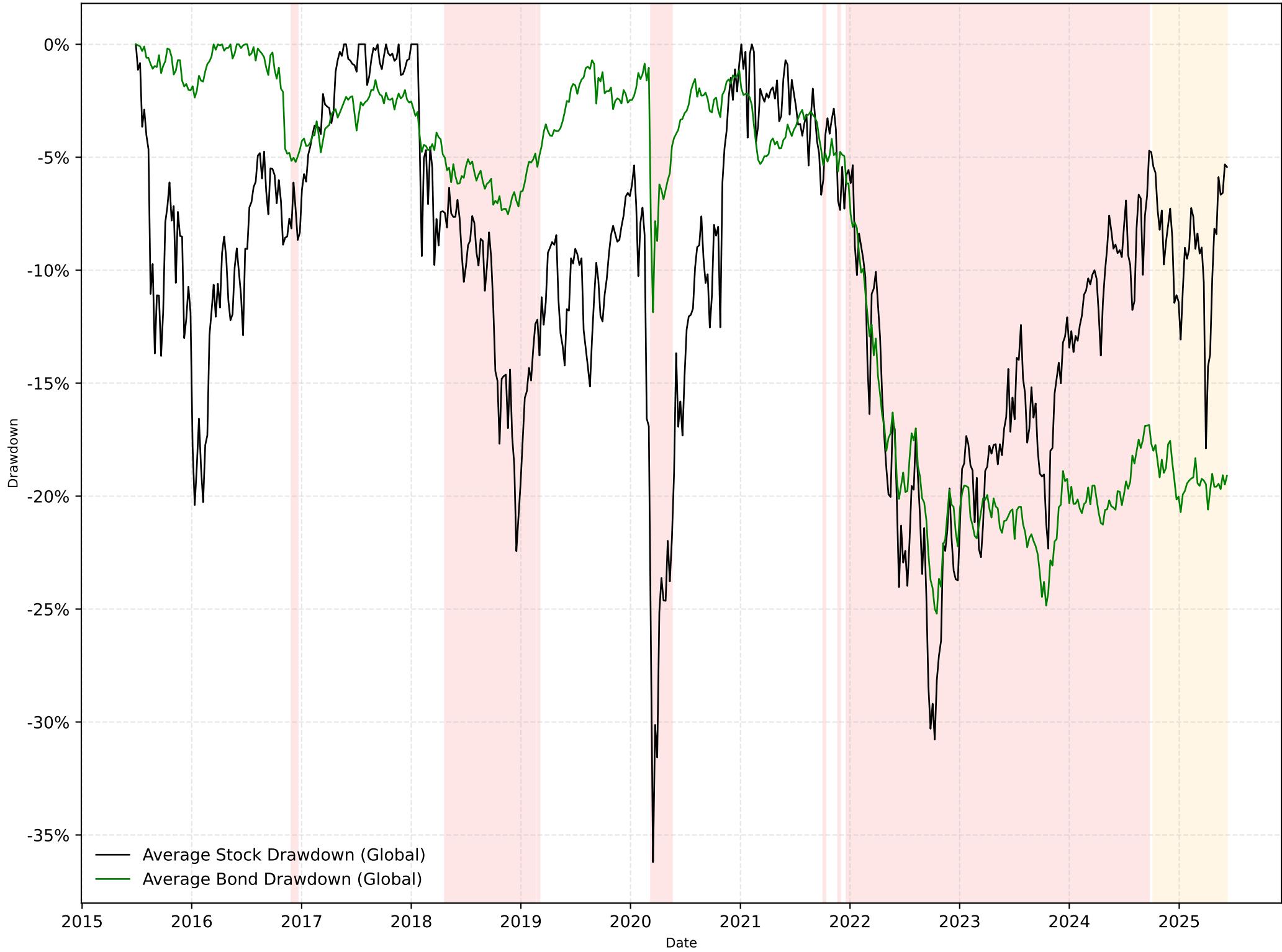
## Cumulative Return - Dev\_Bonds\_ExUS



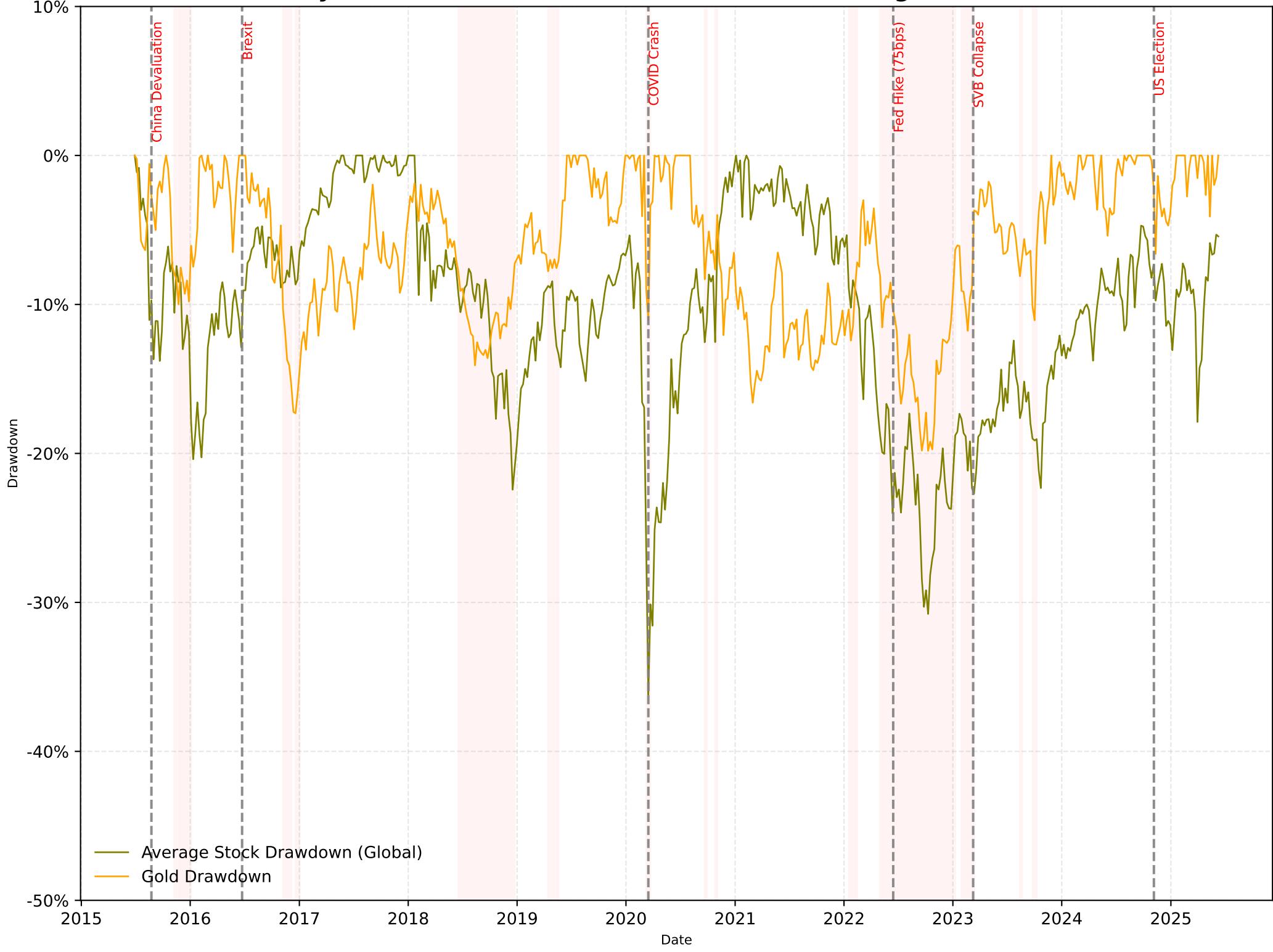
## Drawdown Curve



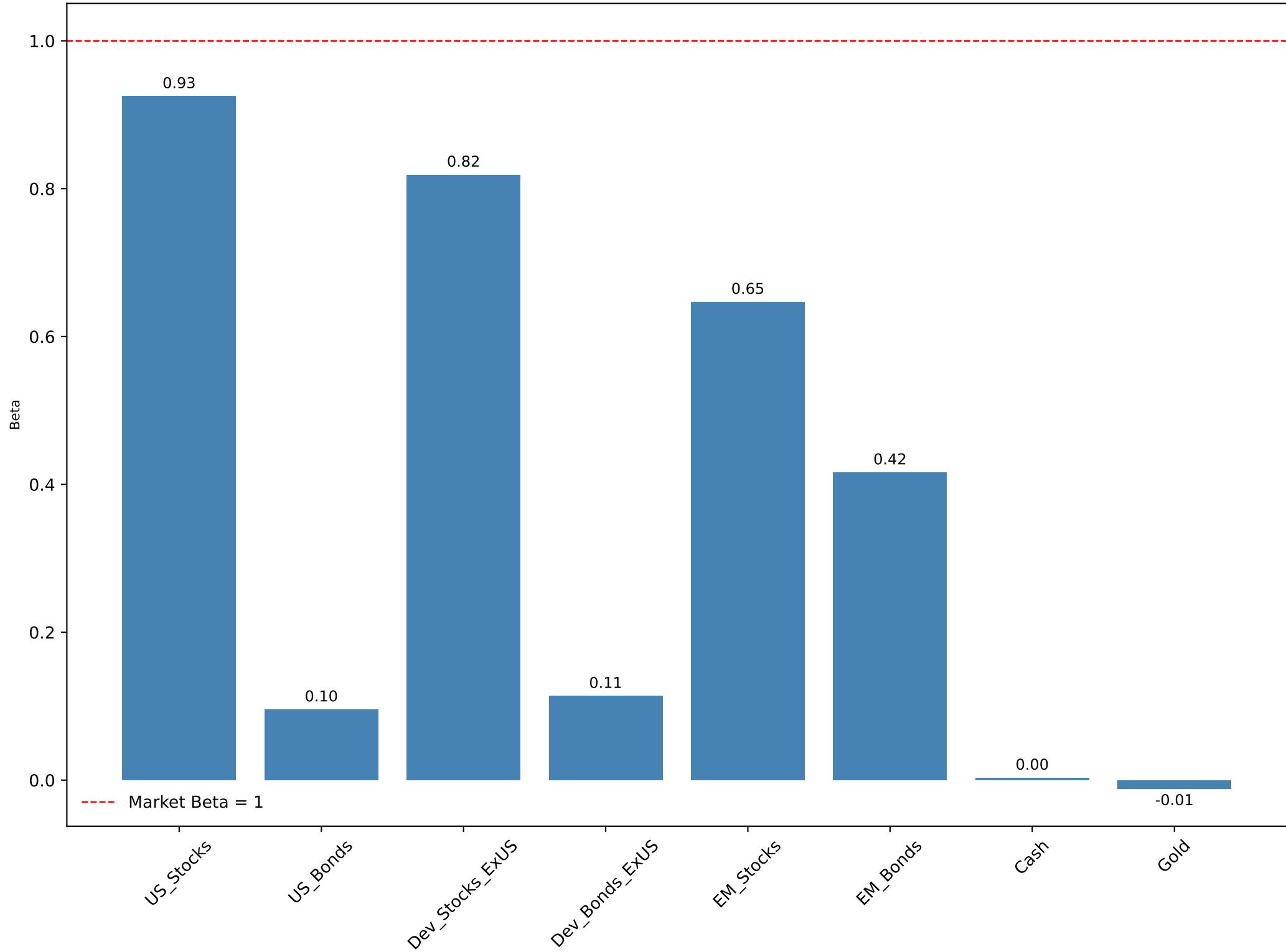
## Synchronized Drawdowns: Stocks vs Bonds



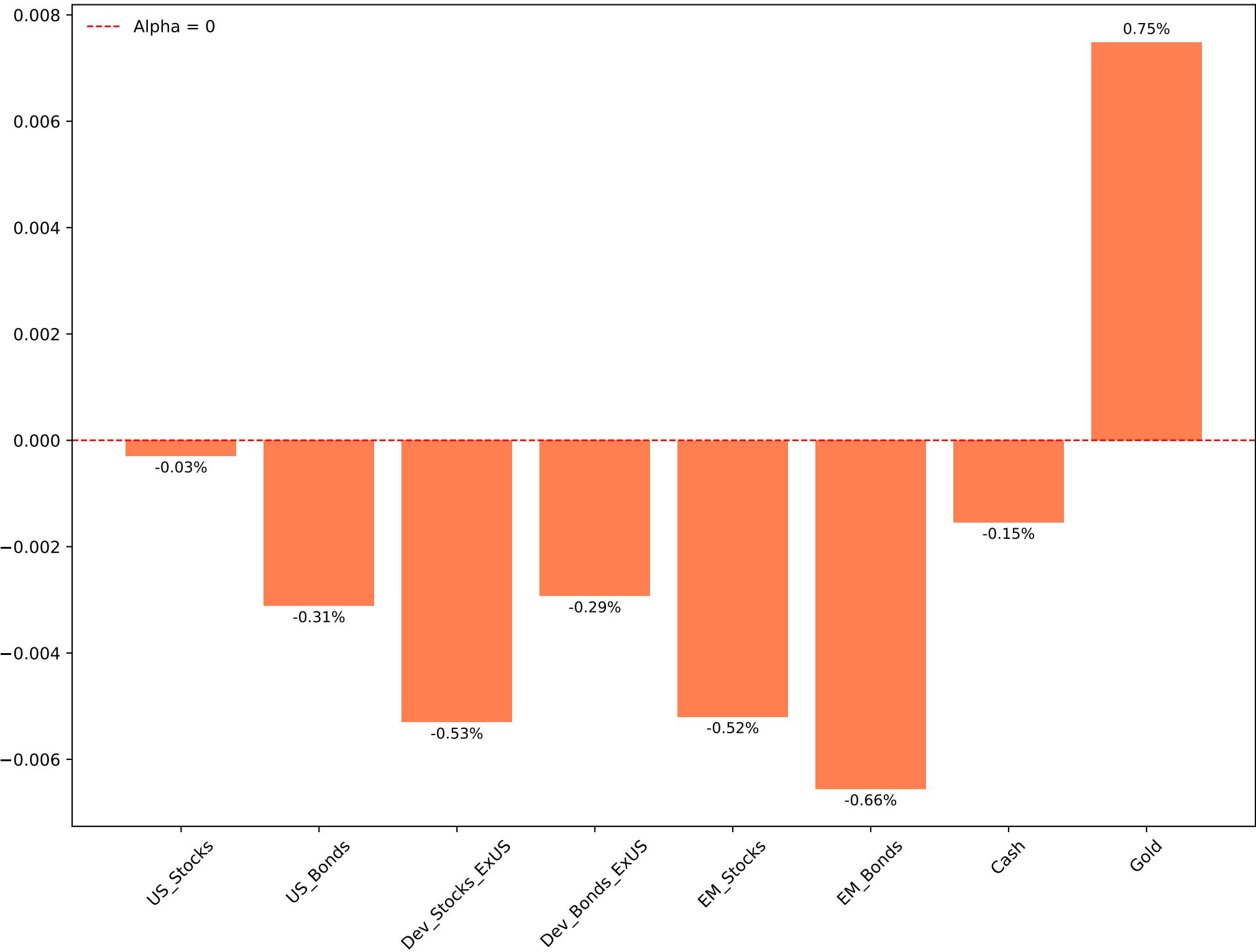
# Synchronized Drawdowns: Stocks vs Gold (Regime Shift?)



## CAPM Beta (vs. Fama-French Market Factor)

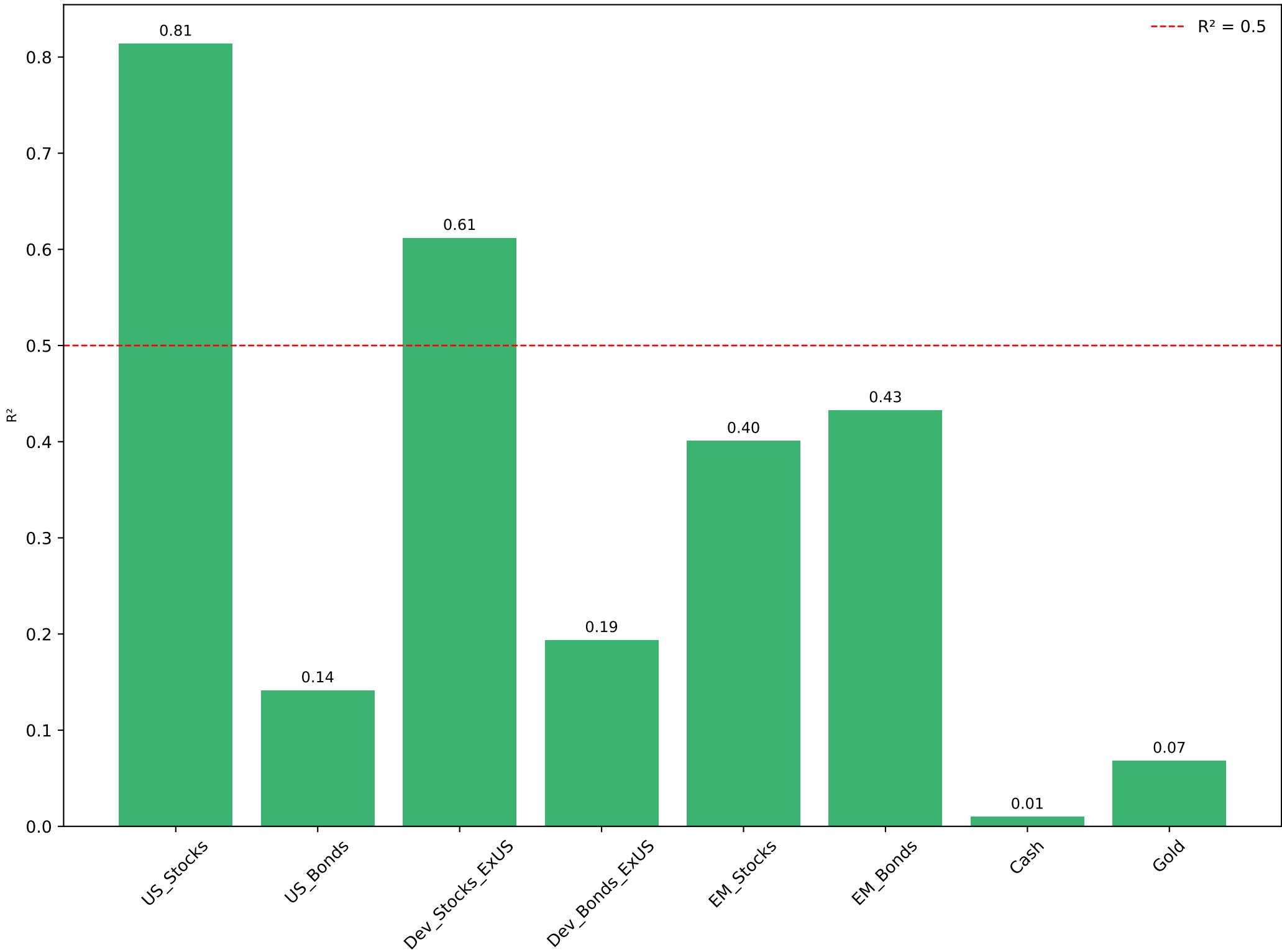


## CAPM Alpha (vs. Fama-French Market Factor)



## Multi-Factor Model R<sup>2</sup>

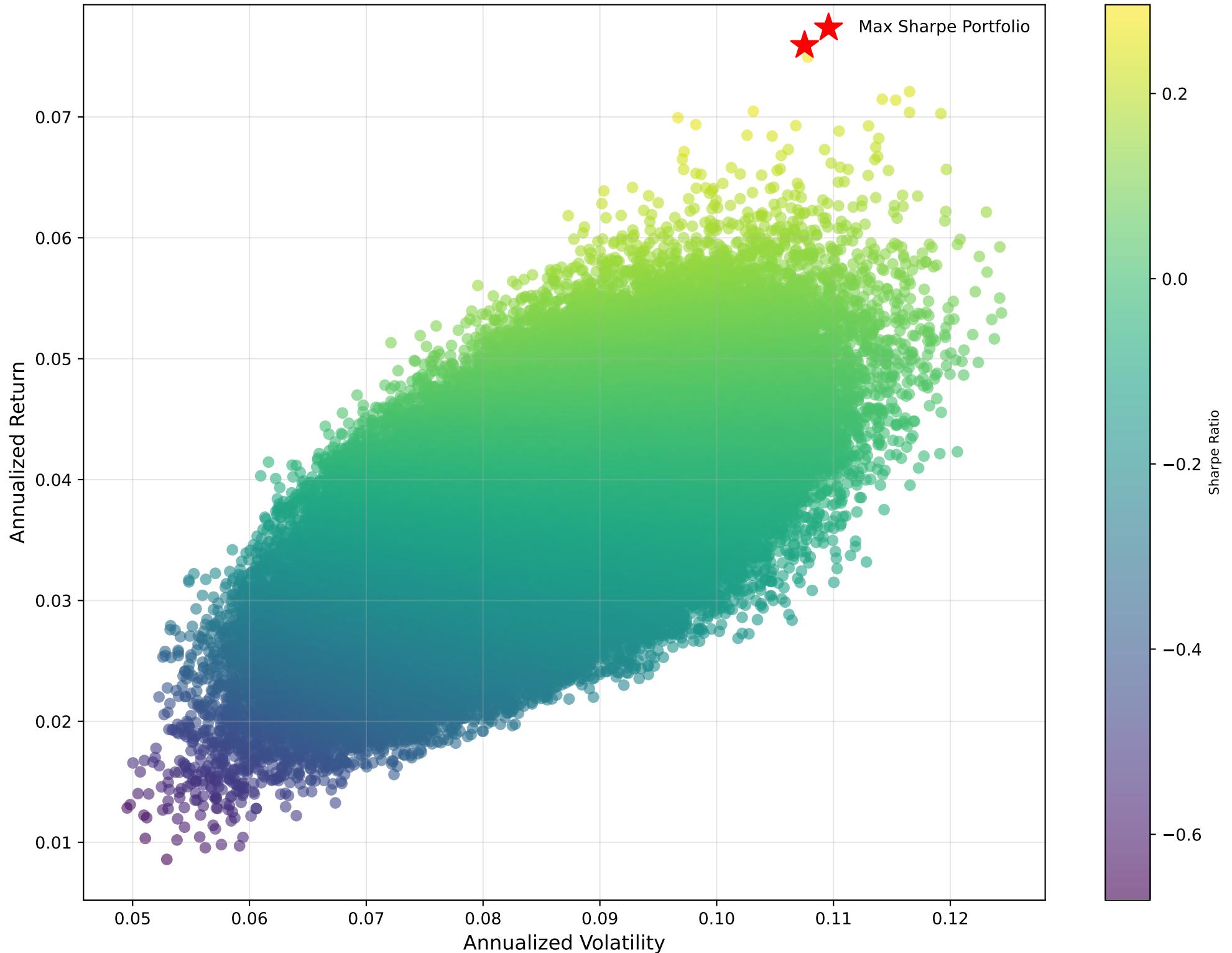
R<sup>2</sup> = 0.5



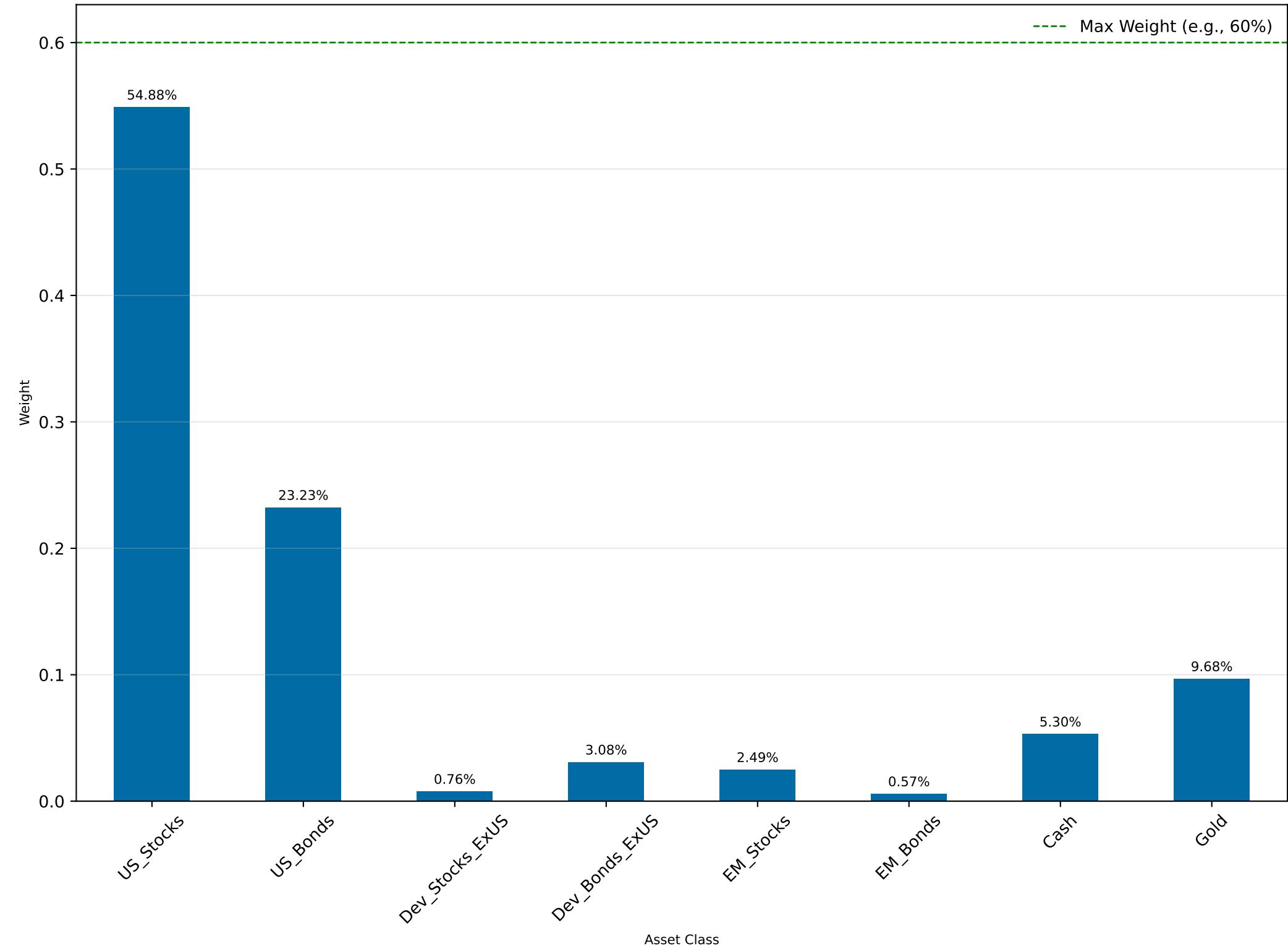
# CAPM & Multi-Factor Regression Summary

Asset Class	CAPM Beta	CAPM Alpha	MFC R <sup>2</sup>
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

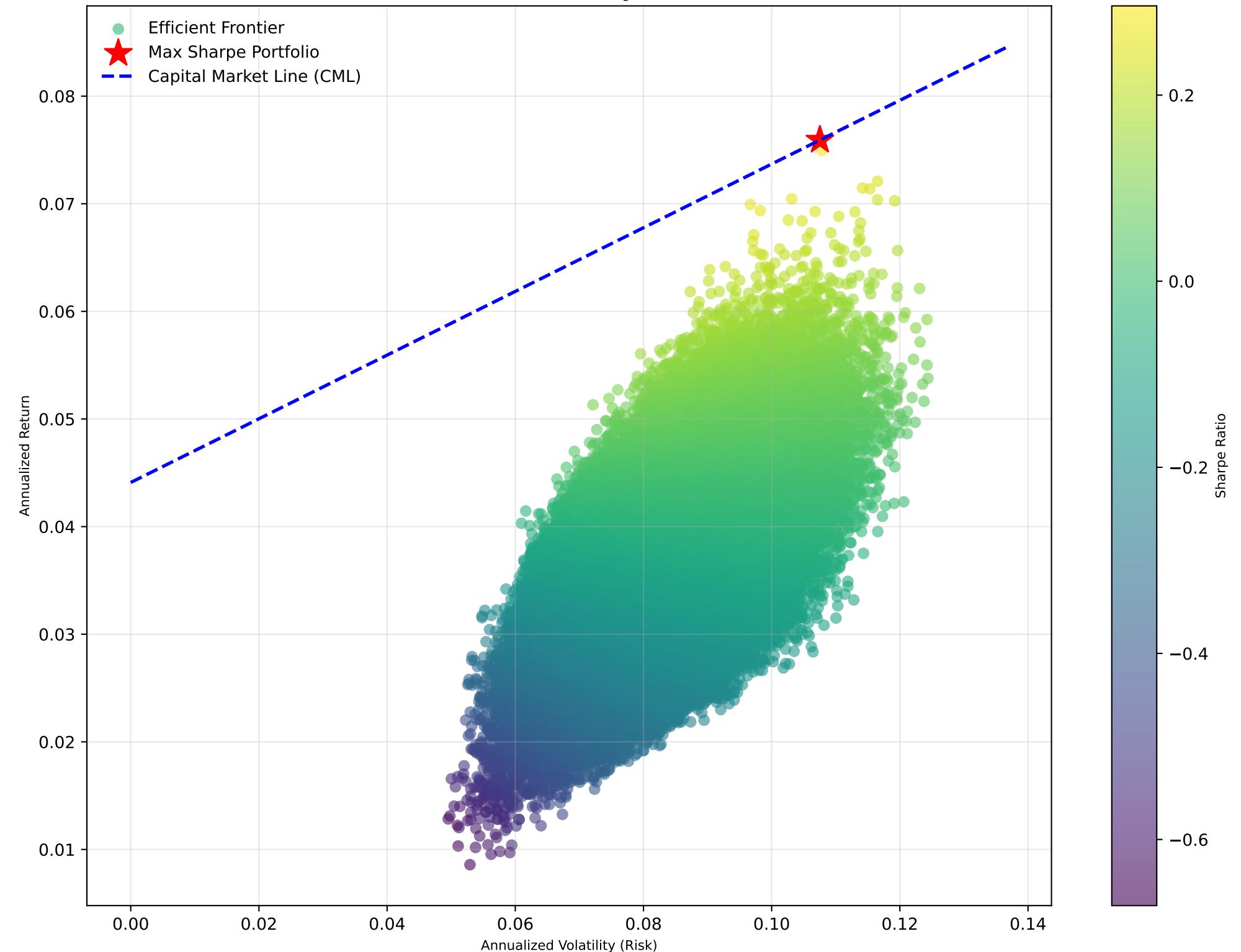
## Efficient Frontier with Constraints



## Optimal Portfolio Allocation



# Efficient Frontier with Capital Market Line



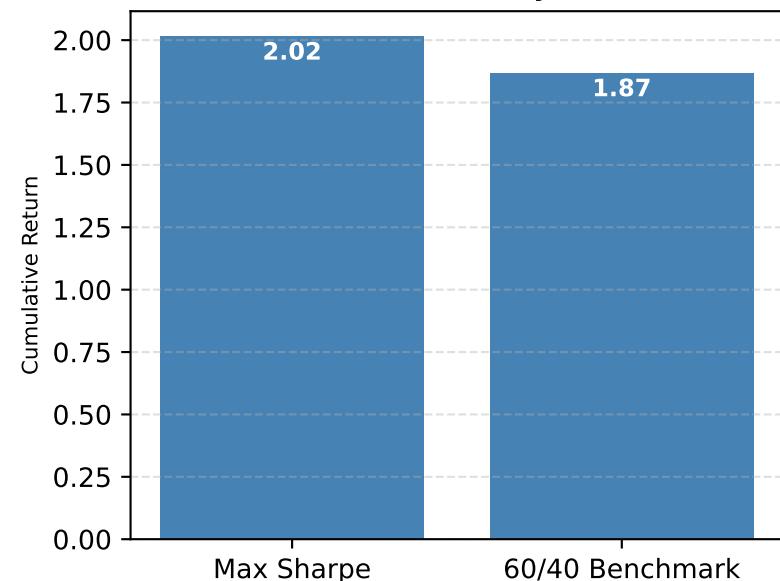
## Comparison of Optimal and Minimum Variance Portfolios with Constraints

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

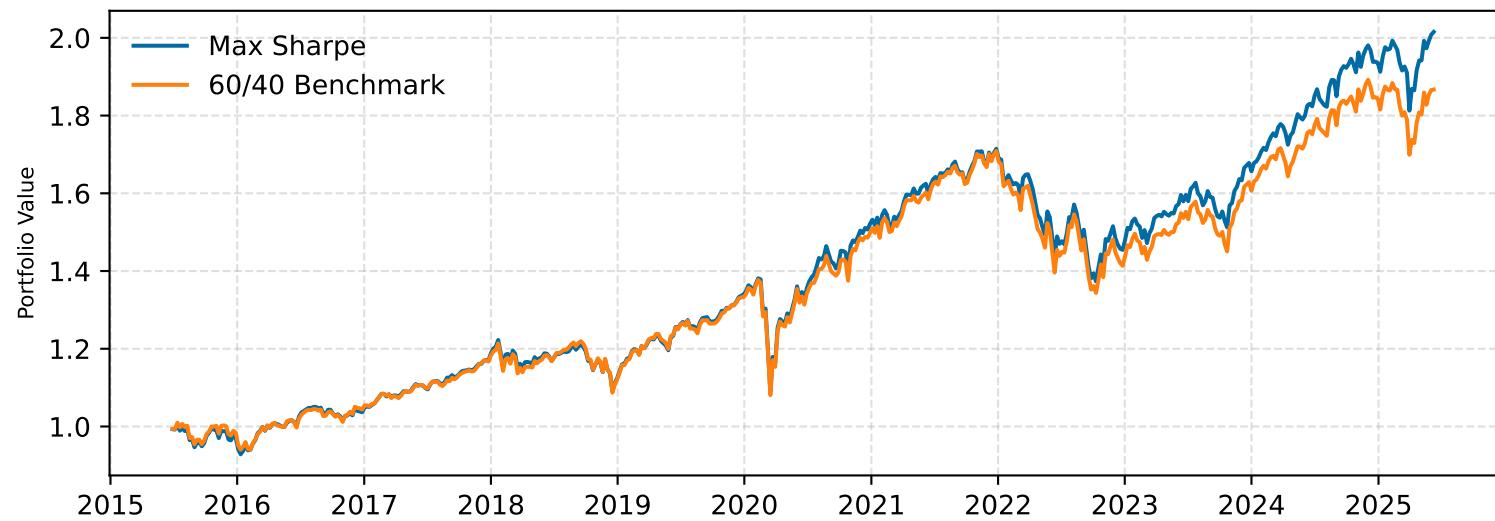
# Backtest Performance Summary

## Cumulative Return by Portfolio

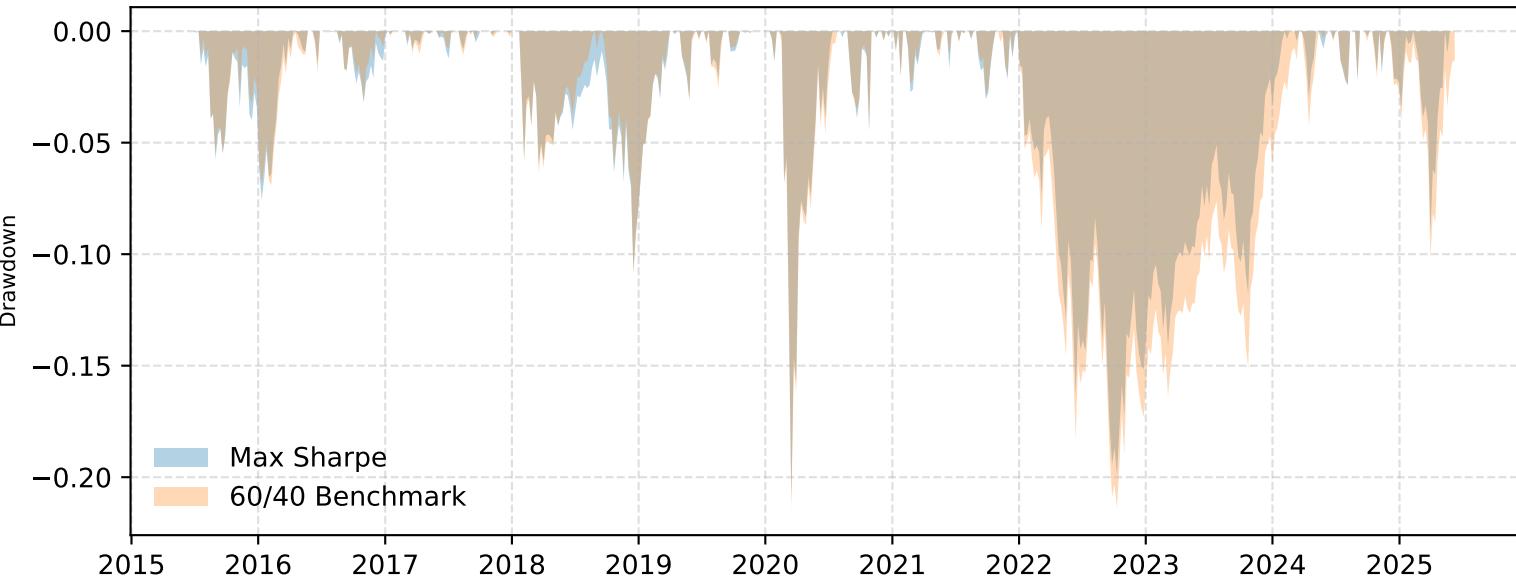


Metric	Max Sharpe	60/40 Benchmark
Cumulative Return	1.0152	0.8671
Annualized Return	0.0759	0.0686
Annualized Volatility	0.1075	0.1109
Sharpe Ratio	0.2959	0.2213
Sortino Ratio	0.3716	0.2775
Max Drawdown	-0.2103	-0.2152

## Cumulative Return Over Time



## Drawdown Curve



## Backtest Summary Statistics For Each Asset w/o Optimal Weight

Asset Class	Cumulative Return	Annualized Return	Annualized Volatility	Sharpe Ratio	Sortino Ratio	Max Drawdown
US_Stocks	1.8519	0.1201	0.1738	0.4375	0.5433	-0.3208
US_Bonds	-0.0947	-0.0086	0.0519	-1.0161	-1.3544	-0.2305
Dev_Stocks_ExUS	0.3872	0.0476	0.1721	0.0206	0.0269	-0.3758
Dev_Bonds_ExUS	-0.0534	-0.0045	0.0444	-1.0947	-1.2904	-0.2038
EM_Stocks	0.1728	0.0334	0.1863	-0.0575	-0.0811	-0.3896
EM_Bonds	-0.173	-0.0139	0.0999	-0.5809	-0.6461	-0.3379
Cash	0.002	0.0002	0.0066	-6.6405	-5.3716	-0.0056
Gold	1.81	0.1136	0.143	0.4862	0.7597	-0.1983