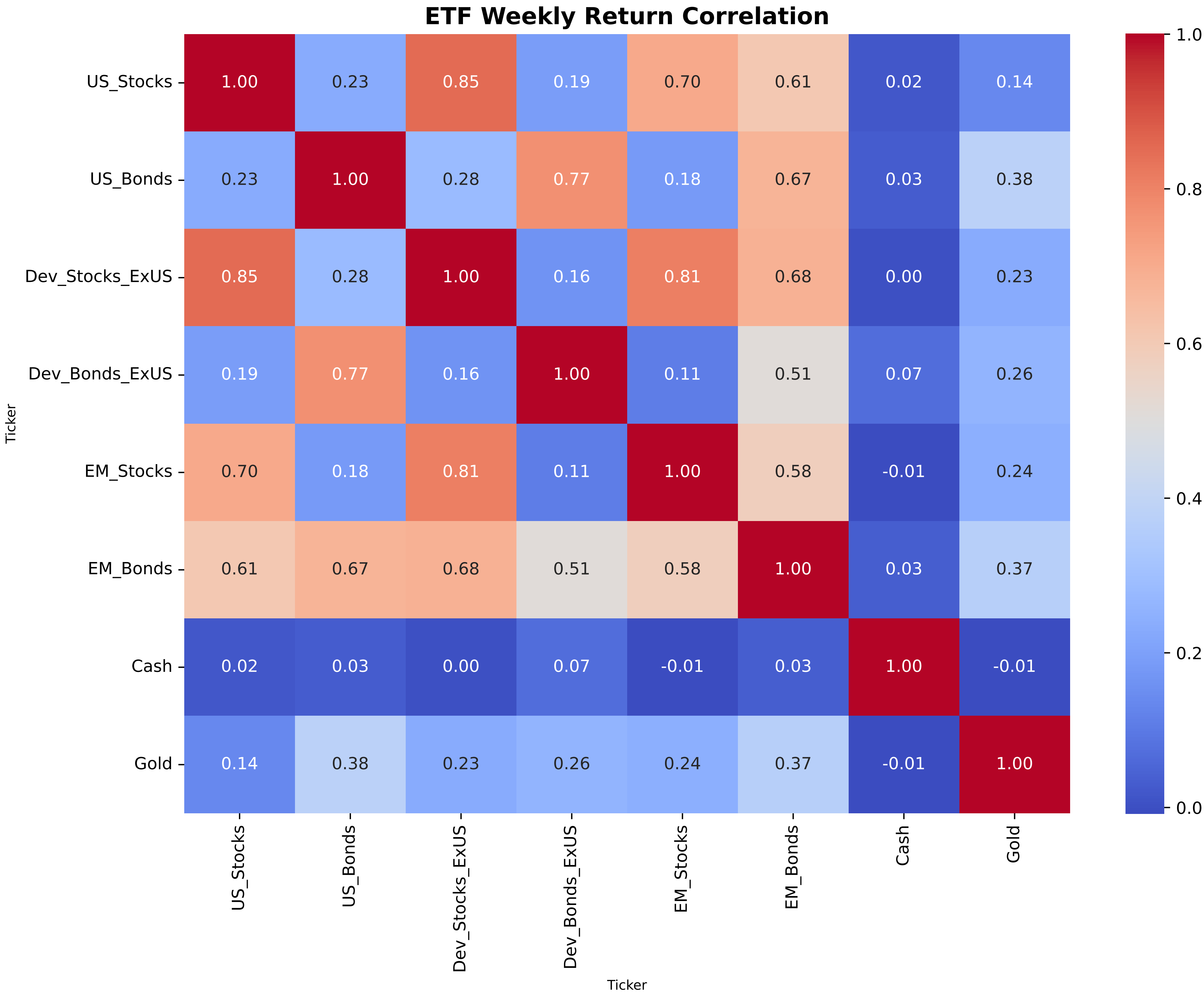
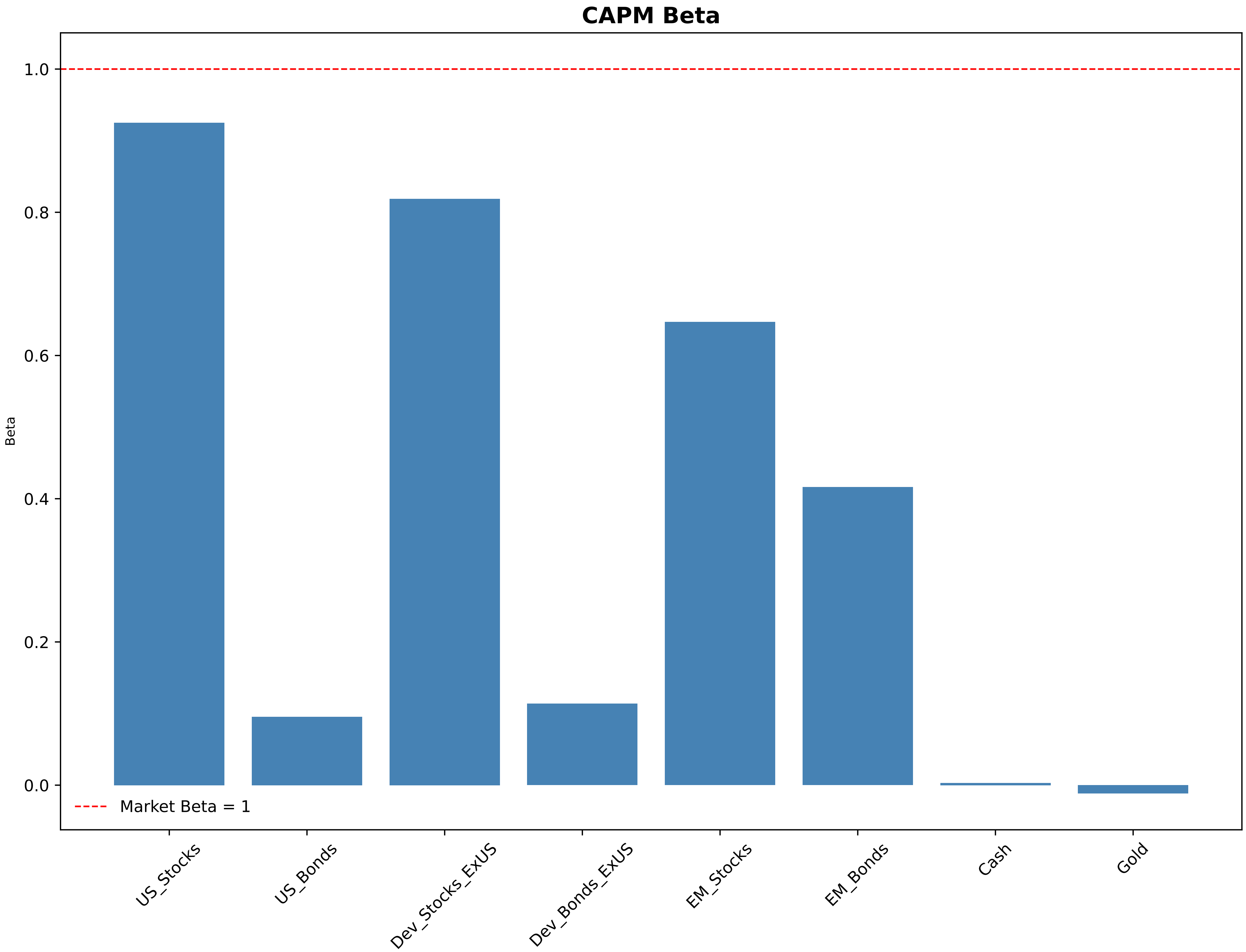
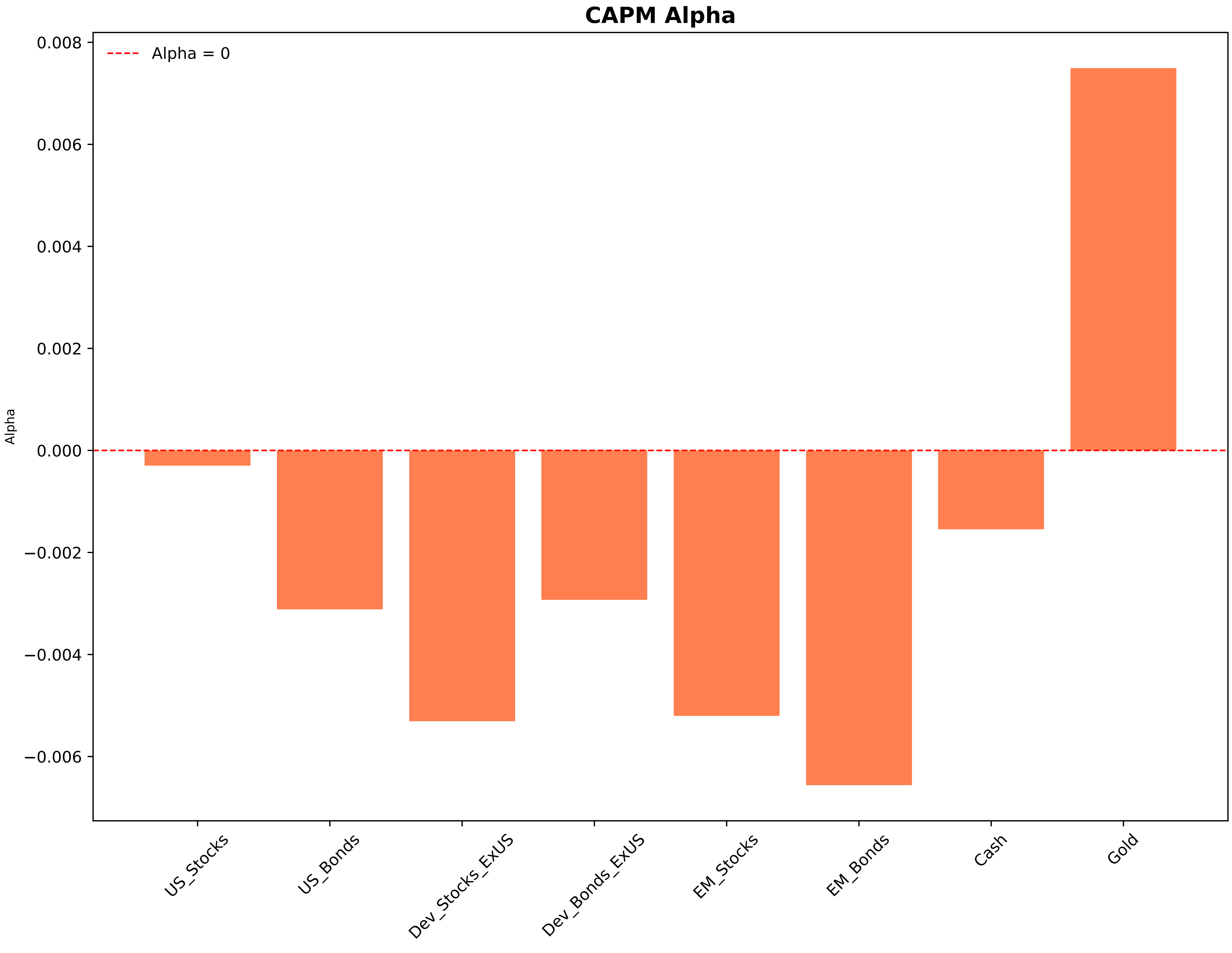
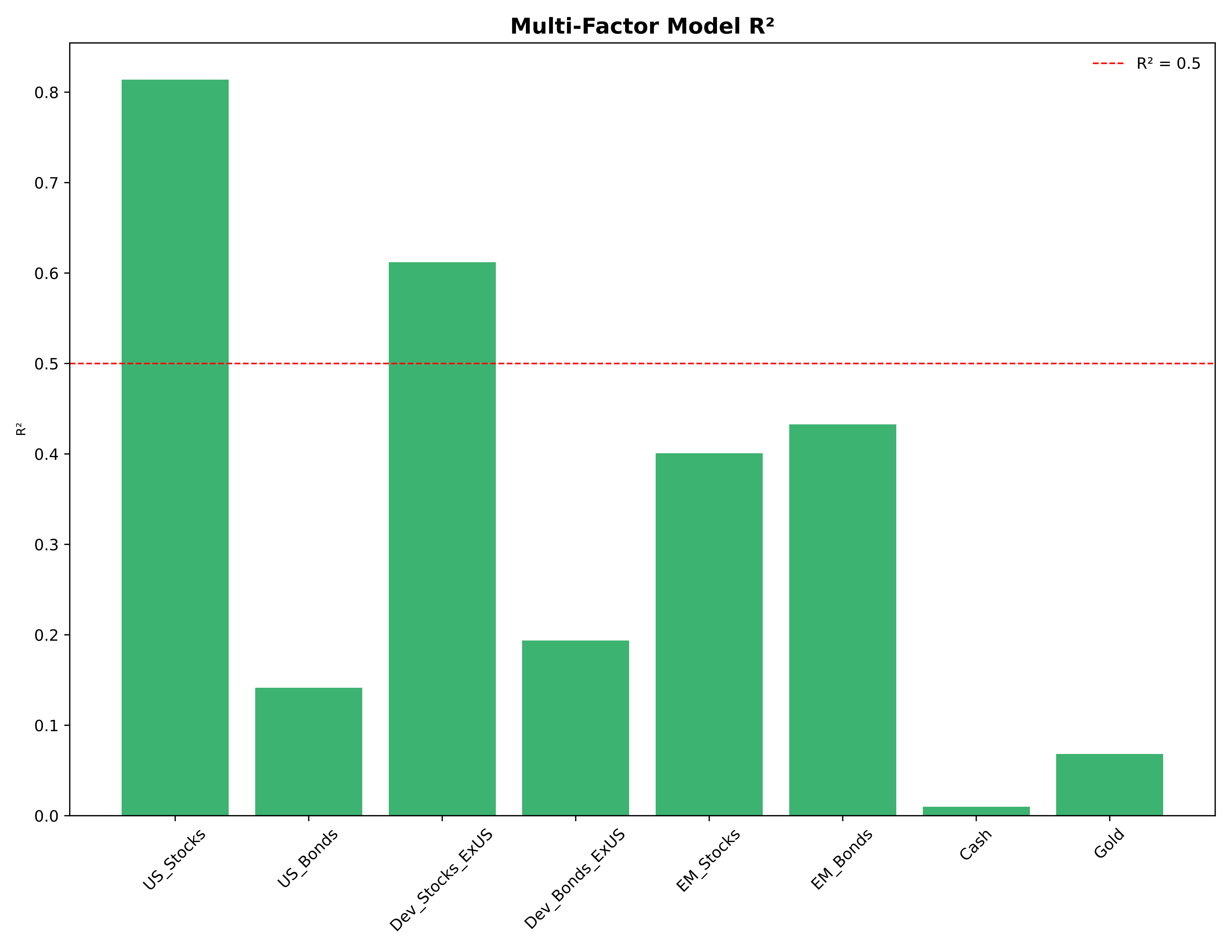

ETF Weekly Return Correlation
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold
Ticker
Ticker
1.00 0.23 0.85 0.19 0.70 0.61 0.02 0.14
0.23 1.00 0.28 0.77 0.18 0.67 0.03 0.38
0.85 0.28 1.00 0.16 0.81 0.68 0.00 0.23
0.19 0.77 0.16 1.00 0.11 0.51 0.07 0.26
0.70 0.18 0.81 0.11 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


CAPM Beta
Beta
1.0
0.8
0.6
0.4
0.2
0.0
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
US_Stocks
US_Bonds
Dev_Stocks_ExUS
Dev_Bonds_ExUS
EM_Stocks
EM_Bonds
Cash
Gold


Multi-Factor Model R²
R² = 0.5
R²
0.0
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

Regression Summary: CAPM & Multi-Factor Model

US_Stocks:
CAPM Beta: 0.925
CAPM Alpha: -0.0297%
MFC R^2: 0.814

US_Bonds:
CAPM Beta: 0.096
CAPM Alpha: -0.3114%
MFC R^2: 0.141

Dev_Stocks_ExUS:
CAPM Beta: 0.819
CAPM Alpha: -0.5303%
MFC R^2: 0.612

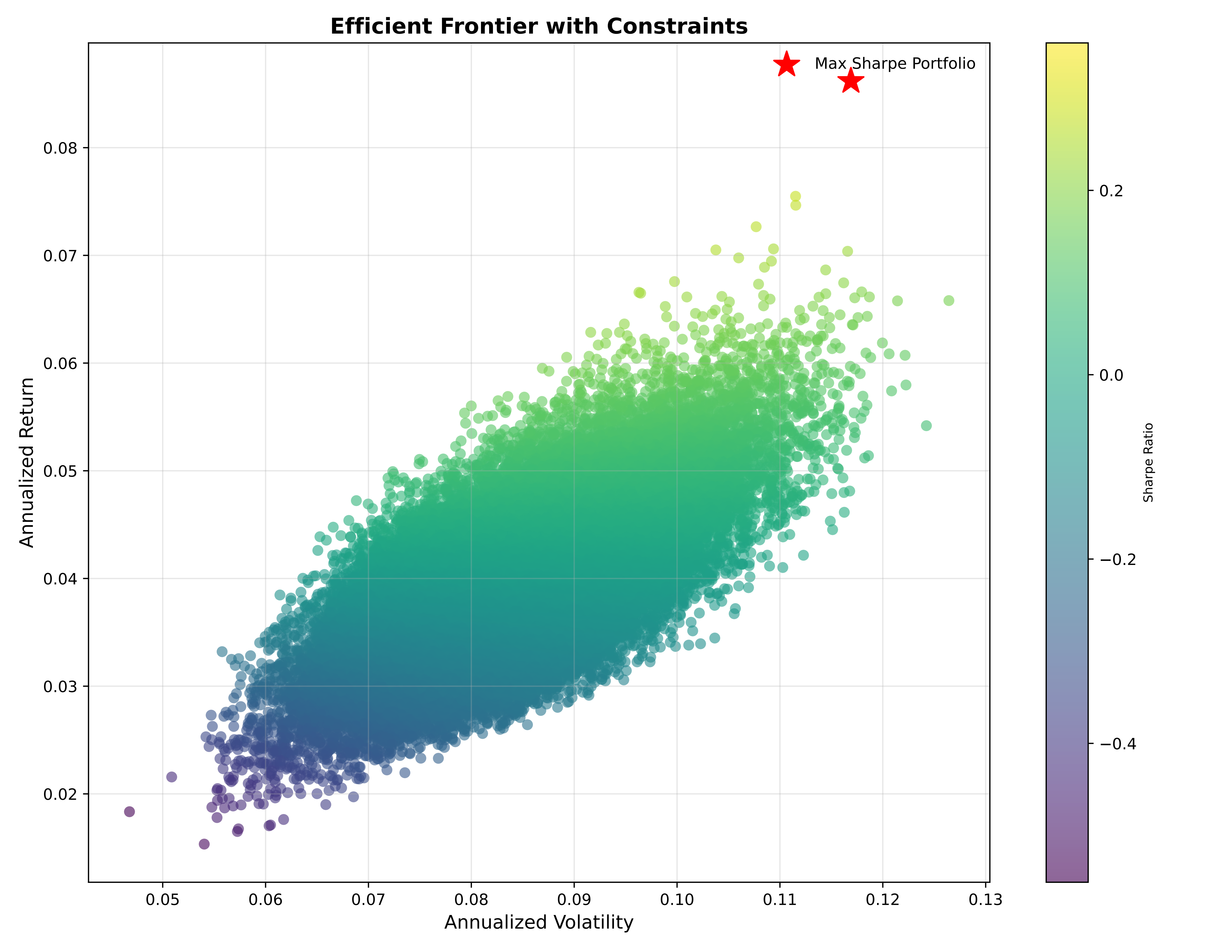
Dev_Bonds_ExUS:
CAPM Beta: 0.114
CAPM Alpha: -0.2928%
MFC R^2: 0.194

EM_Stocks:
CAPM Beta: 0.647
CAPM Alpha: -0.5199%
MFC R^2: 0.401

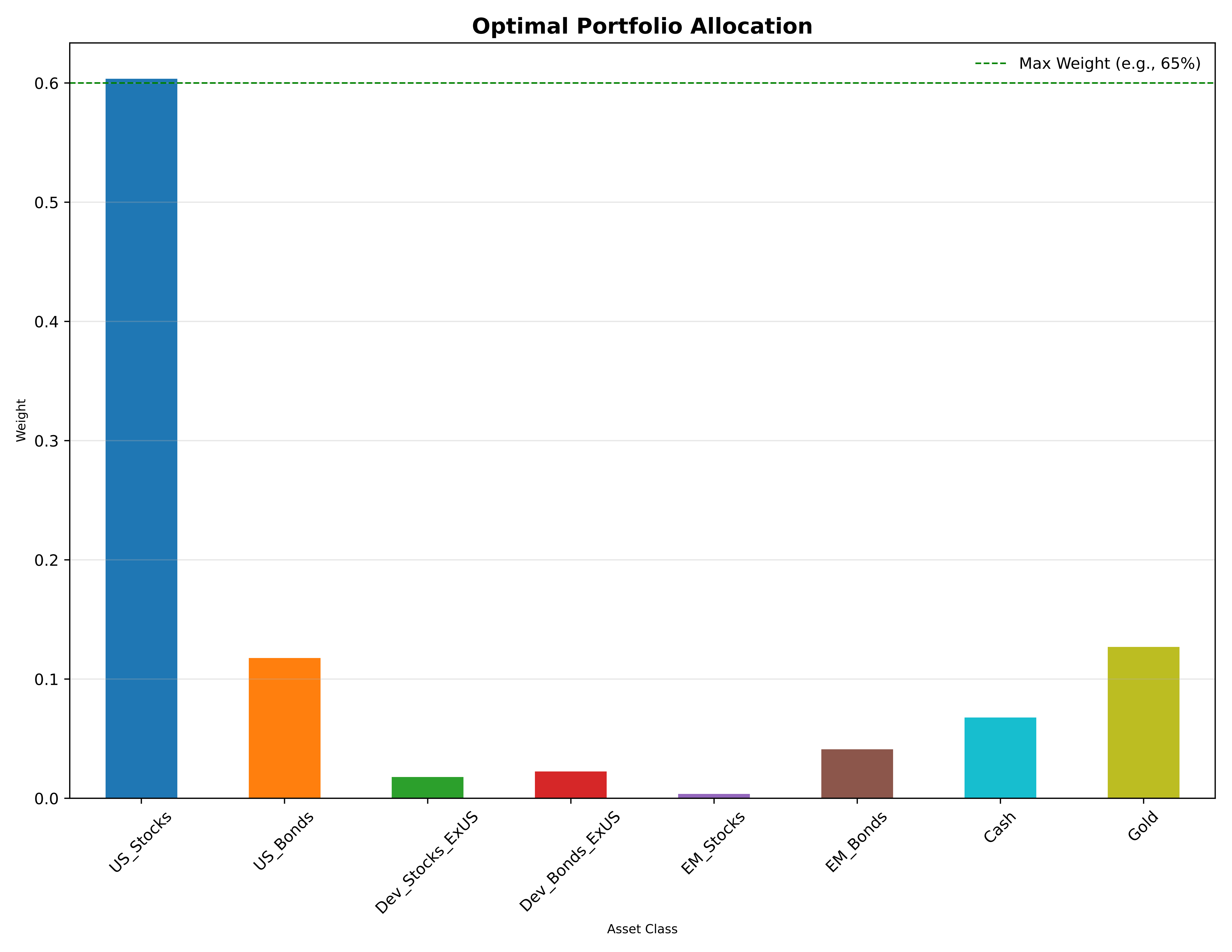
EM_Bonds:
CAPM Beta: 0.416
CAPM Alpha: -0.6557%
MFC R^2: 0.433

Cash:
CAPM Beta: 0.003
CAPM Alpha: -0.1546%
MFC R^2: 0.010

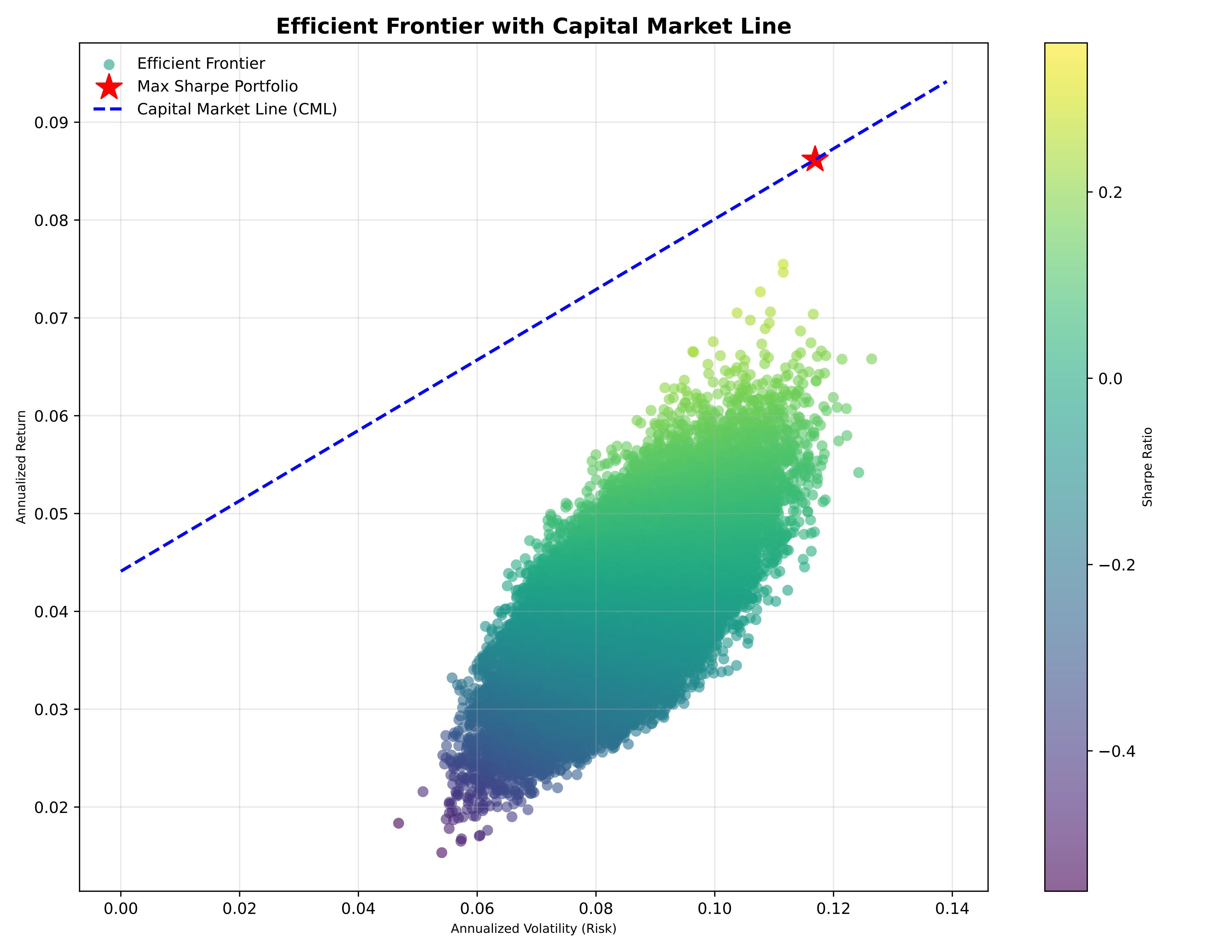
Gold:
CAPM Beta: -0.012
CAPM Alpha: 0.7490%
MFC R^2: 0.068



Efficient Frontier with Constraints
Max Sharpe Portfolio
Annualized Return
Annualized Volatility
Sharpe Ratio
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.05
0.06
0.07
0.08
0.09
0.10
0.11
0.12
0.13
0.2
0.0
−0.2
−0.4



Optimal Portfolio Allocation
Max Weight (e.g., 65%)
Weight
0.0
0.1
0.2
0.3
0.4
0.5
0.6
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
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.2
0.0
−0.2
−0.4

Optimal Portfolio Summary

Expected Annual Return: 8.62%
Expected Annual Volatility: 11.69%
Max Sharpe Ratio: 0.36

Allocation:

Asset_Class	Weight
US_Stocks	0.6034
US_Bonds	0.1176
Dev_Stocks_ExUS	0.0177
Dev_Bonds_ExUS	0.0224
EM_Stocks	0.0035
EM_Bonds	0.0411
Cash	0.0676
Gold	0.1268

Data Columns:
US_Stocks, US_Bonds, Dev_Stocks_ExUS, Dev_Bonds_ExUS, EM_Stocks, EM_Bonds, Cash, Gold

Parsed Portfolio Details:
Tickers: {'US_Stocks': 'VOO', 'US_Bonds': 'AGG', 'Dev_Stocks_ExUS': 'SCHF', 'Dev_Bonds_ExUS': 'BNDX', 'EM_Stocks': 'VWO', 'EM_Bonds': 'EMB', 'Cash': 'BIL', 'Gold': 'GLD'}
Risk-Free Rate: 0.0441
Constraints: {'US_Stocks': {'max': 0.65, 'min': 0.1}, 'US_Bonds': {'max': 0.5, 'min': 0.1}, 'Dev_Stocks_ExUS': {'max': 0.4}, 'Dev_Bonds_ExUS': {'max': 0.4}, 'EM_Bonds': {'max': 0.15}, 'EM_Stocks': {'max': 0.15}, 'Cash': {'max': 0.1, 'min': 0.05}, 'Gold': {'max': 0.15, 'min': 0.05}}
Descriptive Statistics for ETF Weekly Returns (Annualized where appropriate):

Ticker	Mean (Ann.)	Std Dev (Ann.)	Skewness	Kurtosis	Max Return \
US_Stocks	0.1201	0.1738	-0.6203	6.0159	0.1213
US_Bonds	-0.0086	0.0519	-0.0828	9.3329	0.0503
Dev_Stocks_ExUS	0.0476	0.1721	-0.4638	5.4759	0.1216
Dev_Bonds_ExUS	-0.0045	0.0444	-0.9670	4.6920	0.0204
EM_Stocks	0.0334	0.1863	-0.3965	2.0592	0.0940
EM_Bonds	-0.0139	0.0999	-1.9445	20.7643	0.0709
Cash	0.0002	0.0066	-2.0986	4.9929	0.0015
Gold	0.1136	0.1430	0.0317	1.7712	0.0866

Ticker	Min Return	Sharpe Ratio
US_Stocks	-0.1490	0.4375
US_Bonds	-0.0509	-1.0161
Dev_Stocks_ExUS	-0.1440	0.0206
Dev_Bonds_ExUS	-0.0355	-1.0947
EM_Stocks	-0.1331	-0.0575
EM_Bonds	-0.1322	-0.5809
Cash	-0.0036	-6.6405
Gold	-0.0906	0.4862

Downside and Tail Risk Statistics:

	VaR (5%)	CVaR (5%)	Max Drawdown	Beta (vs US_Stocks) \
US_Stocks	-0.0342	-0.0580	-0.3208	1.0000
US_Bonds	-0.0113	-0.0165	-0.2305	0.0683
Dev_Stocks_ExUS	-0.0354	-0.0556	-0.3758	0.8446
Dev_Bonds_ExUS	-0.0098	-0.0168	-0.2038	0.0485
EM_Stocks	-0.0415	-0.0586	-0.3896	0.7555
EM_Bonds	-0.0191	-0.0335	-0.3379	0.3486
Cash	-0.0025	-0.0031	-0.0056	0.0006
Gold	-0.0305	-0.0412	-0.1983	0.1113

	Avg GARCH Vol
US_Stocks	0.0228
US_Bonds	0.0067
Dev_Stocks_ExUS	0.0225
Dev_Bonds_ExUS	0.0060
EM_Stocks	0.0251
EM_Bonds	0.0127
Cash	0.0007
Gold	0.0195

Optimal Portfolio Allocation (with Constraints):

	Asset_Class	Weight
0	US_Stocks	0.6034
1	US_Bonds	0.1176
2	Dev_Stocks_ExUS	0.0177
3	Dev_Bonds_ExUS	0.0224
4	EM_Stocks	0.0035
5	EM_Bonds	0.0411
6	Cash	0.0676
7	Gold	0.1268

Expected Annual Return: 0.0862
Expected Annual Volatility: 0.1169
Max Sharpe Ratio: 0.3600

Minimum Volatility Portfolio (No Constraints):

Ticker	
US_Stocks	0.1017
US_Bonds	0.3451
Dev_Stocks_ExUS	0.0080
Dev_Bonds_ExUS	0.3497
EM_Stocks	0.0001
EM_Bonds	0.0065
Cash	0.0977
Gold	0.0912

dtype: float64
Minimum Volatility Portfolio
Expected Annual Return: 0.0183
Expected Annual Volatility: 0.0468
Max Sharpe Ratio: -0.5507

Minimum Variance Portfolio Weights:
Minimum Variance Portfolio:

Asset	Weight
US_Stocks	0.1017
US_Bonds	0.3451
Dev_Stocks_ExUS	0.0080
Dev_Bonds_ExUS	0.3497
EM_Stocks	0.0001
EM_Bonds	0.0065
Cash	0.0977
Gold	0.0912