

Multi-Asset Portfolio

(Equity Bond Commodity REIT ETFs and Cryptos)





Research Question

- How does a multi-asset portfolio that uses Markowitz weights calculated based on data between November 2021-March 2024 perform in the period after March 2024 to November 2024 (out-of-sample analysis) ?
- 1/N Rebalancing
- Maximum Sharpe Ratio
- Minimum Variance
- Risk Parity Portfolio



Data



- Weekly data is retrieved from Yahoo Finance. It captures November 1, 2021 and February 26, 2024 period.
- Checking model performance for the period between February 26, 2024 and November 1, 2024
- Training Data: 80% of 36 months = $0.80 \times 36 = 28.8$ months \rightarrow 28 months (121 weeks)
- Test Data: 20% of 36 months = $0.20 \times 36 = 7.2$ months \rightarrow 8 months (35 weeks)
- **80/20** split

Asset Elimination

- Variance Inflation Factor
- Returns
- Standard Deviations
- Market Capitalization



Portfolio Content



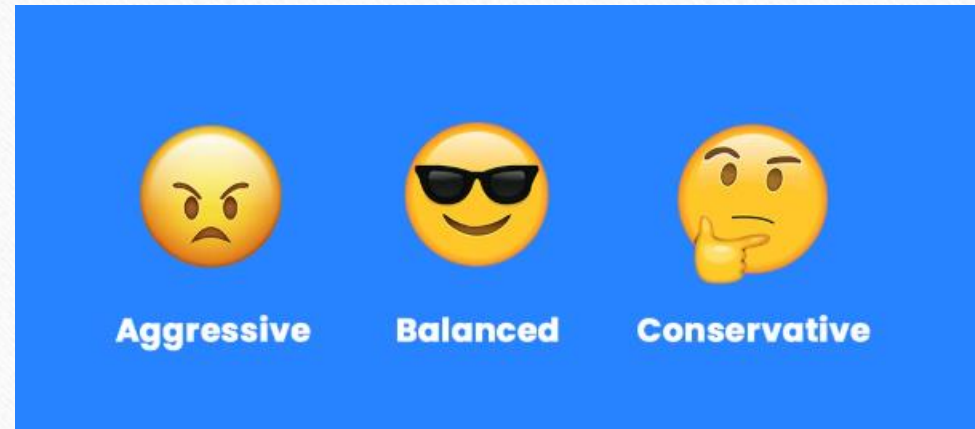
| Ticker | Name | Country | Content | Type |
|----------------|---|--------------------|---------------------------------|------------------------|
| EWJ | iShares MSCI Japan ETF | Japan | Japanese equities | Equity ETF |
| EZU | iShares MSCI EMU ETF | Eurozone Countries | Eurozone equities | Equity ETF |
| FXI | iShares China Large-Cap ETF | China | Chinese large-cap stocks | Equity ETF |
| XLC | Communication Services Select Sector SPDR Fund | United States | Communication services stocks | Equity ETF |
| XLK | Technology Select Sector SPDR Fund | United States | Technology stocks | Equity ETF |
| XLU | Utilities Select Sector SPDR Fund | United States | Utilities sector stocks | Equity ETF |
| XLV | Health Care Select Sector SPDR Fund | United States | Health care sector stocks | Equity ETF |
| EMB | iShares J.P. Morgan USD Emerging Markets Bond ETF | Global | Emerging market bonds | Bond ETF |
| DBA | Invesco DB Agriculture Fund | Global | Agriculture commodities | Commodity ETF |
| GLD | SPDR Gold Shares | Global | Gold | Commodity ETF |
| SCCO | Southern Copper Corporation | Peru-Mexico | Mining-Copper | Commodity Equity Stock |
| OIH | VanEck Vectors Oil Services ETF | United States | U.S. oil services sector stocks | Commodity ETF |
| BTC-USD | Bitcoin (BTC) | Global | Cryptocurrencies | Crypto |
| ETH-USD | Ethereum (ETH) | Global | Cryptocurrencies | Crypto |
| PSA | Public Storage | United States | Storage REIT | REIT ETF |



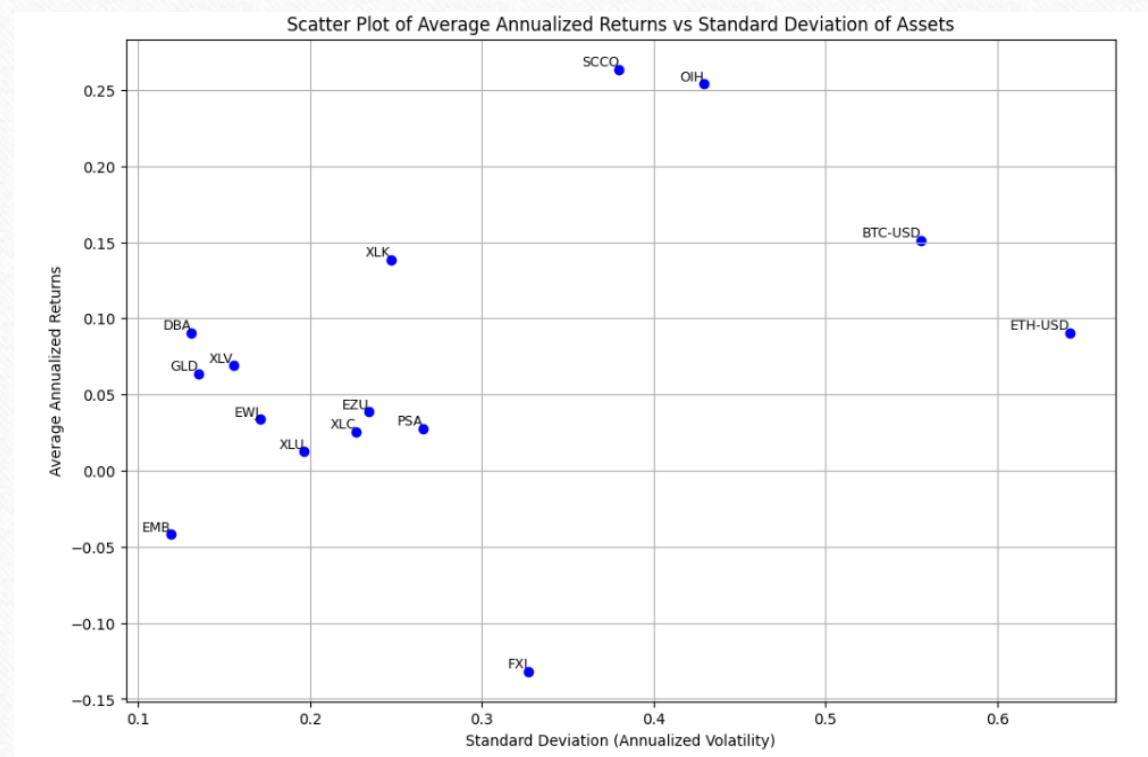
3 Types of Investors

Aggressive, Balanced and Conservative Investors (Volatility of the Portfolio)

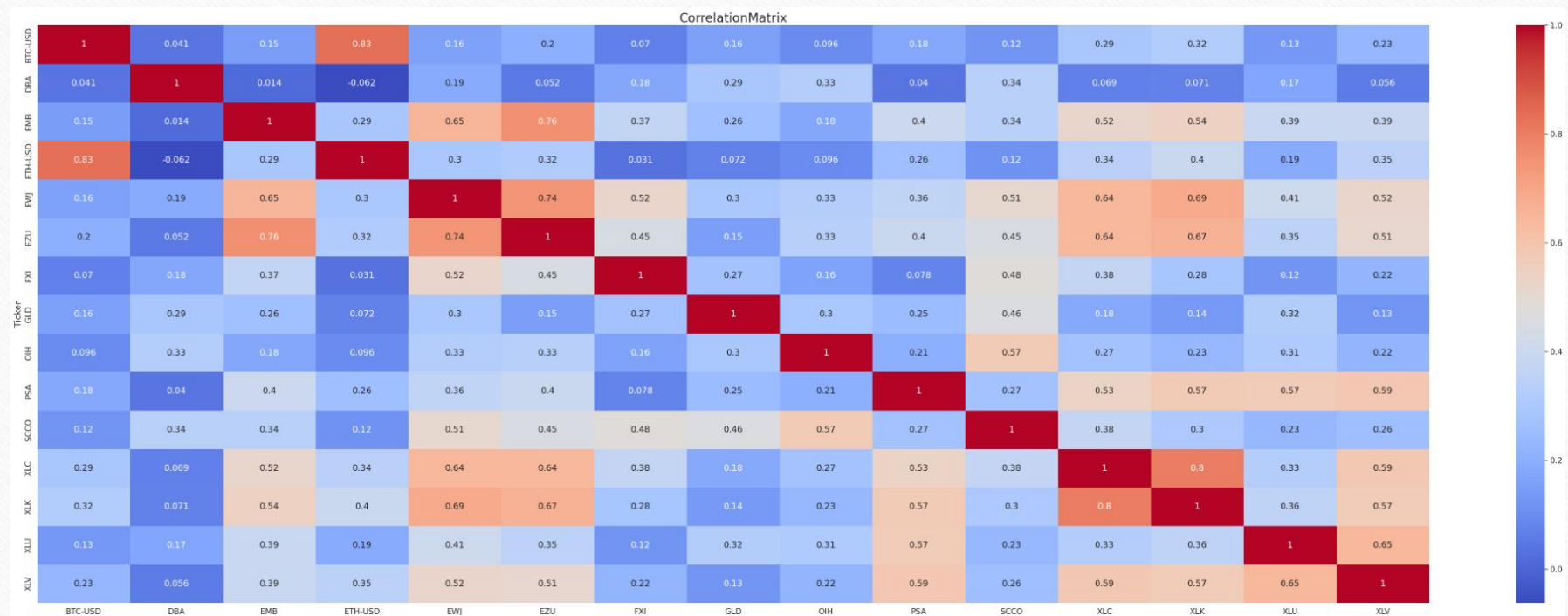
- Rebalancing ($1/N$)
- Maximum Sharpe Ratio
- Minimum Variance
- Risk Parity Portfolio Models



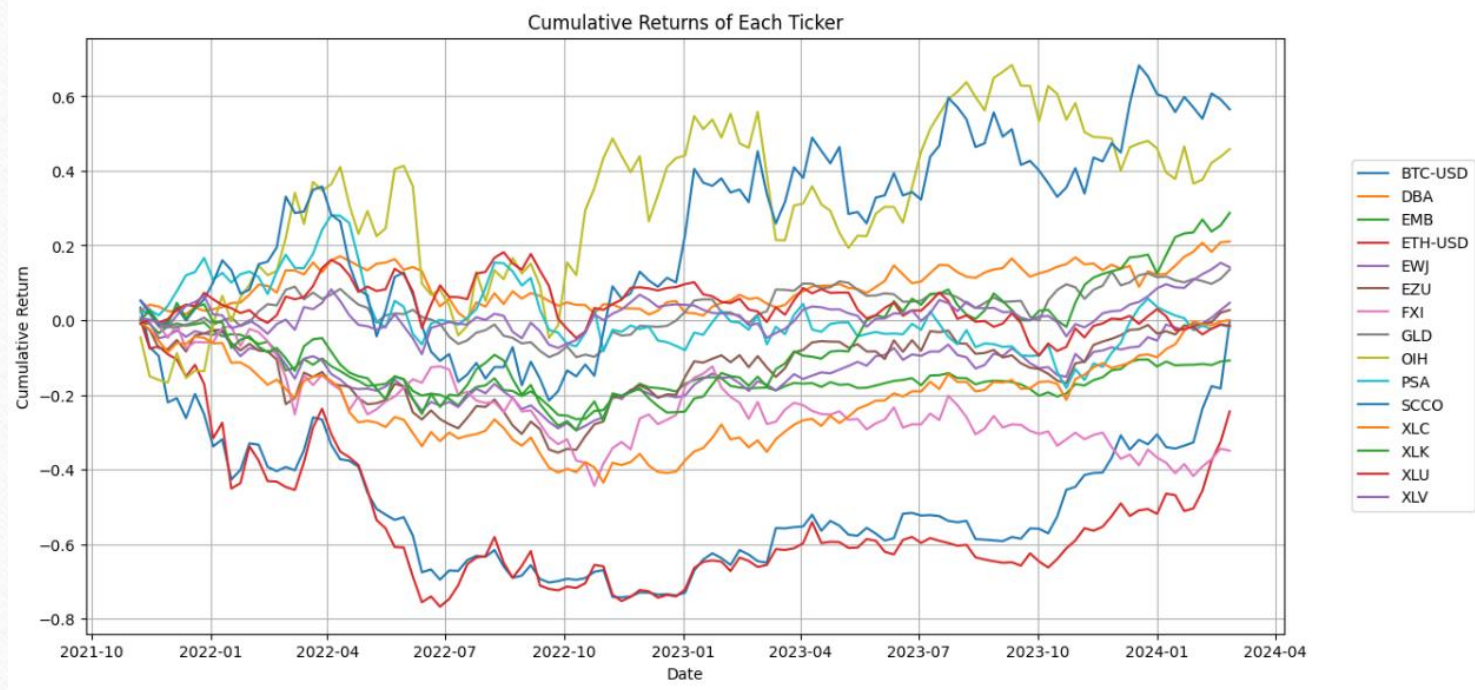
Annualized Returns vs Standard Deviation



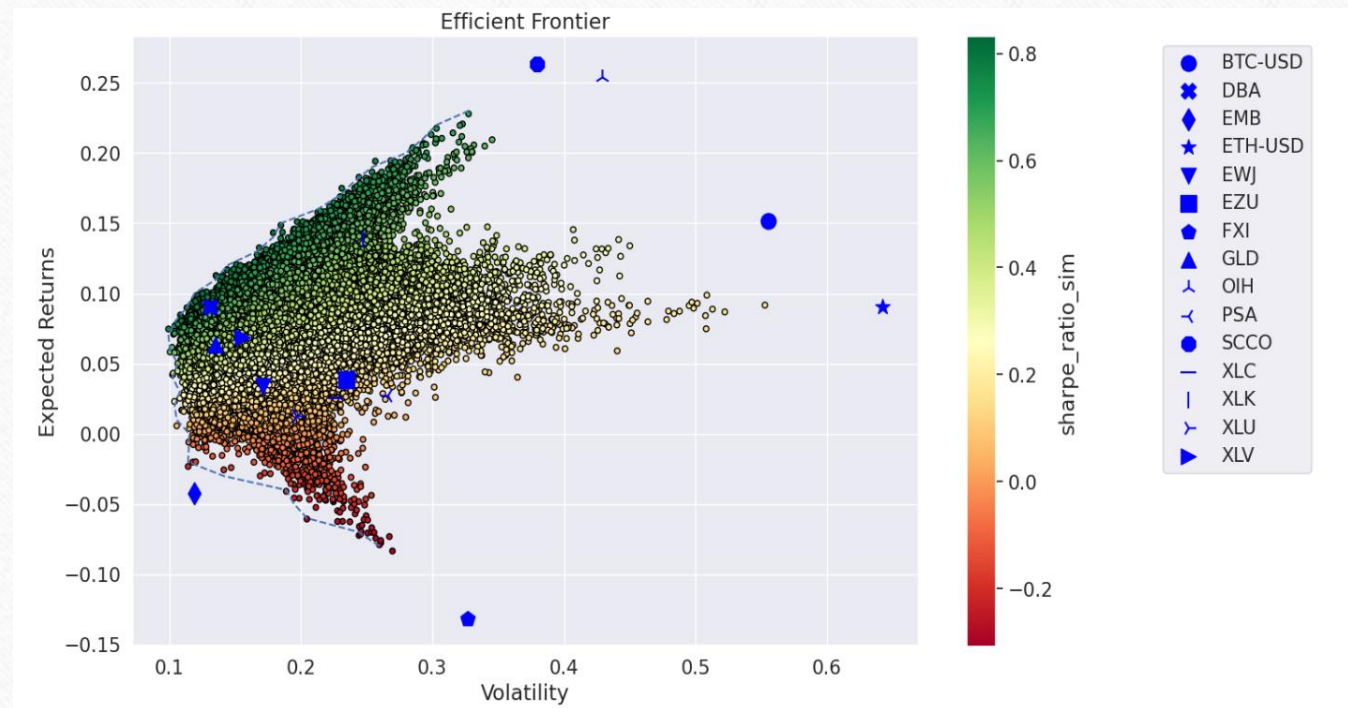
Correlation Matrix



Train Data



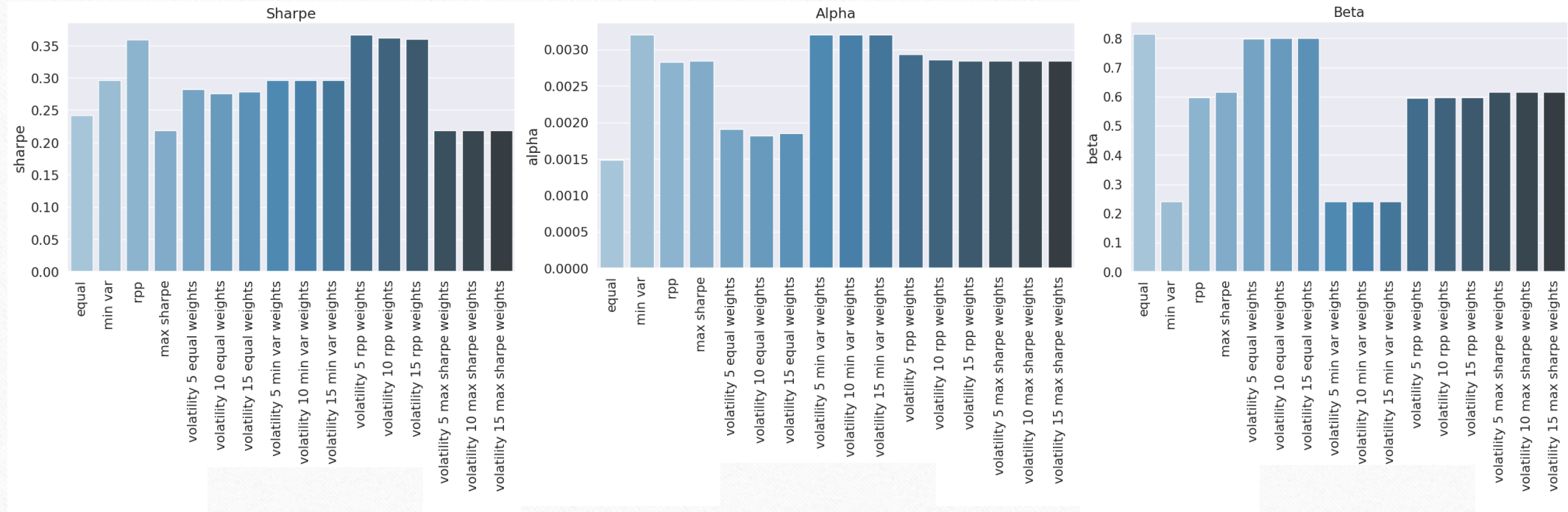
Efficient Frontier with Monte Carlo Simulation



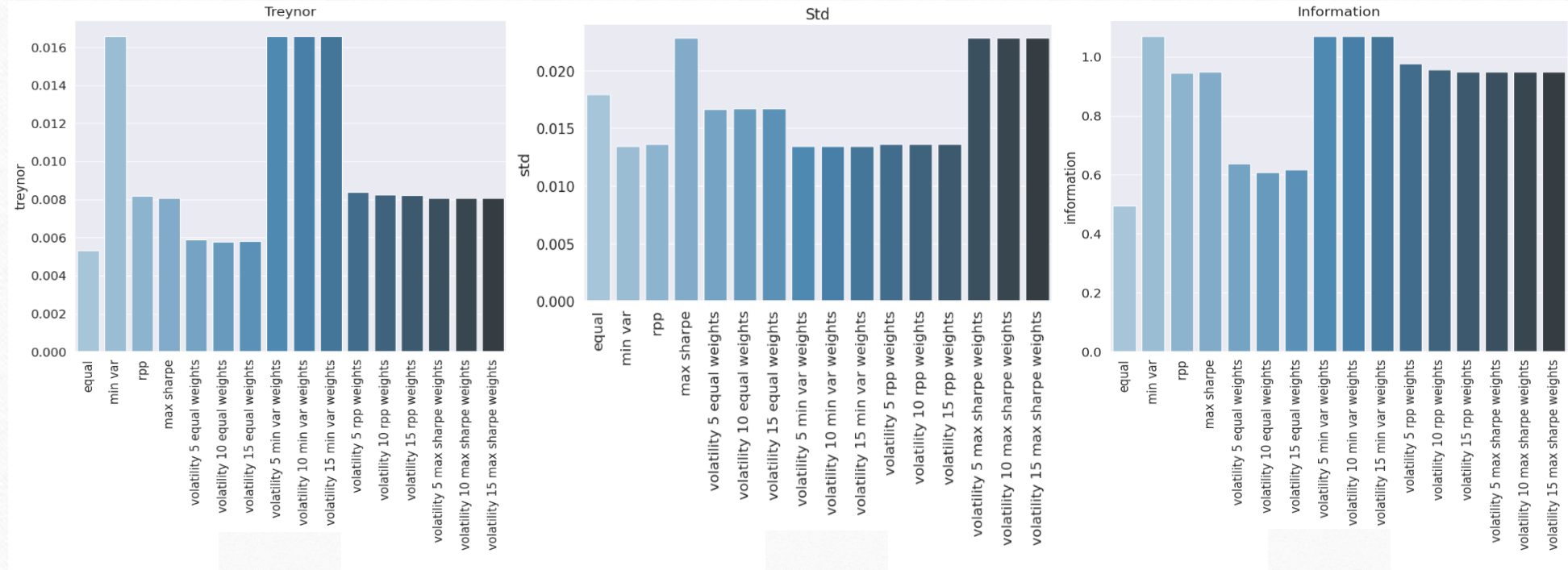
Weight Distribution

| Tickers | Equal Weights | Minimum Variance | Risk Parity Portfolio | Maximum Sharpe Ratio | Volatility %5 With Equal Weights | Volatility %10 With Equal Weights | Volatility %15 With Equal Weights | Volatility %5 With Minimum Variance Weights | Volatility %10 With Minimum Variance Weights | Volatility %15 With Minimum Variance Weights | Volatility %5 With Risk Parity Portfolio Weights | Volatility %10 With Risk Parity Portfolio Weights | Volatility %15 With Risk Parity Portfolio Weights | Volatility %5 With Maximum Sharpe Weights | Volatility %10 With Maximum Sharpe Weights | Volatility %15 With Maximum Sharpe Weights |
|---------|---------------|------------------|-----------------------|----------------------|----------------------------------|-----------------------------------|-----------------------------------|---|--|--|--|---|---|---|--|--|
| BTC-USD | 0,0667 | - | 0,0322 | 0,0160 | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0127 | 0,0255 | 0,0382 | 0,0063 | 0,0127 | 0,0190 |
| DBA | 0,0667 | 0,3385 | 0,1712 | 0,5000 | 0,0197 | 0,0394 | 0,0591 | 0,2047 | 0,4094 | 0,6141 | 0,0676 | 0,1352 | 0,2028 | 0,1978 | 0,3956 | 0,5935 |
| EMB | 0,0667 | 0,3184 | 0,1086 | - | 0,0197 | 0,0394 | 0,0591 | 0,1926 | 0,3851 | 0,5777 | 0,0429 | 0,0858 | 0,1287 | - | - | - |
| ETH-USD | 0,0667 | - | 0,0258 | - | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0102 | 0,0203 | 0,0305 | - | - | - |
| EWJ | 0,0667 | - | 0,0639 | - | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0252 | 0,0505 | 0,0757 | - | - | - |
| EZU | 0,0667 | - | 0,0493 | - | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0194 | 0,0389 | 0,0583 | - | - | - |
| FXI | 0,0667 | - | 0,0507 | - | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0200 | 0,0400 | 0,0601 | - | - | - |
| GLD | 0,0667 | 0,1870 | 0,1236 | 0,0851 | 0,0197 | 0,0394 | 0,0591 | 0,1131 | 0,2262 | 0,3393 | 0,0488 | 0,0976 | 0,1463 | 0,0337 | 0,0673 | 0,1010 |
| OIH | 0,0667 | - | 0,0371 | 0,0449 | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0147 | 0,0293 | 0,0440 | 0,0177 | 0,0355 | 0,0532 |
| PSA | 0,0667 | - | 0,0524 | - | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0207 | 0,0414 | 0,0621 | - | - | - |
| SCCO | 0,0667 | - | 0,0340 | 0,0978 | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0134 | 0,0268 | 0,0402 | 0,0387 | 0,0774 | 0,1160 |
| XLC | 0,0667 | - | 0,0509 | - | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0201 | 0,0402 | 0,0603 | - | - | - |
| XLK | 0,0667 | - | 0,0470 | 0,1716 | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0186 | 0,0371 | 0,0557 | 0,0679 | 0,1358 | 0,2037 |
| XLU | 0,0667 | - | 0,0713 | - | 0,0197 | 0,0394 | 0,0591 | - | - | - | 0,0282 | 0,0563 | 0,0845 | - | - | - |
| XLV | 0,0667 | 0,1560 | 0,0820 | 0,0846 | 0,0197 | 0,0394 | 0,0591 | 0,0944 | 0,1887 | 0,2831 | 0,0324 | 0,0647 | 0,0971 | 0,0335 | 0,0669 | 0,1004 |

Out of Sample Performance



Out of Sample Performance



Portfolio Allocation

- Initial investment: 1.000.000 \$
- $\text{Weights} * \text{Investment} / \text{Prices in test period}$

Weekly Portfolio Development

| Date | Equal Weights | Minimum Variance | Risk Parity Portfolio | Maximum Sharpe Ratio | Volatility %5 With Equal Weights | Volatility %10 With Equal Weights | Volatility %15 With Equal Weights | Volatility %5 With Minimum Variance Weights | Volatility %10 With Minimum Variance Weights | Volatility %15 With Minimum Variance Weights | Volatility %5 With Risk Parity Portfolio Weights | Volatility %10 With Risk Parity Portfolio Weights | Volatility %15 With Risk Parity Portfolio Weights | Volatility %5 With Maximum Sharpe Weights | Volatility %10 With Maximum Sharpe Weights | Volatility %15 With Maximum Sharpe Weights |
|------------|---------------|------------------|-----------------------|----------------------|----------------------------------|-----------------------------------|-----------------------------------|---|--|--|--|---|---|---|--|--|
| 26.02.2024 | 995.304 | 999.828 | 965.739 | 983.616 | 272.948 | 550.043 | 823.824 | 604.613 | 1.209.227 | 1.813.946 | 377.958 | 760.435 | 1.142.935 | 388.867 | 778.005 | 1.167.459 |
| 4.03.2024 | 1.022.411 | 1.016.119 | 983.909 | 997.382 | 278.985 | 562.515 | 842.348 | 614.465 | 1.228.929 | 1.843.501 | 384.820 | 774.566 | 1.164.336 | 394.304 | 788.894 | 1.183.792 |
| 11.03.2024 | 1.031.156 | 1.027.552 | 993.013 | 1.042.944 | 281.899 | 568.114 | 850.855 | 621.378 | 1.242.756 | 1.864.242 | 388.609 | 781.886 | 1.175.186 | 412.317 | 824.934 | 1.237.872 |
| 18.03.2024 | 1.038.928 | 1.041.081 | 1.004.947 | 1.060.677 | 284.644 | 573.429 | 858.932 | 629.559 | 1.259.119 | 1.888.787 | 393.456 | 791.405 | 1.189.378 | 419.328 | 838.958 | 1.258.922 |
| 25.03.2024 | 1.060.549 | 1.059.229 | 1.023.190 | 1.082.234 | 289.698 | 583.738 | 874.312 | 640.534 | 1.281.069 | 1.921.713 | 400.496 | 805.699 | 1.210.924 | 427.851 | 856.011 | 1.284.502 |
| 1.04.2024 | 1.058.807 | 1.066.893 | 1.027.059 | 1.095.978 | 289.879 | 583.913 | 874.668 | 645.169 | 1.290.337 | 1.935.615 | 402.174 | 808.857 | 1.215.561 | 433.278 | 866.879 | 1.300.813 |
| 8.04.2024 | 1.040.565 | 1.065.917 | 1.018.340 | 1.105.073 | 285.760 | 575.356 | 861.961 | 644.578 | 1.289.156 | 1.933.843 | 398.969 | 802.133 | 1.205.320 | 436.879 | 874.088 | 1.311.611 |
| 15.04.2024 | 1.030.785 | 1.084.878 | 1.019.668 | 1.117.025 | 283.127 | 570.068 | 854.015 | 656.045 | 1.312.089 | 1.968.243 | 399.513 | 803.191 | 1.206.889 | 441.610 | 883.553 | 1.325.783 |
| 22.04.2024 | 1.042.866 | 1.074.845 | 1.024.806 | 1.115.588 | 287.161 | 578.258 | 866.241 | 649.978 | 1.299.955 | 1.950.042 | 401.452 | 807.190 | 1.212.947 | 441.041 | 882.412 | 1.324.086 |
| 29.04.2024 | 1.042.640 | 1.044.187 | 1.015.051 | 1.066.562 | 286.907 | 577.618 | 865.347 | 631.438 | 1.262.876 | 1.894.422 | 397.692 | 799.552 | 1.201.430 | 421.651 | 843.628 | 1.265.901 |
| 6.05.2024 | 1.055.995 | 1.065.016 | 1.035.300 | 1.093.851 | 291.739 | 587.085 | 879.665 | 644.034 | 1.288.067 | 1.932.210 | 405.827 | 815.641 | 1.225.471 | 432.440 | 865.215 | 1.298.289 |
| 13.05.2024 | 1.083.271 | 1.057.464 | 1.046.638 | 1.085.152 | 298.277 | 600.316 | 899.458 | 639.467 | 1.278.934 | 1.918.510 | 410.175 | 824.508 | 1.238.857 | 428.989 | 858.325 | 1.287.969 |
| 20.05.2024 | 1.081.359 | 1.064.221 | 1.042.314 | 1.098.654 | 296.598 | 597.696 | 895.129 | 643.553 | 1.287.106 | 1.930.769 | 407.910 | 820.710 | 1.233.526 | 434.344 | 869.018 | 1.303.999 |
| 27.05.2024 | 1.080.852 | 1.070.265 | 1.045.134 | 1.106.472 | 296.697 | 597.856 | 895.393 | 647.208 | 1.294.416 | 1.941.734 | 409.059 | 822.960 | 1.236.876 | 437.435 | 875.201 | 1.313.275 |
| 3.06.2024 | 1.068.107 | 1.071.182 | 1.036.506 | 1.101.542 | 292.431 | 589.228 | 882.482 | 647.763 | 1.295.525 | 1.943.398 | 405.708 | 816.187 | 1.226.682 | 435.497 | 871.313 | 1.307.426 |
| 10.06.2024 | 1.061.402 | 1.082.505 | 1.038.305 | 1.114.232 | 291.395 | 587.064 | 879.280 | 654.609 | 1.309.219 | 1.963.939 | 406.471 | 817.647 | 1.228.842 | 440.519 | 881.358 | 1.322.497 |
| 17.06.2024 | 1.061.087 | 1.067.392 | 1.035.249 | 1.096.873 | 292.438 | 588.959 | 882.241 | 645.470 | 1.290.941 | 1.936.522 | 405.409 | 815.334 | 1.225.277 | 433.647 | 867.615 | 1.301.895 |
| 24.06.2024 | 1.057.142 | 1.051.139 | 1.027.322 | 1.076.711 | 291.402 | 586.911 | 879.165 | 635.642 | 1.271.285 | 1.907.036 | 402.274 | 809.070 | 1.215.886 | 425.668 | 851.656 | 1.277.963 |
| 1.07.2024 | 1.061.112 | 1.065.546 | 1.043.037 | 1.103.386 | 294.912 | 593.423 | 889.186 | 644.354 | 1.288.708 | 1.933.172 | 408.850 | 821.738 | 1.234.645 | 436.215 | 872.765 | 1.309.630 |
| 8.07.2024 | 1.086.089 | 1.079.096 | 1.060.633 | 1.110.857 | 300.629 | 605.188 | 906.693 | 652.548 | 1.305.097 | 1.957.756 | 415.543 | 835.460 | 1.255.395 | 439.168 | 878.671 | 1.318.495 |
| 15.07.2024 | 1.074.537 | 1.062.368 | 1.040.131 | 1.071.283 | 294.844 | 593.919 | 889.646 | 642.433 | 1.284.866 | 1.927.408 | 407.238 | 819.122 | 1.231.024 | 423.514 | 847.352 | 1.271.510 |
| 22.07.2024 | 1.069.966 | 1.069.350 | 1.040.046 | 1.076.249 | 293.621 | 591.214 | 885.724 | 646.655 | 1.293.310 | 1.940.076 | 407.409 | 819.195 | 1.230.999 | 425.477 | 851.277 | 1.277.400 |
| 29.07.2024 | 1.034.811 | 1.068.705 | 1.027.651 | 1.044.491 | 286.608 | 576.578 | 864.054 | 646.265 | 1.292.530 | 1.938.905 | 402.953 | 809.706 | 1.216.473 | 412.922 | 826.167 | 1.239.692 |
| 5.08.2024 | 1.036.219 | 1.081.703 | 1.034.200 | 1.063.966 | 286.937 | 577.093 | 864.893 | 654.125 | 1.308.250 | 1.962.487 | 405.636 | 814.943 | 1.224.265 | 420.631 | 841.584 | 1.262.808 |
| 12.08.2024 | 1.062.385 | 1.090.691 | 1.055.487 | 1.080.811 | 294.697 | 592.687 | 888.263 | 659.560 | 1.319.121 | 1.978.793 | 413.977 | 831.716 | 1.249.472 | 427.286 | 854.907 | 1.282.812 |
| 19.08.2024 | 1.088.920 | 1.109.803 | 1.076.629 | 1.104.107 | 300.722 | 604.880 | 906.509 | 671.118 | 1.342.236 | 2.013.468 | 422.198 | 848.325 | 1.274.468 | 436.502 | 873.339 | 1.310.463 |
| 26.08.2024 | 1.073.750 | 1.112.474 | 1.074.887 | 1.102.204 | 298.509 | 600.131 | 899.548 | 672.733 | 1.345.467 | 2.018.314 | 421.754 | 847.117 | 1.272.496 | 435.752 | 871.835 | 1.308.200 |
| 2.09.2024 | 1.036.042 | 1.097.615 | 1.046.580 | 1.058.882 | 288.200 | 579.351 | 868.428 | 663.748 | 1.327.495 | 1.991.356 | 410.691 | 824.835 | 1.238.994 | 418.626 | 837.576 | 1.256.767 |
| 9.09.2024 | 1.070.076 | 1.128.132 | 1.078.954 | 1.104.201 | 296.962 | 596.903 | 894.758 | 682.202 | 1.364.403 | 2.046.721 | 423.424 | 850.373 | 1.277.336 | 436.550 | 873.435 | 1.310.568 |
| 16.09.2024 | 1.100.904 | 1.136.616 | 1.098.876 | 1.121.936 | 304.576 | 612.415 | 917.910 | 687.332 | 1.374.663 | 2.062.111 | 431.080 | 865.961 | 1.300.855 | 443.555 | 887.454 | 1.331.618 |
| 23.09.2024 | 1.135.695 | 1.153.013 | 1.126.762 | 1.166.052 | 314.241 | 631.810 | 946.956 | 697.247 | 1.394.494 | 2.091.859 | 442.028 | 887.936 | 1.333.856 | 461.001 | 922.365 | 1.383.985 |
| 30.09.2024 | 1.135.889 | 1.131.056 | 1.123.551 | 1.141.580 | 315.251 | 633.631 | 949.793 | 683.970 | 1.367.940 | 2.052.025 | 440.939 | 885.527 | 1.330.125 | 451.314 | 902.989 | 1.354.941 |
| 7.10.2024 | 1.129.238 | 1.142.371 | 1.121.253 | 1.159.444 | 313.261 | 629.675 | 943.841 | 690.812 | 1.381.624 | 2.072.552 | 440.008 | 883.698 | 1.327.399 | 458.382 | 917.126 | 1.376.146 |
| 14.10.2024 | 1.132.772 | 1.139.712 | 1.118.940 | 1.140.563 | 312.331 | 628.075 | 941.294 | 689.205 | 1.378.409 | 2.067.729 | 438.875 | 881.721 | 1.324.577 | 450.919 | 902.200 | 1.353.735 |
| 21.10.2024 | 1.115.166 | 1.124.207 | 1.102.580 | 1.128.657 | 307.599 | 618.360 | 926.828 | 679.828 | 1.359.656 | 2.039.598 | 432.610 | 868.934 | 1.305.269 | 446.207 | 892.782 | 1.339.607 |
| 28.10.2024 | 1.104.582 | 1.125.616 | 1.095.490 | 1.125.850 | 304.016 | 611.190 | 916.055 | 680.680 | 1.361.361 | 2.042.154 | 429.820 | 863.339 | 1.296.869 | 445.103 | 890.567 | 1.336.268 |

Thank you for listening !

Yasemin Çıkıkcı (S009590)

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