Risk-Parity Investment Portfolio in Python

Meiru Zhong

It's common that investors tend to put more weight on equity compared to bonds as they think stocks generate higher returns over a long enough period of time. But in fact, bonds have a higher Sharpe ratio than equities, which means bonds provide higher excess return per unit of risk. Based on this finding, we can scale up the risk of the bond portfolio so it has the same risk as the equity one. As a result, the bond portfolio provides higher returns than equity under the same risk level.

The Risk-Parity strategy uses the same idea to build investment portfolios by allocating weights to different assets based on their risk contribution through optimizations. The objective here is to ensure each asset has equal risk contribution as 1/N (N is the number of assets within the portfolio) Generally, there are two types: Classical Risk Parity and Hierarchical Risk Parity**.**

Here I use six assets, among which two are equity ETFs *(VGT - Vanguard Information Technology ETF and QQQ - Invesco QQQ Trust)*, two are bond ETFs *(VCIT - Vanguard Intermediate-Term Corporate Bond ETF, BNDX - Vanguard Total International Bond ETF, and AGG - iShares Core U.S. Aggregate Bond ETF)*, and one commodity ETF *(GLD - SPDR Gold Shares).* The rolling time window is 90 days and the model will be rebalanced monthly. Data source comes from yahoo finance dating from 2013/03/ to 2023/03/01. The risk parity objective functions have several constraints, for example, each asset accounted for more than 10% and Exponential Weighted Moving Average (EWMA) method was applied to calculate the covariance matrix for risk contribution.

Strategy 1: Classical Risk Parity

The Classical Risk Parity strategy is to allocate weights to different assets based on their individual risk contribution. The assumed leveraged investment was not allowed, the total weights of all assets would be 100%. The risk-parity strategy offered around 0.83 Sharpe ratio, higher than each underlying asset. The average annual return of the portfolio is about 6%.

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sharpe ratio of strategies vs assets:
 risk_parity    [0.8283598854569117]
VCIT                        0.377687
GLD                         0.160197
BNDX                        0.432216
VGT                         0.798126
QQQ                         0.763384
AGG                         0.255118
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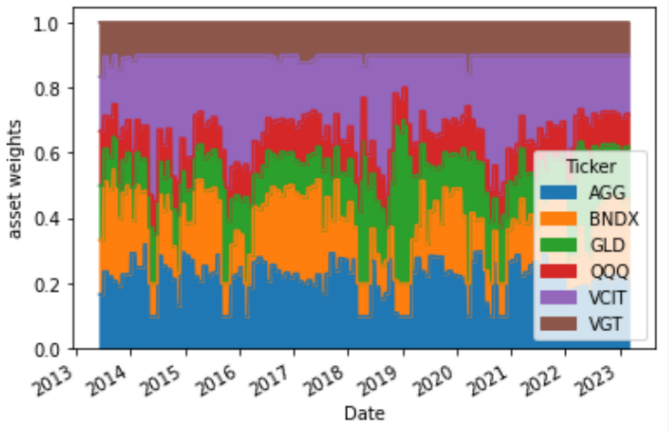
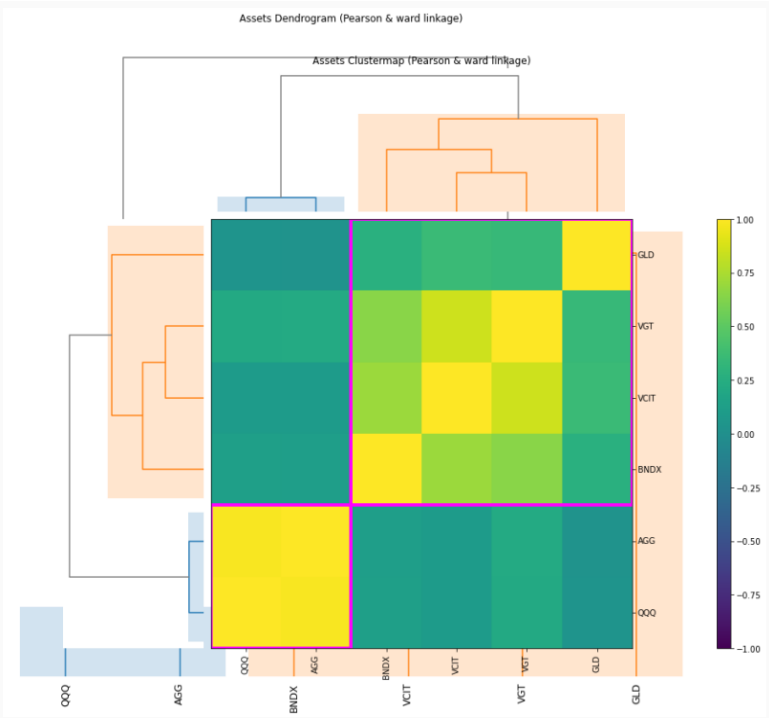
Here is the change in the allocation of 6 assets. On the last day of the investment period (2023-03-01), AGG accounted for 19%, BNDX 23%, GLD 20%, QQQ 10%, VCIT 18%, and VGT 10%. That is, equity ETFs made up 20%, bond ETFs 70%, and commodities 10%.



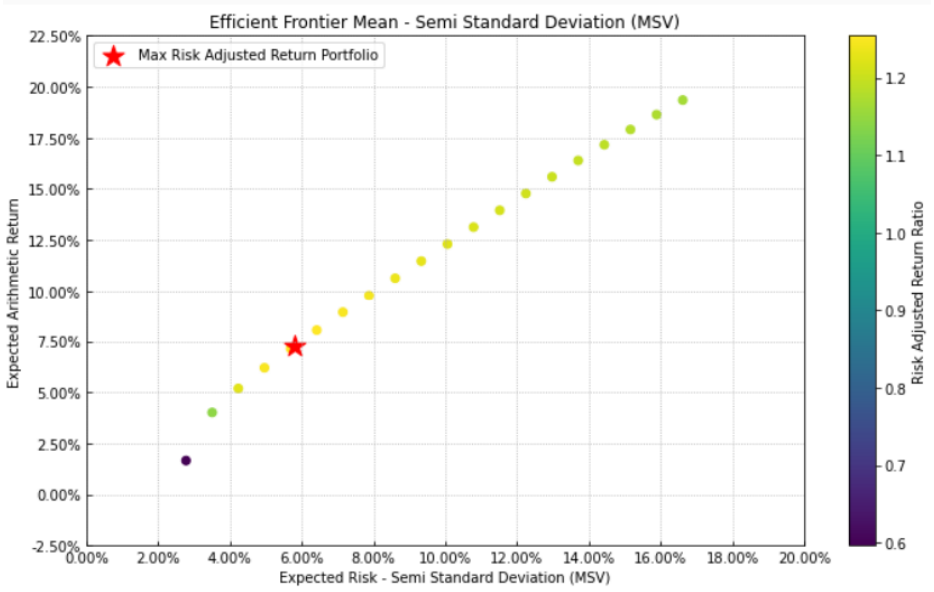
Strategy 2: Hierarchical Risk Parity

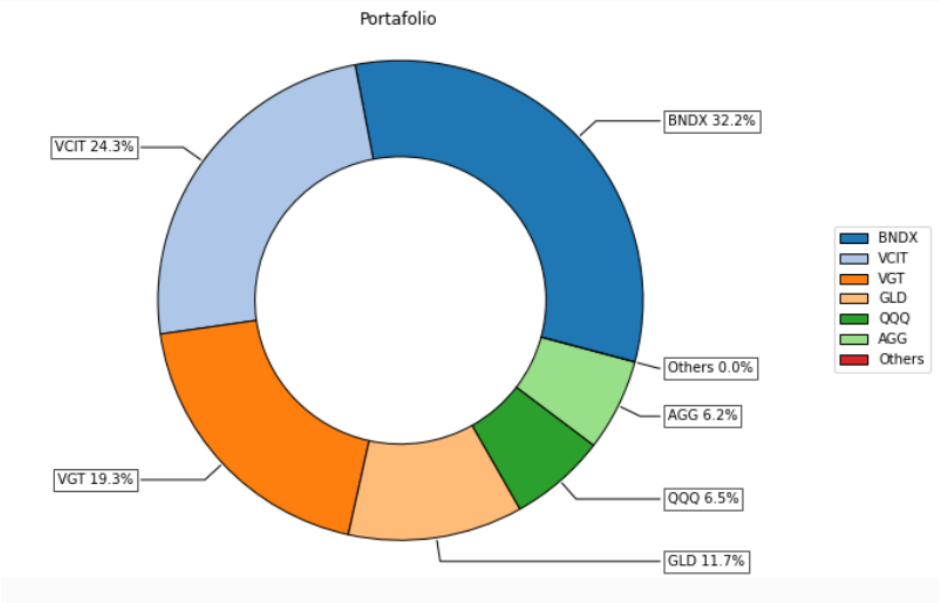
The classical Risk-Parity strategy may not work well when allocating assets among different clusters as it would favor one group with a higher number of assets than the other group. To address this issue, the hierarchical Risk-Parity strategy can be used to create clustering groups and allocate risks equally across the groups.

This is the dendrogram of the hierarchical clustering and it's clear that six assets were classified as two groups. Group 1 consisted of QQQ and AGG and Group 2 included GLD, VGT, VCIT, and BNDX.



Then I built an effective frontier to identify the adjusted return of the current portfolio, which was around 7.5%, better than the classical risk-parity portfolio's performance. The optimal portfolio constituted 32.2% BNDX, 24.3% VCIT, 19.3% VGT,11.7% GLD, 6.5% QQQ, and 6.2% AGG.





Adjusted Investment Period to Exclude the Impacts of Higher Interest Rate

Since the Fed kept rising interest rates in April 2022, causing huge negative impacts on all investments, I adjusted the time frame and studied data from 2013/03/ to 2021/03/01. It's

surprising that the Sharpe ratio of the Classical Risk-Parity portfolio jumped from 0.83 to 1.28, rising by 54%, and its average annual return also increased from 6.0% to 8.2%. This portfolio had 22% AGG, 24% BNDX, 15% GLD, 10% QQQ, 19% VCIT, and 10% VGT. That is, equity ETFs made up 20%, bond ETFs 65%, and commodities 15% while the 2023 classical portfolio had 20% equity, 70% bond, and 10% commodity.

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sharpe ratio of strategies vs assets:
 risk_parity    [1.2800212795709334]
VCIT                        0.844866
GLD                         0.157321
BNDX                        1.203525
VGT                         1.099504
QQQ                         1.095644
AGG                         0.763502
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Conclusion

The Risk-Parity strategy allocates weights to different assets based on their risk contribution through optimizations. There are two types: the Classical Risk-Parity strategy allocated weights based on an individual asset's risk contribution, while the Hierarchical one first allocated risks equally across the groups and then within groups. Compared with the two portfolio's Sharpe ratios, the Hierarchical Risk-Parity had better performance with higher returns and lower risks. Besides, when adjusted for the investment period to exclude the impacts of higher inflation and interest rate, we can see how impactful the regulations are to the investment and how important it is for us to adjust the portfolio weights accordingly to minimize the negative influence on the dismal outlook.