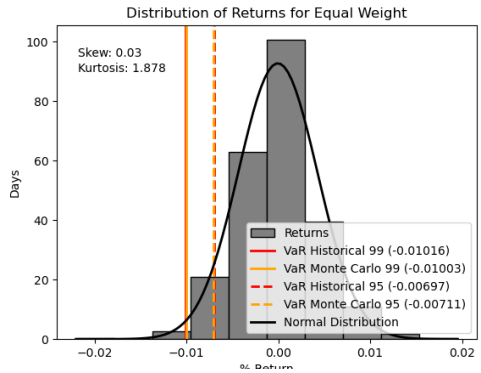
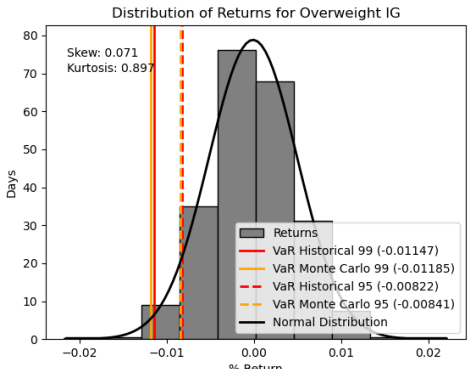
Portfolio Construction

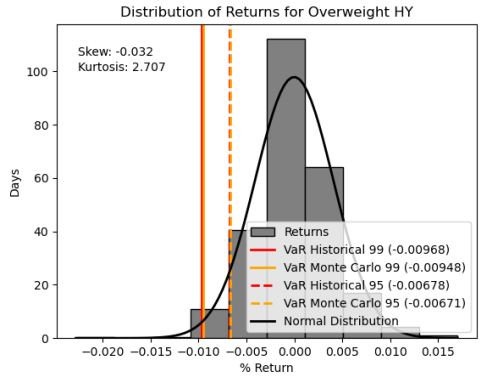
I chose to simulate a portfolio of bond indices of various credit qualities, specifically, AAA, BBB, BB, and CCC. To do this, I used the BofA index products since these are publicly available via the FRED API. All indices track a subset of bonds in the ICE BofA US Corporate Master Index tracking the performance of dollar-denominated corporate debt publicly issued in the US domestic market.

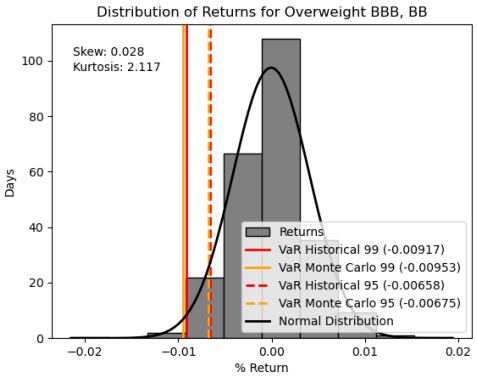
Var Calculations

I decided to calculate VaR using both the Historical Simulation (HS) method as well as the Monte Carlo (MC) method to compare the results of each calculation. In addition, I performed this calculation for 95% and 99% confidence levels across four arbitrarily weighted portfolios. The different portfolios include: equal weight (EW) ([0.25, 0.25, 0.25, 0.25]), overweight investment grade (OW IG) ([0.5, 0.25, 0.15, 0.1]), overweight BBB BB (OW BBB BB) ([0.1, 0.4, 0.4, 0.1]), and overweight high yield (OW HY) ([0.1, 0.15, 0.25, 0.5]). These portfolio weightings were selected to analyze the effect of credit quality on the riskiness of the portfolio determined by the VAR using a 2-year lookback. The VaR for each portfolio over the two-year period was for -1% (99%), -0.7% (95%) EW, -1.1% (99%), -0.8% (95%) for OW IG, -0.9% (99%), -0.7% (95%) for OW BBB BB, and -0.97% (99%) -0.68% (95%) for OW HY. These are HS VaR calculations, although the MC VaR returns were within 0.05% of the HS VaR calculation.









Based on the results, it is important to note the counterintuitive observation that investment-grade debt was riskier than junk bonds from a VaR perspective in this return window. This can be explained by the fact that the driving force in bond returns over the past two years has been increasing interest rates. When only taking into account yield curve risk, cheaper bonds will be less sensitive to interest rate moves since the percentage change in a cheaper high yield bond will be less than that of a more expensive investment-grade bond due to the convex non-linear relationship of price and yield.

These results are not a realistic depiction of risk, since they are only based on returns in the past two years, a relatively short window of time in which no major crisis or periods of great market stress were observed. There has been volatility in prices as interest rates have climbed, although the period of 2022-2024 is not a large enough sample window to adequately assess the risk of these portfolios. A better window would include the 2020 period as well as 2008 GFC and the 2012-2019 of ultra-low volatility and

rock-bottom interests. If these windows were included, I believe that the overweight IG bond portfolios would show lower VaR profiles than the overweight HY portfolios.

Comparing HS and MC VaR Methods

The HS method is arguably the simplest and most computationally expedient, as it simply involves ordering the returns from worst to best and then selecting the largest return in the desired confidence level (represented as a percentile here). The MC methodology is still based on returns; however, it fits a distribution (usually normal) to these returns and then randomly samples from this distribution to construct a distribution of hypothetical portfolio returns. The greatest of the returns in the desired confidence interval is taken as the VaR.

The key difference between the HS and MC is that the MC method assumes a distribution, whereas the HS method assumes that future returns will resemble historical ones. In this case, the HS and MC VaR calculations are very similar since the returns are somewhat normal. However, in cases where the distributions are highly kurtotic and/or skewed, the MC might produce drastically different results than HS.

Lastly, it is important to note that VaR is limited in its assessment of risk because it only provides confidence on what is the likelihood of the worst case, but not what the magnitude of the worst case might be! To better understand how the fat tails of the returns impact the risk of the portfolio, a metric such as conditional VaR (CVaR) might be more helpful. In short, CVaR integrates all the losses occurring within the VaR interval to provide an estimate of the total amount of losses one might expect to experience given the worst case materializes.

Daily DV01

Daily DV01 was calculated by linearly interpolating the daily change in price / change in yield. For daily movements, this method of estimating DV01 should be approximately correct. For larger movements, there will be some approximation error since the DV01 changes non-linearly with respect to the price/yield.