Value at Risk (VaR) Analysis

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Value at Risk (VaR) is a financial metric used to estimate the theoretical loss that an investment will not exceed with a defined confidence level or probability.

The method of using VaR to manage financial risk is based on the following assumptions:

- The returns of the investment portfolio are normally distributed
- The distribution of the returns is approximately stable over time

There are many different methods of calculating the VaR. In this analysis we focus on the Parametric Method that estimates the mean and variance of the returns and calculate the corresponding percentile from the normal distribution. We calculate or VaR with the confidence level 95% using the assets values from 9/26/2021 to 9/27/2022.

Our investment portfolio includes the following assets:

Ticker	Type	Sector	Units	Amount
US30Y	U.S. 30 Year Treasury	NaN	467317.00	42262981.19
HSON	Common Stock	COMMERCIAL SERVICES	36138.24	1263031.49
GOGO	Common Stock	COMMUNICATIONS	94822.19	1263031.57
JAKK	Common Stock	CONSUMER DURABLES	54044.99	1263031.42
CALM	Common Stock	CONSUMER NON-DURABLES	22216.91	1263031.33
HRB	Common Stock	CONSUMER SERVICES	28111.09	1263031.27
HDSN	Common Stock	DISTRIBUTION SERVICES	159071.98	1263031.52
BELFA	Common Stock	ELECTRONIC TECHNOLOGY	44285.81	1263031.30
ARLP	Common Stock	ENERGY MINERALS	52890.76	1263031.35
CI	Common Stock	HEALTH SERVICES	4350.03	1263031.21
SRTS	Common Stock	HEALTH TECHNOLOGY	85339.97	1263031.56
LNG	Common Stock	INDUSTRIAL SERVICES	7551.75	1263030.19
BSM	Common Stock	MISCELLANEOUS	80447.87	1263031.56
HUDI	Common Stock	NON-ENERGY MINERALS	42612.40	1263031.54
CF	Common Stock	PROCESS INDUSTRIES	12810.95	1263031.56

Ticker	Type	Sector	Units	Amount
CSL	Common Stock	PRODUCER MANUFACTURING	4335.84	1263030.19
MUSA	Common Stock	RETAIL TRADE	4561.65	1263029.65
AZPN	Common Stock	TECHNOLOGY SERVICES	5579.50	1263031.42
ASC	Common Stock	TRANSPORTATION	126303.15	1263031.50
ED	Common Stock	UTILITIES	12966.13	1263030.72
YCS	ETF	NaN	25261.96	1599839.93
UUP	ETF	NaN	54416.32	1599839.81
EUO	ETF	NaN	47870.73	1599839.80
EWV	ETF	NaN	79832.33	1599839.89
DIG	ETF	NaN	44390.67	1599839.75
TTT	ETF	NaN	23645.28	1599839.64
ERX	ETF	NaN	29349.47	1599839.61
TMV	ETF	NaN	13430.49	1599839.97
TBT	ETF	NaN	54509.02	1599839.74
TYO	ETF	NaN	127782.74	1599839.90

For the U.S. 30 Year Treasury Bonds, we calculate the daily market value of the bonds from the start date to the end date defined aboved. The calculation is based on the implied yield rates from:
https://www.marketwatch.com/investing/bond/tmubmusd30y?countrycode=bx
The values are calculated with the assumption that the **coupons received are not re-invested**, since the coupon is relatively small and the return within one year for that small amount is neglectable.

For the common stocks and ETFs, we then retrieve the adjusted close prices using the yfinance package.

We then calculate the VaR using the approach from https://www.interviewqs.com/blog/value-at-risk. The daily Percent Return at Risk of our portfolio is **-0.9897%** and the daily Value at Risk is **$814,110.08**. Additionally, we calculated the daily Percent Return at Risk using the Historical Method. The return of the 11th worst day (out of 249 days) is -0.9753%. The two numbers are approximately the same. Our calculation of VaR is plausible.

One of the assumption our VaR calculation is that the returns of our portfolio are normally distributed. We find that the returns of each individual asset in a portfolio may not be normal (see the plots at the end of this post), but the returns of a well-diversified portfolio are approximately normal. Hence, it may be inappropriate to use VaR to measure the risk of individual asset, but it is reasonable to do so for well diversified portfolios. The plots below show the distributions of the returns of our portfolio, and the S&P 500 ("^GSPC"), Dow Jones ("^DJI"), and Nasdaq Composite ("^IXIC") indexes. The solid lines are the hypothetical normal distributions for comparison.
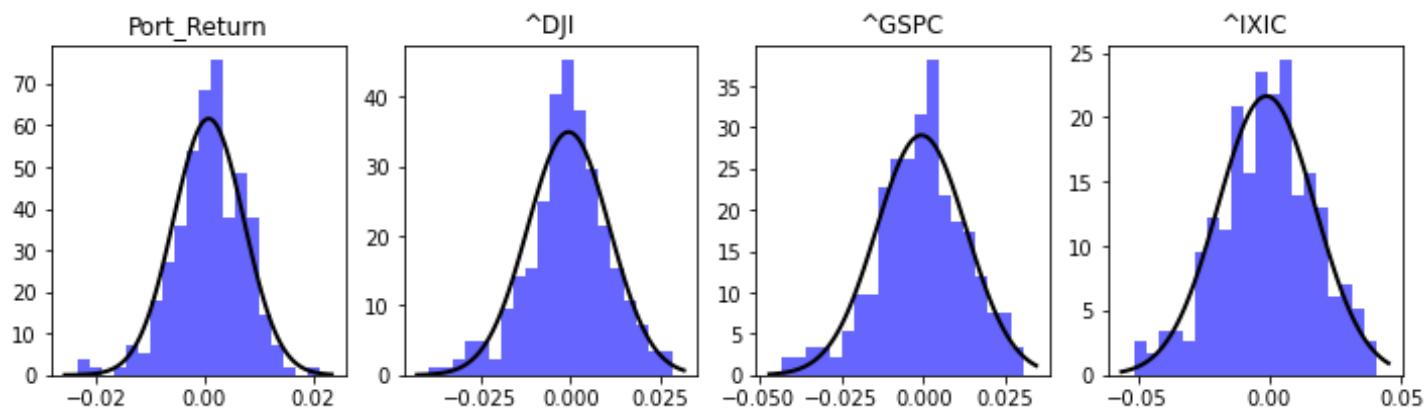
As the data available, we can also compare the historical performance of our portfolio to the performance of the three market indexes.

	mean	std
Port_Return	0.000767	0.006483
^DJI	-0.000592	0.011442
^GSPC	-0.000664	0.013751
^IXIC	-0.001134	0.018472

Our portfolio has the highest expected daily return and the lowest volatility. We can also confirm that our portfolio has smaller fluctuation than the three market indexes
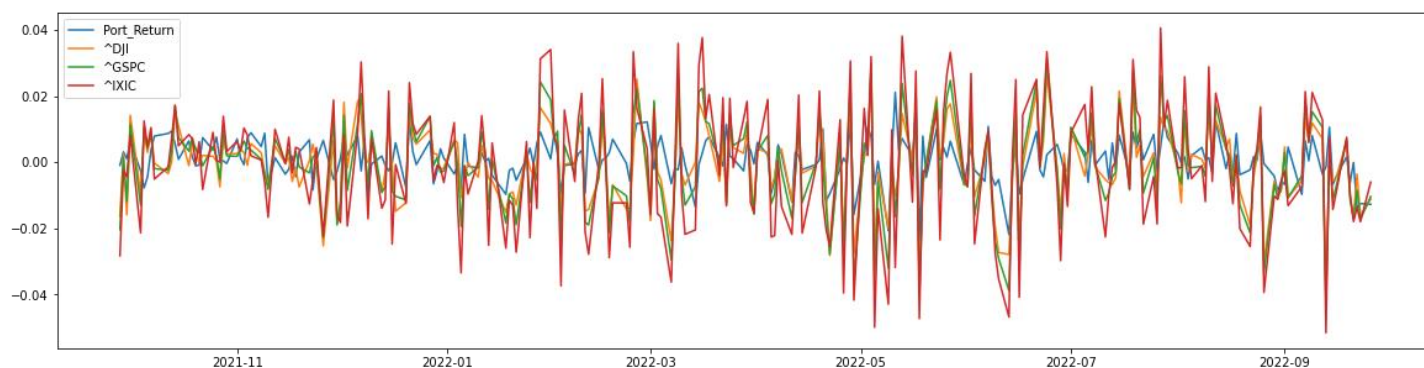
Additional Insight: The risk management of using VaR is also based on another assumption that the distribution of the returns is approximately stable over time. This may be valid for a short period, but for long term capital management, we need to handle the problem of volatility clustering.

Distributions of the Historical returns of each asset in our portfolio. Most of the distributions are approximately normal. However, there are a few assets such as AZPN and LNG with distributions somewhat different from their hypothetical normal distributions.