Raccoon Capital
Final Presentation

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Everything Starts With...

Using **Bollinger Bands** to Gauge Trends

Bollinger Bands are composed of **three lines**.

- a **20-day** simple moving average (SMA) for the middle band.
- The upper band is calculated by taking the middle band and adding twice the daily standard deviation to that amount.
- The lower band is calculated by taking the middle band minus two times the daily standard deviation.

Strengths:

- Low Trading Frequency
- Apparent Trading Signal

$$BOLU = MA(TP,n) + m * \sigma[TP,n]$$
$$BOLD = MA(TP,n) - m * \sigma[TP,n]$$ **where:**

MA = Moving average

TP (typical price) $= (High + Low + Close) \div 3$

n = Number of days in smoothing period

m = Number of standard deviations

$\sigma[TP,n]$ = Standard Deviation over last n periods of TP

Data Collection

Closing price of each asset: directly scraped from yahoo finance. To ensure data integrity, we exclude any data that occurred during the weekend for cryptocurrency.

Return of each asset: return of assets is calculated with percentage daily/weekly change in the closing price, depending on the method adopted each week.

MA20: The moving average of closing price/return of the past 20 trading days/weeks, depending on the method adopted each week.

Standard deviation of historical performance: the standard deviation of daily/weekly closing price/return of each asset, depending on the method adopted each week.

Z-score: the normalized daily/weekly closing price/return. We use MA20 as the mean and Standard deviation of historical performance as the standard deviation for normalization.

Methods for **Decision Making**

Phase 1 (Week 1-3)

➢ **Upper/lower Bollinger Band** = MA20 +/- 2 × standard deviation

➢ **Approach**: Collect the latest 20 days closing price data of each asset and calculate the average. Calculate **z-scores** for assets, then invest in assets based on their z-scores (e.g. long assets with 5 smallest z-scores & short assets with 5 largest z-scores).

➢ **Problem**:

- Invested assets with extreme z-scores in subjective quantity, which does not reflect the **magnitude in deviation**
- 10 assets in total may partially fall **within** upper and lower Bollinger Bands
- As a weekly strategy, should employ **weekly data** instead of daily

Methods for **Decision Making**

Phase 2 (Week 4-7)

➢ Use Python **PuLP** package to apply the **optimization method**.

Max sum (weights * return)

s.t.

w1 + w2 +w3 + w4 + ... + w15 = 1

-1 <= w <= 1

➢ **Approach:** Use Z score to select asset candidates for decision making, then use the above optimization to distribute the according weights

➢ **Problem**:

- Without constraint on risk, the optimization will generate highly random results

https://coin-or.github.io/pulp/

Methods for **Decision Making**

Phase 3 (Week 8-10)

➢ **Upper/lower Bollinger Band** = MA20 +/- 1.5 × standard deviation

➢ **Advanced Optimization Method**:

Max sum (weights * **adjusted returns**)

s.t.

w1 + w2 +w3 + w4 + ... + w15 = 1

0 <= w <= 1

$\sqrt{(\sum\sum W_i \cdot W_j \cdot \sigma_{ij})} <= 0.05$

$W <= 0.2_i$

➢ **Approach**: Use Z score (smaller threshold of 1.5) to select asset candidates for decision making, then use optimization to distribute the weights

➢ **Improvement**:

1. Add more constraints
2. Maximize Sharpe Ratio

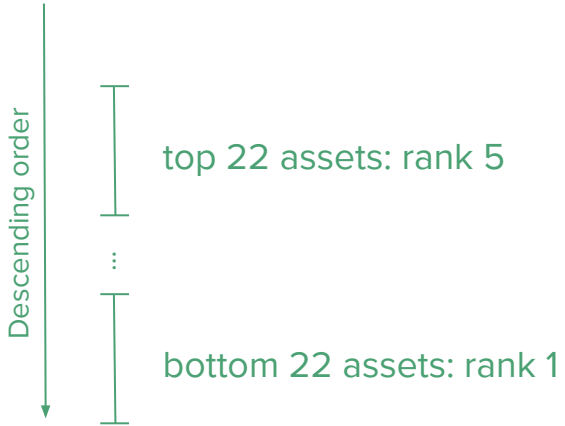
Methods for **Ranking**

Phase 1 (Week 1-3)

➢ **Binary Assignment:** assign 0 and 1 to each rank for assets according to their z-scores

➢ **Problem:** no probability distribution. A wrong decision will lead to huge cost

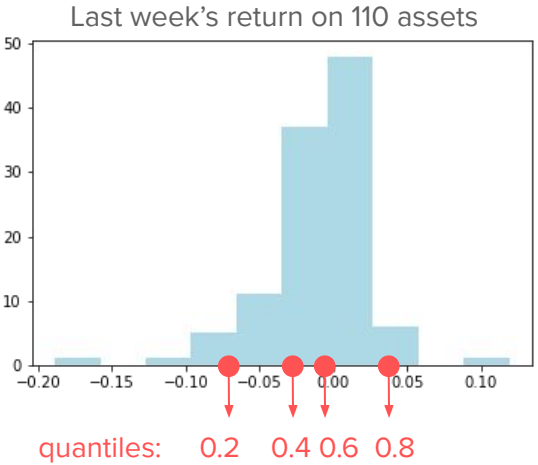
Asset	Weekly Return	Rank 1	…	Rank 5
Asset Y	0.2567	0	…	1
…	…	…	…	…
Asset X	-0.198	1	…	0
Asset Z	-1.275	1	…	0

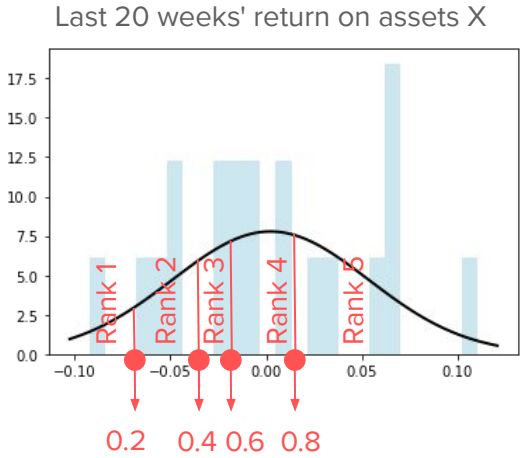


Methods for **Ranking**

Phase 2 (Week 4-7)

➢ **Probability Assignment:** utilize last week's return to find the cutoff value for each rank. Then use a fitted normal distribution on the historical return of an asset to estimate the probability that this asset falls into a rank.





Methods for **Ranking**

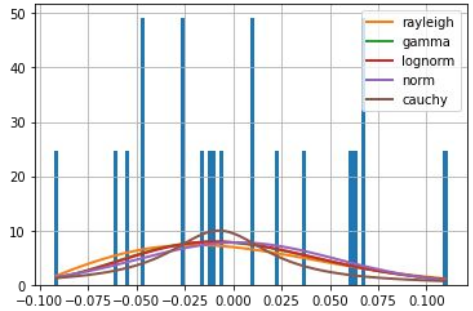
Phase 3 (Week 8-10)

➢ **Probability Assignment:** utilize last week's return to find the cutoff value for each rank. Then use a fitted normal distribution on the historical return of an asset to estimate the probability that this asset falls into a rank.

➢ **Improvement**:

1. Find the best fit distribution for each asset
2. Normalize final result to avoid extreme probability distribution. The assigned probability of each rank adds up to 22.

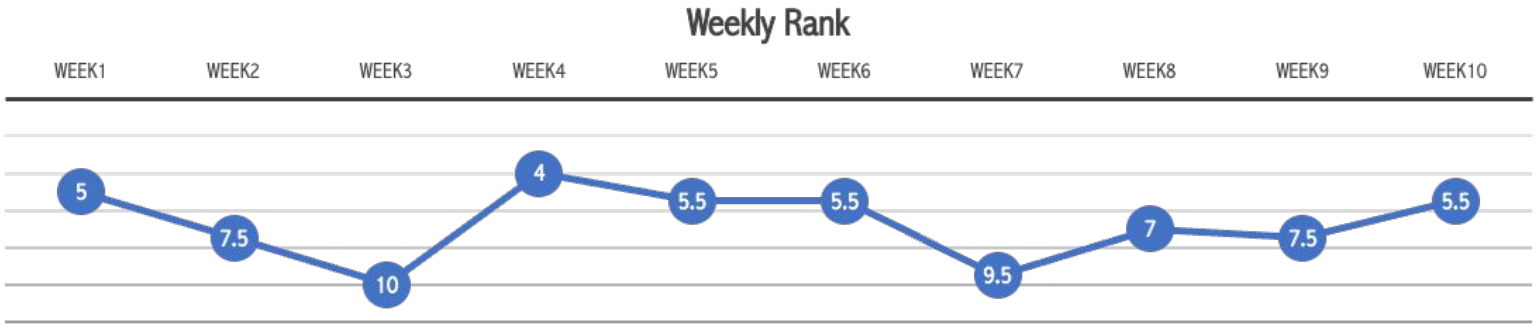
Last 20 weeks' return on assets X



	sumsquare_error	aic	bic	kl_div	ks_statistic	ks_pvalue
rayleigh	14296.509633	-281.500976	137.432233	inf	0.108216	0.953451
gamma	14296.526255	-271.724544	140.427989	inf	0.118424	0.911040
lognorm	14303.848401	-271.041425	140.438229	inf	0.119764	0.904341
norm	14368.129432	-273.595574	137.532175	inf	0.122657	0.889042
cauchy	14450.289741	-209.940831	137.646214	inf	0.119630	0.905021

https://medium.com/the-researchers-guide/finding-the-best-distribution-that-fits-your-data-using-pythons-fitter-library-319a5a0972e9

Result and Discussion



Bollinger Band & z-score

Binary assignment

Return optimization

Normal distribution fit
CDF assignment

Sharpe Ratio optimization
Constraint improvement

Various distribution fit
Normalization

Conclusion

Raccoon Capital 10-Week Compounded Rate of Return: **7.68%**
S&P 500 10-Week Compounded Rate of Return: **3.95%**

What we learned

1. One strategy would not always win, unless it is investing in S&P 500
2. It takes time for Bollinger Bands' Mean Reversion to take effect
3. If we want to make a decision based on last week's return, we should exclude last week's data when calculating parameters (MA20 etc.) because decision variable should no be used to calculate benchmark values
4. How to use data-driven approaches to build a portfolio: **optimization**, **probability distribution**, **time series**...