Simple Trading Strategy based on Nelson Siegel Model

Contents

Data Cleaning

- For bonds issued within the month, Total Return is estimated using the following formula:

$$TotalReturn_{BondA} = \frac{TotalReturn_{BondB}}{Mod.DurationToWorst_{BondB}} Mod.DurationToWorst_{BondA}$$

  where Bond B is the bond with the closest Modified Duration To Worst to Bond A. The underlying assumption is that bonds' returns were constant throughout the month.

- For bonds matured during the month, the latest available data are used for the following fields: Coupon Rate, Coupon Frequency, Coupon Type.[1] The other fields are correctly set equal to 0.
- No other data anomalies have been detected.

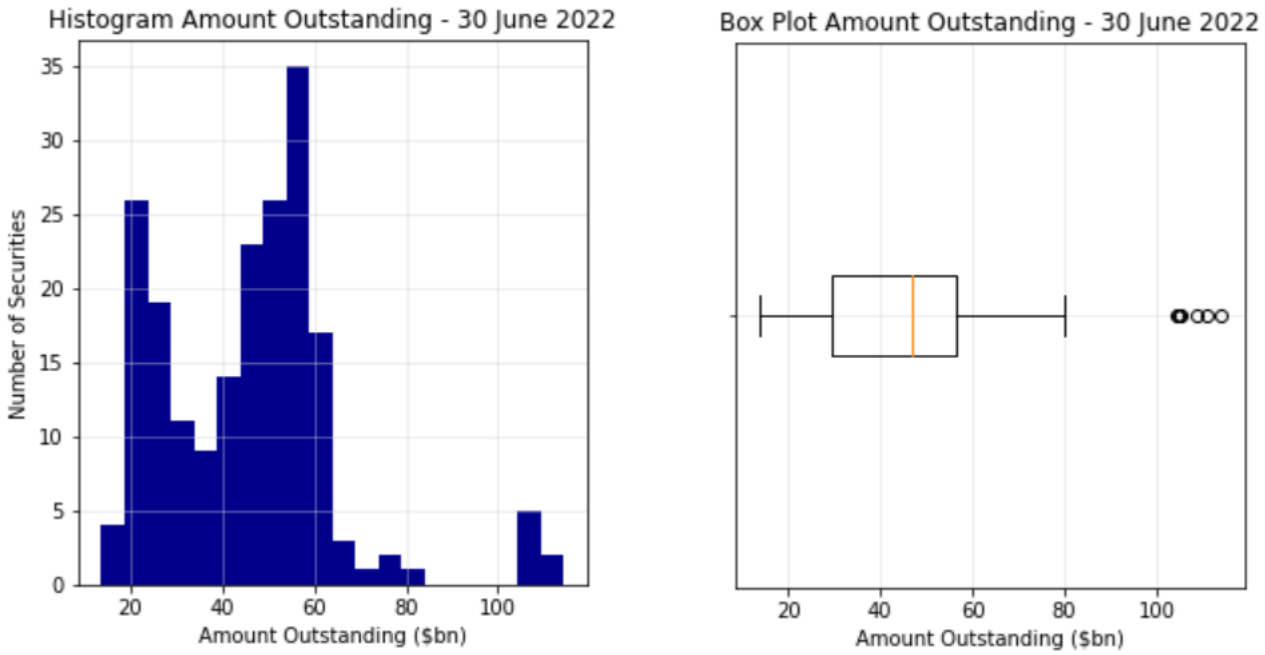
Assumptions:

- The column AMOUNTOUTSTANDING refers to the total dollar amount issued in the market and it's measured in $1000s.
- Given the point above, I have to make an assumption bonds' denomination. For each bond, I assumed an arbitrary denomination proportional to the amount outstanding.
- Please note that the metrics showed in this report are computed as of post-rebalance. Returns refer to the current month.

Opportunity set

The opportunity set consists of bonds issued by the U.S. Government with maturity between 1 and 20 years, and that were issued not more than 10 years ago.

Investment Universe Amount Outstanding



[1] It was not possible to apply this logic for three bonds (US912828ZX16, US912828XW50, US912828XG01) maturing in June 2022

I decided not to apply a minimum cut off for the amount outstanding as I believe it is not needed: this is because the smallest issuance in the investment universe is more than $13bn, so much more than the typical minimum threshold for Fixed Income indices. Secondly, Treasuries are regarded as one of the most liquid markets as these securities are used as collateral in a variety of transactions.[2]

Investment Universe Summary Statistics

Date	Mod Duration To Worst (%)	Yield to Worst (%)	Number of Securities	Market Value ($bn)	Amount Outstanding ($bn)
30/06/2022	4.37	3.05	198	8,445	9,018
29/07/2022	4.36	2.84	201	8,743	9,201
31/08/2022	4.37	3.42	199	8,476	9,133
30/09/2022	4.28	4.16	199	8,307	9,193
31/10/2022	4.24	4.39	199	8,309	9,255

In line with what observed in other Fixed Income markets in 2022, yields sharply increased and the aggregated market value went down.

Benchmark

The benchmark used is a market value weighted index tracking the largest bonds in the investment universe (Amount Outstanding greater than $50bn). For this reason, the benchmark closely reflects the dynamics of the broader investment universe.

Benchmark Summary Statistics

Date	Mod Duration To Worst (%)	Yield to Worst (%)	Number of Securities	Period Return (%)	Cumulative Performance
30/06/2022	5.17	3.07	86	0.00	100.00
29/07/2022	5.15	2.82	86	1.71	101.71
31/08/2022	5.11	3.40	84	-2.48	99.19
30/09/2022	5.04	4.12	84	-3.05	96.16
31/10/2022	4.99	4.35	83	-0.81	95.39

Model

I used the Nelson & Siegel model to interpolate the yield curve and find mispriced bonds. This is a parametric model where the continuously compounded spot rate is defined according to:

$$R_{NS}(t, t+\tau) = \beta_0 + \beta_1 \frac{1 - e^{-\tau k}}{\tau k} + \beta_2 \left(\frac{1 - e^{-\tau k}}{\tau k} - e^{-\tau k} \right)$$

Where $\beta_0, \beta_1, \beta_2, k$ are the unknown parameters

- β_0 is the long-term yield to which the spot rate tends to (if τ tends to ∞)
- β_1 is the weight attached to the short-term component, a measure of the slope of the yield curve.
- β_2 is the weight attached to the medium-term component of the yield curve and measures its curvature.
- k measures the point of the beginning of decay.

I decided to use this model for various reasons:

[2] Moreover, in 2022 this market showed some forms of stress: https://www.bloomberg.com/news/articles/2022-10-06/us-treasuries-liquidity-problem-exposes-fed-to-biggest-nightmare?leadSource=uverify%20wall

- It’s a flexible model capable of capturing different shapes of the yield curve.
- It’s a parsimonious model with only four parameters used to estimate the entire yield curve.
- Provides an easy interpretation of the factors affecting the shape of the yield curve.

Model Fit: Summary Measures

Date	Mean Squared Error (%)	Root Mean Squared Error (%)	Mean Absolute Error (%)	R Squared (%)
30/06/2022	0.000	0.048	0.040	82.040
29/07/2022	0.000	0.026	0.020	97.379
31/08/2022	0.000	0.053	0.045	78.246
30/09/2022	0.000	0.047	0.040	90.829
31/10/2022	0.000	0.039	0.030	95.334

The model fitted the data very well, leading to a high R Squared and low Mean Squared Error. On the other hand, it would be difficult to make predictions on new issuances between 10 and 19 years given the absence of observations.

Investment Strategy

I developed a long-only strategy with the objective of enhancing performance while keeping a similar risk profile as the Benchmark. At each rebalance date, a Nelson-Siegel model is fitted on the investment universe of the Parent Index with the goal of identifying mispriced securities comparing the predicted Yield To Worst with the one observed in the market. Constituents are reweighted according to the following weighting scheme:

Objective functions

1. Minimize the difference between the Modify Duration To Worst of the strategy and the Parent index
2. Minimize the difference between the Yield To Worst of the strategy and the Parent index

Constraints

- The top 25% (weight) most overvalued bonds receive a weight equal to zero
- The top 25% (weight) most undervalued bonds are going to be overweighted by at least 25%
- Each constituent is capped at 5%

I coded this strategy in the AlphaStrategy class. However, this is still an index strategy, not an actual portfolio. I created a Portfolio class where I ran the strategy with an initial $100M investment. The position in each security is chosen with the goal to minimize the tracking error with the alpha index strategy. No leverage is allowed.

Portfolio's Performance

Date	Portfolio Returns (%)	Alpha Index Returns (%)	Parent Index Returns (%)	Portfolio Cumulative Returns	Alpha Cumulative Returns	Parent Cumulative Returns
2022-06-30	0.00	0.00	0.00	100.00	100.00	100.00
2022-07-29	1.63	1.63	1.71	101.63	101.63	101.71
2022-08-31	-2.45	-2.44	-2.49	99.14	99.14	99.18
2022-09-30	-2.84	-2.84	-3.06	96.33	96.33	96.15
2022-10-31	-0.81	-0.81	-0.81	95.55	95.55	95.37

The strategy outperformed the Benchmark while maintaining a relatively similar risk profile in terms of duration and yield. Turnover is higher than the Benchmark, however these securities are expected to be very liquid with narrow bid-ask spreads.

Comparison Investment Strategies

Date	Portfolio Value ($mln)	Portfolio Duration	Alpha Index Duration	Benchmark Duration	Portfolio YTW (%)	Alpha Index YTW (%)	Benchmark YTW (%)
2022-06-30	100.00	4.80	4.80	5.17	3.09	3.09	3.07
2022-07-29	101.63	4.97	4.97	5.15	2.84	2.84	2.82
2022-08-31	99.14	4.72	4.72	5.11	3.46	3.46	3.40
2022-09-30	96.33	5.03	5.03	5.04	4.17	4.17	4.12
2022-10-31	95.55	5.04	5.04	4.99	4.37	4.37	4.35