Methodology for Yield Curve Volatility Tracker

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1 Introduction

This document outlines the methodology used in the **Yield Curve Volatility Tracker** project, which analyzes U.S. Treasury yield curves to understand their volatility dynamics. The project involves collecting daily yield data, visualizing yield curve trends, and calculating volatility metrics. Rather than measuring volatility based on the common 2s10s spread, the model uses the fitting parameters of the Nelson-Siegel-Svensson (NSS) model, more precisely the ratio of β_0, short-end, and β_1, long-end, parameters. This project was made as tool to assess the robustness of the conclusions made in the accompanying paper.

2 Data Collection

Daily Treasury yield data is sourced from the U.S. Department of the Treasury's public API. The data includes yields across multiple maturities, ranging from short-term (1-month) to long-term (30-year) maturities.

2.1 API Request Function

The data is retrieved using an API request function that sends an HTTP GET request to the Treasury's data endpoint. The function is implemented as follows:

```
def get_daily_treasury_yield(year):
    url = f'https://home.treasury.gov/resource-center/data-chart-center/interest-rates/pages
    response = requests.get(url)
    # Parse XML response and store in a data structure
```

This function parses the XML response to extract daily yield values for various maturities, storing the data in a structured format for analysis.

3 Methodology

3.1 Yield Curve Visualization

To visualize the yield curve, we plot the yield rates against their respective maturities. This allows us to observe changes in the yield curve over time and identify patterns indicative of economic trends.

3.2 Nelson-Siegel-Svensson Fitting Model

The Nelson-Siegel-Svensson (NSS) model is used to fit the yield curve, providing a smooth representation of yield across maturities. The NSS model is expressed as:

$$y(\tau) = \beta_0 + \beta_1 \frac{1 - e^{-\tau/\lambda_1}}{\tau/\lambda_1} + \beta_2 \left(\frac{1 - e^{-\tau/\lambda_1}}{\tau/\lambda_1} - e^{-\tau/\lambda_1} \right) + \beta_3 \left(\frac{1 - e^{-\tau/\lambda_2}}{\tau/\lambda_2} - e^{-\tau/\lambda_2} \right) \tag{1}$$

where:

- $y(\tau)$ is the yield for maturity τ.
- β_0, β_1, β_2, and β_3 are parameters representing the level, slope, and curvature of the yield curve.
- λ_1 and λ_2 control the rate of decay, shaping the curve for short and long maturities.

The model parameters are estimated by minimizing the error between the observed and model-predicted yields across maturities, using a non-linear optimization technique.

3.3 Volatility Calculation

The volatility of the yield curve is derived using an **inversion indicator** based on the Nelson-Siegel-Svensson model's β_0 and β_1 parameters. These parameters respectively represent the level and slope of the yield curve, and their ratio can indicate curve inversion, a potential economic signal.

3.3.1 Inversion Indicator

We calculate an inversion indicator as follows:

$$\text{Inversion Indicator} = \frac{\beta_0}{\beta_1} \tag{2}$$

This indicator's daily values are then analyzed by taking the natural log of their daily ratios, which provides insight into daily yield shifts:

$$\text{log ratios}_t = \ln \left(\frac{\text{Inversion Indicator}_t}{\text{Inversion Indicator}_{t-1}} \right) \tag{3}$$

3.3.2 Rolling Volatility

The volatility is estimated using a rolling 50-day standard deviation of these daily log ratios, denoted as:

$$\sigma_{\text{daily, 50-day}} = \sqrt{\frac{1}{50} \sum_{i=0}^{49} \left(\text{log ratios}_{t-i} - \overline{\text{log ratios}_t}\right)^2} \tag{4}$$

This rolling standard deviation provides a smoothed measure of yield curve volatility over recent periods. The plot of this volatility measure highlights fluctuations and trends over time, which can be monitored for signals of economic stress or stability.

4 Assumptions

- Daily yield changes are assumed to follow a normal distribution for the purpose of calculating annualized volatility.
- Treasury yields across maturities are assumed to be independent.
- The Nelson-Siegel-Svensson model accurately captures the shape of the yield curve, though it may not reflect extreme yield behaviors.

5 Conclusion

The **Yield Curve Volatility Tracker** project uses these calculations and visualizations to generate insights on the U.S. Treasury yield curve, helping to assess economic trends based on yield curve dynamics.