MF728 Group 9 Project Proposal

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Motivation

For active management of bond's portfolio, it is a requirement to have a view of how the yield curve will behave over time. If the forecasting of the yield curve is right, and the view has not been reflected in security prices, the prediction on the yield curve can add value to the portfolio's performance. [CFA III] **Project Focus**

We consider two approaches to create reliable yield signals: We leverage both time series and machine learning models to predict the change in YTM at different points along the yield curve. We identify three major patterns of yield curve shifts and construct trading strategies accordingly.

Outline

We approach our topic in the following steps:

1. We obtain US treasury yield curve data with a time span from 2010 to 2020 on Bloomberg and FRED.
2. We will explore various visualization and statistical analysis framework to get data descriptives
3. We create yield curve forecast model by employing OLS. Based on one of our references Gamage and Rangika, we utilize the following models to forecast

different term structures: Nelson-Siegel (NS) model with AR(1) & VAR(1) to forecast short-term structures (up to 2Y) and Gaussian Process Regression (GPR) to forecast long term structures (up to 30Y). To check our model accuracy, we separate data set into training and test sets and create confusion matrix to visualize the accuracy.

4. We will also use machine learning models to predict different in YTM for bonds with different maturities:
    a) Download daily YTM of 2Y,10Y,20 Year Bond.
    b) Calculate the difference between two days YTM.
    c) Using machine learning algorithms like SVM, decision tree, CNN, etc. to predict future YTM based on machine learning algorithms. Split the dataset to train dataset (from 2010-2020) and test dataset (2020-now). Train the model with the train dataset and predict the value in the test dataset. Compare each model performance and choose the best model.
    d) Use the model we choose to predict future yield based on all history data.
    e) We may use different models to predict the YTM of Bonds with different maturity. Finally, we will get the difference between tomorrow's YTM (predicted) and today's YTM for the 2,10,20 Year bonds.
5. We construct trading strategies to adjust or portfolio

Yield Curve Strategies

(1) Describe the factors affecting fixed-income portfolio returns due to a change in benchmark yields

A yield curve plots the yield of a specific type of fixed-income security as a function of its maturity. Yield curves are most typically plotted for credit risk-free government bonds to act as a benchmark for other types of fixed-income securities. Here, the yield curve that we used is to depict the changes of YTM. Thus, in the United States, the typical benchmark yield curve will be for YTM as a function of maturity for U.S. Treasury securities.

Yield curves are generally not stable but change over time. To determine how to profit from expected changes in the yield curve, it is helpful to view yield changes as resulting from three sources: level, slope, and curvature.

- Level means that there is a parallel shift where all yields shift up (or down) by the same amount.
- Slope means that the curve becomes flatter or steeper.
- Curvature means that the curve becomes more or less curved.

In reality, most changes in the curve involve more than one source.

Now, we can turn our attention to the methods that can make excess returns based on the view on the shape and level of the yield curve.

(2) Trades for a dynamic yield curve

The first strategy that we use to get excess return is to formulate a portfolio positioning strategy given forward interest rates and an interest rate view that diverge

from the market view in terms of rate level, slope, and shape.

Now, suppose we have a view that the yield curve will change level, slope or curvature. Here, we not the falling as a bullish view, because this means that the fixed-income security will rise. Conversely, the view that interest rates will rise more than expected is a bearish view.

- **Divergent Rate Level View**

We can earn excess return from a bullish view that the benchmark yield curve will shift down by increasing the duration of their portfolio. Conversely, with the bearish view that yield curve will shift up, we should lower the duration of the portfolio.

We could use cash bonds to alter the duration of the portfolio. To increase the duration, we could overweight the longer-dated bonds. To decrease the duration, we should short sell bonds or overweight shorter-dated bonds.

Note that we have the following formula to calculate the price change of the benchmark as well as the price change of the portfolio.

$$\text{Price change of the benchmark} = -\text{MD}_{\text{benchmark}} \times \Delta Y + (\frac{1}{2}\text{C}_{\text{benchmark}} \times \Delta Y2)$$

$$\text{Price change of the portfolio} = -\text{MD}_{\text{portfolio}} \times \Delta Y + (\frac{1}{2}\text{C}_{\text{portfolio}} \times \Delta Y2)$$

Here, MD is the modified duration, C is the convexity. By subtract the price change of the benchmark from the price change of the portfolio, we can generate the excess return.

- **Divergent Yield Curve Slope View**

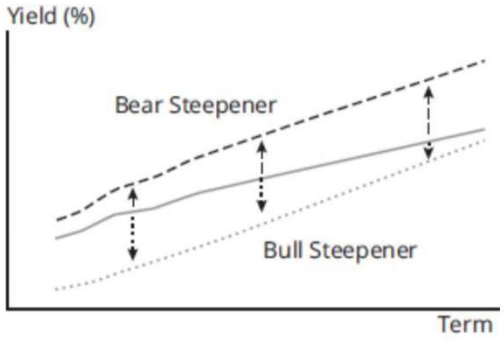
Due to the inverse relationship between rates and bond prices, an active manager that expects a change in the shape of the yield curve should buy bonds with rates that are

expected to fall relative to the rest of the curve (because prices will rise) and short sell bonds with rates that are expected to rise relative to the rest of the curve (because prices will fall).

Therefore, a manager expecting a steepening curve, where long-term rates are rising and short-term rates are falling, should short long-dated bonds and buy short-dated bonds. Conversely, a manager expecting a flattening curve where short-term rates are rising and long-term rates are falling should buy long-dated bonds and sell short-dated bonds.

We can divide the view of interest rate level and slope changes into four categories:

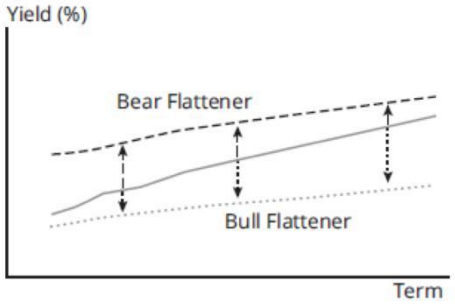
1. A bull steepener is the view that short-term rates will fall by more than long-term rates. This might occur when central banks cut short term during economic contraction.
2. A bear steepener is the view that long-term rates will rise more than short-term rates. This might occur when central banks keep short-term rates too low for too long, increasing longer-term inflation expectations and the required return on longer-term bonds.



3. A bear flattener is the view that short-term rates will rise by more than long-term rates. This might occur when central banks begin to raise short-term rates in

response to rising inflation expectations.

4. A bull flattener is the view that long-term rates will fall by more than short-term rates. This might occur when there is a flight to quality in uncertain markets as investors sell risky assets and purchase risk-free benchmark securities.



A summary of these curve changes and the associated strategies are displayed here:

View	Portfolio Duration	Short-Term Bonds	Long-Term Bonds
Steepener(no change in level)	Zero	Buy	Short Sell
Bear Steepener	Negative		
Bull Steepener	Positive		
Flattener(no change in level)	Zero	Short Sell	Buy
Bear Flattener	Negative		
Bull Flattener	Positive		

- **Divergent Yield Curve View – Change in Curvature**

A bullet bond is a bond with single maturity. Bullet bond pays at fixed interest rate until it matures, and the principal is repaid in a lump sum at maturity. A barbell bond,

on the other hand, is a bond with two extreme maturities, i.e., a combination of one short-term bond and one long-term bond while avoiding the intermediate-term bond. Usually, bullets are more sensitive to changes in yield curve curvature than barbell. When the yield curve becomes more convex, the curvature of the yield curve increases, there will be a larger increase in rates at intermediate maturities than that at short or long maturities, so bullet price will decrease more. In this case, we can adopt the butterfly strategy to short-sell bullet bonds and long barbell bonds at the same time to make profit from change in curvature. On the other hand, if the curvature of the yield curve is expected to decrease, we long the bullet and short sell the barbell instead.

- **Key Rate Duration**

We will use key rate duration to evaluate a bond portfolio's sensitivity against changes in key rate at specific maturity, while keeping other rates constant. The formula for key rate duration is as follows:

$$Key\ rate\ duration = -\frac{1}{portfolio\ value} * (\frac{change\ in\ portfolio\ value}{change\ in\ key\ rate})$$

The key rate duration of a bond portfolio will be the weighted sum of key rate duration of all individual bonds, in the sense that it is the aggregate sensitivity of the portfolio with corresponding shift at different key points in a yield curve.

Key rate duration allows us to quantify a bond portfolio's overall exposure to yield curve changes. A bond portfolio with highly positive key rate duration expects this maturity rate is going to fall, and a bond portfolio with highly negative key rate duration expects this maturity rate is going to rise.

References

1. Dodampe Gamage, R. (2021). Empirical analysis and forecasting of yield curves (Unpublished master's thesis). University of Calgary, Calgary, AB.
2. Christoph Gerhart, Eva Lütkebohmert,Empirical analysis and forecasting of multiple yield curves,Insurance: Mathematics and Economics,Volume 95, 2020.
3. Bredillet, Christophe, Stephane Tywoniak, and Mahshid Tootoonchy. “Exploring the Dynamics of Project Management Office and Portfolio Management Co-Evolution: A Routine Lens.” International journal of project management 36.1 (2018): 27–42. Web.
4. Stoyanov, Stoyan V. et al. “Option Pricing in an Investment Risk-Return Setting.” Applied economics 54.14 (2022): 1625–1638. Web.