US Treasury Yield Curve Trading Strategy

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Summary

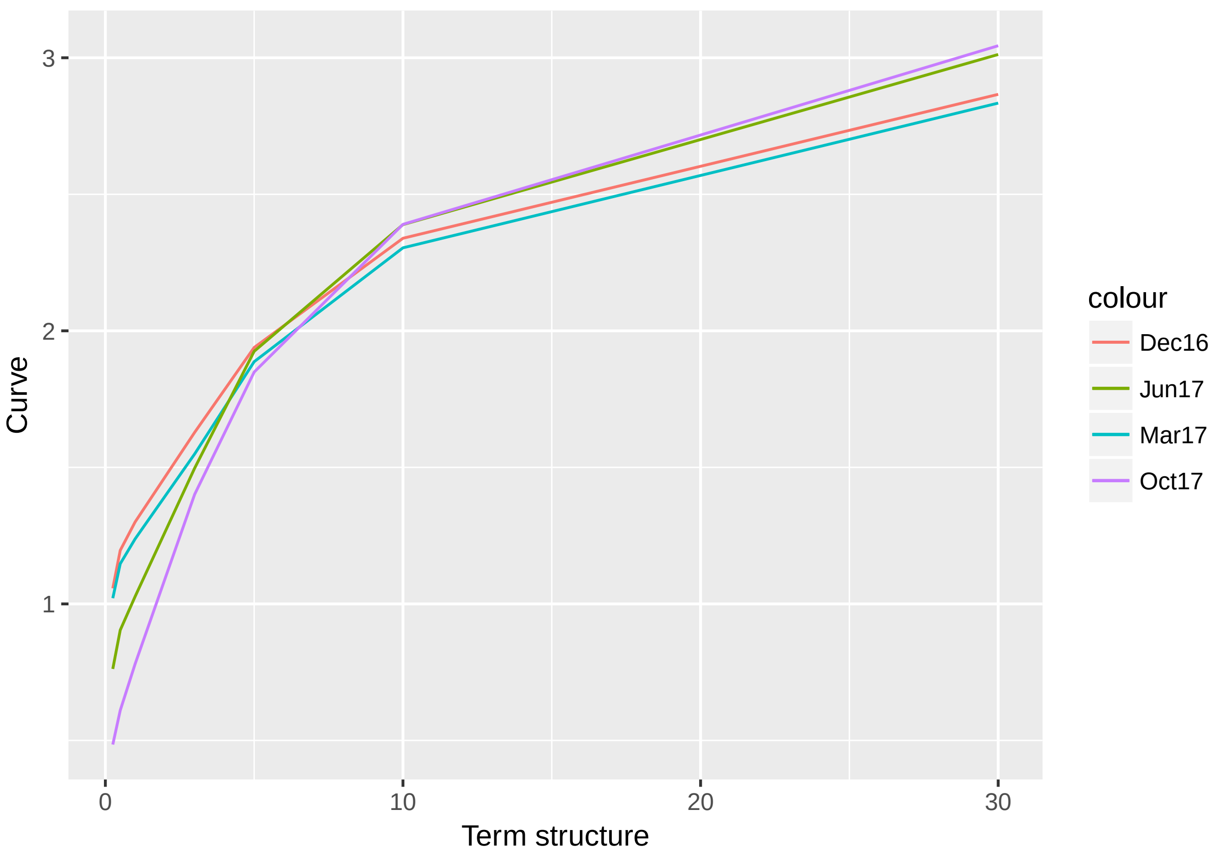
This is a trading strategy based on US Treasury yield curve changes. It forecasts future yield changes caused by rates hike events.

US Fed Rates Hike History

From 2015, the Fed has had 4 rates hikes, raising the fed fund rate to 1-1.25% now. Here are a table of US Fed rates hike history.

Date	Fed Fund Rate
Jun 22, 2011	0-0.25%
Dec 16, 2015	0.25-0.5%
Dec 14, 2016	0.5-0.75%
Mar 15, 2017	0.75-1%
Jun 14, 2017	1-1.25%

US Treasury Yield Curve Changes



Break down the curve change

Before forecasting the curve change on Dec 2017, it is necessary to take a closer look at previous curve changes after rate hikes.

We can break down the curve change into three categories: **Parallel shift**, **Slope shift** and **Curvature shift**. All these shifts are orthogonal, which means they do not have cross effects.

$\Delta\vec{C} \approx \Delta x_1 \vec{P_1} + \Delta x_2 \vec{P_2} + \Delta x_3 \vec{P_3}$
$\Delta\vec{C}$ stands for curve change denoted by a vector.

We can easily use a set of orthogonal basis – polynomials (1,x,x^2).

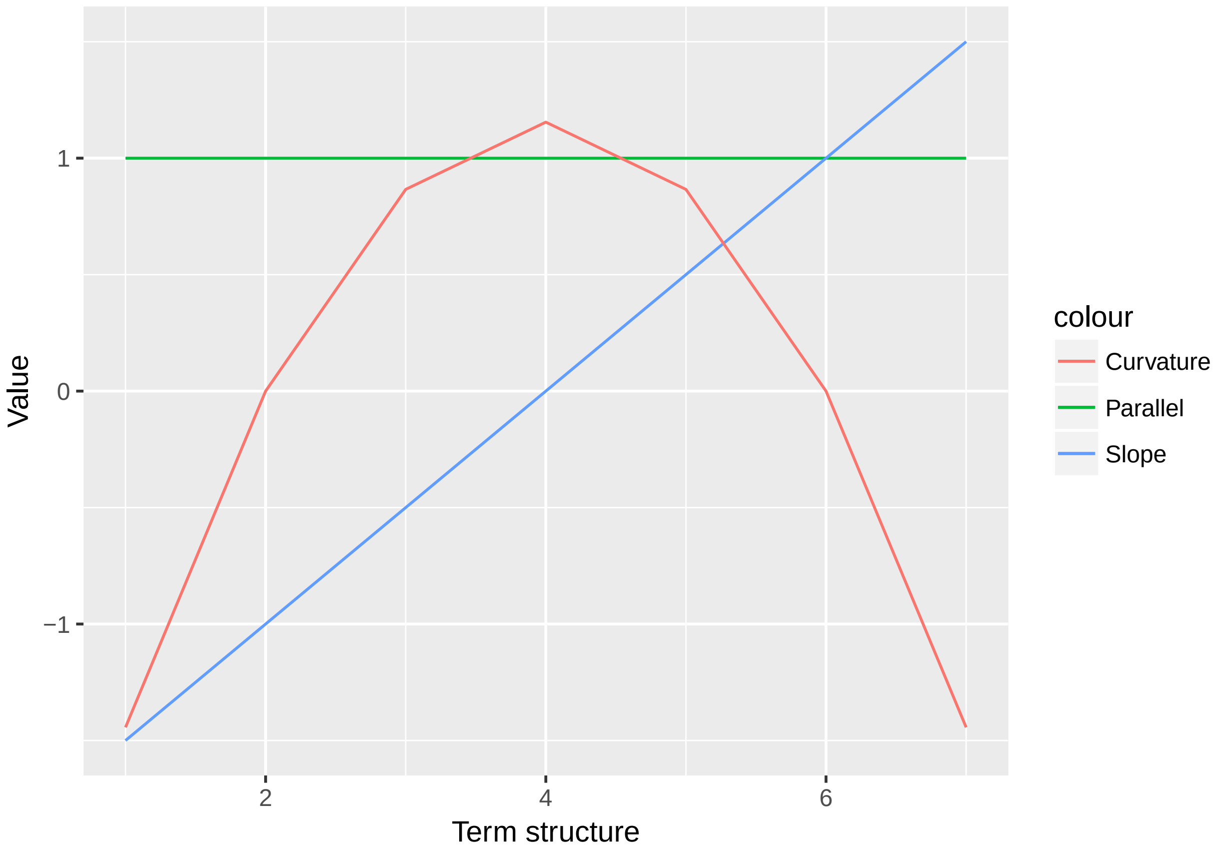
$\vec{V_1} = [1, 1, 1, 1, 1, 1, 1]^T$

$\vec{V_2} = [1, 2, 3, 4, 5, 6, 7]^T$

$\vec{V_3} = [1^2, 2^2, 3^2, 4^2, 5^2, 6^2, 7^2]^T$

After standardizing vectors, we got unit basis.

3 orthogonal basis



With the tool of orthogonal basis, we can nail down what effect the rate hike had on the curve structure and forecast next curve change.

We can get the changes by following formula:
$\Delta x_1 = \frac{\Delta\vec{C} \cdot \vec{P_1}}{\|\vec{P_1}\|}$

```
##     temp        dx1          dx2         dx3
## 8 Mar 17 0.13671429 -0.120571429 0.005278631
## 5 Jun 17 0.06628571 -0.158285714 0.013279056
## 2 Oct 17 0.04928571 -0.003571429 0.013114099
```

Here are what we observed:
1. Rate hikes caused an upward parallel shift. However, marginal effects on parallel shifts are decreasing.
2. Rate hikes made the curve less tilted.
3. Rate hikes caused an increasing concave change. Curvature change effect is quite stable.

Furthermore, we observe that these three basis explained 90% of curve changes.

Forecast curve change on Dec 2017

It is predicted that there will be another rate hike in Dec 2017. Assume it has similar effect on the curve, that is, assume same factor loading on **Parallel shift**, **Slope shift** and **Curvature shift**. Hence, we forecast that the curve will have a slight upward parallel shift, and become more flat and more concave.

To illustrate it with numbers, we have:
$\Delta x_1 = 0.035$

$\Delta x_2 = -0.094$

$\Delta x_3 = 0.131$

Trading strategy

As we forecasted, the rate curve will move upward with a less tilted slope and a more concave curve.

Treasury	Modified Duration	Price (Jun 2017)	Current Price
5-year	4.742	$118.74	$117.56
10-year	8.771	$126.45	$125.43
30-year	20.064	$ 154.84	$152.83

Source: WSJ.com

The strategy trades on 5-year notes, 10-year notes and 30-year bonds.

Let the weights be x1, x2, x3, or $\mathbf{x} = [x_1, x_2, x_3]^T$

At the beginning, weights should satistify following equations:

$$x_1 D_1 P_1 + x_2 D_2 P_2 + x_3 D_3 P_3 \leq 0$$

$$x_1 P_1 + x_2 P_2 + x_3 P_3 = 0$$

$$x_2 < 0$$

To solve the equations, assume $x_2 = -1$.

$$\begin{bmatrix} x_1 \\ x_3 \end{bmatrix} = \begin{bmatrix} D_1 P_1 & D_2 P_2 \\ P_1 & P_2 \end{bmatrix}^{-1} \begin{bmatrix} D_2 P_2 \\ P_2 \end{bmatrix}$$

```
## [1] "One possible solution of weights"
## [1]  1.7742753 -1.0000000 -0.5439644
## [1] 0
## [1] 0.0197236
```

Backtest

1. On June 2017, long 5-year notes and 30-year bonds and short 10-year notes. Cost = 0.
2. On Oct 2017, close out positions. Gain = $0.0197236