MAT1856/APM466 Assignment 1

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Fundamental Questions - 25 points

1.

   (a) Printing more money will increase the money supply, which will lead to inflation and devalue the currency. By issuing bonds, government can borrow from people and don't increase the money supply.

   (b) For example if a Canadian 10 year bond's yield is 3%, while a 20 year bond's yield is 3.1%.This could occur when government increases its short-term target and investors expect the future pace of economic growth to slow down.

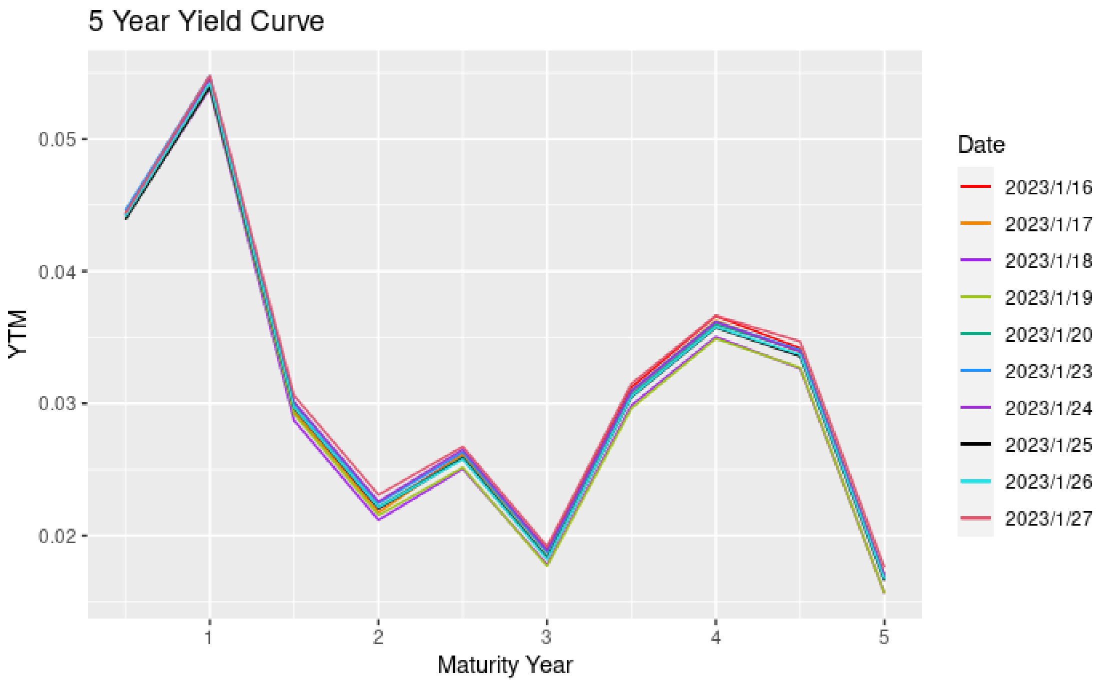
   (c) Quantitative easing is a kind of monetary policy. It means that central bank will purchase bond and securities from the market to reduce interest rates and increase the money supply. During the pandemic, US fed bought a lot of treasury securities, which is a form of quantitative easing.

2. I chose the following 10 bonds: CAN1.5June23, CAN0.5Nov23, CAN2.5June24, CAN3.0Nov24, CAN2.25June25, CAN3.0Oct25, CAN1.5June26, CAN1.0Sep26, CAN1.0June27, CAN2.75Sep27. There are several reasons why I chose them. First, they almost spread evenly across 5 year period and they all mature in 5 years. Second, the coupon rate of them are very similar.

3. The eigenvalues and eigenvectors of the covariance matrix represent the direction and strength of the relationship between the processes. The eigenvectors indicate the direction of maximum variation in the data, and the eigenvalues tell us the amount of variation along each eigenvector. They will also lower the dimensions for us.

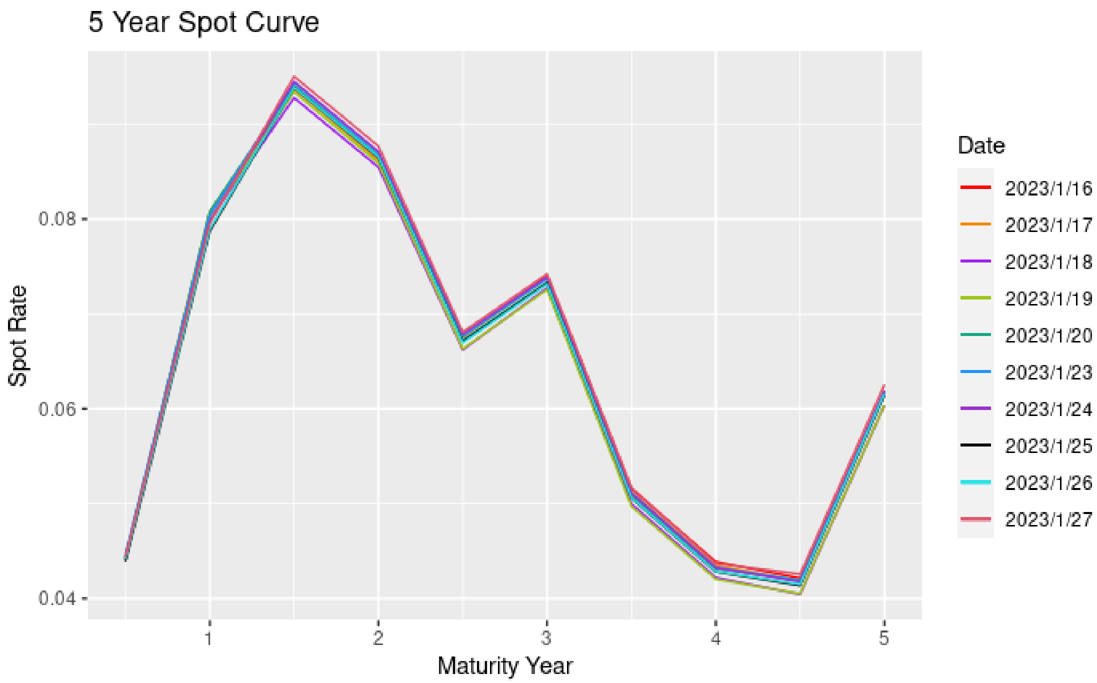
Empirical Questions - 75 points

4.



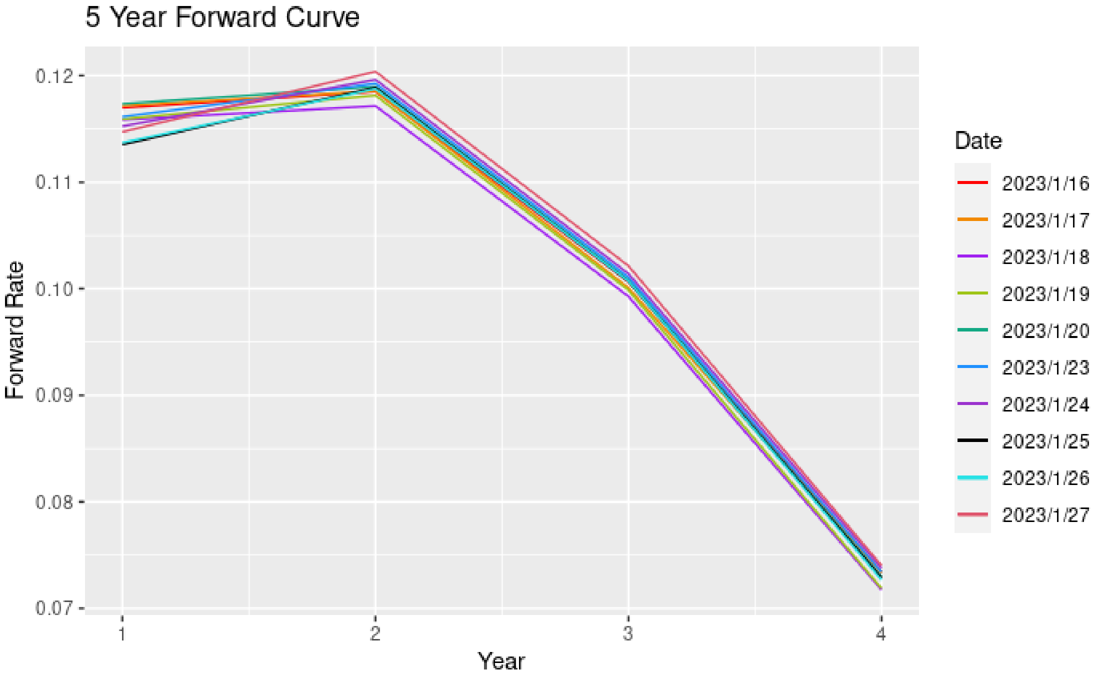
(a)

This is the graph of 5 Year Yield Curve.



(b)

This is the graph of 5 Year spot curve. First we create a matrix of spot rates of each bond on different days. Since for t=0.5, the spot rate is exactly equal to YTM, so we can apply it directly. Since we have price of the bond, face value of the bond, coupon payments and spot rate of the bond, it will be sufficient for us to use bootstrapping method to calculate the spot rate of the bonds. We can do bootstrapping by *spotrate* =-log((Price− All coupon payment except last one)/Final payment)/0.5T. Therefore, by using for loop, we can assign value of each bond on each day successfully.



(c) This is the graph of 5 Year forward curve. First we create a matrix of forward rates. Since all we require is the spot rates of different years, so we can apply it and calculate the forward rates directly by using the formula $Forward$ =(spotratei(i+1)-spotrate1)/i.

5.

```
                [,1]         [,2]         [,3]         [,4]         [,5]
[1,] 0.00006042679 0.0001287587 0.0002017778 0.0001199504 0.0002487096
[2,] 0.00012875868 0.0004877628 0.0006970197 0.0003860786 0.0007854066
[3,] 0.00020177778 0.0006970197 0.0010479348 0.0005913628 0.0011970076
[4,] 0.00011995039 0.0003860786 0.0005913628 0.0003660297 0.0007490154
[5,] 0.00024870964 0.0007854066 0.0011970076 0.0007490154 0.0015385991
```

This is the Covariance Matrix of log return of yield.

```
                [,1]         [,2]         [,3]         [,4]         [,5]
[1,] 0.00006042679 0.0001287587 0.0002017778 0.0001199504 0.0002487096
[2,] 0.00012875868 0.0004877628 0.0006970197 0.0003860786 0.0007854066
[3,] 0.00020177778 0.0006970197 0.0010479348 0.0005913628 0.0011970076
[4,] 0.00011995039 0.0003860786 0.0005913628 0.0003660297 0.0007490154
[5,] 0.00024870964 0.0007854066 0.0011970076 0.0007490154 0.0015385991
```

This is the Covariance Matrix of log forward rate

```
eigen() decomposition
$values
[1] 0.0033595706793 0.0001065946273 0.0000215057896 0.0000129237639 0.0000001583812

$vectors
           [,1]        [,2]        [,3]       [,4]       [,5]
[1,] -0.1100753 -0.05615358  0.89039630 -0.4248254 -0.1069954
[2,] -0.3648780  0.55142330 -0.33894227 -0.6581595 -0.1214111
[3,] -0.5491821  0.52092222  0.25985208  0.5770157  0.1629992
[4,] -0.3270868 -0.23547798 -0.07353918  0.1866354 -0.8929297
[5,] -0.6679526 -0.60495395 -0.13921726 -0.1362702  0.3871938
```

6. This is the eigenvalue and eigenvectors of Covariance Matrix of log return of yield.

```
eigen() decomposition
$values
[1] 0.000320695801 0.000033366631 0.000008117531 0.000003870482

$vectors
           [,1]       [,2]        [,3]         [,4]
[1,] -0.4407859  0.8969594  0.03416045  0.002161844
[2,] -0.4122151 -0.1879909 -0.33045425 -0.827972320
[3,] -0.4017700 -0.1710072 -0.72751111  0.529211643
[4,] -0.6887433 -0.3617731  0.60030045  0.185451343
```

This is the eigenvalue and eigenvectors of Covariance Matrix of log forward rate. The first eigenvalue represents the direction of the highest variability in the data. The first eigenvector gives the direction of that variability.

References and GitHub Link to Code

Reference:
1) https://cran.r-project.org/web/packages/jrvFinance/jrvFinance.pdf
2) https://www.investopedia.com/terms/q/quantitative-easing.asp
Github: https://github.com/BradQ66/APM466-AS1.git