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Homework-1
FEG904 - Fixed Income Securities
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Problem 1
This problem will require you to use the Excel file named CONSMATRATES. It contains mid yields (average of ask and bid yields) for the constant maturity yield rates calculated by the Federal Reserve (These are special portfolios of securities that always have a similar maturity). This will make the basis for modelling interest rates and establish the main properties and relationship between yields of different maturities.

a. Compute average yields over the sample. What is the shape of the term structure of average yields? (plot average yields against time to maturity). Is this as you expected? Explain.

b. Compute the standard deviation of yields. What is the shape of the term structure of the standard deviation of yields? (plot standard deviation of yields against time to maturity). Is this as you expected? Explain.

c. Compute the correlation of each yield with its own lagged value. This is also called an autocorrelation. How high are the correlations?

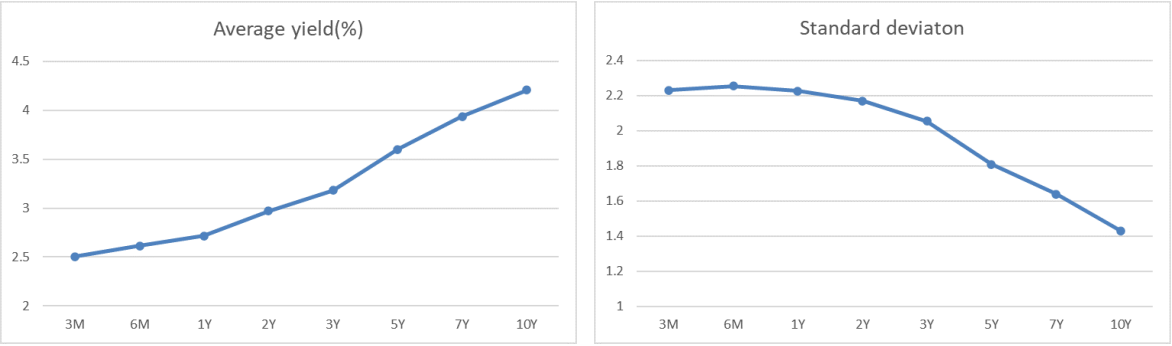
d. Now, calculate the first differences of the yields (Yield at time t minus yield at time t-1). Please calculate the correlation between the first differences of the different yields (e.g., 3m and 6m, 3m and 10-year, 7-year and 10-year etc.) How do these correlations vary as the difference in maturity changes?

e. How can we use these basic relationships to develop a model of the behavior of interest rates?

Solution:

Table 1

	3-month	6-month	1-year	2-year	3-year	5-year	7-year	10-year
Average yield(%)	2.505	2.615	2.716	2.969	3.183	3.598	3.937	4.206
Standard deviation	2.232	2.255	2.227	2.170	2.055	1.809	1.639	1.431



(a) (b)

Figure 1: Term structure of average yields and standard deviation of yields

a. Figure 1(a) shows that the term structure of average yields is upward sloping, where long term yields are higher than short term yields.

This is what I expected since a upward sloping yield curve is considered to be "normal" where investors demand higher interest rates for longer-term investments as compensation for investing their money in longer-duration investments.

b. The term structure of the standard deviation of yields is downward sloping shown in Figure 1(b), which means longer rate has small volatility. It's reasonable that longer-term yield is less sensitive to short-term market fluctuations and therefore being more stable over time.

Table 2: Autocorrelation

	3-month	6-month	1-year	2-year	3-year	5-year	7-year	10-year
lag 1	0.996	0.996	0.996	0.994	0.992	0.988	0.986	0.982
lag 2	0.989	0.990	0.989	0.985	0.981	0.975	0.970	0.963
lag 3	0.980	0.981	0.979	0.975	0.971	0.962	0.956	0.948
lad 4	0.969	0.970	0.969	0.963	0.958	0.948	0.941	0.931
lag 5	0.957	0.958	0.958	0.953	0.946	0.934	0.926	0.913

c. Table 2 shows the correlation of each yield with its own lagged value, from which we can notice that the correlations are quite high. Even lag 5 autocorrelation is bigger than 0.9 for all the 8 time series. Also, from Figure 2, I find that, generally:

- The longer the maturity is, the lower the autocorrelation is.
- The higher the lag order is, the lower the autocorrelation is.

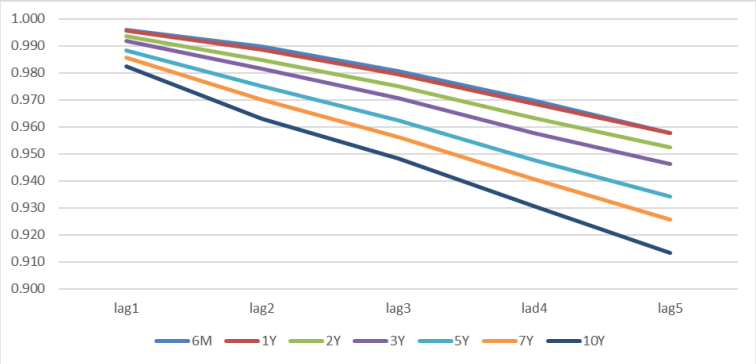


Figure 2

d. The correlation between the first differences of the different yields is shown in Table 3. The correlation for yields with similar maturities is higher, in other words, the correlation between yields decreases as the difference in their maturities increases.

Table 3: Correlation coefficients table

	3-month	6-month	1-year	2-year	3-year	5-year	7-year	10-year
3-month	1.000	0.919	0.793	0.597	0.524	0.407	0.344	0.283
6-month	0.919	1.000	0.922	0.737	0.656	0.541	0.475	0.412
1-year	0.793	0.922	1.000	0.892	0.828	0.713	0.643	0.566
2-year	0.597	0.737	0.892	1.000	0.977	0.899	0.834	0.748
3-year	0.524	0.656	0.828	0.977	1.000	0.953	0.901	0.823
5-year	0.407	0.541	0.713	0.899	0.953	1.000	0.981	0.932
7-year	0.344	0.475	0.643	0.834	0.901	0.981	1.000	0.972
10-year	0.283	0.412	0.566	0.748	0.823	0.932	0.972	1.000

e. The above analysis has the following findings:

- The mean of the yield is increasing as maturity increases
- The standard deviation is decreasing as maturity increase
- The bond yield is strongly autocorrelated
- Correlation of 1st difference of yields is higher between bonds with similar maturities.

Therefore, it's reasonable to make the following assumptions to develop a model of the behavior of the interest rates:

- **Non-negative**
  The interest rate is non-negative, and is positively related to the length of the maturity.
- **Mean-reverting**
  The interest rate is mean-reverting and its volatility is negatively related to the length of the maturity.
- **Autocorrelated**
  The time series of interest rate is autocorrelated and the the autocorrelation is negatively related to lag length and length of maturity.
- **Serial-correlated**
  The 1-st difference of interest rates with different maturities are serial correlated and the correlation is negatively related to the difference in the length of maturity.

Note: we can use Vector autoregression model (VAR) to capture the linear interdependencies among multiple time series. Here, we can use the relationship between

Let $Y_t = (y_{1t}, y_{2t}, ..., y_{8t})$' denote an (8×1) vector of time series variables, where Y_{it} refers to one of the eight given time series of yields with different maturities.

The basic p-lag vector autoregressive VAR(p) model has the form:

$$Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \epsilon_t$$

where A_i are (n× n) coefficient matrices and ϵ_t is an (8×1) unobservable zero mean white noise vector process (serially uncorrelated or independent) with time invariant covariance matrix Σ.

We can use this model to capture the relationships between different yields and between their lagged values.

Problem 2
For this exercise we need to use the daily time series file (please erase the missing values!). In the first news video I said that the 10-year rate was more sensitive to changes due to a flight to safety than the 3-month rate. Can you show if this is true or false?

We need to find dates of flights to safety, some examples:

- Russian financial crisis and collapse of Long-term Capital Management in 1998
- 2007-2009 many events, but the collapse of Bearn Sterns and Lehman Brothers are solid choices.
- The new events related to the Coronavirus (when exactly did it begin, also we need to measure before the Fed dropped the FFR to 0)
- Choose the events, and measure the change in yields during the event, how much is the difference? Which maturity is more sensitive?
- Anything else interesting about the yield curve in 2020?

Solution:

Procedures

Here, I choose to focus my study on 2008 financial crisis and R has been used to conduct my analysis, which can be divided into following three parts:

- Find the evidence of "flight to safety".
- Determine the dates of flights to safety related to specific events in 2008 financial crisis (Guardian, 2013).

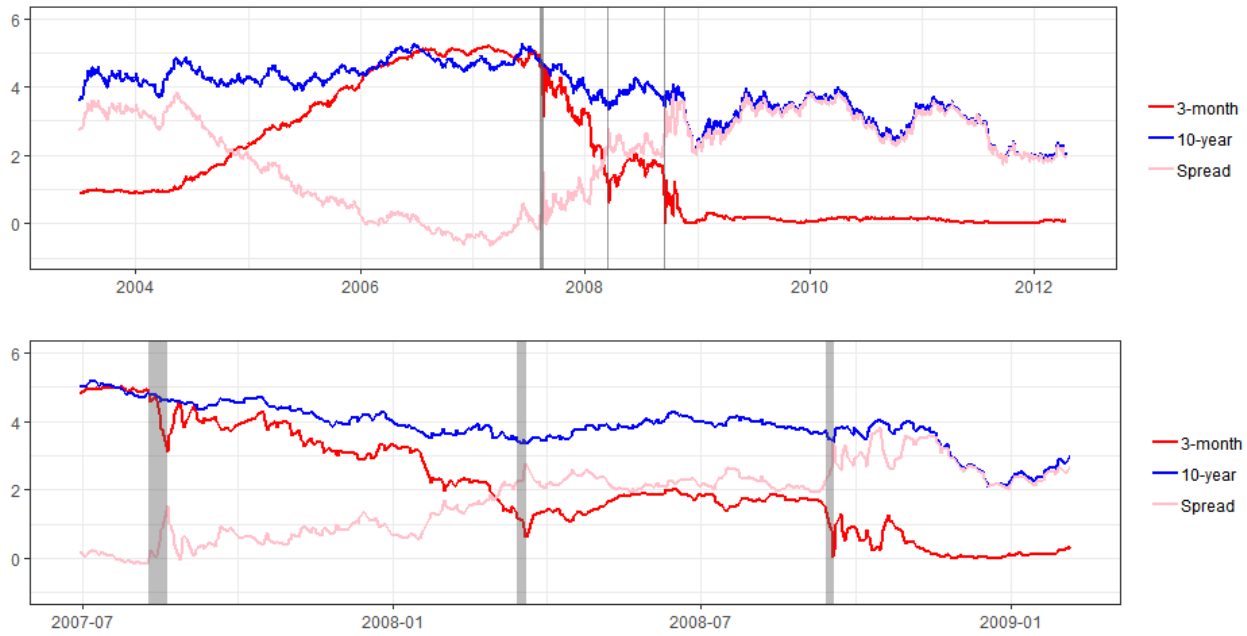


Figure 3

- Measure the change in yields during the event and figure out which maturity is more sensitive.

Analysis

a. Evidence of "flight to safety"

Figure 3 shows the yields on the three-month and 10-year Treasuries, providing evidence that investors found safety in U.S. Treasuries, especially T-bills, which. As shown in Figure 3, there was no significant change in the difference of yields (spread) between the 3-month and 10-year rate before the onset of the current financial crisis. The spread fluctuated around zero which resulted from a the increase of 3-month rate since 2004 after a series of steady quarter-point rate increases by the Fed between 2004 and 2006 (Schwartz, 2015).

However, when the mortgage market began to slide in August 2007, yields on short-term Treasuries fell sharply. The larger decline in the short-term Treasuries reflects the greater demand for liquidity during this period. The uncertainty in the mortgage market also encouraged investors to switch from other debt instruments, such as mortgage-backed securities, into government securities. While there has been a large expansion in the amount of Treasury security offerings, yields on Treasuries have actually declined and the prices on Treasury securities have actually increased in the face of a rapidly expanding supply of these securities (Noeth et al., 2010). This anomalous behavior in the market for Treasuries can be explained by a significant increase in the demand for Treasuries — "the flight to safety" in the event of a financial crisis.

b. Dates of flights to safety:

- August 9, 2007
  BNP Paribas blocked withdrawals from three of its hedge funds,since there was no liquidity, making valuation of the funds impossible – a clear sign that banks were refusing to do business with each other (Times, 2007).
  Figure 3 shows that 3-month rate had experienced a rapid decline staring at August 9, 2007. Therefore, it's reasonable to consider August 9, 2007 as the beginning of "flight to safety". Barr considers August 9, 2007 as the day the mortgage crisis went global and the first glimpse of the global financial crisis came into view.
- March 15, 2008
  The investment bank Bear Stearns was bought out by JP Morgan and the Federal Reserve guaranteed Bear Stearns' bad loans to facilitate its acquisition by JP Morgan.

- September 15, 2008

  Lehman Brothers went bankrupt after the Federal Reserve declined to guarantee its loans, causing the Dow Jones to drop 504 points, its worst decline in seven years, prompting worldwide financial panic.

c. Which maturity is more sensitive?

- The change in yields during the three events is shown in Table 4.

Table 4: Change in yields

Event	3-month	10 year	Spread
2007-08-09	-1.69	-0.15	1.54
2008-03-15	-0.55	-0.10	0.45
2008-09-15	-1.38	-0.10	1.28

- Relative sensitivity

  All the three events described above were followed by a decrease in the yields for Treasury especially the 3-month rate. Investors increased their demand for safer assets, namely U.S. Treasuries, and this led to a further decline in the yields on U.S. Treasuries. Figure 3 shows that Yields on short-term U.S. securities decreased sharply to near zero in November. However, the movement in long-term Treasury yields was sluggish—hovering about 4 percent before falling to about 2 percent in December 2008 (Noeth et al., 2010). In part, this later decline was also prompted by the Federal Reserve's measures to buy long-term Treasuries under its large-scale asset purchase programs. Table 4 also shows that the change in yields for 10-year rate is much smaller than 3 year rate.

  Therefore, we might draw a conclusion that 3-month rate seemed to be more sensitive than 10-year rate as it being more liquid and in a greater demand in the period of financial turmoil.

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