Predictive Financial Analysis

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Interest rates

Numerous financial concepts and financial models are based on current state of interest rates.

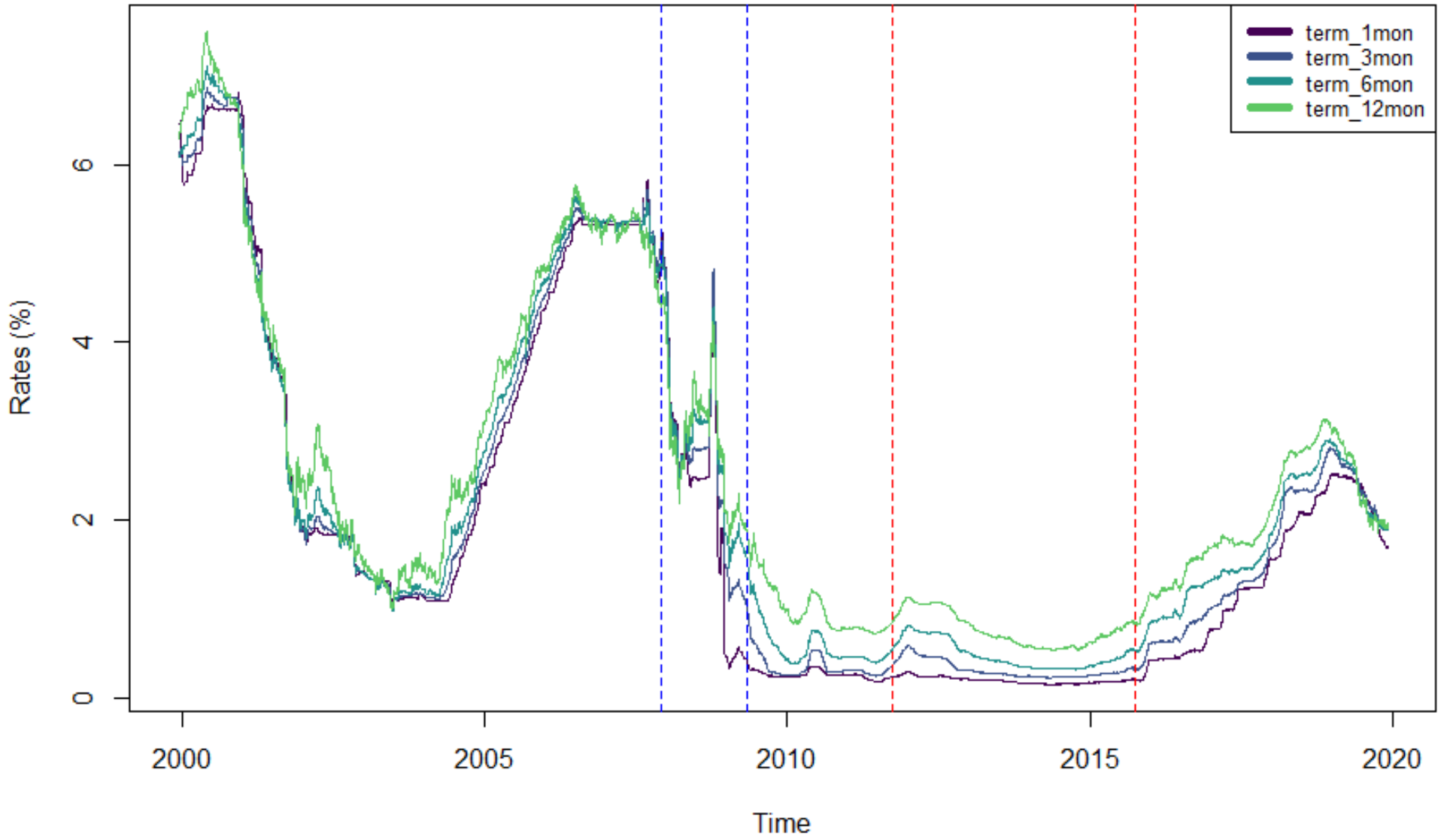
- Price of most derivatives is dependent on interest rates.
- Bonds are valued based on the interest rates.
- Mortgage calculations rely on interest rates.

Thus modelling interest rates to predict future trends can be of great value when putting together a financial portfolio, such that it manages risk appropriately.

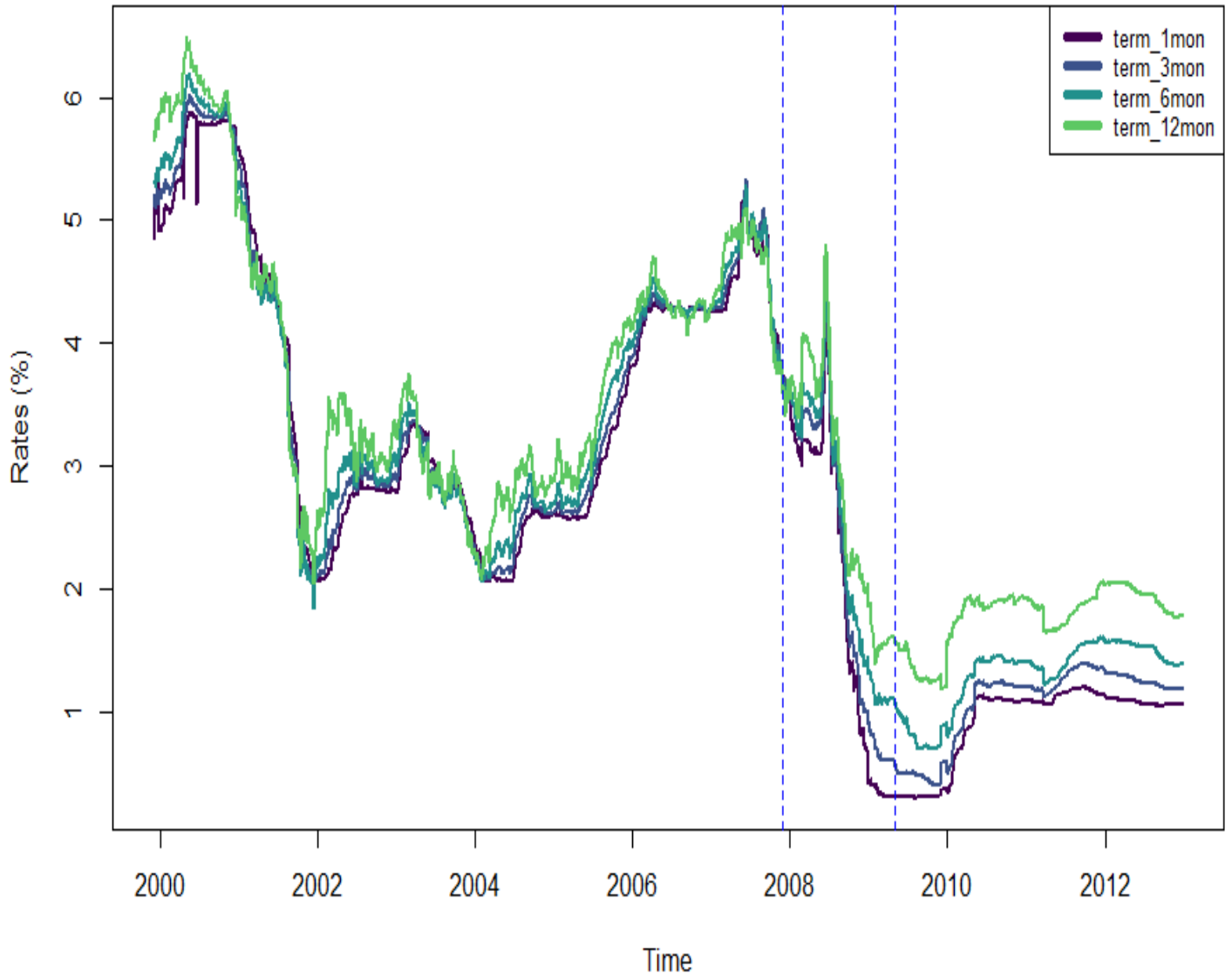
Interest Rates

- There are many different interest rates (Treasury rates, swap rates etc.) in any given currency.
- I selected the LIBOR USD Interest rates from the FRED website for analysis.
- LIBOR CAD rates are also shown for comparison occasionally.

Historical LIBOR USD Interest rates



Historical LIBOR CAD Interest rates



(CAD rates were discontinued in 2013.)

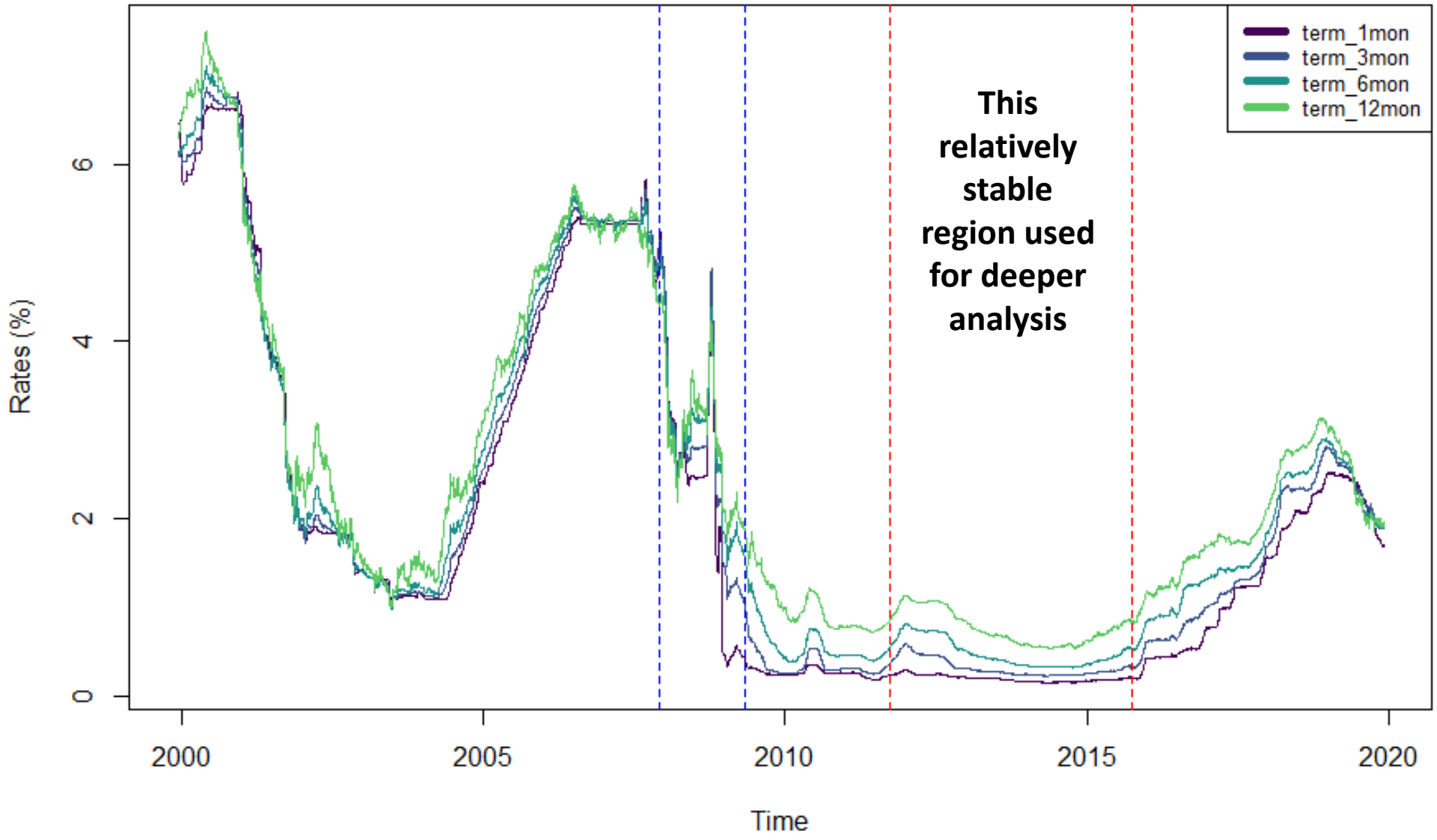
Volatility & Correlation

- Volatility (which is analogous to standard deviation)
- conventionally helps to measure risk.

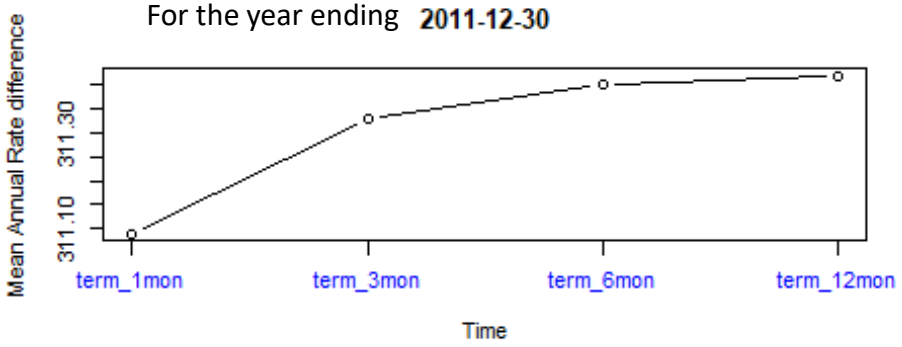
- The highest volatility is observed around the end of 2008 - the most severe period of the recent financial crisis.

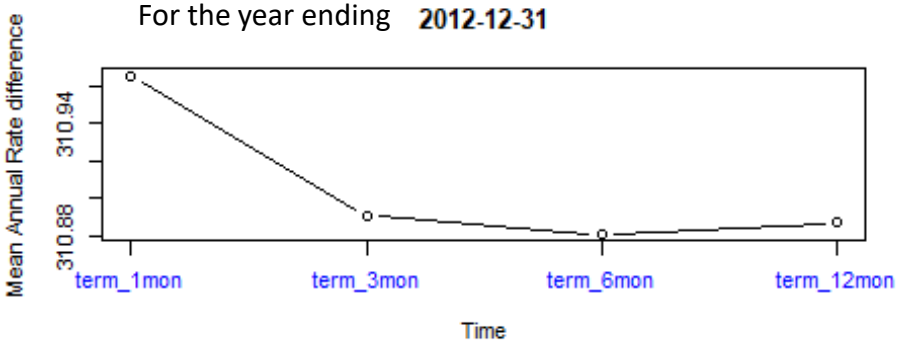
- volatility tends to move together for USD & CAD but is not perfectly correlated.

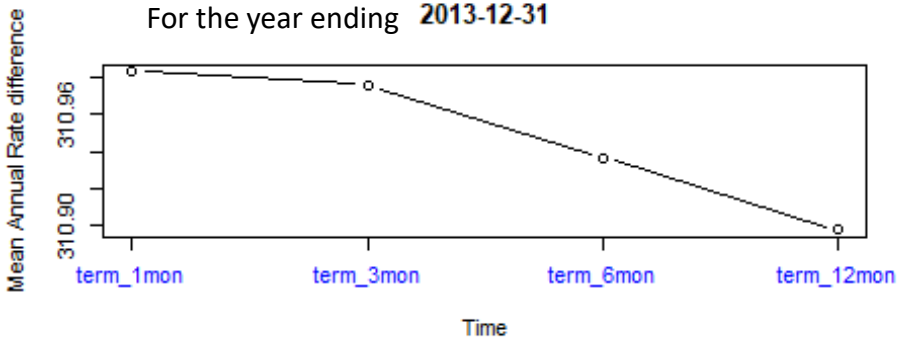
Historical LIBOR USD Interest rates

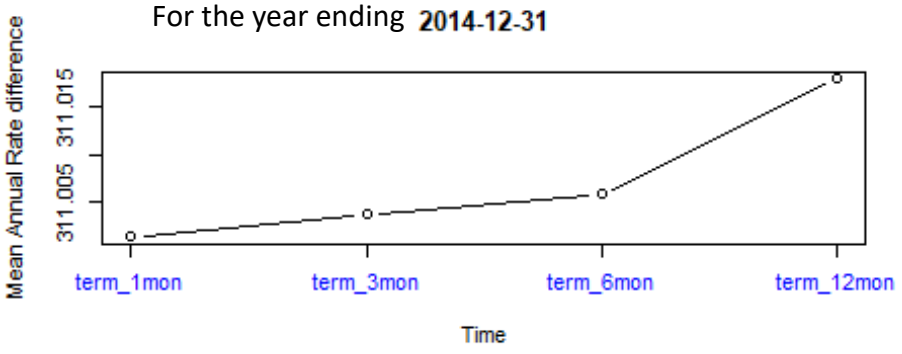


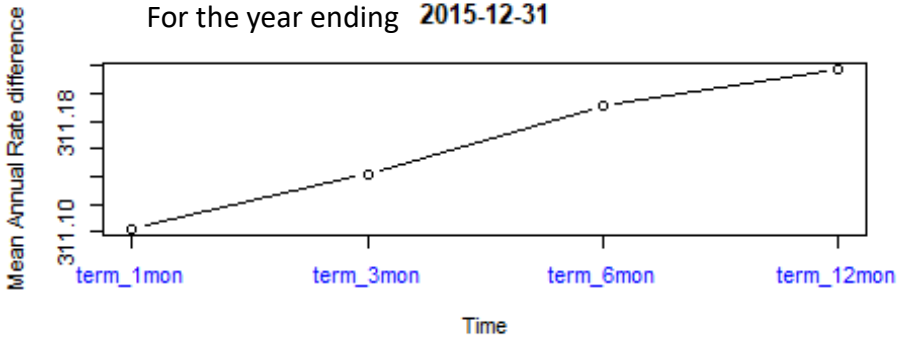
Term structure of Interest rates

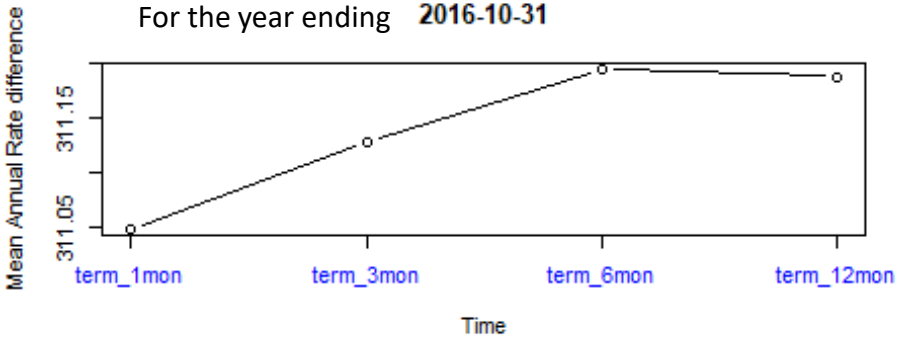




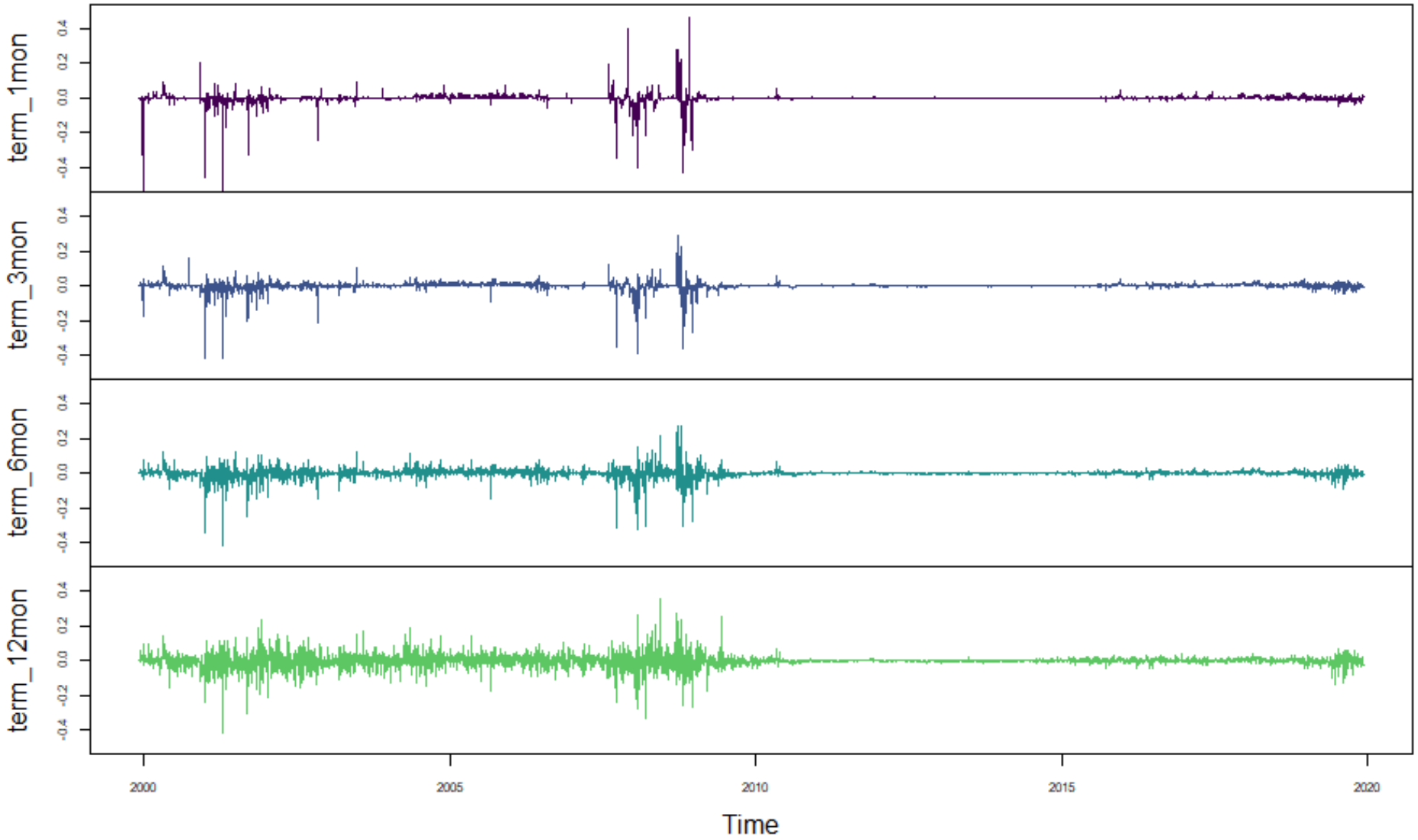




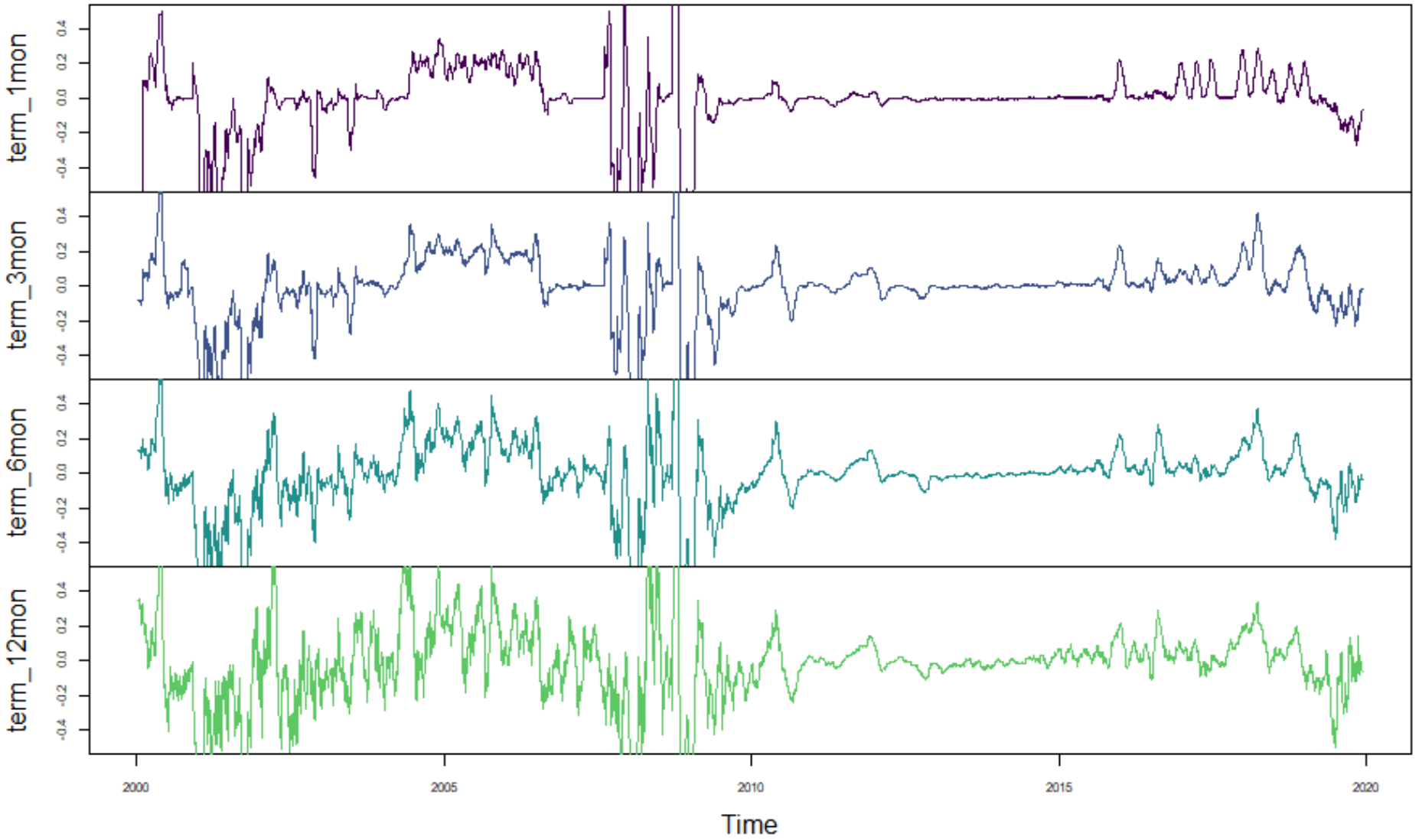




1 Day differenced USD IRs for various ‘terms’ between 1 month to 12 month.



25 Day differenced USD IRs for various ‘terms’ between 1 month to 12 month.



Differenced rates were modeled

- Differencing makes data more stationary.
- Differencing has the added benefit of making a time series independent of time.

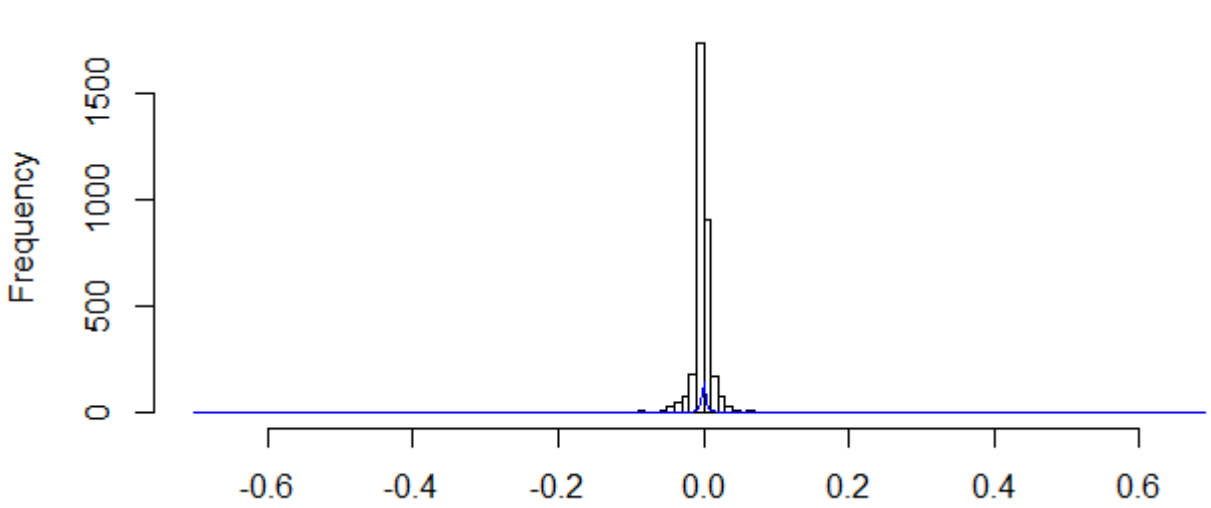
- The direction (positive or negative) of a return is mostly independent of the previous day's return. In other words, you don't know if the next day's return will be positive or negative just by looking at the time series.
- The magnitude of the return is similar to the previous day's return. That means, if markets are calm today, we expect the same tomorrow. However, in a volatile market (crisis), you should expect a similarly turbulent tomorrow.

Modelling Interest Rate

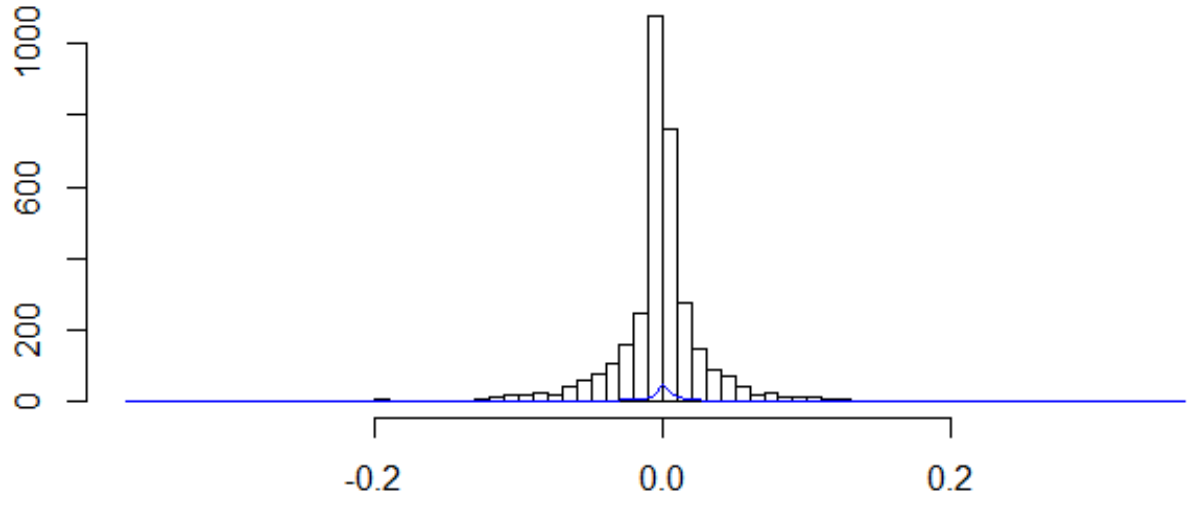
- A Markov stochastic process is one where value of a variable does not depend on its historic values.
- Only the current value of the variable can be taken into account to predict the future values.
- As a result, future predictions are expressed in probability distributions.

- Interest rates(IRs) can be assumed to behave this way.
- **I will first fit historical IRs to probability distributions and measure goodness of fit.**

Histogram of term_1month vs term_12month



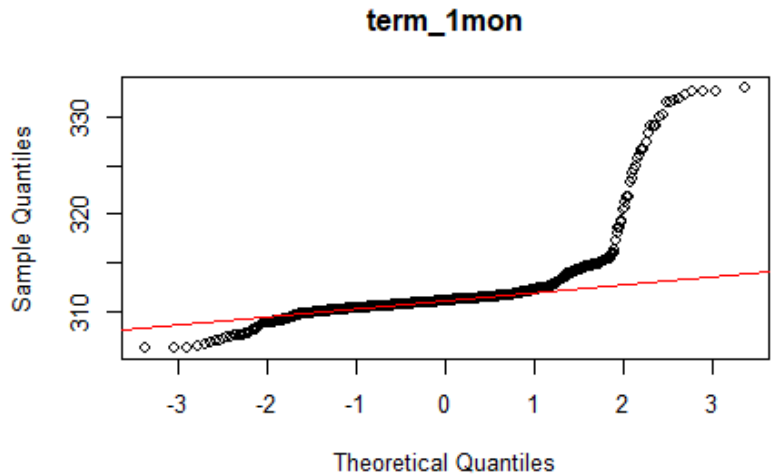
Term = 1 month (USD)

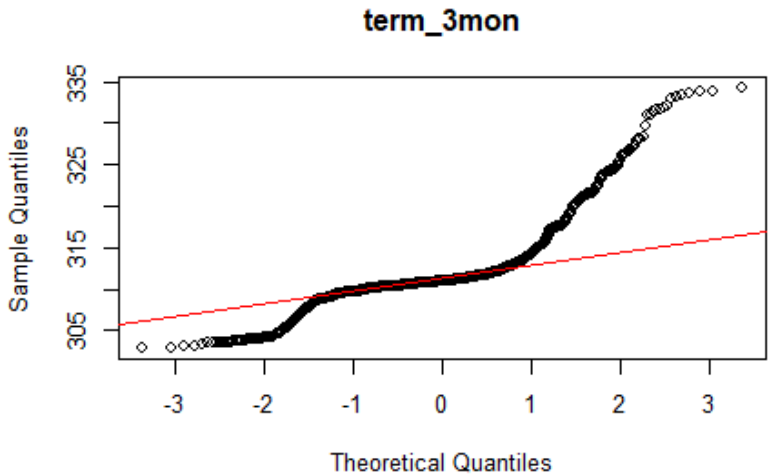


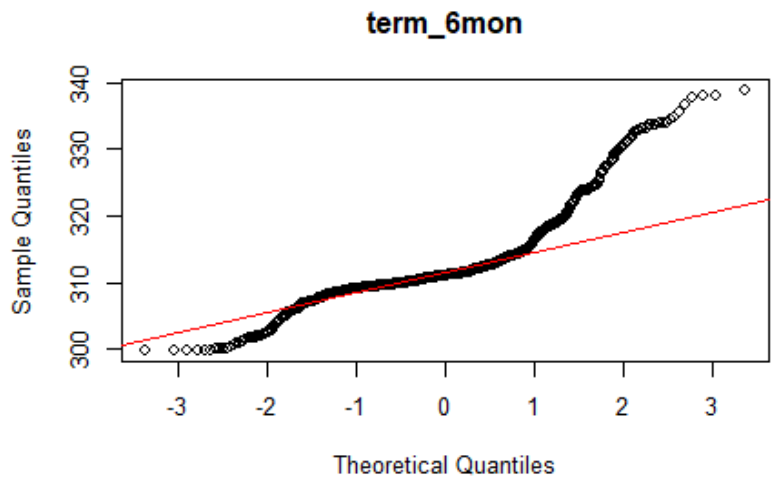
Term = 12 months (USD)

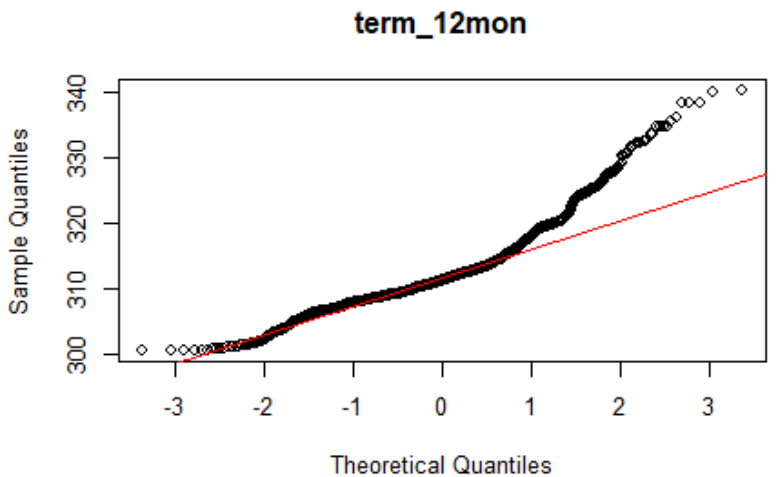
- Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point.
- Kurtosis is a measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution. That is, data sets with high kurtosis tend to have heavy tails, or outliers. Data sets with low kurtosis tend to have light tails, or lack of outliers. A uniform distribution would be the extreme case.

Q-Q curves
(Examine fit to normal distribution)



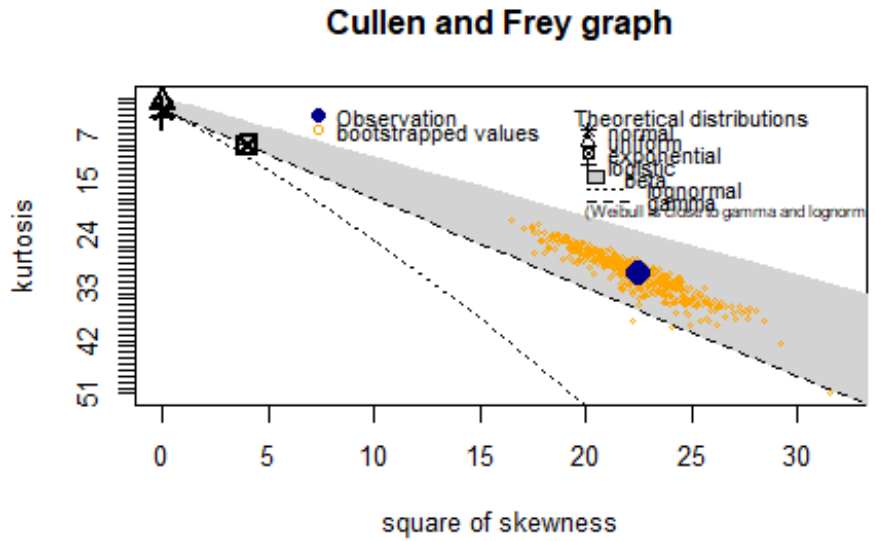




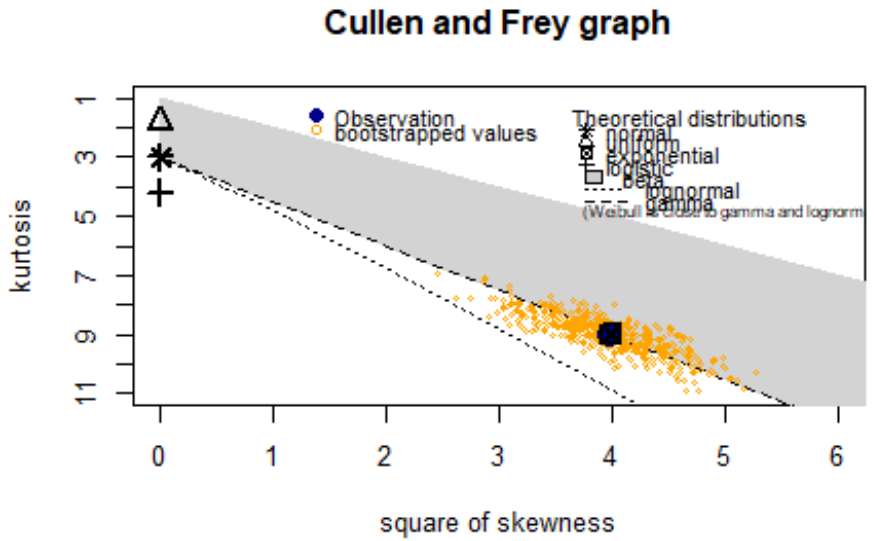


Which distribution fits data best?

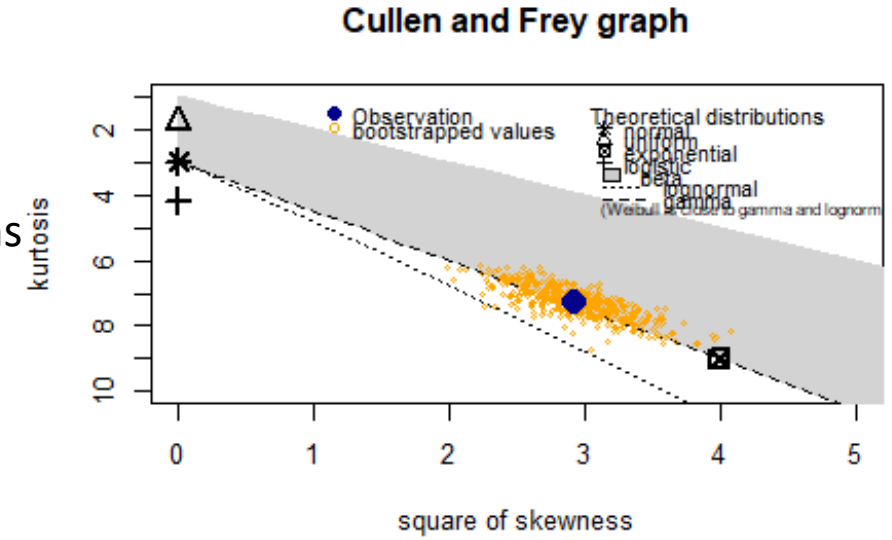
Term = 1 month (USD)



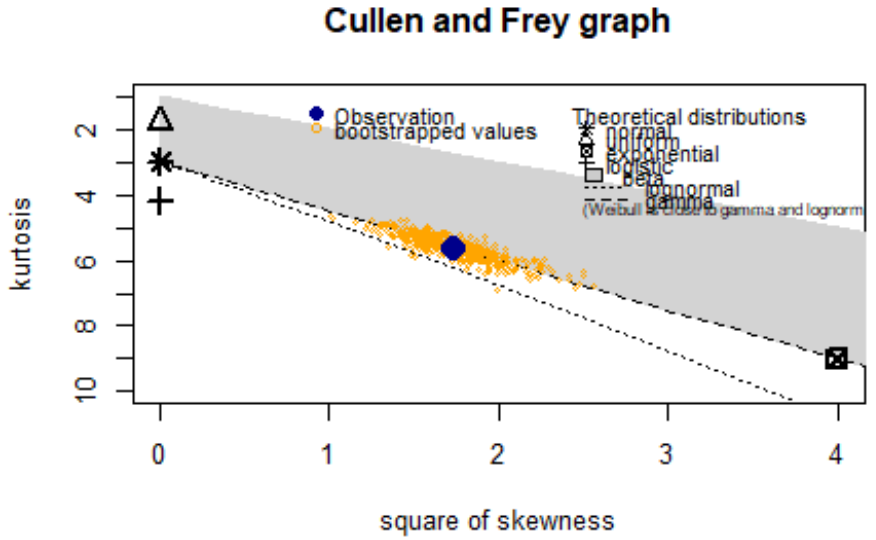
Term = 3 months (USD)



Term = 6 months (USD)



Term = 12 months (USD)



Fitting probability distributions to estimate Interest Rate

- Each probability distribution has a mean and variance –

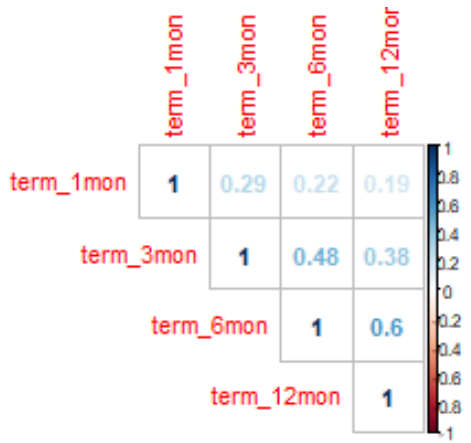
- Mean is also known as return.
- Variance is known as risk, as it adds uncertainty in our interest rate values.

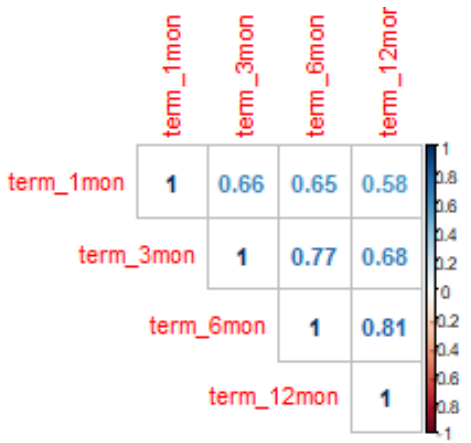
PCA

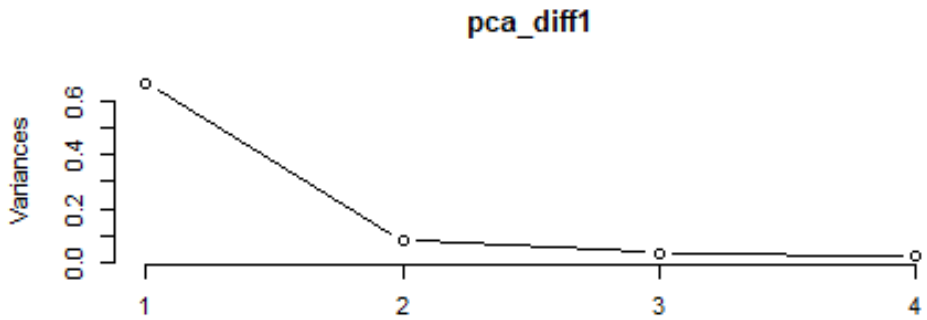
- Interest rates depend on a large set of variables.

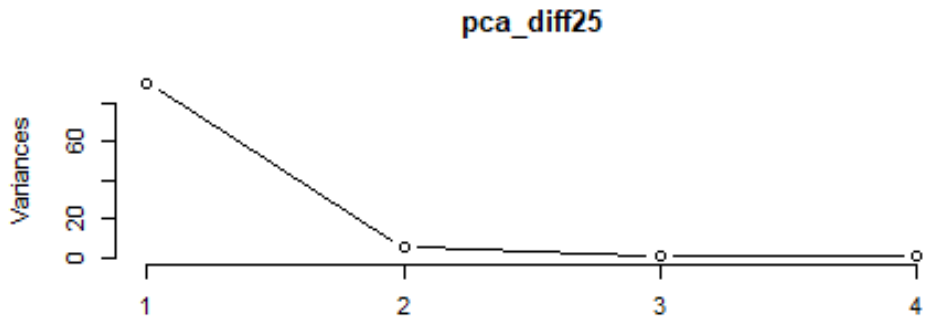
- PCA finds correlation between different variables and produces a set of uncorrelated variables.
- These uncorrelated variables are then combined in a linear model to explain the entire dataset.

Correlation & PCA









A better model

- Can be devised using a Monte Carlo Simulation process.
- These models have a Drift and variance rate : functions of current value and time.

Monte Carlo Simulation process

1. Time is divided into a large number of intervals

2. Drift and Variance rates of a variable are calculated.

3. A random variable is retrieved from a sample of values. This random variable needs to follow the same probability distribution as our target variable. For example, if we believe our variable follows normal distribution then we need to draw a random variable that also follows normal distribution.

4. To get the next value of a variable, its current value is multiplied by its drift rate and added to the product of variance rate, its current value and a random variable.

Short Term Rate Models

- There are a large number of models that can evolve and forecast interest rates.
- Short rate models use the spot interest rate variable to describe current state. Also called term structure models.
- One factor models
- Two factor models
- N factor models..
- Equilibrium Short Rate Models
- No arbitrage Short Rate Models

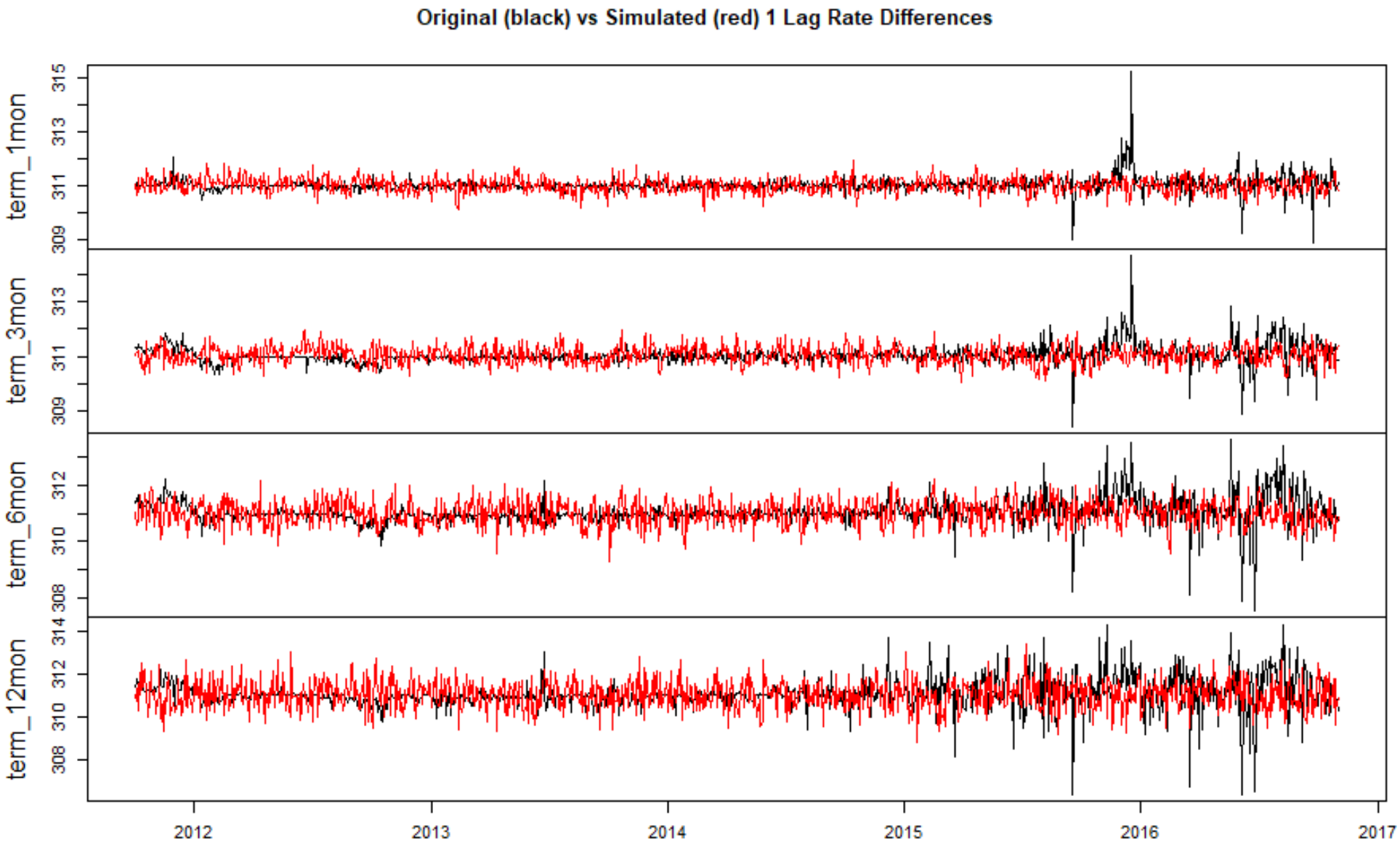
Vasicek model (famous fundamental model)

- Vasicek is a mean reverting equilibrium short term interest rate model.
- The short rate will end up being closer to the mean-reverting level over time.

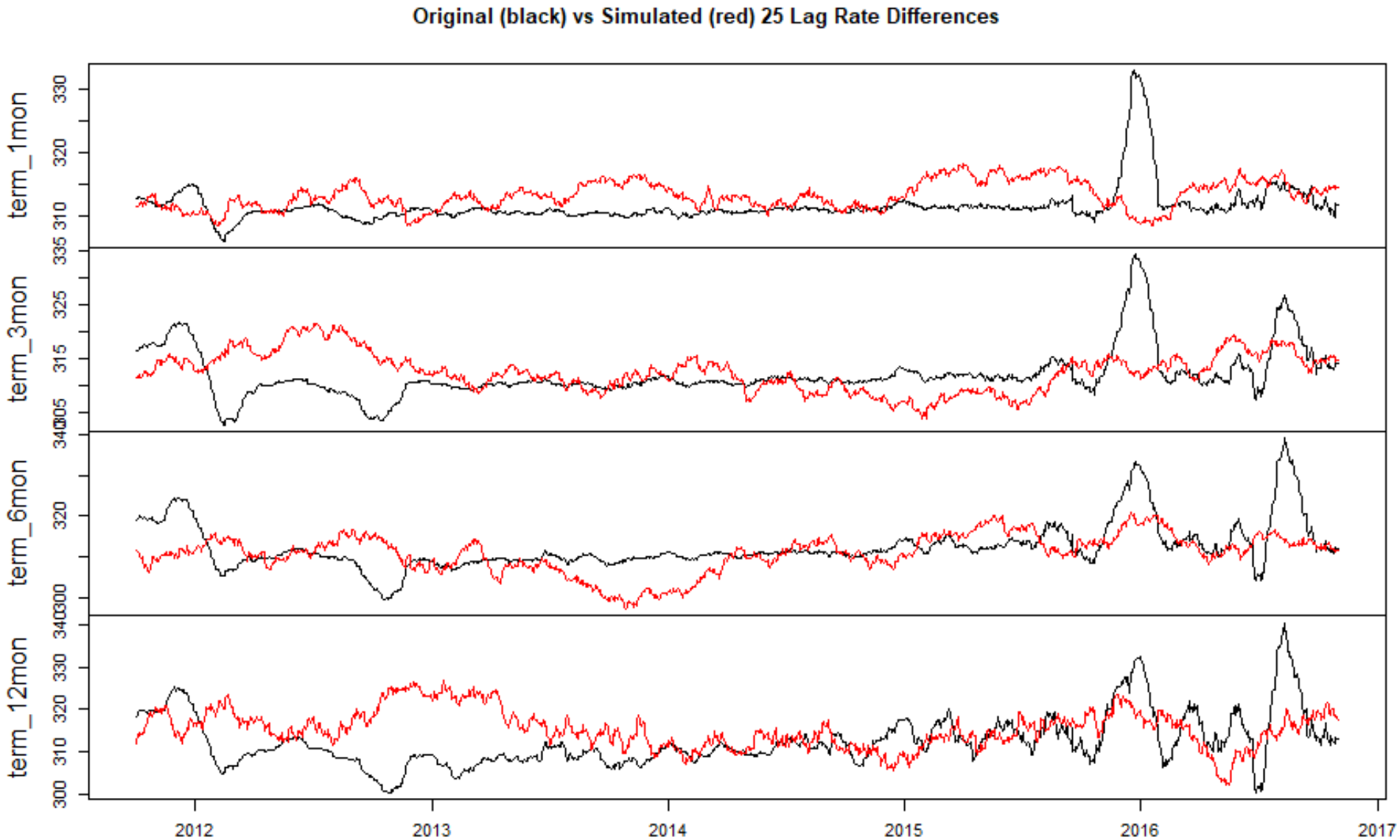
- Mean reversion – periodic oscillations around some fixed level.

(Mean reversion concept fails in economical stresses, high inflation and during crises.)

Vasicek simulation



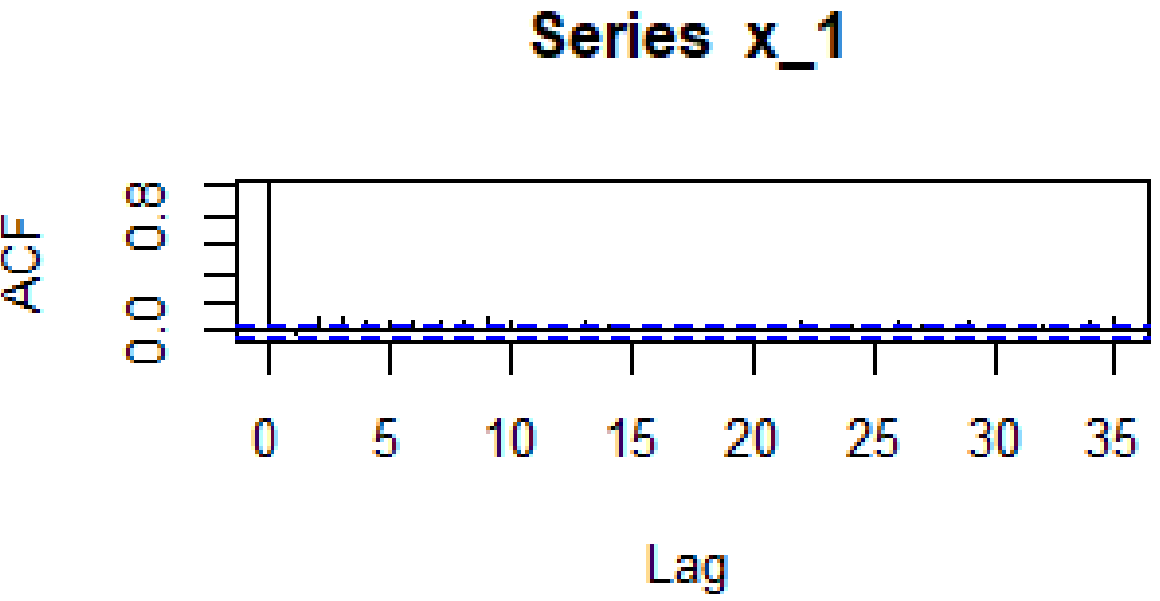
Vasicek simulation

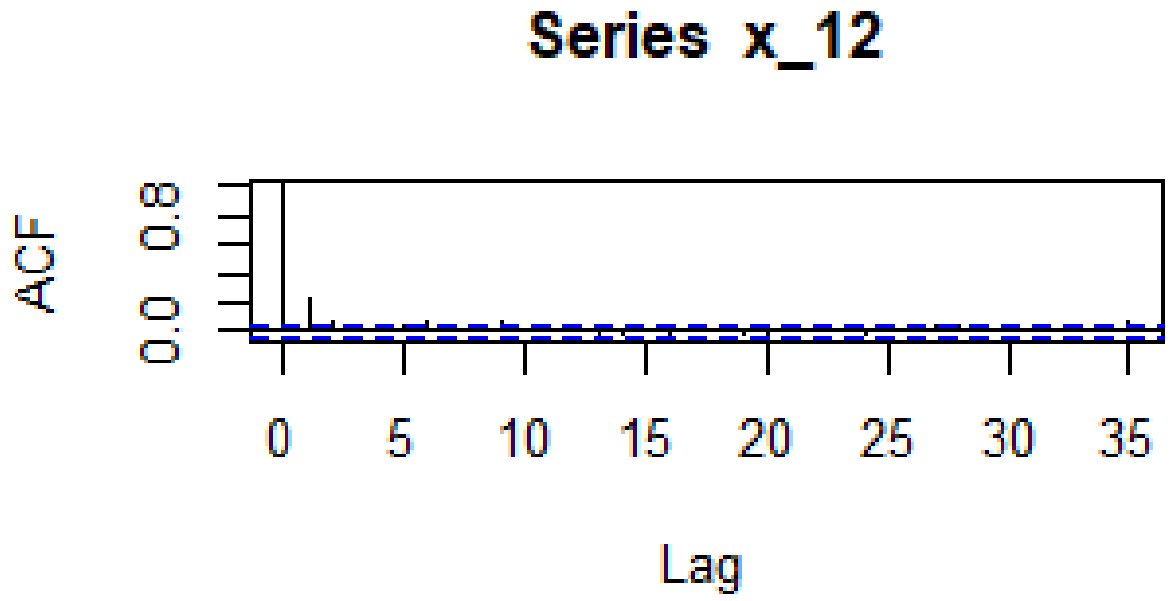


Thank you

Autocorrelation

- Autocorrelation measures how a datapoint's past determines the future of a time series.
- If the autocorrelation is close to 1, the next day's value will be very close to today's value.
- If the autocorrelation is close to 0, the next day's value will be unaffected by today's value.
- Because we are interested in the recent evolution of bond yields, we will filter the time series for data from 2000 onward.


Series x_1
ACF
0.0
0.8
0
5
10
15
20
25
30
35
Lag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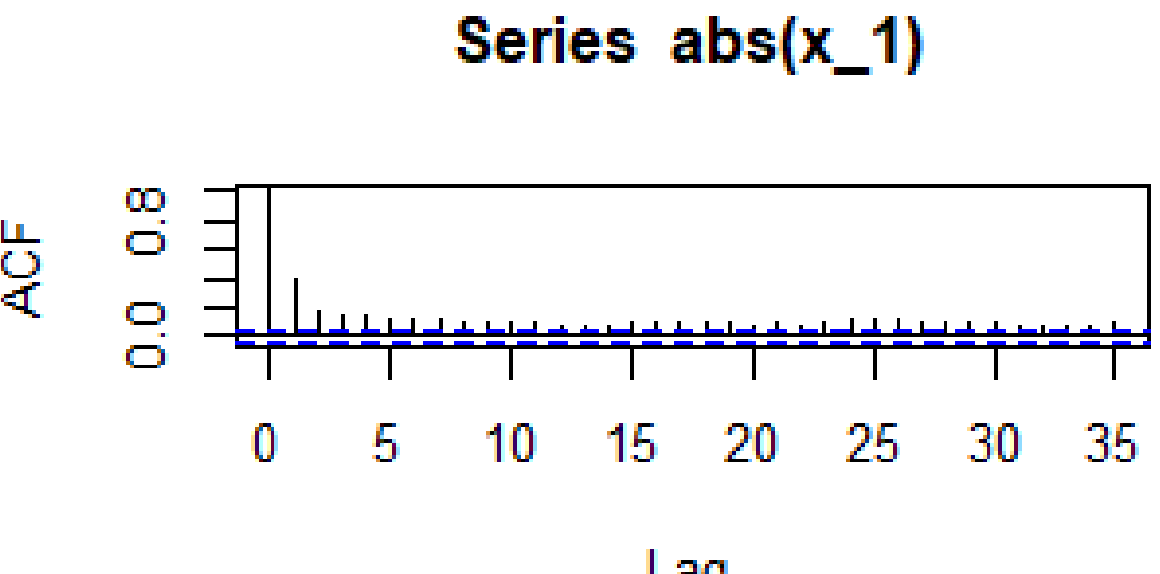
Lag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ACF
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5
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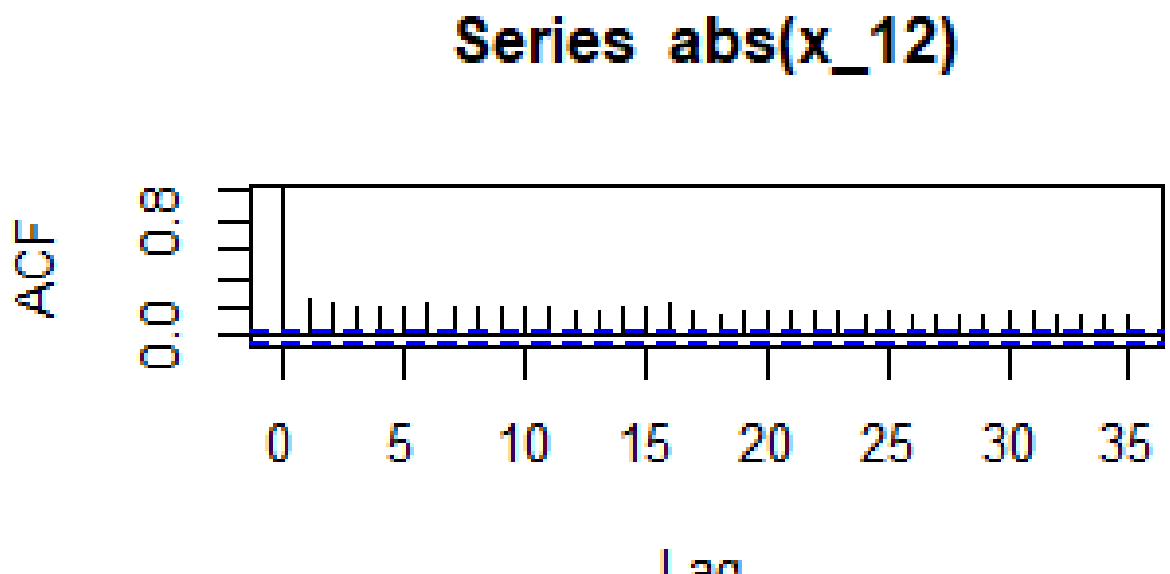
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ACF
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0.8
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