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REPORT LAB 6-7

Q1. Given the *Federal Funds Rate* dataset, find a four-period moving average forecast for the monthly rate data, compute MAD, MSE, RMSE, and MAPE error metrics. What is the *Federal Funds Rate* in April 2013 forecasted?

First, use this formula to calculate four-period moving average forecast for March-1960 and do the same for the whole dataset.

	A	B	C
1	**Federal Funds Rate: Percent**		
2			
3	**Month/Year**	**Rate**	Moving average
4	Jan-1960	3,99%	NA
5	Feb-1960	3,97%	NA
6	Mar-1960	=(B4+B5+B6+B7)/4	
7	Apr-1960	3,92%	3,90%

Second, drop data that is not suitable and reselect sample to calculate, that sample dropped first two data and the last one (Jan-1960, Feb-1960 and Nov-2013). This is part of dataset:

	Actual	Predicted
Mar-1960	3,84%	3,93%
Apr-1960	3,92%	3,90%
May-1960	3,85%	3,73%
Jun-1960	3,32%	3,58%
Jul-1960	3,23%	3,35%
Aug-1960	2,98%	3,03%
Sep-1960	2,60%	2,82%
Oct-1960	2,47%	2,62%
Nov-1960	2,44%	2,37%
Dec-1960	1,98%	2,09%
Jan-1961	1,45%	2,10%
Feb-1961	2,54%	2,00%
Mar-1961	2,02%	1,88%

Final, apply formula:

- Mean absolute deviation (MAD) $$\text{MAD} = \frac{\sum_{t=1}^{n} |A_t - F_t|}{n}$$
- Mean square error (MSE) $$\text{MSE} = \frac{\sum_{t=1}^{n} (A_t - F_t)^2}{n}$$
- Root mean square error (RMSE) $$\text{RMSE} = \sqrt{\frac{\sum_{t=1}^{n} (A_t - F_t)^2}{n}}$$
- Mean absolute percentage error (MAPE) $$\text{MAPE} = \frac{\sum_{t=1}^{n} \left|\frac{A_t - F_t}{A_t}\right|}{n} \times 100$$

The result of these formula:

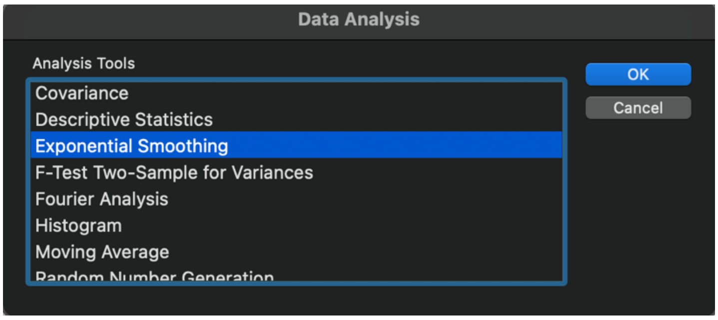
Mean =	5,47%
MAD =	2,66%
MSE =	0,0011%
RMSE =	0,33%
MAPE =	3,91

Based on moving average prediction, the Federal Funds Rate in April 2013 forecasted was approximately 0.14%.

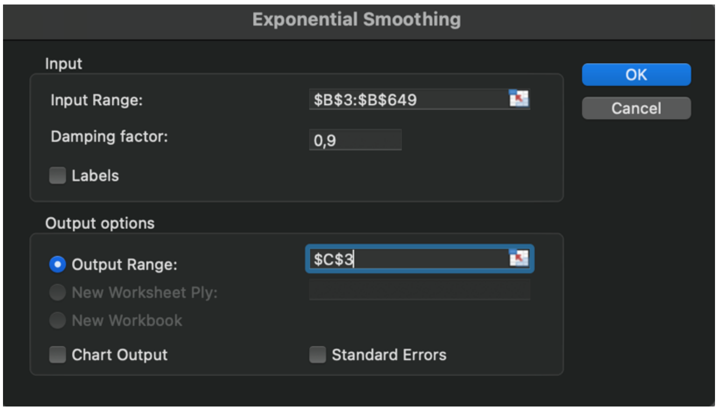
Q2. Do the same as Q1, but apply exponential smoothing models, e.g., using log (predicted value).

<u>For excel:</u>

First, use Exponential Smoothing in the Data Analysis on the Data tab.



Second, set up, using damping factor = 0.9 this mean alpha = 0.1, smaller alpha levels (larger damping factors), smooths out the peaks and valleys more than larger alpha levels (smaller damping factors). Smaller damping factors also mean that your smoothed values are closer to the actual data points than larger damping factors.



The smoothed value for the first data point won't be calculated because there is no data point before that, so we drop that value and choose this sample to calculate

	Actual	Predicted
Feb-1960	3,97%	3,99%
Mar-1960	3,84%	3,99%
Apr-1960	3,92%	3,97%
May-1960	3,85%	3,97%
Jun-1960	3,32%	3,96%
Jul-1960	3,23%	3,89%
Aug-1960	2,98%	3,83%
Sep-1960	2,60%	3,74%
Oct-1960	2,47%	3,63%
Nov-1960	2,44%	3,51%

Final, with the same formula as Q1, this is the result:

Mean =	5,46%
MAD =	2,66%
MSE =	0,0210784001%
RMSE =	1,45%
MAPE =	48,75066016

For Java:

Firstly, built formula to calculate the predicted value:

```
        levels[0] = data[0];
        levels[1] = (1 - alpha)*data[0] + alpha*data[1];

        for (int i = 2; i < data.length; i++) {
            levels[i] = (1 - alpha)*levels[i - 1]+ alpha*data[i];

        }
```

"levels" here is the predicted outcome using Exponential Smoothing.

```
private static void validateParams(double alpha) {
        if (alpha < 0 || alpha > 1) {
            throw new RuntimeException("The value of alpha must be between 0 and 
1");
        }
    }
```

Another step to make sure our alpha value is valid.
Since the value of predicted value has been defined, secondly, we start to calculate the requirement of this problem.
Mean:

```
//Calculate sum of actual data to calculate mean later
    private static double calculateSum(double[] data){
        double sum = 0;
        for (int i = 1; i < data.length; i++) {
            sum += data[i];
        }
        return sum;
    }
//Mean
        public double getMean(){
            return sum/646;
        }
```

Mean absolute deviation:

```
//Calculate sum of average deviation to calculate MAD later
    private static double calculateAverageDeviation(double[] data){
        double summ = 0;
        double sum1 = 0;
        //Sum of actual data
        for (int i = 1; i < data.length; i++) {
            summ += data[i];
        }
        //Sum of AD
        for (int j = 1; j < data.length; j++) {
            sum1 += Math.abs(data[j] - summ/646);
        }
        return sum1;
    }
//MAD
        public double getMAD(){
            return sum1/646;
        }
```

Mean squares error and root mean squares error:

```
//Calculate sum of squares error to calculate MSE and RMSE later
    private static double calculateSquaresError(double[] data, double[] levels){
        double sum2 = 0;
        for (int i = 1; i < data.length; i++) {
            sum2 += Math.pow(data[i] - levels[i - 1], 2);
        }
        return sum2;
    }
//MSE
        public double getMSE(){
            return (sum2/646)*100;
        }
//RMSE
        public double getRMSE(){
            return Math.sqrt((sum2/646))*100;
        }
```

Mean absolute percentage error:

```
//Calculate the sum of absolute percentage error to calculate MAPE later
    private static double calculateAbsolutePercentageError(double[] data, double[]
levels){
        double sum3 = 0;
        for (int i = 1; i < data.length; i++) {
            sum3 += (Math.abs(data[i] - levels[i - 1]))/data[i]*100;
        }
        return sum3;
    }
//MAPE
        public double getMAPE(){
            return sum3/646;
        }
```

Finally, print out result:

```
//Print mean
        System.out.println("Mean is: " + model.getMean());
        //Print MAD
        System.out.println("Mean absolute deviation is: " + model.getMAD());
        //Print MSE
        System.out.println("Mean squares error is: " + model.getMSE() + "%");
        //Print RMSE
        System.out.println("Root mean squares error is: " + model.getRMSE() + "%");
        //Print MAPE
        System.out.println("Mean absolute percentage errror is: " +
model.getMAPE());
        //Print predicted value of April 2013
        System.out.println("Predicted value for April 2013: " + model.levels[638]);
```

The result compiled by Java:

```
Mean is: 0.054555572755417954
Mean absolute deviation is: 0.02664202139385981
Mean squares error is: 0.021078400096177462%
Root mean squares error is: 1.4518402149058092%
Mean absolute percentage errror is: 48.750660160939816
Predicted value for April 2013: 0.0014967952093395051
```

Compared with that of Excel, it is the same, the prediction for April 2013 was approximately 0.15%

Q3. Do the same as Q1, but apply the 3rd order Autoregressive model. Evaluate the used forecasting models

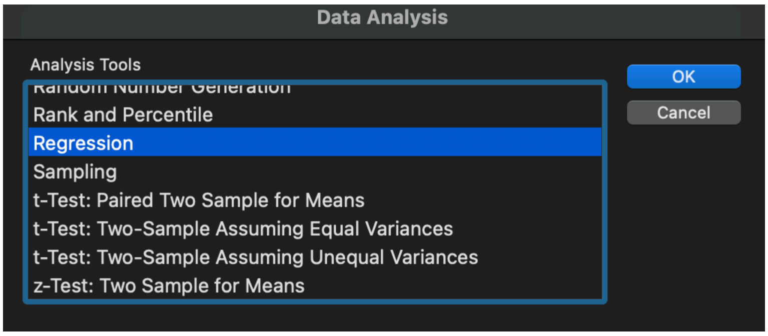
Apply third-order Autoregressive model to data sample, we got:

Month/Year	Rate			
Jan-1960	3,99%			
Feb-1960	3,97%	3,99%		
Mar-1960	3,84%	3,97%	3,99%	
Apr-1960	3,92%	3,84%	3,97%	3,99%
May-1960	3,85%	3,92%	3,84%	3,97%
Jun-1960	3,32%	3,85%	3,92%	3,84%
Jul-1960	3,23%	3,32%	3,85%	3,92%
Aug-1960	2,98%	3,23%	3,32%	3,85%
Sep-1960	2,60%	2,98%	3,23%	3,32%
Oct-1960	2,47%	2,60%	2,98%	3,23%
Nov-1960	2,44%	2,47%	2,60%	2,98%
Dec-1960	1,98%	2,44%	2,47%	2,60%
Jan-1961	1,45%	1,98%	2,44%	2,47%
Feb-1961	2,54%	1,45%	1,98%	2,44%
Mar-1961	2,02%	2,54%	1,45%	1,98%
Apr-1961	1,49%	2,02%	2,54%	1,45%
May-1961	1,98%	1,49%	2,02%	2,54%
Jun-1961	1,73%	1,98%	1,49%	2,02%
Jul-1961	1,17%	1,73%	1,98%	1,49%
Aug-1961	2,00%	1,17%	1,73%	1,98%
Sep-1961	1,88%	2,00%	1,17%	1,73%
Oct-1961	2,26%	1,88%	2,00%	1,17%
Nov-1961	2,61%	2,26%	1,88%	2,00%

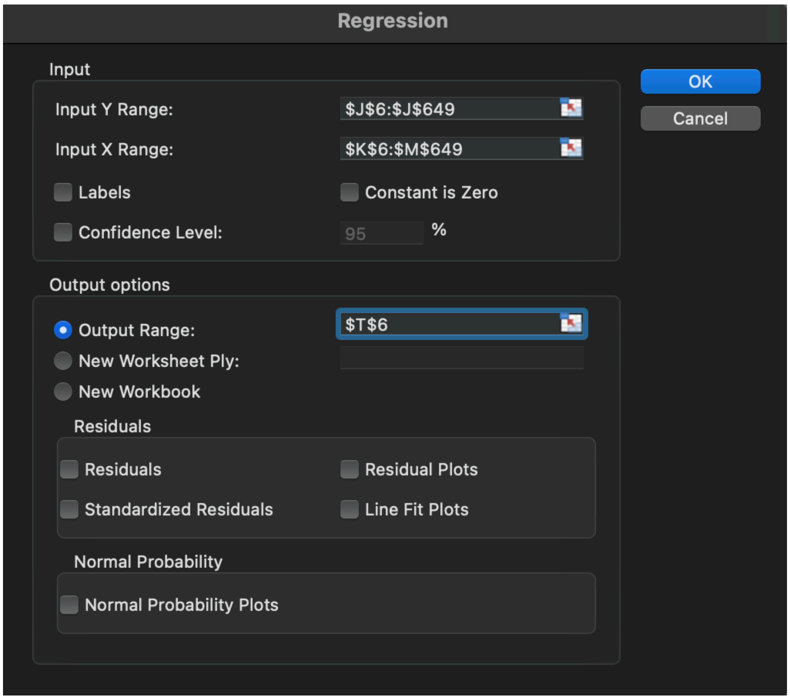
Drop data that is not suitable and reselect sample to calculate, that sample dropped first three data (Jan-1960, Feb-1960 and Mar-1960). This is part of dataset:

	Original	1st order	2nd order	3rd order
Apr-1960	3,92%	3,84%	3,97%	3,99%
May-1960	3,85%	3,92%	3,84%	3,97%
Jun-1960	3,32%	3,85%	3,92%	3,84%
Jul-1960	3,23%	3,32%	3,85%	3,92%
Aug-1960	2,98%	3,23%	3,32%	3,85%
Sep-1960	2,60%	2,98%	3,23%	3,32%
Oct-1960	2,47%	2,60%	2,98%	3,23%
Nov-1960	2,44%	2,47%	2,60%	2,98%
Dec-1960	1,98%	2,44%	2,47%	2,60%
Jan-1961	1,45%	1,98%	2,44%	2,47%
Feb-1961	2,54%	1,45%	1,98%	2,44%
Mar-1961	2,02%	2,54%	1,45%	1,98%

To calculate the predicted value, we use Regression in Data Analysis tool:



Setting up like this:



Excel will print out the result like this:

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0,99055605							
R Square	0,98120129							
Adjusted R S	0,98111317							
Standard Erro	0,00492531							
Observations	644							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	3	0,81035942	0,27011981	11134,9654	0			
Residual	640	0,01552557	2,4259E-05					
Total	643	0,82588499						
	Coefficients	*Standard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,00063539	0,00035768	1,77641753	0,07613911	-6,698E-05	0,00133776	-6,698E-05	0,00133776
X Variable 1	1,44140757	0,03903168	36,9291715	9,303E-161	1,36476194	1,5180532	1,36476194	1,5180532
X Variable 2	-0,611849	0,06469589	-9,4573085	5,8951E-20	-0,7388909	-0,4848071	-0,7388909	-0,4848071
X Variable 3	0,15807396	0,03909588	4,04323834	5,9143E-05	0,08130226	0,23484566	0,08130226	0,23484566

Based on the output, the model will be:

$Y_i = 0.00063539 + 1.44140757Y_{i-1} - 0.611849Y_{i-2} + 0.15807396Y_{i-3}$

Applying this model to calculate the predicted column:

	Original	1st order	2nd order	3rd order	Predict value	Average deviation	Squares error	Absolute p
Apr-1960	3,92%	3,84%	3,97%	3,99%	= 0,00063539 + 1,44140757*K6 - 0,611849*L6 + 0,15807396*M6			

Using the same formula as Q1, the result is:

Mean =	5,46%
MAD =	2,67%
MSE =	0,0024%
RMSE =	0,49%
MAPE =	9,41

Based on Third-order Autoregressive, the Federal Funds Rate in April 2013 forecasted was approximately 0.2%.