



MMAI 5200 Assignment 2

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# Monthly Demand Prediction

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## **Executive Summary**

Kordsa a global manufacturing firm operating in the tire and construction reinforcement as well as the advanced composites industries, is looking for a model to predict monthly demand based on the given advanced demands. In this analysis, we used OLS model and discussed about the different conditions to help company have a better insights into the demands.

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## OLS Implementation

### Introduction

We used OLS model to predict the demands. We need to calculate Lambda and discuss about its values.

$$\lambda = 2(X(X^T X)^{-1} X^T)^{-1} L - 2Y$$

Then, we can go and calculate Beta values.

$$B = (X^T X)^{-1} (X^T Y + \frac{1}{2} \lambda X^T)$$

We received the following values for the Lambda:

```
Lambda =  
[-1.64000000e+02, -6.40000000e+01, -7.80000000e+01, -1.00000000e+02,  
-6.80000000e+01, -8.40000000e+01, -6.80000000e+01, -4.40000000e+01,  
-6.40000000e+01, 2.72848411e-12, -6.80000000e+01, 2.44426701e-12,  
-6.60000000e+01, -6.00000000e+01, -7.00000000e+01, -9.00000000e+01,  
5.68434189e-13, -2.04636308e-12, -8.80000000e+01, -1.06000000e+02,  
-9.09494702e-13, -1.06000000e+02, -1.18000000e+02, -9.60000000e+01]
```

### Interpretation of Lambda Values

#### ➤ Negative Values

If Lambda is negative then it is not binding. In the results, we can see that, the Lambda values are negative for 21 months, and there are only three positive values for the rest of three months. For the negative Lambda values, the constraint is not binding, and the optimal solution for unconstrained model is the optimal value for the constrained model. As such, we set the negative lambda values to zero. On the other hand, for the positive lambda values, the constraint is binding. Thus, we keep the positive lambda values. The updated Lambda vector is like this:

```
Lambda =  
[0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  
2.7284841053187847e-12, 0.0, 2.4442670110147446e-12,  
0.0, 0.0, 0.0, 0.0, 5.684341886080801e-13,  
0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
```

➤ *Near to Zero Values*

If lambda is close to zero assume the order is not urgent for that month. Here are the list of months (zero-indexing) with Lambdas close to zero:

```
Lambda_near_to_zero = [ 9, 11, 16, 17, 20]
```

➤ *Computation Optimization*

For computation optimization we round the near to zero values of Lambda to zero, so we consider that Epsilon ( $1e-10$ ) is a close to zero number and any number close to it considered to be zero. Here is the optimized value of Lambda:

```
Lambda_rounded =  
[0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  
0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,  
0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
```

## Results Interpretation

Now we can analyze our results based on the crated model.

$$\hat{Y} = X.B$$

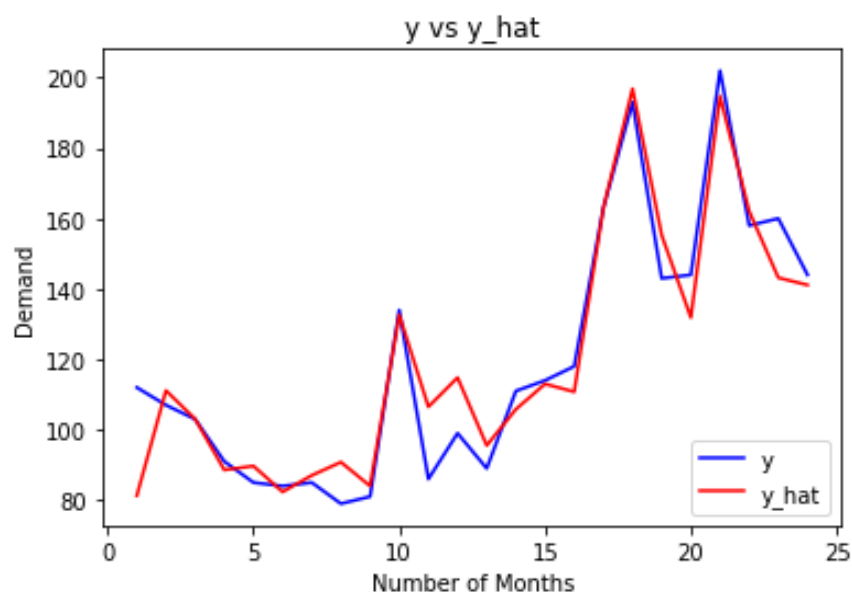
The value of  $\hat{Y}$  is like this:

```
y_hat =  
[ 81.26473915, 111.13577478, 103.05236003, 88.59176095, 89.68288734,  
 82.34717293, 87.03551206, 90.79139893, 84.01863292, 132.62563988,  
106.50828387, 114.81342821, 95.52320109, 105.81494641, 113.00937191,  
110.76627091, 162.94441281, 196.85170589, 155.28045031, 131.8670397,  
194.7325086 , 162.06190892, 143.16947072, 141.11112166]
```

Here are the value of our monthly demand:

```
monthly_demand =  
[100, 112, 107, 103, 91, 85,  
 84, 85, 79, 81, 134, 86, 99,  
 89, 111, 114, 118, 163, 193,  
143, 144, 202, 158, 160, 144]
```

As we can observe, all the predicted demand values are bigger than advanced demands, which means model works fine. Here is the  $\hat{Y}$  performance against Y:



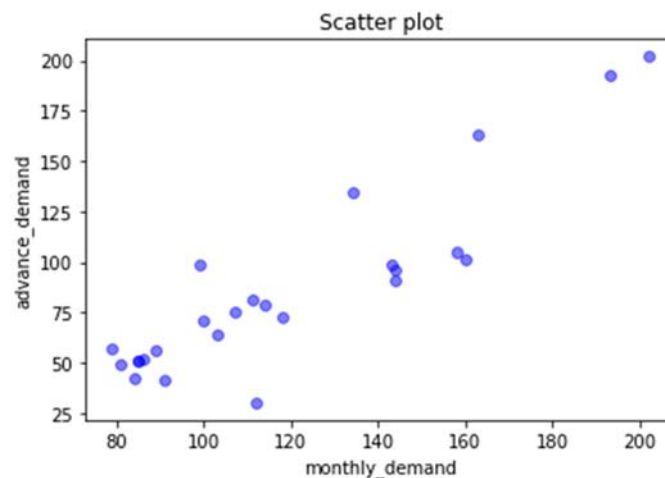
## Evaluation of the Model

We used RMSE to measure the standard deviation of the standard deviation of residuals. Based on our forecasting model, the prediction errors still exist. The company Kordsa collects advanced demand from their customers as they work in the B2B environment, in which some of them may place an order to be delivered in two weeks, two months or five months, which can lead to a huge variance in demand lead-time. With the calculation of our RMSE, it means on average, the forecast values are 10.34 values away from the actual. We also utilized MSE for evaluation and the results are listed below:

MSE: 108.89958521169275,  
RMSE: 10.435496404661004,

## Other Visualizations

To illustrate the correlation between advance demand and monthly demand, we plot scattered and heat map visuals.





As we can see, there is always a positive correlation between advance demand and monthly demand. The advance demand sets a lower bound for monthly demand.

### **Recommendation**

We recommend that the company take the demands with Lambda values which are far from zero and positive more seriously, since those orders are more urgent.