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ENM 319&BIM213

PRODUCTION AND OPERATIONS PLANNING & DATA STRUCTURES AND ALGORİTHMS

FINAL REPORT

GROUP-7

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ABSTRACT

This report is a joint project of the courses ENM319 and BIM213 coded Production and Operations Planning & Data Structures and Algorithms. The report includes the table of work packages, the flowchart developed for the problem, the software developed, the program outputs of the problem and analytical calculations for the solution of the problem. In addition to all these, the project was evaluated from the perspective of industrial and computer engineers.

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FIGURES

1. INTRODUCTION

The problem given within the scope of the ENM319 & BIM213 courses named Production and Operations Planning & Data Structures and Algorithms is given below.

You are working in the production planning department of a company manufacturing luxury SUV cars for the customers in various countries. This morning, your department manager request from you to work with two new friends from the IT department to develop a simple decision support system that will be used in the forecasting processes. The software must have the following characteristics:

• The software should first request the data about last two years (24 months) from the user.

• Based on the data, forecasts must be made by using all the following methods:

o Exponential smoothing (α=0.2)

o Double-exponential smoothing (α=0.2, β=0.2, S_0=200, G_0=50)

o Regression analysis

o Deseasonalized regression analysis

• MSE must be calculated for each forecasting method and the software must indicate the user that "based on the MSE comparisons, the best method for this data is ….."

• By using the best method for that data, the software must then provide the forecasts for the next two years (next 24 months).

2. MEETINGS AND WORK PACKAGES

For the successful completion of the project, four meetings were held until the delivery of the midterm report. Another meeting was held until the delivery of the final report. The first meeting is a general meeting between computer and industrial engineers. In this meeting, all the students got to know each other and explained the purpose of the project, what is aimed at the end of this project, etc. determined by the division of labor. The division of labor is given in Table 1.

Table 1. *Work Package*

Task	Responsible Person	Task due to time
Solution of the problem with exponential smoothing and double exponential smoothing for Dataset 1	Elifnaz ÖZBULAK	12.11.2021
Solution of the problem with regression analysis and deseasonalized regression analysis for Dataset 1	Elif Melis GEÇGİNCİ	12.11.2021
Flow chart + checking + coding	Ramazan GENCER	29.11.2021
Solution of the problem with exponential smoothing and double exponential smoothing for Dataset 2	Elif Melis GEÇGİNCİ	06.12.2021
Solution of the problem with regression analysis and deseasonalized regression analysis for Dataset 2	Elifnaz ÖZBULAK	06.12.2021
Coding	Furkan ALLİŞ	09.12.2021
Coding	Radwan Rachid HOUSSEIN	10.12.2021

The second meeting is the meeting of industrial engineers among themselves. In this meeting, the problem and the purpose of solving the problem were determined. Then, in the given problem, the first data set was solved with four different methods and the method with the least error was selected. In the third meeting, computer and industrial engineers came together again. In this meeting, industrial engineers explained to computer engineers how the problem was solved with four different methods for the first data set and how the best method was determined. The last meeting held before the interim report is between the computer engineers. In this meeting, computer engineers adopted the purpose of the question and decided which program to develop.

Following the completion of the work packages given in Table 1, industrial and computer engineers held another meeting. In this last meeting, the analytical solutions of the second data set and the developed program were discussed. The results obtained from the program were examined and evaluated in detail.

3. SOLUTIONS FOR DATASET 1

Dataset 1 is given in Table 2.

Table 2. *Dataset 1*

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Year 1 Demand	300	350	330	340	390	430	480	460	490	510	550	560
Year 2 Demand	550	590	600	610	630	620	680	690	710	730	740	770

3.1. Exponential Smoothing Method

$(\alpha = 0.2)$

Formula : $F_{t+1} = \alpha D_t + (1- \alpha)F_t$

Calculation :

300 is accepted as a forecast 1 (F_1).

$F_2 = 0.2*300+(1-0.2)*F_1$

$F_2 = 0.2*300+(1-0.2)*300 = 200$

$F_3 = 0.2*350+(1-0.2)*F_2$

$F_3 = 0.2*350+(1-0.2)*200 = 220$

Other forecasts are calculated in the same way and are given in the Table 3.

Table 3. *Forecasts Calculated By Exponential Smoothing Method*

Month (x)	Demand (y)	F_t
1	300	300
2	350	300
3	330	310
4	340	314
5	390	319
6	430	333
7	480	353
8	460	378
9	490	395
10	510	414
11	550	433
12	560	456
13	550	477
14	590	492
15	600	511
16	610	529
17	630	545
18	620	562
19	680	574
20	690	595
21	710	614
22	730	633
23	740	653
24	770	670

3.2. Mean Squared Error (MSE) for Exponential Smoothing Method

Formula : $\dfrac{\sum_{i=1}^{n}(Actual-Forecast)^2}{n} = \dfrac{\sum_{i=1}^{n}(D_t-F_t)^2}{n}$

Calculation :

Firstly, squarred error was calculated.

1. For January : $(300 - 300)^2 = 0$
2. For February : $(350 - 300)^2 = 2500$
3. For March : $(330 - 310)^2 = 400$

Other squarred errors are calculated in the same way and are given in Table 4.

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Table 4. *Squarred Errors for Exponential Smoothing Method*

Month (x)	Demand (y)	Squarred Error
1	300	0
2	350	2500
3	330	400
4	340	676
5	390	5041
6	430	9409
7	480	16384
8	460	6889
9	490	9409
10	510	9604
11	550	14161
12	560	11236
13	550	5625
14	590	10000
15	600	8100
16	610	6724
17	630	7396
18	620	3481
19	680	11664
20	690	9409
21	710	9604
22	730	9801
23	740	8100
24	770	10404

Sum of squarred error : (0+2500+400+676+5041+…………………………9801 + 8100+10404) = 186017

Now, we can find mean squarred error for exponential smoothing method.

$$\text{MSE} = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n} = \frac{186017}{24} = 7750.71$$

3.3. Double Exponential Smoothing Method

($\alpha = 0.2$, $\beta = 0.2$, $S_0 = 200$, $G_0 = 50$)

Formulas :

$S_t = \alpha D_t + (1-\alpha)(S_{t-1} + G_{t-1})$

$G_t = \beta(S_t - S_{t-1}) + (1-\beta)G_{t-1}$

$F_{t,t+\tau} = S_t + \tau \times G_t$ (forecast for time τ into the future)

Where ;

D_t is observed demand,

S_t is current estimate of 'intercept',

G_t is current estimate of slope,

S_{t-1} is last estimate of 'intercept',

G_{t-1} is the last estimate of slope.

Calculations :

1. For January :

$S_1 = 0.2*300 + (1-0.2)*(200 + 50) = 260$

$G_1 = 0.2*(260 - 200) + (1-0.2)*50 = 52$

$F_1 = 200 + 1*50 = 250$

2. For February :

$S_2 = 0.2*350 + (1-0.2)*(260 + 52) = 319.60$

$G_2 = 0.2*(319.60 - 260) + (1-0.2)*52 = 53.52$

$F_2 = 260 + 1*52 = 312$

3. For March :

$S_3 = 0.2*330 + (1-0.2)*(319.60 + 53.52) = 364.50$

$G_3 = 0.2*(364.50 - 319.60) + (1-0.2)*53.52 = 51.80$

$F_3 = 319.60 + 1*53.52 = 373$

Other intercepts,slopes and forecasts are calculated in the same way and are given in the Table 5.

Table 5. *Intercepts, Slopes and Forecasts Calculated By Exponential Smoothing Method*

Month (x)	Demand (y)	Double Exponential Smoothing Method		
		St	Gt	Ft
1	300	260.00	52	250
2	350	319.60	53.52	312
3	330	364.50	51.80	373
4	340	401.03	48.74	416
5	390	437.82	46.35	450
6	430	473.34	44.19	484
7	480	510.02	42.68	518
8	460	534.16	38.98	553
9	490	556.51	35.65	573
10	510	575.73	32.36	592
11	550	596.48	30.04	608
12	560	613.21	27.38	627
13	550	622.47	23.76	641
14	590	634.98	21.51	646
15	600	645.19	19.25	656
16	610	653.55	17.07	664
17	630	662.50	15.44	671
18	620	666.35	13.13	678
19	680	679.58	13.15	679
20	690	692.19	13.04	693
21	710	706.18	13.23	705
22	730	721.53	13.65	719
23	740	736.14	13.85	735
24	770	753.99	14.65	750

3.4. Mean Squared Error (MSE) for Double Exponential Smoothing Method

Formula : $\dfrac{\sum_{i=1}^{n}(Actual - Forecast)^2}{n} = \dfrac{\sum_{i=1}^{n}(D_t - F_t)^2}{n}$

Calculation :

Firstly, squarred error was calculated.

1. For January : $(300 - 250)^2 = 2500$

2. For February : $(350 - 312)^2 = 1444$

3. For March : $(330 - 373)^2 = 1849$

Other squarred errors are calculated in the same way and are given in Table 6.

Table 6. *Squarred Errors for Double Exponential Smoothing Method*

Month (x)	Demand (y)	Squarred Error
1	300	2500
2	350	1444
3	330	1849
4	340	5776
5	390	3481
6	430	2916
7	480	1369
8	460	8464
9	490	6889
10	510	6724
11	550	3364
12	560	4356
13	550	8100
14	590	3136
15	600	3136
16	610	2916
17	630	1600
18	620	3249
19	680	1
20	690	4
21	710	25
22	730	121
23	740	25
24	770	441

Sum of squarred error : (2500+1444+1849+5776+…………………………121 +25 +441) = 71886

Now, we can find mean squarred error for exponential smoothing method.

$$MSE = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n} = \frac{71886}{24} = 2995.25$$

3.5. Regression Analysis Method

Formula : $y_i = a + bx_i$

Where ;

y_i is actual observations,

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$a + bx_i$ is prediction.

Calculation :

A and b values need to be calculated before forecasting for other months. The data required to calculate these values are given in Table 7.

Table 7. *Values to be Calculated for Data a and b*

	Month (x)	Demand (y)	x^2	xy
	1	300	1	300
	2	350	4	700
	3	330	9	990
	4	340	16	1360
	5	390	25	1950
	6	430	36	2580
	7	480	49	3360
	8	460	64	3680
	9	490	81	4410
	10	510	100	5100
	11	550	121	6050
	12	560	144	6720
	13	550	169	7150
	14	590	196	8260
	15	600	225	9000
	16	610	256	9760
	17	630	289	10710
	18	620	324	11160
	19	680	361	12920
	20	690	400	13800
	21	710	441	14910
	22	730	484	16060
	23	740	529	17020
	24	770	576	18480
Sum	300	13110	4900	186430
Mean	13	546		

$$b = \frac{n\sum_i x_i y_i - (\sum_i x_i)(\sum_i y_i)}{n\sum_i x_i{}^2 - (\sum_i x_i)^2} = \frac{24*186430 - (300)*(13110)}{24*4900 - (300)^2} = 19.61$$

$$a = \bar{y} - b\bar{x} = 546 - 19.61*13 = 301.09$$

$$y(x) = 301.09 + 19.61x$$

1. For January :

$x = 1$

y(1) = 301.09 + 19.61*1 = 320

2. For February :

x = 2

y(2) = 301.09 + 19.61*2 = 340

3. For March :

x = 3

y(3) = 301.09 + 19.61*3 = 359

Other forecasts are calculated in the same way and are given in the Table 8.

Table 8. *Forecasts Calculated By Regression Analysis Method*

Month (x)	Demand (y)	Ft
1	300	320
2	350	340
3	330	359
4	340	379
5	390	399
6	430	418
7	480	438
8	460	457
9	490	477
10	510	497
11	550	516
12	560	536
13	550	556
14	590	575
15	600	595
16	610	614
17	630	634
18	620	654
19	680	673
20	690	693
21	710	712
22	730	732
23	740	752
24	770	771

3.6. Mean Squared Error (MSE) for Regression Analysis Method

Formula : $\frac{\sum_{i=1}^{n}(\text{Actual}-\text{Forecast})^2}{n} = \frac{\sum_{i=1}^{n}(D_t-F_t)^2}{n}$

Calculation :

Firstly, squarred error was calculated.

1. For January : $(300 - 320)^2 = 400$
2. For February : $(350 - 340)^2 = 100$
3. For March : $(330 - 359)^2 = 841$

Other squarred errors are calculated in the same way and are given in Table 9.

Table 9. *Squarred Errors for Regression Analysis Method*

Month (x)	Demand (y)	Squarred Error
1	300	400
2	350	100
3	330	841
4	340	1521
5	390	81
6	430	144
7	480	1764
8	460	9
9	490	169
10	510	169
11	550	1156
12	560	576
13	550	36
14	590	225
15	600	25
16	610	16
17	630	16
18	620	1156
19	680	49
20	690	9
21	710	4
22	730	4
23	740	144
24	770	1

Sum of squarred error : (400+100+841+1521+…………………….4 +144 +1) = 8615

Now, we can find mean squarred error for regression analysis method.

$$MSE = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n} = \frac{8615}{24} = 358.96$$

3.7. Deseasonalized Regression Analysis Method

In order to be able to find a solution with deseasonal regression analysis method, first of all, seasonal data must be deseasonalized. Then it is solved according to the regression analysis method. Finally, the obtained data is converted back to seasonal data.

Calculation :

Expected Demand $Q1_{year3} = (300+550)/2 = 425$

Expected Demand $Q2_{year3} = (350+590)/2 = 470$

Expected Demand $Q3_{year3} = (330+600)/2 = 465$

Overall average demand $= (\sum_i D_i) / 24 = (300+350+330+340+\ldots\ldots+740+770) / 24$

$= 546.25$

Other expected demands are calculated in the same way and are given in Table 10.

Table 10. *Calculated Expected Demands for Deseasonal Regression Analysis Method*

Season	Cycle	Demand	Season	Cycle	Demand	Season	Cycle	Expected Demand
Q1	Year 1	300	Q1	Year 2	550	Q1	Year 3	425
Q2	Year 1	350	Q2	Year 2	590	Q2	Year 3	470
Q3	Year 1	330	Q3	Year 2	600	Q3	Year 3	465
Q4	Year 1	340	Q4	Year 2	610	Q4	Year 3	175
Q5	Year 1	390	Q5	Year 2	630	Q5	Year 3	510
Q6	Year 1	430	Q6	Year 2	620	Q6	Year 3	525
Q7	Year 1	480	Q7	Year 2	680	Q7	Year 3	580
Q8	Year 1	460	Q8	Year 2	690	Q8	Year 3	575
Q9	Year 1	490	Q9	Year 2	710	Q9	Year 3	600
Q10	Year 1	510	Q10	Year 2	730	Q10	Year 3	620
Q11	Year 1	550	Q11	Year 2	740	Q11	Year 3	645
Q12	Year 1	560	Q12	Year 2	770	Q12	Year 3	665

Seasonal Demand Factors:

Q1: $425/546.25 = 0.78$

Q2: $470/546.25 = 0.86$

Q3: 465/546.25 = 0.85

Deseasonal demand data should be obtained from seasonal data. Therefore, the demand values should be divided by the seasonal demand factors.

Deseason Demand:

Q1: 300 /0.78 = 385.59

Q2: 350/0.86 = 406.78

Q3: 330/0.85 = 387.78

The other seasonal demand factors and deaseason demands are calculated in the same way. These values are given in Table 11.

Table 11. *Calculated Values to Work on Deaseasonal Data*

Month	Actual Demand	Period Average	Period Factor	Deseason Demand (y)	Period in (x)	xy	x^2
1	300	425	0.78	385.59	1	385.6	1
2	350	470	0.86	406.78	2	813.6	4
3	330	465	0.85	387.66	3	1163	9
4	340	475	0.87	391	4	1564	16
5	390	510	0.93	417.72	5	2088.6	25
6	430	525	0.96	447.40	6	2684.4	36
7	480	580	1.06	452.07	7	3164.5	49
8	460	575	1.05	437	8	3496	64
9	490	600	1.10	446.10	9	4014.9	81
10	510	620	1.14	44933	10	4493.3	100
11	550	645	1.18	465.79	11	5123.7	121
12	560	665	1.22	460	12	5520	144
13	550	425	0.78	706.91	13	9189.9	169
14	590	470	0.86	685.72	14	9600.1	196
15	600	465	0.85	704.84	15	10572.6	225
16	610	475	0.87	701.50	16	11224	256
17	630	510	0.93	674.78	17	11471.3	289
18	620	525	0.96	645.10	18	11611.7	324
19	680	580	1.06	640.43	19	12168.2	361
20	690	575	1.05	655.50	20	13110	400
21	710	600	1.10	646.40	21	13574.3	441
22	730	620	1.14	643.17	22	14149.6	484
23	740	645	1.18	626.71	23	14414.2	529
24	770	665	1.22	632.50	24	15180	576
			SUM	13110	300	180777.5	4900
			MEAN	546	13		

A and b values need to be calculated before forecasting for other months.

$$b = \frac{n \sum_i x_i y_i - (\sum_i x_i)(\sum_i y_i)}{n \sum_i x_i{}^2 - (\sum_i x_i)^2} = \frac{24*180777.5 - (300)*(13110)}{24*4900 - (300)^2} = 14.70$$

$$a = \bar{y} - b\bar{x} = 546 - 14.70*13 = 362.53$$

$$y(x) = 362.53 + 14.70x$$

The results from this equation should be seasonalized. Therefore, it should be multiplied by the period factor.

$$y(x) = \text{period factor} * (362.53 + 14.70x)$$

1. For January :

$$x = 1$$

$$y(1) = 0.78*(362.53 + 14.70*1) = 293$$

2. For February :

$$x = 2$$

$$y(2) = 0.86*(362.53 + 14.70*2) = 337$$

3. For March :

$$x = 3$$

$$y(3) = 0.85*(362.53 + 14.70*3) = 346$$

Other forecasts are calculated in the same way and are given in the Table 12.

Table 12. *Forecasts Calculated By Deseasonal Regression Analysis Method*

Month (x)	Demand (y)	Ft
1	300	293
2	350	337
3	330	346
4	340	366
5	390	407
6	430	433
7	480	494
8	460	505
9	490	543
10	510	578
11	550	619
12	560	656
13	550	431
14	590	489
15	600	496
16	610	520
17	630	572
18	620	603
19	680	681
20	690	691
21	710	737
22	730	778
23	740	827
24	770	871

3.8. Mean Squared Error (MSE) for Deseasonalized Regression Analysis Method

Formula : $\dfrac{\sum_{i=1}^{n}(\text{Actual}-\text{Forecast})^2}{n} = \dfrac{\sum_{i=1}^{n}(D_t - F_t)^2}{n}$

Calculation :

Firstly, squarred error was calculated.

1. For January : $(300 - 293)^2 = 49$
2. For February : $(350 - 337)^2$ 169
3. For March : $(330 - 346)^2 = 256$

Other squarred errors are calculated in the same way and are given in Table 13.

Table 13. *Squarred Errors for Regression Analysis Method*

Month (x)	Demand (y)	Squarred Error
1	300	49
2	350	169
3	330	256
4	340	676
5	390	289
6	430	9
7	480	196
8	460	2025
9	490	2809
10	510	4624
11	550	4624
12	560	9216
13	550	14400
14	590	10404
15	600	10816
16	610	8281
17	630	3481
18	620	324
19	680	1
20	690	1
21	710	729
22	730	2304
23	740	7569
24	770	10000

Sum of squarred error : (49+169+256+676+………………………2304+7569+10000) = 93252

Now, we can find mean squarred error for regression analysis method.

$$\text{MSE} = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n} = \frac{93252}{24} = 3885.50$$

4. SOLUTIONS FOR DATASET 2

Dataset 2 is given in Table 14.

Table 14. *Dataset 2*

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Year 1 Demand	200	300	250	600	650	670	400	440	430	900	980	990
Year 2 Demand	300	370	380	710	730	790	450	480	490	930	960	980

4.1. Exponential Smoothing Method

$(\alpha = 0.2)$

Formula : $F_{t+1} = \alpha D_t + (1- \alpha)F_t$

Calculation :

200 is accepted as a forecast 1 (F_1).

$F_2 = 0.2*200+(1-0.2)*F_1$

$F_2 = 0.2*200+(1-0.2)*200= 200$

$F_3 = 0.2*300+(1-0.2)*F_2$

$F_3 = 0.2*300+(1-0.2)*200 = 220$

Other forecasts are calculated in the same way and are given in the Table 15.

Table 15. *Forecasts Calculated By Exponential Smoothing Method*

Month (x)	Demand (y)	F_t
1	200	200
2	300	200
3	250	220
4	600	226
5	650	300
6	670	370
7	400	430
8	440	424
9	430	427
10	900	427
11	980	521
12	990	612
13	300	687
14	370	609
15	380	561
16	710	524
17	730	561
18	790	594
19	450	633
20	480	596
21	490	572
22	930	555
23	960	630
24	980	696

4.2. Mean Squared Error (MSE) for Exponential Smoothing Method

Formula : $\dfrac{\sum_{i=1}^{n}(Actual-Forecast)^2}{n} \quad = \quad \dfrac{\sum_{i=1}^{n}(D_t-F_t)^2}{n}$

Calculation :

Firstly, squarred error was calculated.

1. For January : $(200-200)^2 = 0$

2. For February : $(300-200)^2 = 10000$

3. For March : $(250-220)^2 = 900$

Other squarred errors are calculated in the same way and are given in Table 16.

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Table 16. *Squarred Errors for Exponential Smoothing Method*

Month (x)	Demand (y)	Squarred Error
1	200	0
2	300	10000
3	250	900
4	600	139876
5	650	122500
6	670	90000
7	400	900
8	440	256
9	430	9
10	900	223729
11	980	210681
12	990	142884
13	300	149769
14	370	57121
15	380	32761
16	710	34596
17	730	28561
18	790	38416
19	450	33489
20	480	13456
21	490	6724
22	930	140625
23	960	108900
24	980	80656

Sum of squarred error : (0+10000+900+139876+122500+…………………………+ 108900+80656) = 1666809

Now, we can find mean squarred error for exponential smoothing method.

$$\text{MSE} = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n} = \frac{1666809}{24} = 69450.375$$

4.3. Double Exponential Smoothing Method

($\alpha = 0.2$, $\beta = 0.2$, $S_0 = 200$, $G_0 = 50$)

Formulas :

$S_t = \alpha D_t + (1-\alpha)(S_{t-1} + G_{t-1})$

$G_t = \beta(S_t - S_{t-1}) + (1-\beta)G_{t-1}$

$F_{t,t+\tau} = S_t + \tau \times G_t$ (forecast for time τ into the future)

Where ;

D_t is observed demand,

S_t is current estimate of 'intercept',

G_t is current estimate of slope,

S_{t-1} is last estimate of 'intercept',

G_{t-1} is the last estimate of slope.

Calculations :

1. For January :

$S_1 = 0.2*200 + (1-0.2)*(200 + 50) = 240$

$G_1 = 0.2*(240 - 200) + (1- 0.2)*50 = 48$

$F_1 = 200 + 1*50 = 250$

2. For February :

$S_2 = 0.2*300 + (1-0.2)*(240 + 48) = 290.4$

$G_2 = 0.2*(290.4 - 240) + (1- 0.2)*48 = 48.48$

$F_2 = 240 + 1*48 = 288$

3. For March :

$S_3 = 0.2*250 + (1-0.2)*(290.4 + 48.48) = 321.10$

$G_3 = 0.2*(321.10 - 290.4) + (1- 0.2)*48.48 = 44.92$

$F_3 = 290.4 + 1*48.48 = 338$

Other intercepts,slopes and forecasts are calculated in the same way and are given in the Table 17.

Table 17. *Intercepts, Slopes and Forecasts Calculated By Exponential Smoothing Method*

Month (x)	Demand (y)	Double Exponential Smoothing Method		
		St	Gt	Ft
1	200	240	48	250
2	300	290.40	48.48	288
3	250	321.10	44.92	338
4	600	412.82	54.28	366
5	650	503.69	61.60	467
6	670	586.23	65.79	565
7	400	601.61	55.71	652
8	440	613.86	47.01	657
9	430	614.70	37.78	660
10	900	701.98	47.68	652
11	980	795.73	56.89	749
12	990	880.10	62.39	852
13	300	813.99	36.69	942
14	370	754.54	17.46	850
15	380	693.61	1.78	772
16	710	698.31	2.37	695
17	730	706.54	3.54	700
18	790	726.06	6.74	710
19	450	676.24	-4.58	732
20	480	633.33	-12.24	671
21	490	594.87	-17.49	621
22	930	647.91	-3.38	577
23	960	707.62	9.24	644
24	980	769.49	19.76	716

4.4. Mean Squared Error (MSE) for Double Exponential Smoothing Method

Formula : $\frac{\sum_{i=1}^{n}(\text{Actual}-\text{Forecast})^2}{n} = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n}$

Calculation :

Firstly, squarred error was calculated.

1. For January : $(200 - 250)^2 = 2500$
2. For February : $(300 - 288)^2 = 144$
3. For March : $(250 - 338)^2 = 7744$

Other squarred errors are calculated in the same way and are given in Table 18.

Table 18. *Squarred Errors for Double Exponential Smoothing Method*

Month (x)	Demand (y)	Squarred Error
1	200	2500
2	300	144
3	250	7744
4	600	54756
5	650	33489
6	670	11025
7	400	63504
8	440	47089
9	430	52900
10	900	61504
11	980	53361
12	990	19044
13	300	412164
14	370	230400
15	380	153664
16	710	225
17	730	900
18	790	6400
19	450	79524
20	480	36481
21	490	17161
22	930	124609
23	960	99856
24	980	69696

Sum of squarred error : (2500+144+7744+54756+…………………+99856 +69696) = 1638140

Now, we can find mean squarred error for exponential smoothing method.

$$\text{MSE} = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n} = \frac{1638140}{24} = 68255.8$$

4.5. Regression Analysis Method

Formula : $y_i = a + bx_i$

Where ;

y_i is actual observations,

$a + bx_i$ is prediction.

Calculation :

A and b values need to be calculated before forecasting for other months. The data required to calculate these values are given in Table 19.

Table 19. *Values to be Calculated for Data a and b*

Month (x)	Demand (y)	x^2	xy
1	200	1	200
2	300	4	600
3	250	9	750
4	600	16	2400
5	650	25	3250
6	670	36	4020
7	400	49	2800
8	440	64	3520
9	430	81	3870
10	900	100	9000
11	980	121	10780
12	990	144	11880
13	300	169	3900
14	370	196	5180
15	380	225	5700
16	710	256	11360
17	730	289	12410
18	790	324	14220
19	450	361	8550
20	480	400	9600
21	490	441	10290
22	930	484	20460
23	960	529	22080
24	980	576	23520
Sum 300	14380	4900	200340
Mean 13	599		

$$b = \frac{n\sum_i x_i y_i - (\sum_i x_i)(\sum_i y_i)}{n\sum_i x_i{}^2 - (\sum_i x_i)^2} = \frac{24*200340 - (300)*(14380)}{24*4900 - (300)^2} = 17.90$$

$$a = \bar{y} - b\bar{x} = 599 - 17.90*13 = 375.36$$

$$y(x) = 375.36 + 17.90x$$

1. For January :

24

x = 1

y(1) = 375.36+ 17.90*1 = 393

2. For February :

x = 2

y(2) = 375.36+ 17.90*2 = 411

3. For March :

x = 3

y(3) = 375.36+ 17.90*3 = 429

Other forecasts are calculated in the same way and are given in the Table 20.

Table 20. *Forecasts Calculated By Regression Analysis Method*

Month (x)	Demand (y)	Ft
1	200	393
2	300	411
3	250	429
4	600	446
5	650	464
6	670	482
7	400	500
8	440	518
9	430	536
10	900	554
11	980	572
12	990	590
13	300	608
14	370	626
15	380	643
16	710	661
17	730	679
18	790	697
19	450	715
20	480	733
21	490	751
22	930	769
23	960	787
24	980	805

4.6. Mean Squared Error (MSE) for Regression Analysis Method

Formula : $\frac{\sum_{i=1}^{n}(\text{Actual}-\text{Forecast})^2}{n} = \frac{\sum_{i=1}^{n}(D_t-F_t)^2}{n}$

Calculation :

Firstly, squarred error was calculated.

1. For January : $(200 - 393)^2 = 37249$

2. For February : $(300 - 411)^2 = 12321$

3. For March : $(250 - 429)^2 = 32041$

Other squarred errors are calculated in the same way and are given in Table 21.

Table 21. *Squarred Errors for Regression Analysis Method*

Month (x)	Demand (y)	Squarred Error
1	200	37249
2	300	12321
3	250	32041
4	600	23716
5	650	34596
6	670	35344
7	400	10000
8	440	6084
9	430	11236
10	900	119716
11	980	166464
12	990	160000
13	300	94864
14	370	65536
15	380	69169
16	710	2401
17	730	2601
18	790	8649
19	450	70225
20	480	64009
21	490	68121
22	930	25921
23	960	29929
24	980	30625

Sum of squarred error :

(37249+12321+32041+23716……………………+25921+29929+30625) =

1180817

Now, we can find mean squarred error for regression analysis method.

$$\text{MSE} = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n} = \frac{1180817}{24} = 49200.71$$

4.7. Deseasonalized Regression Analysis Method

In order to be able to find a solution with deseasonal regression analysis method, first of all, seasonal data must be deseasonalized. Then it is solved according to the regression analysis method. Finally, the obtained data is converted back to seasonal data.

Calculation :

Expected Demand $Q1_{year3} = (200+300)/2 = 250$

Expected Demand $Q2_{year3} = (300+370)/2 = 335$

Expected Demand $Q3_{year3} = (250+380)/2 = 315$

Overall average demand $= (\sum_i D_i)/24 = (200+300+250+\ldots\ldots+960+980)/24$

$= 599.17$

Other expected demands are calculated in the same way and are given in Table 22.

Table 22. *Calculated Expected Demands for Deseasonal Regression Analysis Method*

Season	Cycle	Demand	Season	Cycle	Demand	Season	Cycle	Expected Demand
Q1	Year 1	200	Q1	Year 2	300	Q1	Year 3	250
Q2	Year 1	300	Q2	Year 2	370	Q2	Year 3	335
Q3	Year 1	250	Q3	Year 2	380	Q3	Year 3	315
Q4	Year 1	600	Q4	Year 2	710	Q4	Year 3	655
Q5	Year 1	650	Q5	Year 2	730	Q5	Year 3	690
Q6	Year 1	670	Q6	Year 2	790	Q6	Year 3	730
Q7	Year 1	400	Q7	Year 2	450	Q7	Year 3	425
Q8	Year 1	440	Q8	Year 2	480	Q8	Year 3	460
Q9	Year 1	430	Q9	Year 2	490	Q9	Year 3	460
Q10	Year 1	900	Q10	Year 2	930	Q10	Year 3	915
Q11	Year 1	980	Q11	Year 2	960	Q11	Year 3	970
Q12	Year 1	990	Q12	Year 2	980	Q12	Year 3	985

Seasonal Demand Factors:

Q1: $250/599.17 = 0.42$

Q2: $335/599.17 = 0.56$

Q3: 315/599.17 = 0.53

Deseasonal demand data should be obtained from seasonal data. Therefore, the demand values should be divided by the seasonal demand factors.

Deseason Demand:

Q1: 200 /0.42 = 479.33

Q2: 300/0.56 = 536.57

Q3: 250/0.53 = 475.53

The other seasonal demand factors and deaseason demands are calculated in the same way. These values are given in Table 23.

Table 23. *Calculated Values to Work on Deaseasonal Data*

Month	Actual Demand	Period Average	Period Factor	Deseason Demand (y)	Period in (x)	xy	x^2
1	200	250	0.42	479.33	1	479.3	1
2	300	335	0.56	536.57	2	107.1	4
3	250	315	0.53	475.53	3	1426.6	9
4	600	655	1.09	548.85	4	2195.4	16
5	650	690	1.15	564.43	5	2822.2	25
6	670	730	1.22	549.92	6	3299.5	36
7	400	425	0.71	563.92	7	3947.5	49
8	440	460	0.77	573.12	8	4584.9	64
9	430	460	0.77	560.09	9	5040.8	81
10	900	915	1.53	589.34	10	5893.4	100
11	980	970	1.62	605.34	11	6658.8	121
12	990	985	1.64	602.21	12	7226.5	144
13	300	250	0.42	719.00	13	9347.0	169
14	370	335	0.56	661.77	14	9264.7	196
15	380	315	0.53	722.80	15	10842.1	225
16	710	655	1.09	649.48	16	10391.7	256
17	730	690	1.15	633.90	17	10776.3	289
18	790	730	1.22	648.41	18	11671.4	324
19	450	425	0.71	634.41	19	12053.8	361
20	480	460	0.77	625.22	20	12504.3	400
21	490	460	0.77	638.24	21	13403.1	441
22	930	915	1.53	608.99	22	13397.8	484
23	960	970	1.62	592.99	23	13638.8	529
24	980	985	1.64	596.13	24	14307	576
			SUM	14380	300	186246.07	4900
			MEAN	599	13		

A and b values need to be calculated before forecasting for other months.

$$b = \frac{n \sum_i x_i y_i - (\sum_i x_i)(\sum_i y_i)}{n \sum_i x_i^2 - (\sum_i x_i)^2} = \frac{24*186246.07 - (300)*(14380)}{24*4900 - (300)^2} = 5.65$$

$a = \bar{y} - b\bar{x} = 599 - 5.65*13 = 528.56$

$y(x) = 528.56 + 5.65x$

The results from this equation should be seasonalized. Therefore, it should be multiplied by the period factor.

$y(x) = $ period factor $* (528.56 + 5.65x)$

1. For January :

$x = 1$

$y(1) = 0.42*(528.56 + 5.65*1) = 222$

2. For February :

$x = 2$

$y(2) = 0.56*(528.56 + 5.65*2) = 301$

3. For March :

$x = 3$

$y(3) = 0.53*(528.56 + 5.65*3) = 288$

Other forecasts are calculated in the same way and are given in the Table 24.

Table 24. *Forecasts Calculated By Deseasonal Regression Analysis Method*

Month (x)	Demand (y)	Ft
1	200	222
2	300	301
3	250	286
4	600	602
5	650	641
6	670	685
7	400	402
8	440	440
9	430	444
10	900	893
11	980	956
12	990	980
13	300	251
14	370	339
15	380	322
16	710	676
17	730	719
18	790	767
19	450	451
20	480	492
21	490	496
22	930	996
23	960	1066
24	980	1091

4.8. Mean Squared Error (MSE) for Deseasonalized Regression Analysis Method

Formula : $\quad \frac{\sum_{i=1}^{n}(\text{Actual}-\text{Forecast})^2}{n} \;=\; \frac{\sum_{i=1}^{n}(D_t-F_t)^2}{n}$

Calculation :

Firstly, squarred error was calculated.

5. For January : $(200 - 222)^2 = 484$

6. For February : $(300 - 301)^2 = 1$

7. For March : $(250 - 286)^2 = 1296$

Other squarred errors are calculated in the same way and are given in Table 25.

Table 25. *Squarred Errors for Regression Analysis Method*

Month (x)	Demand (y)	Squarred Error
1	200	484

2	300	1
3	250	1296
4	600	4
5	650	81
6	670	225
7	400	4
8	440	0
9	430	196
10	900	49
11	980	576
12	990	100
13	300	2401
14	370	961
15	380	3364
16	710	1156
17	730	121
18	790	529
19	450	1
20	480	144
21	490	36
22	930	4356
23	960	11236
24	980	12321

Sum of squarred error : (484+1+1296+4+……………………….4356+11236+12321) = 39643

Now, we can find mean squarred error for regression analysis method.

$$\text{MSE} = \frac{\sum_{i=1}^{n}(D_t - F_t)^2}{n} = \frac{39643}{24} = 1651.75$$

5. THE FLOWCHART OF THE PROBLEM
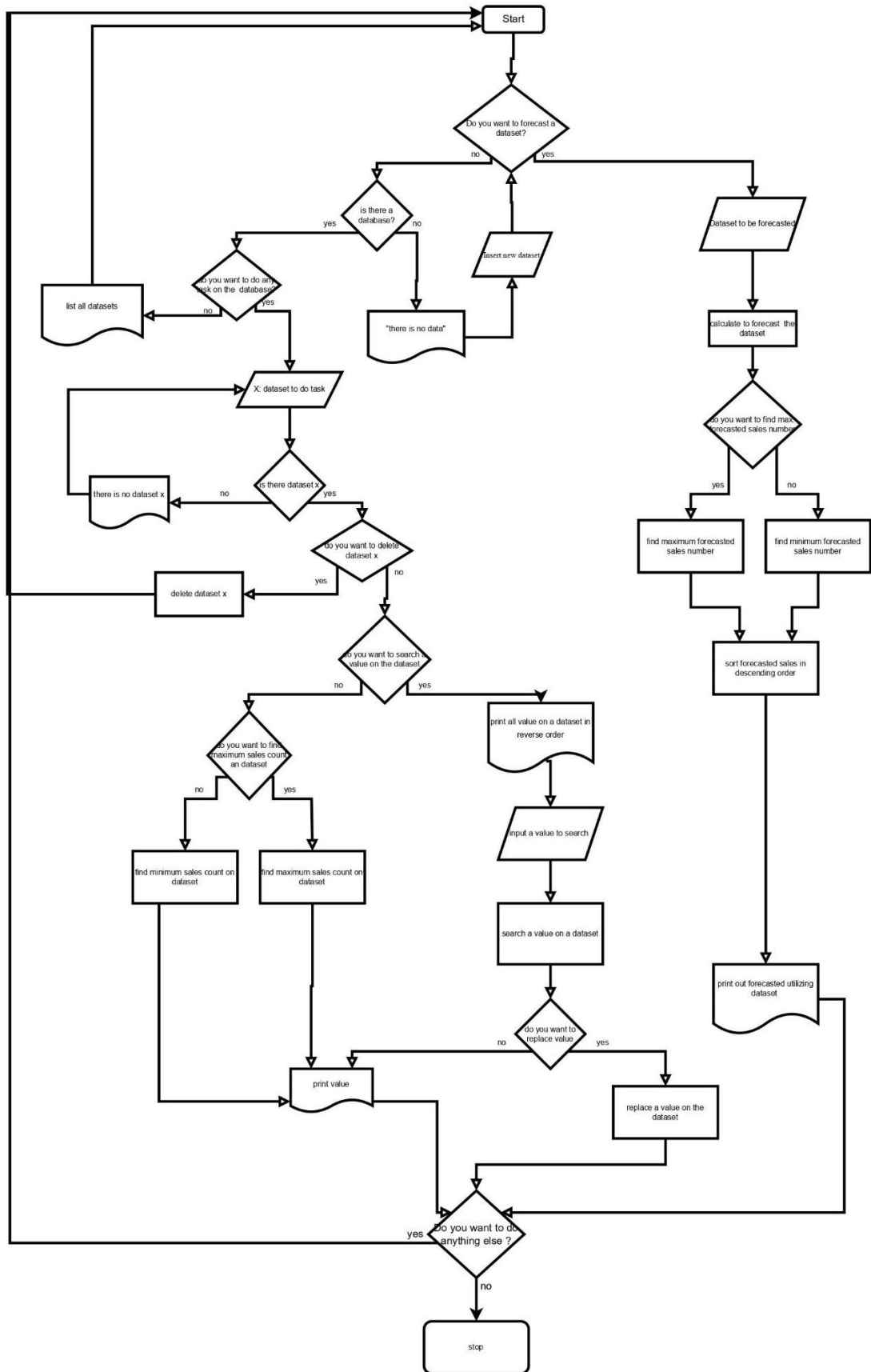
Figure 1. *The flowchart developed for the problem*

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Computer engineers are developing a simple decision support system that a luxury SUV car manufacturer will use in forecasting processes. The system requests data from the user for the last two years and tries to predict forecasts for the next two years by analyzing and calculating with appropriate methods, based on the given data. The flowchart for this system to be developed is given in Figure 1 and the language of the program to be used is JAVA.

6. THE DEVELOPED PROGRAM

```java
import java.io.*;

public class FirstMethod {
    private static  double a= 0.2;
    static Ft gess=new Ft();

    public static Ft calculation() throws IOException {

        //Formula : Ft+1 = α Dt + (1- α)Ft
        // 300 is accepted as a forecast 1 (F1).
        // f1 , f2 ,f3 aylardır tahminler

        gess.insert( name: 300, pos: 0);
        int f=0;
        for (int i = 0; i<24; i++){
            f=(int) (a*Home.data1()[i]+(1-a)*gess.getByPosition(0).getName());
            gess.insert(f);
        }
        return gess;
    }

    public static double error() throws IOException {
        return Mse.Mse(gess,Home.data1());
    }
}
```

Figure-1 Exponential Smoothing Method

This is implementation code of the first method that was calculated in the first report.

Time complexity is O(n) because of the for loop.

```java
import java.io.IOException;

public class SecondMethod {

    static Ft gess=new Ft();

    public static Ft calculation() throws IOException {
        // (α = 0.2, β = 0.2, S0 = 200, G0 = 50)
        //  Formulas :
        //St = αDt + (1-α)(St-1 + Gt-1 )
        // Gt = β(St - St-1 ) + (1- β)Gt-1
        // Ft,t+♦ = St + ♦×Gt (forecast for time ♦ into the future)
        // Where ;
        // Dt is observed demand,
        // St is current estimate of 'intercept',
        // Gt is current estimate of slope,
        //St-1 is last estimate of 'intercept',
        // Gt-1 is the last estimate of slope.
        double B = 0.2;
        double[] St = new double[24];
        double[] Gt = new double[24];

        St[0]=200;
        Gt[0]=50;
        for (int i = 0; i<24; i++){
            if(i==0){
                St[0]=200;
                Gt[0]=50;
            }else {
                double a=0.2;
                St[i]=  a*Home.data1()[i-1]+(1-a)*(St[i-1] + Gt[i-1]);


                Gt[i]=  B*(St[i]-St[i-1])+(1-B)*Gt[i-1];
            }

            gess.insert((int) (St[i]+Gt[i]));
            // System.out.println(St[i]+"    "+Gt[i]+"    "+ft[i]);
        }
        return gess;
    }
    public static double error() throws IOException {
        return Mse.Mse(gess,Home.data1());
    }
}
```

Figure-2 Double-Exponential Smoothing

This is implementation code of the second method that was calculated in the first report.

Time complexity is O(n) because of the for loop.

```java
import java.io.IOException;

public class ThirdMethod {

    static Ft gess = new Ft();

    public static Ft calculation() throws IOException {

        int[] xy = new int[24];
        int[] xx = new int[24];

        int xytoplam = 0;
        for (int i = 0; i < 24; i++) {
            xy[i] = Home.data1()[i] * (i + 1);
            xytoplam = xytoplam + xy[i];
        }


        int xxtoplam = 0;
        for (int i = 0; i < 24; i++) {
            xx[i] = (i + 1) * (i + 1);
            xxtoplam = xxtoplam + xx[i];
        }

        double ytoplam = 0;
        for (int i = 0; i < 24; i++) {
            ytoplam = Home.data1()[i] + ytoplam;
        }

        int xtoplam = 0;
        for (int i = 0; i < 24; i++) {
            xtoplam = xtoplam + i + 1;
        }

        double q = (24 * xytoplam - xtoplam * ytoplam);
        double w = (24 * xxtoplam - xtoplam * xtoplam);
        double b = q / w;
        double z = ytoplam / 24;

        double aa = (z) - ((b * xtoplam) / 24);

        for (int i = 0; i < 48; i++) {
            gess.insert((int) (aa + b * (i + 1)));
        }
        return gess;
    }

    public static double error() throws IOException {
        return Mse.Mse(gess, Home.data1());
    }
}
```

Figure-3 Regression Analysis

This is implementation code of the third method that was calculated in the first report.

Time complexity is O(n) because of the for loop.

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```java
import java.io.IOException;

public class FourthMethod {
    static Ft gess = new Ft();

    public static Ft calculation() throws IOException {

        double overall = 0;
        for (int i = 0; i < 24; i++) {
            overall = Home.data1()[i] + overall;
        }

        overall = overall / 24;

        double[] Seasonal = new double[12];
        for (int i = 0; i < 12; i++) {
            Seasonal[i] = ((Home.data1()[i] + Home.data1()[i + 12]) / 2) / overall;
        }

        double[] Deseason = new double[24];
        for (int i = 0; i < 24; i++) {
            Deseason[i] = Home.data1()[i] / Seasonal[i % 12];
        }

        double ytoplam = 0;
        for (int i = 0; i < 24; i++) {
            ytoplam = Deseason[i] + ytoplam;
        }

        int xtoplam = 0;
        for (int i = 0; i < 24; i++) {
            xtoplam = xtoplam + i + 1;
        }

        double[] xy = new double[24];
        int[] xx = new int[24];
        int xxtoplam = 0;
        for (int i = 0; i < 24; i++) {
            xx[i] = (i + 1) * (i + 1);
            xxtoplam = xxtoplam + xx[i];
        }
        double xytoplam = 0;
        for (int i = 0; i < 24; i++) {
            xy[i] = Deseason[i] * (i + 1);
            xytoplam = xytoplam + xy[i];
        }

        double b = (24 * xytoplam - xtoplam * ytoplam) / (24 * xxtoplam - xtoplam * xtoplam);

        double aa = ytoplam / 24 - b * xtoplam / 24;

        for (int i = 0; i < 48; i++) {
            gess.insert((int) ((aa + b * (i + 1)) * Seasonal[i % 12]));
        }

        return gess;
    }
    public static double error() throws IOException {
        return Mse.Mse(gess, Home.data1());
    }
}
```

Figure-4 Deseasonalized Regression Analysis

This is implementation code of the fourth method that was calculated in the first report.

Time complexity is O(n) because of the for loop

```
1   public class Mse {
2       public static double Mse(Ft ft, int[] dt){
3           double MSE=0;
4           //MSE = (∑_(i=1)^n [ [(D] _(t-) F_t)] ^2 )/n
5           double toplam=0;
6           double[] SquarredError = new double[24];
7
8           for (int i = 0; i<24; i++){
9               SquarredError[i]=(dt[i]-ft.getByPosition(i).getName())*(dt[i]-ft.getByPosition(i).getName());
10              toplam= (toplam+SquarredError[i]);
11          }
12
13          MSE=toplam/24;
14
15      return MSE;
16      }
17  }
18
```

Figure-5 MSE

This is implementation code of the fourth method that was calculated in the first report.

Time complexity is O(n) because of the for loop.

```
1    public class LinkList {
2
3            private int name;
4        LinkList next;
5        LinkList previous;
6            //Constructor
7            public LinkList(int n){
8                this.name = n;
9                this.next=null;
10               this.previous=null;
11           }
12           //Getter method
13           public int getName() { return this.name; }
16     }
17
```

Figure-6 LinkedList

We chose doubly LinkedList because we are assuming that we do not know the size of dataset before the user inserts it.

7. THE RESULTS OF THE PROBLEM


```
Welcome to the forecasting system
Please choose what you want to do :
 1: Add New Dataset              2: Forecast Datasets
 3: List All Datasets            4: Delete All Datasets
 5: Search Value On DataSet      6: Find Max Sales Count
 7: Find Min Sales Count         8: Replace Value On Dataset
 9: Print Dataset In Reverse     10: Sort Forecasted Sales
11: exit
```

Figure-7

This is the first page that the user will encounter to choose what operation they want to execute.


```
1                               please input 13. mounth
please input 1. mounth          550
300                             please input 14. mounth
please input 2. mounth          590
350                             please input 15. mounth
please input 3. mounth          600
330                             please input 16. mounth
please input 4. mounth          610
340                             please input 17. mounth
please input 5. mounth          630
390                             please input 18. mounth
please input 6. mounth          620
430                             please input 19. mounth
please input 7. mounth          680
480                             please input 20. mounth
please input 8. mounth          690
460                             please input 21. mounth
please input 9. mounth          710
490                             please input 22. mounth
please input 10. mounth         730
510                             please input 23. mounth
please input 11. mounth         740
550                             please input 24. mounth
please input 12. mounth         770
560                             Record is added.
```

Figure-8

This is the first operation which is adding new dataset.

```
The values resulting from the estimations according to the most optimal method:
 Deseasonalized Regression Analysis Method
1. month: 222
2. month: 301
3. month: 286
4. month: 602
5. month: 641
6. month: 685
7. month: 402
8. month: 440
9. month: 444
10. month: 893
11. month: 956
12. month: 980
13. month: 251
14. month: 339
15. month: 322
16. month: 676
17. month: 719
18. month: 767
19. month: 451
20. month: 492
21. month: 496
22. month: 996
23. month: 1066
24. month: 1091
Record is added.
```

Figure-8.a Dataset-1.

This is the forecasted dataset

```
The values resulting from the estimations according to the most optimal method:
 Regression Analysis Method
1. month: 320
2. month: 340
3. month: 359
4. month: 379
5. month: 399
6. month: 418
7. month: 438
8. month: 457
9. month: 477
10. month: 497
11. month: 516
12. month: 536
13. month: 556
14. month: 575
15. month: 595
16. month: 614
17. month: 634
18. month: 654
19. month: 673
20. month: 693
21. month: 712
22. month: 732
23. month: 752
24. month: 771
Record is added.
```

Figure-8.b Dataset-2

This is the forecasted dataset.

```
Please choose what you want to do :
 1: Add New Dataset              2: Forecast Datasets
 3: List All Datasets            4: Delete All Datasets
 5: Search Value On DataSet      6: Find Max Sales Count
 7: Find Min Sales Count         8: Replace Value On Dataset
 9: Print Dataset In Reverse     10: Sort Forecasted Sales
11: exit

3

dataset 1: 300   350 330 340 390 430 480 460 490 510 550 560 550 590 600 610 630 620 680 690 710 730 740 770
dataset 2: 200   300 250 600 650 670 400 440 430 900 980 990 300 370 380 710 730 790 450 480 490 930 960 980
```

Figure-9

This options lists all datasets.

```
Welcome to the forecasting system
Please choose what you want to do :
 1: Add New Dataset              2: Forecast Datasets
 3: List All Datasets            4: Delete All Datasets
 5: Search Value On DataSet      6: Find Max Sales Count
 7: Find Min Sales Count         8: Replace Value On Dataset
 9: Print Dataset In Reverse     10: Sort Forecasted Sales
11: exit

5

Enter the value to find
390
5. month 390
```

Figure-10

This option is for searching a data in the dataset.

```
Please choose what you want to do :
 1: Add New Dataset              2: Forecast Datasets
 3: List All Datasets            4: Delete All Datasets
 5: Search Value On DataSet      6: Find Max Sales Count
 7: Find Min Sales Count         8: Replace Value On Dataset
 9: Print Dataset In Reverse     10: Sort Forecasted Sales
11: exit

6
770
```

Figure-11

This option is for finding the max sales count in the dataset.

41

Figure-12

This option is for finding the min sales count in the dataset.

Figure-13

This option is for replacing a data in the dataset.

```
 9: Print Dataset In Reverse
11: exit

9
770
740
730
710
690
680
620
630
610
600
590
550
560
550
510
490
460
480
430
390
340
330
350
```

```
 9: Print Dataset In Reverse
11: exit

10
1.   320
2.   340
3.   359
4.   379
5.   399
6.   418
7.   438
8.   457
9.   477
10.  497
11.  516
12.  536
13.  556
14.  575
15.  595
16.  614
17.  634
18.  654
19.  673
20.  693
21.  712
22.  732
23.  752
24.  771
```

Figure-14

This option is for printing dataset in reverse.

Figure-15

This option is for sorting forecasted datasets.

43

```
The values resulting from the estimations according to the most optimal method:
 Regression Analysis Method
1. month of next date: 791
2. month of next date: 811
3. month of next date: 830
4. month of next date: 850
5. month of next date: 869
6. month of next date: 889
7. month of next date: 909
8. month of next date: 928
9. month of next date: 948
10. month of next date: 967
11. month of next date: 987
12. month of next date: 1007
13. month of next date: 1026
14. month of next date: 1046
15. month of next date: 1065
16. month of next date: 1085
17. month of next date: 1105
18. month of next date: 1124
19. month of next date: 1144
20. month of next date: 1164
21. month of next date: 1183
22. month of next date: 1203
23. month of next date: 1222
24. month of next date: 1242
Record is added.
```

Figure-16

The outputs here are the forecast of dataset 1 data for the next two years resulting from the program..

```
The values resulting from the estimations according to the most optimal method:
 Deseasonalized Regression Analysis Method
1. month of next date: 279
2. month of next date: 377
3. month of next date: 358
4. month of next date: 750
5. month of next date: 797
6. month of next date: 850
7. month of next date: 499
8. month of next date: 544
9. month of next date: 548
10. month of next date: 1100
11. month of next date: 1175
12. month of next date: 1203
13. month of next date: 307
14. month of next date: 415
15. month of next date: 393
16. month of next date: 824
17. month of next date: 875
18. month of next date: 933
19. month of next date: 547
20. month of next date: 596
21. month of next date: 600
22. month of next date: 1203
23. month of next date: 1285
24. month of next date: 1314
Record is added.
```

Figure-16

The outputs here are the forecast of dataset 2 data for the next two years resulting from the program..

8. CONCLUSION

The problem given within the scope of ENM319 & BIM213 courses named Production and Operation Planning & Data Structures and Algorithms has been solved and the requirements have been completed.

A project was carried out with the cooperation of industrial engineers working in the production planning department of a company that produces luxury SUVs for customers in various countries and computer engineers working in the IT department. Within the scope of the project, a simple decision support system has been developed to be used in estimation processes.

Industrial engineers solved the given problem analytically for each dataset. In line with the solution methods solved by industrial engineers, Regression Analysis Method was determined as the best method for the first data set and Deseasonalized Regression Analysis Method for the second data set. Mean Squarred Errors (MSE) calculated for the selection of the best method were examined and the methods with the least error were selected. Here, MSE values were calculated as 358.96 in Regression Analysis Method for the first data set and as 1651.75 in the Deseasonalized Regression Analysis Method for the second data set.

Industrial engineers transferred all calculations and evaluations to computer engineers and helped them to develop programs. With this program developed by computer engineers, in line with the demand values entered by the user, the program will be able to determine the appropriate method according to these data and make the necessary estimation for the cars. In addition, in this report, the automobile demand forecasts for the next two years were calculated by the program in line with the appropriate method with the two data sets examined within the scope of the project.