IE333 REPORT
The effect of seasons and type of rebar on the sales of rebar

Done By:

Faisal Aljeaithen 442101897

Abdulrahman Altowaim 442101679

Abdulaziz Alsalem 442101642

Group Section: 91622

Supervised by:

Dr. Ibrahim Almhaidib

Abstract:

In this report, we collected rebar sales data in tons for three consecutive years to present a study on the effect of three seasons and three types of rebar on the sales, beginning with an introduction to rebar and a description of the problem, going to the solution methodology and our use of the factorial design, and then the results we have reached through Minitab.

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Problem description:

Rebar is a steel bar or mesh of steel wires used in reinforced concrete and masonry constructions to strengthen and keep the concrete in tension. It is also referred to as reinforcement steel and reinforcing steel. The surface of rebar is frequently textured to enhance the quality of the bond with the concrete.

Construction operations are based on several foundations, the most important of which is rebar. It is an important element in construction and no construction process is carried out without it. The manufacture of rebar is a dangerous and important process where the engineer must observe the specifications and standards as well as use them so that any misuse of the type in construction may lead to a lot of problems in the facility.

In this report, we are going to use what we learned in this course (IE333) to study the impact of three seasons and three types of rebar on the sales of rebar. We have collected data for the three best-selling types of rebar (6mm, 8mm, 10mm) in three consecutive years (2017, 2018, 2019) and divided them into three seasons: summer, autumn and winter, to find out if there is an impact and whether there is a relationship between the types of rebar and the seasons.

So, we want to answer three questions:

1- Does the season affect the sales of rebar?

2- Does the type of rebar affect the sales of rebar?

3- Does the interaction between the two factors affect the sales?

Solution methodology:

Since we want to study the impacts of the factors and their interactions on the sales, we employed general factorial design to solve the issue with a 95% confidence level, ($\alpha = 0.05$). and we used Minitab software to do so.

1. Table of data Table

Season	Type of Rebar		
	6mm	8mm	10mm
Winter	866	706	757
	1181	582	645
	1173	678	643
Summer	1244	987	1039
	1782	1245	1046
	1056	1628	1026
Autumn	1229	402	692
	1236	619	936
	1161	681	943

*Note: The response is the sales in ton

We have two factors as shown in Table 1:

- Factor (A): Season, with three levels.
- Factor (B): Type of rebar, with three levels.

Also, we have three replications (n) as shown in

table 1. Therefore, **a= 3, b= 3, n= 3**

Total runs= **N= a×b×n= 3×3×3= 27** runs**.**

Results and discussion:

Analysis of Variance:

Table 2. ANOVA table

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	8	2046261	255783	6.97	0.000
Linear	4	1735097	433774	11.81	0.000
season	2	925986	462993	12.61	0.000
type of rebar	2	809111	404556	11.02	0.001
2-Way Interactions	4	311163	77791	2.12	0.120
season*type of rebar	4	311163	77791	2.12	0.120
Error	18	660911	36717		
Total	26	2707171			

For factor (A) we can see that the p-value is equal to zero so, p-value $< \alpha$, $(0 < 0.05)$ which means that the season has a significant effect on the sales of rebar, and that is because the amount of projects varies from season to season and this will affect the demand for rebar, and that answers the first question of our project.

For factor (B), as shown in the table that p-value $< \alpha$, $(0.001 < 0.05)$ so we conclude that there is a significant effect, this is because each type of rebar has a use, some of which are used in larger quantities in construction and some in smaller quantities, and that answers the second question of our project.

However, the p-value of the interaction between factor (A) and (B) is 0.120, which means p-value $> \alpha$, $(0.120 > 0.05)$ meaning that there is no significant affect, and that also answers the last question of our project.

Pareto Chart:

Pareto Chart of the Standardized Effects
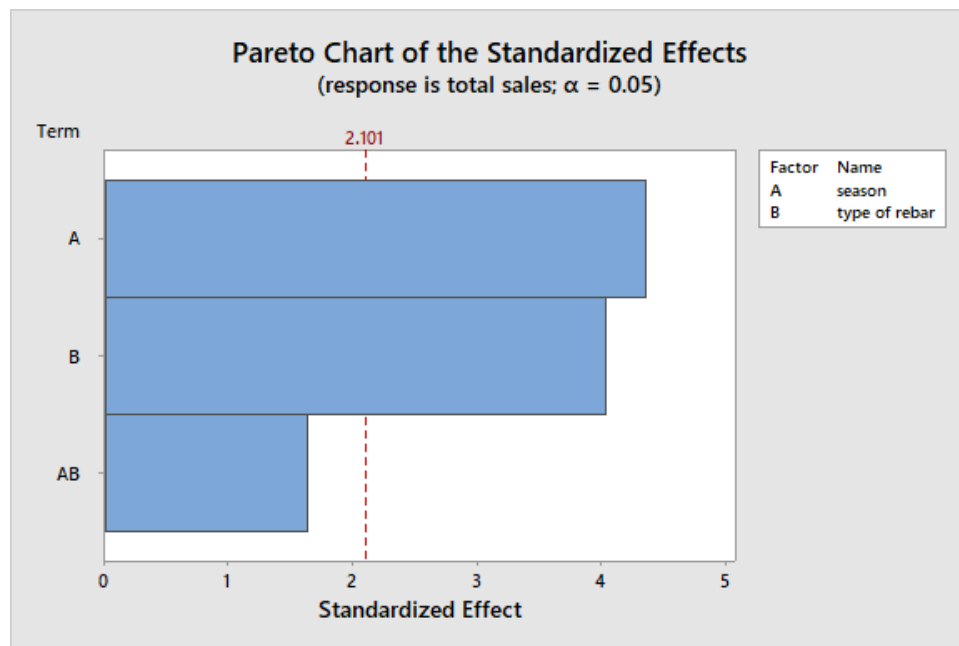(response is total sales; α = 0.05)

Figure 1. Pareto chart

The pareto chart summarizes what we talked about in the ANOVA table. It is easy to notice that factor (A) has the largest effect and factor (B) has a significant effect. However, the interaction between them has no effect.
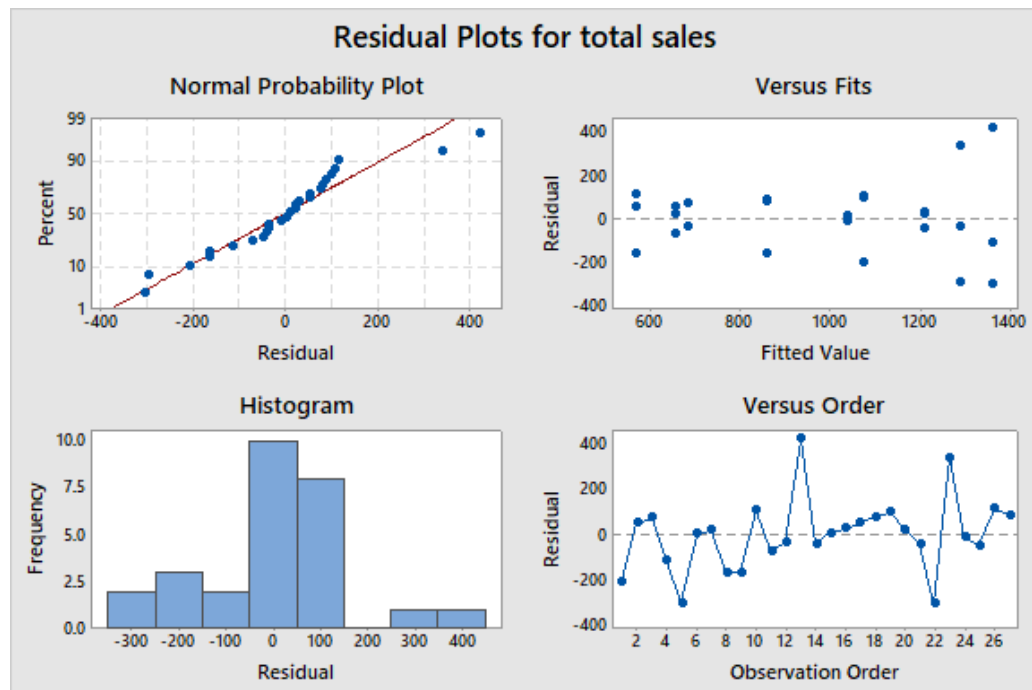
Residual plots (Four in One):

Figure 2. Residual plots

- From the normal probability plot we can see that the data is normally distributed, also we can conclude the same answer from the histogram.

- The versus fits shows that there is no pattern, so the residuals have constant variance.

- From the versus order we can obtain that the residuals are independent from one another.

R-squared:

Table 3. R-squared

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
191.617	75.59%	64.74%	45.07%

$R^2 = 75.59\% > 70\%$, meaning that the model (factorial design) fits the data.

Regression Model:

Table 4. Coefficients table

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	969.7	36.9	26.30	0.000	
season					
1	-166.3	52.2	-3.19	0.005	1.33
2	258.4	52.2	4.95	0.000	1.33
type of rebar					
1	244.5	52.2	4.69	0.000	1.33
2	-133.3	52.2	-2.56	0.020	1.33
season*type of rebar					
1 1	25.4	73.8	0.34	0.734	1.78
1 2	-14.8	73.8	-0.20	0.843	1.78
2 1	-111.9	73.8	-1.52	0.146	1.78
2 2	191.9	73.8	2.60	0.018	1.78

Regression Equation

total sales = 969.7 - 166.3 season_1 + 258.4 season_2 - 92.1 season_3 + 244.5 type of rebar_1
- 133.3 type of rebar_2 - 111.2 type of rebar_3 + 25.4 season*type of rebar_1 1
- 14.8 season*type of rebar_1 2 - 10.6 season*type of rebar_1 3
- 111.9 season*type of rebar_2 1 + 191.9 season*type of rebar_2 2
- 79.9 season*type of rebar_2 3 + 86.5 season*type of rebar_3 1
- 177.0 season*type of rebar_3 2 + 90.5 season*type of rebar_3 3

Main effect graphs:

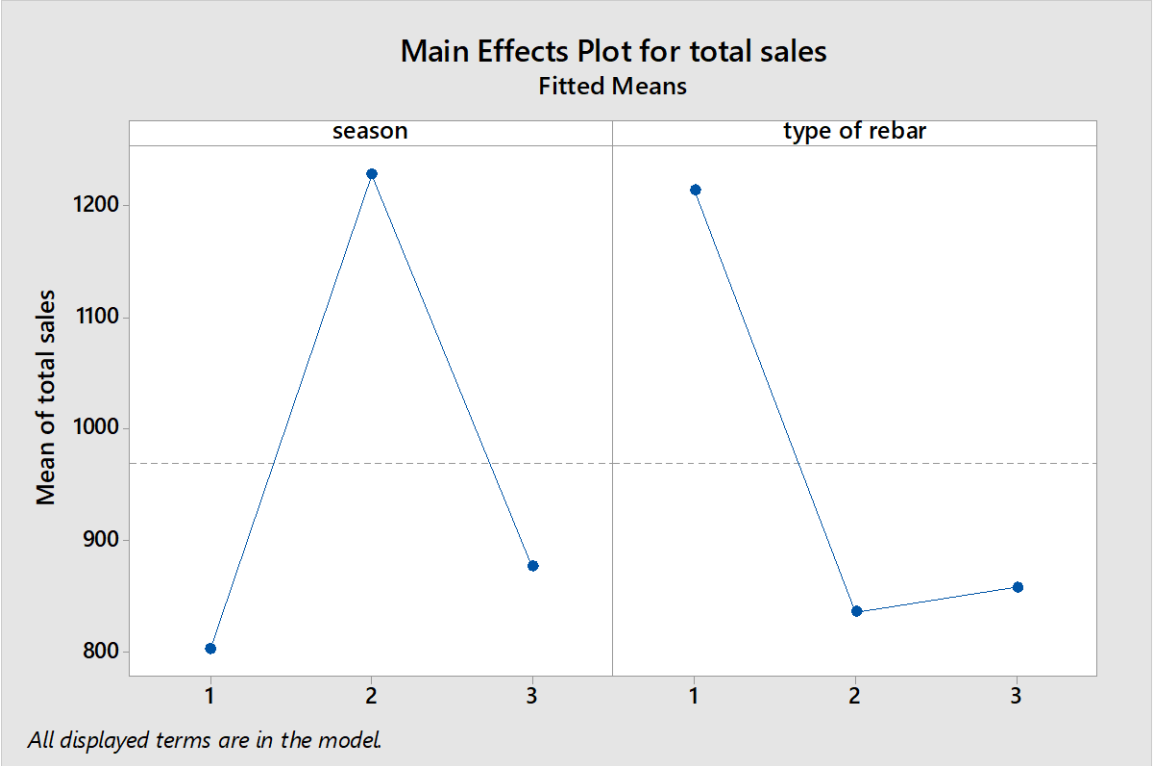This figure clearly shows the significant effect of factors A and B on the data
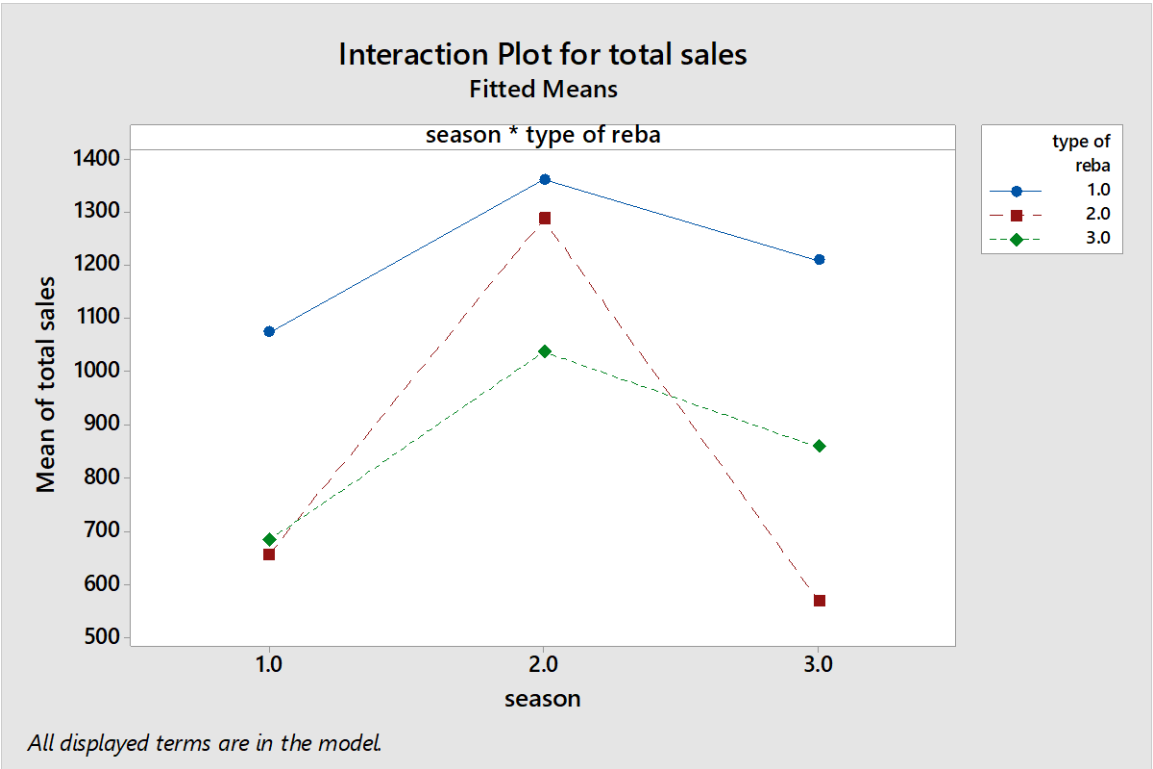

Figure 3. Main effects plot

Figure 4. Interaction plot

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Conclusion:

In conclusion, after we have studied whether season and the type of rebar has an effect on sales, we can say that there is a significant effect for the two factors, and this may be due to several reasons such as the presence of projects in one season more than the others or it may be due to the nature of the weather.