Sensitivity Analysis of a Postoptimility Calculation in the General Company Products for Vegetable Oils

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Abstract

The linear programming is one of the important methods for operational researches, it can be considered as model that faces the industrial companies and it aims for best use of limited resources, for example (amount of production, amount of primary resources and amount of sellings).

The expression about these standards leads to a change in the amount of profit, it's been used sensitivity analysis by (WINQSB) and then apply it on some of the company general products for vegetable oils in year (2020).

Keywords

Linear Programming, Postoptimility, WINQSB.

Introduction

We can find variables value through the optimal solution in linear programming model in coefficient's variable in the objective function, inside constraint, for existence of sources (right hand side) limited, after finding the optimal solution, coefficient variable has been changed in the objective function, which means changing in the costs and profits, when we get a change of what we need per unit's variable from sources in technological circumstances that differs from previous one, if the market's price has been changed and making different offer and demanding for specific requested sources, therefore how we can get benefit from the optimal solution to get into more optimal solution under the influence of one of the condition that has been mentioned before, sometimes we want to know the amount that can increase or decrease the sources after finding the optimal solution and how far that can change in both sides without any change in the optimal solution (V.J. Robert, 2020).

Postoptimality analysis include (V. Hamidreza et al., 2013):

1. Tightness of the constraints, that is changing the right-hand side of the constraints.
2. Coefficient of the objective function (profit or cost).
3. Technological coefficient of decision variable.
4. Addition of new variables to the problem.
5. Addition of new (or secondary) constraints.

Data has been taken from the general company for oils plants and they are ten products, they've produced from the company, therefore to get to the optimal solution that gives us an increase in profits by using the obtainable resources (primary materials, workers, energy products, etc..)

After we get the optimal solution that gives us the best profit by using (WINQSB) program, we deal with the postoptimality way or its also known as sensitivity analysis, any change in values of model constants (model's income), that will fix the problem of linear programming and influence the optimal solution, therefore by studying the changes that will happen with the mathematical model to have the decision maker more information that can be used in case of any changes to the model (A. Abdallah, 2016).

In this research, we're going to talk about two methods of sensitivity analysis and they are:

- Changing the right side of constraint (the available resources)
- Changing the cost

Theoretical Part

Consider the following linear programming problem:
Max or min z = $\sum_{j=1}^{n} c_j x_j$

s.to.

$$\sum_{j=1}^{n} a_{ij} x_j (\leq, =, \geq)\ b_i\,, \qquad i = 1,2,\dots,m$$
$$x_j \geq 0 \qquad j = 1,2,\dots,n$$

We consider c_j, b_i, a_{ij} parameter of the system usually is given in a form of numerical value, the value of finding these information should be the optimal solution z, x_j.

But the numerical values c_j, b_i, a_{ij} or some of it might change because of some (economical, political, natural) factors, and this change may influence the optimal solution z, x_j, but in many cases it doesn't make a change (A.T. Hamdy, 2013).

The study of this change in the value of parameter or more it is called sensitivity analysis, therefore sensitivity analysis includes changing influence in some or all parameter values of the model, therefore we can identify the following cases:

1. If the changed in numerical values c_j, b_i, a_{ij} doesn't influence the parameter value to a change in the optimal solution z, x_j, which means it doesn't influence on the value of objective function or basic variables x_j, which means the optimal solution remains unchanged.
2. If the change in numerical values c_j, b_i, a_{ij} influences the change in these basic variables in the final solution, therefore changing the optimal solution which changes the value of these variable z, x_j

We consider any case of these cases that lead to a change in some parameter values has a higher importance for the decision maker, based on this selection the decision maker can determine his policy (P.K. Sahooet al., 2013):

- Determination the types of resources that we can obtain without making a change in the followed policy (current solution for the model), therefore decreasing the costs.
- Determine the types of resources that influence the current policy.
- Determine the circumstances of market for the price (costs, profits) that can influence the change of current policy (current solution).

Applied Part

Data has been taken from the general company for vegetable oils in year (2020) and there are (10) products to be determined:

X_1.laurel soap
X_2.Cleaners
X_3. liquid cleaner (detergent)
X_4.detergen. (Alqaser)
X_5. dental paste (Anber)
X_6. Adam's shaving paste
X_7.Shampoo

X_8. ordinary soap

X_9. Calcifications removal

X_{10}: Thorya's soap

Table 1 Price of selling for one ton for some products of the general company for vegetable oils in (2020)

product	Selling price (IQD)
X_1laurel soap	2500008
X_2Cleaners	1764708
X_3liquid cleaner	11245550
X_4 detergent (Alqaser)	1124550
X_5dental paste	13333344
X_6 Adam's shaving paste	10000008
X_7Shampoo	2380950
X_8 ordinary soap	2499930
X_9Calcifications removal	2080000
X_{10}thorya's soap	1249950

As for the costs, they are divided into two types (fixed costs), it doesn't change with the production changes and it represents requirements of the company previous association and they include (work cost, extinction cost and the changing cost), Which changes during the production and they are (primary materials, packing, spare materials and other costs). Through the sum of tow costs we get the final cost. The following table illustrates the final result of the cost.

Table 2 Total cost per one ton for some products of the general company for vegetable oils in (2020)

product	Cost (IQD)
X_1laurel soap	2327194
X_2Cleaners	1629266
X_3liquid cleaner	1105557
X_4 detergent (Alqaser)	942289
X_5dental paste	11484175
X_6 Adam's shaving paste	8801673
X_7Shampoo	2230024
X_8 ordinary soap	2406691
X_9Calcifications removal	2070375
X_{10}thorya's soap	1159703

Profit: it is the increase in the value of sellings from materials and services on the costs of production factors that makes production which will be sold later. The standard formula for profit:

$$\text{Profit} = \text{selling price} - \text{production cost}$$

Table 3 Total profit per one ton for some products of the general company for vegetable oils in (2020)

product	Profit (IQD)
X_1laurel soap	172814
X_2Cleaners	135441
X_3liquid cleaner	18992
X_4 detergent (Alqaser)	182260
X_5dental paste	1849168
X_6 Adam's shaving paste	1198334
X_7Shampoo	150925
X_8 ordinary soap	93238
X_9Calcifications removal	9625
X_{10}thorya's soap	90246

Production capacities available for each season:

Productive energy represent the amount for production work for a period of time from specific features and according to certain ways of operation. They are considered important constraints in using mathematical model.

Table 4 Production capacities per ton for some products of the general company for vegetable oils in (2020)

product	Production capacities
X_1laurel soap	4500
X_2Cleaners	24800
X_3liquid cleaner	1200
X_4 detergent (Alqaser)	500
X_5dental paste	75
X_6 Adam's shaving paste	150
X_7Shampoo	300
X_8 ordinary soap	13000
X_9Calcifications removal	100
X_{10}thorya's soap	4000

Table 5 Time required for production (unit/hour) for some products of the general company for vegetable oils in (2020)

product	time
X_1laurel soap	2
X_2Cleaners	0.33
X_3liquid cleaner	1
X_4 detergent (Alqaser)	5.6
X_5dental paste	12
X_6 Adam's shaving paste	12
X_7Shampoo	4
X_8 ordinary soap	0.5
X_9Calcifications removal	10
X_{10}thorya's soap	0.67

Table 6 Number of workers in some factories of the general company for vegetable oils in (2020)

factory	number of workers
Soap factory	304
Cleaners factory	144
shampoo and Zahi factory	78
(Shaving and dental) factory	60
Detergent factory	23
Calcifications Removal factory	10

Supposing the productive hours of work per day (6 hours). And the working days per year (242) days.

Available time = number of workers * number of productive working days in a year *number of hours working per day*allow
Allow = The actual working hour in the company .is the number of minutes = 50 minute
Allow = 60/50 = 0.833

1. Soap factory
   available time = 304 * 242 * 6 * 0.85 = 375196.8
2. Cleaners factory
   available time = 144 * 242 * 6 * 0.85 = 177724.8
3. shampoo + Zahi factory
   available time = 78 * 242 * 6 * 0.85 = 96267.6
4. (Shaving + dental) factory
   available time = 60 * 242 * 6 * 0.85 = 74052
5. Detergent factory
   available time = 23 * 242 * 6 * 0.85 = 28386.6
6. Calcifications Removal factory
   available time = 10 * 242 * 6 * 0.85 = 12342

Materials needed for the production of one unit:

Constraints of primary materials are important in mathematical model. So we must know the percentage of the primary materials within the manufacturing of every product from these products and also the available amount of the primary materials that interferes with production process (represent the right side of the constraints), which influence the production in case of occurring an increase or decrease in it.

Table 7 The primary materials needed for the production of one ton for some products of the general company for vegetableoils in (2020)

	X_1 laurel soap	X_2 Cleaners	X_3liquid cleaner	X_4detergent (Alqaser)	X_5dental paste	X_6 Adam's shaving	X_7Shampoo	X_8ordinary soap	X_9 Calcifications removal	X_{10}thorya's soap
empicol			0.072				0.15			
formaline			0.002				0.002			
STS*		0.02	0.01							
comperlan			0.015							
Lemon acid			0.0005							
EDTA**	0.0002	0.0002	0.0001					0.0002		
embilan							0.005			
Sodium chloride							0.008	0.11		
Caustic soda	0.21					0.075		0.13		0.114
STPP***		0.305								
S.S		0.260								
silicate		0.1								
CSCM****		0.015			0.06					
Shiny substance		0.005								
silicon		0.0025								
Hypochlorite sodium				0.56						
Malaysian plamoils								0.74		
Styrene								0.0085		
Titanium dioxide	0.001				0.005			0.002		0.0015
antioxidant	0.0004							0.002		0.2
Oleic acid	0.123									
Soapy residues	0.696									
alumina					0.55					
Mono sodium					0.003					
fluoride					0.0085					
encrusted					0.005					
skrill					0.002					
brestrin						0.32				
Acetyl alcohol						0.005				
Hydrochloric acid									0.55	

*STS: STEPANIT STS – 90 is an anionic surfactant used in liquid detergents (white powder) (Sodium Toluene Su phonate)

** EDTA: Ethylene Diamine Tetra Acetic acid it is a water soluble solid used in soap industry

***STPP: Sodium triphosphate (Sodium Tri Polyphosphate)

****CSCM: Zeolite citrate silicates crystalline material

Table 8 Available quantity of primary materials in the general company for vegetable oils in (2020)

primary materials	Available quantity	primary materials	Available quantity
empicol	22	Hypochlorite sodium	160
formaline	1.2	Malaysian plamoils	140
STS	40	Styrene	32
comperlan	2.5	Titanium dioxide	1.4
Lemon acid	0.85	antioxidant	8
EDTA	8.5	Oleic acid	5
embilan	3.5	Soapy residues	80
Sodium chloride	7.7	alumina	7
Caustic soda	40	Mono sodium	0.2
STPP	20	fluoride	0.5
S.S	440	encrusted	0.47
silicate	107	skrill	1.48
CSCM	17	brestrin	18.8
Shiny substance	2.9	Acetyl alcohol	3.2
silicon	4.5	Hydrochloric acid	30

Linear programming model:

Objective function

$$\max z = 172814X_1 + 135441X_2 + 18992X_3 + 182260X_4 + 1849168X_5 + 1198334X_6 + 150925X_7 + 93238X_8 + 9625X_9 + 90246X_{10}$$

Constraints:

Production Constraints:

$$\boldsymbol{X_1 \leq 4500 X_2 \leq 24800}$$
$$\boldsymbol{X_3 \leq 1200 X_4 \leq 500}$$
$$\boldsymbol{X_5 \leq 75 X_6 \leq 150}$$
$$\boldsymbol{X_7 \leq 300 X_8 \leq 13000}$$
$$\boldsymbol{X_9 \leq 100 X_{10} \leq 4000}$$

Time Constraints:

$$\boldsymbol{2X_1 + 0.5X_8 + 0.67X_{10} \leq 375196.8}$$
$$\boldsymbol{0.33X_2 \leq 177724.8}$$
$$\boldsymbol{X_3 + 4X_7 \leq 96267.6}$$
$$\boldsymbol{12X_5 + 12X_6 \leq 74052}$$
$$\boldsymbol{5.6X_4 \leq 28386.6}$$
$$\boldsymbol{10X_9 \leq 123}$$

Primary materials Constraints

Empicol $\mathbf{0.072}X_3 + \mathbf{0.15}X_7 \leq \mathbf{22}$

Formaline $\mathbf{0.002}X_3 + \mathbf{0.002}X_7 \leq \mathbf{1.2}$

STS $\mathbf{0.02}X_2 + \mathbf{0.01}X_3 \leq \mathbf{40}$

Comperlan $\mathbf{0.015}X_3 \leq \mathbf{2.5}$

Lemon acid $\mathbf{0.0005}X_3 \leq \mathbf{0.85}$

EDTA $\mathbf{0.0002}X_1 + \mathbf{0.0002}X_2 + \mathbf{0.0001}X_3 + \mathbf{0.002}X_8 \leq \mathbf{8.5}$

Embilan $\mathbf{0.005}X_7 \leq \mathbf{3.5}$

Sodium chloride $\mathbf{0.0008}X_7 + \mathbf{0.11}X_8 \leq \mathbf{7.7}$

Caustic soda $\mathbf{0.21}X_1 + \mathbf{0.075}X_6 + \mathbf{0.13}X_8 + \mathbf{0.114}X_{10} \leq \mathbf{40}$

STPP $\mathbf{0.305}X_2 \leq \mathbf{20}$

S.S $\mathbf{0.260}X_2 \leq \mathbf{440}$

Silicate $\mathbf{0.1}X_2 \leq \mathbf{107}$

CSCM $\mathbf{0.015}X_2 + \mathbf{0.06}X_4 \leq \mathbf{17}$

Shiny substance $\mathbf{0.005}X_2 \leq \mathbf{2.9}$

Silicon $\mathbf{0.0025}X_2 \leq \mathbf{4.5}$

Hypochlorite $\mathbf{0.56}X_4 \leq \mathbf{160}$

Malaysian plamoils $\mathbf{0.74}X_8 \leq \mathbf{140}$

Styrene $\mathbf{0.0085}X_8 \leq \mathbf{32}$

Titanium dioxide $\mathbf{0.001}X_1 + \mathbf{0.005}X_5 + \mathbf{0.002}X_8 + \mathbf{0.0015}X_{10} \leq \mathbf{1.4}$

Antioxidant $\mathbf{0.0004}X_1 + \mathbf{0.002}X_8 + \mathbf{0.2}X_{10} \leq \mathbf{8}$

Oleic acid $\mathbf{0.123}X_1 \leq \mathbf{5}$

Soapy residues $\mathbf{0.696}X_1 \leq \mathbf{80}$

Alumina $\mathbf{0.55}X_5 \leq \mathbf{7}$

Mono sodium $\mathbf{0.003}X_5 \leq \mathbf{0.2}$

Fluoride $\mathbf{0.0085}X_5 \leq \mathbf{0.5}$

encrusted $\mathbf{0.005}X_5 \leq \mathbf{0.47}$

skrill $\mathbf{0.002}X_5 \leq \mathbf{1.48}$

brestrin $\mathbf{0.32}X_6 \leq \mathbf{18.8}$

Acetyl alcohol $\mathbf{0.005X_6 \leq 3.2}$

Hydrochloric acid $\mathbf{0.55X_9 \leq 30}$

Non-negative Constraints:

$$\boldsymbol{X_1 \geq 0 X_2 \geq 0}$$

$$X_3 \geq 0X_4 \geq 0$$

$$X_5 \geq 0X_6 \geq 0$$

$$X_7 \geq 0X_8 \geq 0$$

$$X_9 \geq 0X_{10} \geq 0$$

When we insert the data above in (WINQSB) program, the result will be as the Figure below:

	12:34:44		Wednesday	November	20	2019		
	Decision Variable	Solution Value	Unit Cost or Profit c(j)	Total Contribution	Reduced Cost	Basis Status	Allowable Min. c(j)	Allowable Max. c(j)
1	X1	40.6504	172,814.0000	7,024,959.0000	0	basic	180.4844	M
2	X2	65.5738	135,441.0000	8,881,377.0000	0	basic	45,565.0000	M
3	X3	0	18,992.0000	0	-53,129.6600	at bound	-M	72,121.6600
4	X4	266.9399	182,260.0000	48,652,470.0000	0	basic	0	541,764.0000
5	X5	12.7273	1,849,468.0000	23,538,680.0000	0	basic	0	M
6	X6	58.7500	1,198,334.0000	70,402,120.0000	0	basic	0	M
7	X7	146.6667	150,925.0000	22,135,670.0000	0	basic	40,238.2000	M
8	X8	68.9333	93,238.0000	6,427,206.0000	0	basic	902.4609	15,312,670.0000
9	X9	54.5455	9,625.0000	525,000.0000	0	basic	0	M
10	X10	39.2294	90,246.0000	3,540,294.0000	0	basic	0	9,323,800.0000
	Objective	Function	(Max.) =	191,127,800.0000				
	Constraint	Left Hand Side	Direction	Right Hand Side	Slack or Surplus	Shadow Price	Allowable Min. RHS	Allowable Max. RHS
1	C1	40.6504	<=	4,500.0000	4,459.3500	0	40.6504	M
2	C2	65.5738	<=	24,800.0000	24,734.4300	0	65.5742	M
3	C3	0	<=	1,200.0000	1,200.0000	0	0	M
4	C4	266.9399	<=	500.0000	233.0601	0	266.9399	M
5	C5	12.7273	<=	75.0000	62.2727	0	12.7273	M
6	C6	58.7500	<=	150.0000	91.2500	0	58.7500	M
7	C7	146.6667	<=	300.0000	153.3333	0	146.6667	M
8	C8	68.9333	<=	13,000.0000	12,931.0700	0	68.9336	M
9	C9	54.5455	<=	100.0000	45.4545	0	54.5455	M
10	C10	39.2294	<=	4,000.0000	3,960.7710	0	39.2292	M
11	C11	142.0511	<=	375,196.8000	375,054.8000	0	142.0625	M
12	C12	21.6393	<=	177,724.8000	177,703.2000	0	21.6406	M
13	C13	586.6666	<=	96,267.6000	95,680.9400	0	586.6641	M
14	C14	857.7273	<=	74,052.0000	73,194.2700	0	857.7266	M
15	C15	1,494.8640	<=	28,386.6000	26,891.7400	0	1,494.8630	M
16	C16	545.4545	<=	12,342.0000	11,796.5500	0	545.4541	M
17	C17	22.0000	<=	22.0000	0	1,001,690.0000	0	45.0000

18	C18	0.2933	<=	1.2000	0.9067	0	0.2933	M
19	C19	1.3115	<=	40.0000	38.6885	0	1.3115	M
20	C20	0	<=	2.5000	2.5000	0	0	M
21	C21	0	<=	0.8500	0.8500	0	0	M
22	C22	0.0350	<=	8.5000	8.4650	0	0.0350	M
23	C23	0.7333	<=	3.5000	2.7667	0	0.7333	M
24	C24	7.7000	<=	7.7000	0	839,414.0000	0.1173	19.3297
25	C25	26.3763	<=	40.0000	13.6237	0	26.3763	M
26	C26	20.0000	<=	20.0000	0	294,675.4000	0	176.9000
27	C27	6.5574	<=	107.0000	100.4426	0	6.5574	M
28	C28	17.0000	<=	17.0000	0	3,037,667.0000	0.9836	18.1265
29	C29	0.3279	<=	2.9000	2.5721	0	0.3279	M
30	C30	0.1639	<=	4.5000	4.3361	0	0.1639	M
31	C31	149.4863	<=	160.0000	10.5137	0	149.4863	M
32	C32	51.0107	<=	140.0000	88.9893	0	51.0107	M
33	C33	0.5859	<=	32.0000	31.4141	0	0.5859	M
34	C34	0.3010	<=	1.4000	1.0990	0	0.3010	M
35	C35	8.0000	<=	8.0000	0	451,230.0000	0.1541	31.9012
36	C36	5.0000	<=	5.0000	0	1,403,524.0000	0	12.9883
37	C37	28.2927	<=	80.0000	51.7073	0	28.2927	M
38	C38	7.0000	<=	7.0000	0	3,362,669.0000	0	32.3529
39	C39	0.0382	<=	0.2000	0.1618	0	0.0382	M
40	C40	0.1082	<=	0.5000	0.3918	0	0.1082	M
41	C41	0.0636	<=	0.4700	0.4064	0	0.0636	M
42	C42	0.0255	<=	1.4800	1.4545	0	0.0255	M
43	C43	18.8000	<=	18.8000	0	3,744,794.0000	0	48.0000
44	C44	0.2937	<=	3.2000	2.9063	0	0.2938	M
45	C45	30.0000	<=	30.0000	0	17,500.0000	0	55.0000
46	C46	17.0492	<=	440.0000	422.9508	0	17.0492	M
47	C47	40.6504	>=	0	40.6504	0	-M	40.6504
48	C48	65.5738	>=	0	65.5738	0	-M	65.5738
49	C49	0	>=	0	0	0	-M	0
50	C50	266.9399	>=	0	266.9399	0	-M	266.9399
51	C51	12.7273	>=	0	12.7273	0	-M	12.7273

Figure 1 Program results to find the optimal solution

From Figure (1) we conclude the following:

Decision variable	Solution value
X_1	40.6504
X_2	65.5738
X_3	0
X_4	266.9399
X_5	12.7273
X_6	58.7500
X_7	1460.6667
X_8	68.9333
X_9	54.5455
X_{10}	39.2294
Objective function	191,127,800

Valuable product (40.65) ton of laurel soap

Cleaners (65.57) ton

Liquid cleaner (zero) because its production doesn't change the cost
Alqaser (266.93) ton
Dental paste (12.72) ton
Adam's shaving paste (58.75) ton
Shampoo (1460) ton
Ordinary soap (68.93) ton
CALCIFICATIONS removal (54.54) ton
Thorya's soap (39.22) ton
The optimal value (maximum profit) equal to (191,127,800)

Types of sensitivity analysis:

1. Change the right side of constraints (available resources)

a. If we suppose the deficiency of the primary materials that influences on the perfect solution as According to the program results in Figure (1), they are all drained in the production to give the maximal possible profit, the change is as following:

Table 9 New available quantities of primary materials in the general company for vegetable oils

primary materials	Available quantity	primary materials	Available quantity
empicol	18	Hypochlorite sodium	160
formaline	1.2	Malaysian plamoils	140
STS	40	Styrene	32
comperlan	2.5	Titanium dioxide	1.4
Lemon acid	0.85	antioxidant	5
EDTA	8.5	Oleic acid	3
embilan	3.5	Soapy residues	80
Sodium chloride	6	alumina	4
Caustic soda	40	Mono sodium	0.2
STPP	15	fluoride	0.5
S.S	440	encrusted	0.47
silicate	107	skrill	1.48
CSCM	15	brestrin	17
Shiny substance	2.9	Acetyl alcohol	3.2
silicon	4.5	Hydrochloric acid	25

The change will be in the constraints while the objective function stays the same:

Empicol: $0.072X_3 + 0.15X_7 \leq 18$
Sodium hypochlorite: $0.0008X_7 + 0.11X_8 \leq 6$

STPP: $0.305X_2 \leq 15$
CSCM: $0.015X_2$+$0.06X_4 \leq 15$
Antioxidant: $0.0004X_1 + 0.002X_8 + 0.2X_{10} \leq 5$
Oleic acid$0.123X_1 \leq 3$
Alumina:$0.55X_5 \leq 4$
brestrin $0.32X_6 \leq 17$
Hydrochloric acid: $0.55X_9 \leq 25$

The optimal solution will be:

Table 10 Results of Changing the right side of constraints (available resources) (**Case A**)

Decision variable	**Solution value**
X_1	24.3902
X_2	49.1803
X_3	0
X_4	237.7049
X_5	7.2727
X_6	53.125
X_7	120
X_8	53.6727
X_9	45.4545
X_{10}	42.4145
Objective function	157,068,400

When the available amount of primary materials decrease that influence the optimal solution, amount of production changes, as well as the value of objective function (profit) decreases to (137,068,400).

b. If we suppose the deficiency in some primary materials that doesn't influence the solution as According to the program results in Figure (1), and the change was out of the permitted limit, according to the highest and lowest limits as they are shown in the table below:

Primary material	Available amount
Mono sodium	23
hypochlorite	120

The optimal solution will be:

Table 11 Results of Changing the right side of constraints (available resources) (Case B)

Decision variable	Solution value
X_1	40.6504
X_2	65.5738
X_3	0
X_4	214.2857
X_5	12.7273
X_6	58.7500
X_7	146.6667
X_8	42.7319
X_9	54.5455
X_{10}	39.4914
Objective function	179,111,700

When the available amount of primary materials decrease and it doesn't influence the solution and the change is out of the permitted limit (table 2), the production amount will change as well as the value of objective function will become (179,111,700).

c. If the change was in the permitted limit then the solution won't be affected.

2. Change in cost

If we assume the increase in the cost for the products because of workers salary or increasing in the cost of primary materials or other reasons as it is shown below:

Table 12 New cost of products in the general company for vegetable oils in (2020)

product	Cost (IQD)
X_1laurel soap	2400000
X_2Cleaners	1690000
X_3liquid cleaner	1105557
X_4 detergent (Alqaser)	990000
X_5dental paste	12000000
X_6 Adam's shaving paste	9000000
X_7Shampoo	2290000
X_8 ordinary soap	2406691
X_9Calcifications removal	2070375
X_{10}thorya's soap	1159703

The profit will be as follow:

Table 13 New profit of products in the general company for vegetable oils

product	Profit (IQD)
X_1laurel soap	100008
X_2Cleaners	74708
X_3liquid cleaner	18992
X_4 detergent (Alqaser)	134550
X_5dental paste	1333344
X_6 Adam's shaving paste	1000008
X_7Shampoo	90950
X_8 ordinary soap	93238
X_9Calcifications removal	9625
X_{10}thorya's soap	90246

The objective function will be as follow:

$$\max z = 100008\,X_1 + 74708\,X_2 + 18992\,X_3 + 134550\,X_4 + 1333344\,X_5 + 1000008\,X_6 + 90950\,X_7 + 93238\,X_8 + 9625\,X_9 + 90246\,X_{10}$$

Constraints: (by using the same constraint for the original model because the cost change influences the objective only).

When we insert the data above in the program, the optimal solution will be as following:

Table 14 Results of Changing in cost of some products of the general company for vegetable oils in (2020)

Decision variable	Solution value
X_1	40.6504
X_2	65.5738
X_3	0
X_4	266.9399
X_5	12.7273
X_6	58.7500
X_7	1460.6667
X_8	68.9333
X_9	54.5455
X_{10}	39.2294
Objective function	129,160,400

When the costs of production increase, the amount of production remains the same, the change will influence the value of objective function which becomes (191,127,800) to (129,160,400).

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