

FR Hotel & Spa Customer Segmentation and Revenue Maximization

Introduction

The project focuses on optimizing FR and Spa Hotel's revenue under consideration of the customers visiting the hotel from different countries. By using collected data which includes all the constraints such as room capacities, type of the rooms that the hotel contains, number of customers visited deviated according to their countries, group numbers of customers, and the types of customers like family, group, etc. All the other expenses include food, drinks, soft drinks, cleaning, and others. Average revenues per customer depend on their regional distribution and beverage revenue per room. To improve the result only 16 countries that bring higher revenue than the others were chosen to as a focus of project. These countries are, Algeria, Azerbaijan, France, Germany, Iranian, Iraq, Kazakhstan, Latvia, Moldova, Netherlands, Romania, Serbia, Switzerland, Turkiye, United Kingdom and USA. By considering the given data, after creating a Linear Programming model to solve the problem application of the data and constraints and operation of an objective function steps are handled to integrate the model inside Lingo. With the collected output, a decision on the distribution of the customers is made to maximize the revenue. Moreover, post optimality checks have been applied for bottleneck constraints to understand the how much these constraints can be effective on the objective function of project. First change has applied on the cleaning budget and the decision of the LINGO was no change. On the second stage we decided to apply changes on utilization budget which is one of the most critical constraints. As a result of that, the revenue of the hotel greatly increased with a little change on the total budget. To understand the difference under another scenario, we tried to change the customer constraint and for each country of visitors we changed the expected minimum percentage from %75 to %60 percent. With this change amount of change, the hotel could decide between increasing the revenue or reducing the diversity.

Model Definition



The mathematical model can be defined as follows, the variables of the model are:

F_i = Number of family rooms occupied by residents of country i

S_i = Number of suit rooms occupied by residents of country i

K_i = Number of king rooms occupied by residents of country i

C_i = Average revenue per room for each region i

a_i = Coefficient of food per room from region i

b_i = Coefficient of cleaning per room from region i

c_i = Coefficient of utilization per room from region i

F_{0i} = Number of residents hosted at year 0 from region i for family room

S_{0i} = Number of residents hosted at year 0 from region i for suit room

K_{0i} = Number of residents hosted at year 0 from region i for king room

Objective Function:

$$\max Z = \sum C_i F_i + C_i S_i + C_i K_i$$

Constraints:

1- $\sum F_i \leq 15300$ (Available Room Constraint for family rooms)

2- $\sum S_i \leq 3600$ (Available Room Constraint for suit rooms)

3- $\sum K_i \leq 800$ (Available Room Constraint for king rooms)

4- $\sum (a_i F_i + a_i F_i + a_i F_i) \leq 166400$ (Food expense constraint)

5- $\sum (b_i F_i + b_i F_i + b_i F_i) \leq 52200$ (Cleaning expense constraint)

6- $\sum (c_i F_i + c_i F_i + c_i F_i) \leq 43720$ (Utilization and administrative expense constraint)

7- $\sum F_i \leq 0.75(F_{0i})$ (Minimum regional distribution constraints for family rooms)

8- $\sum S_i \leq 0.75(S_{0i})$ (Minimum regional distribution constraints for suit rooms)

9- $\sum K_i \leq 0.75(K_{0i})$ (Minimum regional distribution constraints for king rooms)

10- $\forall (F_i, S_i, K_i, C_i, a_i, b_i, c_i, F_{0i}, S_{0i}, K_{0i}) \geq 0, i = (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16)$



Assumptions



For the project, some assumptions have been created to be able to generate a linear model for LINGO. These are:

- Room prices are fixed in a stable price.
- At least 75% of the visitors from each country will visit the Hotel again.
- During the season hotel will work with %100 capacity.
- Expenses will not be changing during the season.



Conclusion

Solver Status:	Variables:
Model Class:	LP
State:	Global Opt
Objective:	1.36042e+06
Infeasibility:	0
Iterations:	5
Extended Solver Status:	Constraints:
Solver Type:	Total: 48 Nonlinear: 0 Integers: 0
Best Obj:	Total: 61 Nonlinear: 0
Obj Bound:	Nonzeros:
Steps:	Total: 288 Nonlinear: 0
Active:	Generator Memory Used (K): 48
	Elapsed Runtime [hh:mm:ss]: 00:00:00

As shown in the objective function output the hotel revenue after the program ran observed as 1360420. To improve the revenue we will try to make changes in the current model using post optimality checks to discuss how the constraints can be effective on the problem.

LINGO output of the provided model can be seen on the following slides. For all variables and their right hand side values of these variables care shown in the output.

Model Title: CUSTOMER ANALYSIS FOR FORE RESORT

Variable	Value	Reduced Cost
AVAILABLEROOM1	15300.00	0.000000
AVAILABLEROOM2	3600.000	0.000000
AVAILABLEROOM3	900.0000	0.000000
F(R1)	36.00000	0.000000
F(R2)	8.250000	0.000000
F(R3)	838.9981	0.000000
F(R4)	18.75000	0.000000
F(R5)	8.250000	0.000000
F(R6)	11.25000	0.000000
F(R7)	10.50000	0.000000
F(R8)	10.50000	0.000000
F(R9)	23.25000	0.000000
F(R10)	6.750000	0.000000
F(R11)	9.750000	0.000000
F(R12)	24.75000	0.000000
F(R13)	8.250000	0.000000
F(R14)	2180.250	0.000000
F(R15)	16.50000	0.000000
F(R16)	15.75000	0.000000
S(R1)	9.000000	0.000000
S(R2)	2.250000	0.000000
S(R3)	2701.304	0.000000
S(R4)	4.500000	0.000000
S(R5)	2.250000	0.000000
S(R6)	3.000000	0.000000
S(R7)	3.000000	0.000000
S(R8)	3.000000	0.000000
S(R9)	6.000000	0.000000
S(R10)	1.500000	0.000000
S(R11)	2.250000	0.000000
S(R12)	6.000000	0.000000
S(R13)	2.250000	0.000000
S(R14)	513.0000	0.000000
S(R15)	4.500000	0.000000
S(R16)	3.750000	0.000000

Lingo Output Part I

K(R1)	2.250000	0.000000
K(R2)	0.7500000	0.000000
K(R3)	1.500000	0.000000
K(R4)	1.500000	0.000000
K(R5)	0.7500000	0.000000
K(R6)	0.7500000	0.000000
K(R7)	0.7500000	0.000000
K(R8)	0.7500000	0.000000
K(R9)	1.500000	0.000000
K(R10)	755.2500	0.000000
K(R11)	0.7500000	0.000000
K(R12)	1.500000	0.000000
K(R13)	0.7500000	0.000000
K(R14)	128.2500	0.000000
K(R15)	1.500000	0.000000
K(R16)	1.500000	0.000000
REVENUEPERROOMF(R1)	135.1100	0.000000
REVENUEPERROOMF(R2)	126.3100	0.000000
REVENUEPERROOMF(R3)	152.6900	0.000000
REVENUEPERROOMF(R4)	123.6100	0.000000
REVENUEPERROOMF(R5)	114.7100	0.000000
REVENUEPERROOMF(R6)	125.9200	0.000000
REVENUEPERROOMF(R7)	135.2700	0.000000
REVENUEPERROOMF(R8)	111.7200	0.000000
REVENUEPERROOMF(R9)	109.2300	0.000000
REVENUEPERROOMF(R10)	159.0800	0.000000
REVENUEPERROOMF(R11)	111.2900	0.000000
REVENUEPERROOMF(R12)	121.7800	0.000000
REVENUEPERROOMF(R13)	112.5400	0.000000
REVENUEPERROOMF(R14)	134.4900	0.000000
REVENUEPERROOMF(R15)	125.5100	0.000000
REVENUEPERROOMF(R16)	117.7400	0.000000
REVENUEPERROOMS(R1)	175.6400	0.000000
REVENUEPERROOMS(R2)	164.2000	0.000000
REVENUEPERROOMS(R3)	198.5000	0.000000
REVENUEPERROOMS(R4)	160.6900	0.000000
REVENUEPERROOMS(R5)	149.1200	0.000000
REVENUEPERROOMS(R6)	163.7000	0.000000
REVENUEPERROOMS(R7)	175.8500	0.000000
REVENUEPERROOMS(R8)	145.2400	0.000000
REVENUEPERROOMS(R9)	142.0000	0.000000
REVENUEPERROOMS(R10)	206.8000	0.000000
REVENUEPERROOMS(R11)	144.6800	0.000000
REVENUEPERROOMS(R12)	158.3100	0.000000
REVENUEPERROOMS(R13)	146.3000	0.000000
REVENUEPERROOMS(R14)	174.8400	0.000000
REVENUEPERROOMS(R15)	163.1600	0.000000
REVENUEPERROOMS(R16)	153.0600	0.000000

Lingo Output Part II

K(R1)	2.250000	0.000000
K(R2)	0.7500000	0.000000
K(R3)	1.500000	0.000000
K(R4)	1.500000	0.000000
K(R5)	0.7500000	0.000000
K(R6)	0.7500000	0.000000
K(R7)	0.7500000	0.000000
K(R8)	0.7500000	0.000000
K(R9)	1.500000	0.000000
K(R10)	755.2500	0.000000
K(R11)	0.7500000	0.000000
K(R12)	1.500000	0.000000
K(R13)	0.7500000	0.000000
K(R14)	128.2500	0.000000
K(R15)	1.500000	0.000000
K(R16)	1.500000	0.000000
REVENUEPERROOMF(R1)	135.1100	0.000000
REVENUEPERROOMF(R2)	126.3100	0.000000
REVENUEPERROOMF(R3)	152.6900	0.000000
REVENUEPERROOMF(R4)	123.6100	0.000000
REVENUEPERROOMF(R5)	114.7100	0.000000
REVENUEPERROOMF(R6)	125.9200	0.000000
REVENUEPERROOMF(R7)	135.2700	0.000000
REVENUEPERROOMF(R8)	111.7200	0.000000
REVENUEPERROOMF(R9)	109.2300	0.000000
REVENUEPERROOMF(R10)	159.0800	0.000000
REVENUEPERROOMF(R11)	111.2900	0.000000
REVENUEPERROOMF(R12)	121.7800	0.000000
REVENUEPERROOMF(R13)	112.5400	0.000000
REVENUEPERROOMF(R14)	134.4900	0.000000
REVENUEPERROOMF(R15)	125.5100	0.000000
REVENUEPERROOMF(R16)	117.7400	0.000000
REVENUEPERROOMS(R1)	175.6400	0.000000
REVENUEPERROOMS(R2)	164.2000	0.000000
REVENUEPERROOMS(R3)	198.5000	0.000000
REVENUEPERROOMS(R4)	160.6900	0.000000
REVENUEPERROOMS(R5)	149.1200	0.000000
REVENUEPERROOMS(R6)	163.7000	0.000000
REVENUEPERROOMS(R7)	175.8500	0.000000
REVENUEPERROOMS(R8)	145.2400	0.000000
REVENUEPERROOMS(R9)	142.0000	0.000000
REVENUEPERROOMS(R10)	206.8000	0.000000
REVENUEPERROOMS(R11)	144.6800	0.000000
REVENUEPERROOMS(R12)	158.3100	0.000000
REVENUEPERROOMS(R13)	146.3000	0.000000
REVENUEPERROOMS(R14)	174.8400	0.000000
REVENUEPERROOMS(R15)	163.1600	0.000000
REVENUEPERROOMS(R16)	153.0600	0.000000

Lingo Output Part III

REVENUEPERROOMK(R1)	270.2200	0.000000
REVENUEPERROOMK(R2)	252.6200	0.000000
REVENUEPERROOMK(R3)	305.3800	0.000000
REVENUEPERROOMK(R4)	247.2200	0.000000
REVENUEPERROOMK(R5)	229.4200	0.000000
REVENUEPERROOMK(R6)	251.8400	0.000000
REVENUEPERROOMK(R7)	270.5400	0.000000
REVENUEPERROOMK(R8)	223.4400	0.000000
REVENUEPERROOMK(R9)	218.4600	0.000000
REVENUEPERROOMK(R10)	318.1600	0.000000
REVENUEPERROOMK(R11)	222.5800	0.000000
REVENUEPERROOMK(R12)	243.5600	0.000000
REVENUEPERROOMK(R13)	225.0800	0.000000
REVENUEPERROOMK(R14)	268.9800	0.000000
REVENUEPERROOMK(R15)	251.0200	0.000000
REVENUEPERROOMK(R16)	235.4800	0.000000
AVAILABLEMONEY(C1)	166400.0	0.000000
AVAILABLEMONEY(C2)	52200.00	0.000000
AVAILABLEMONEY(C3)	43720.00	0.000000
GUESTSHOSTEDF(Y1)	36.00000	0.000000
GUESTSHOSTEDF(Y2)	8.250000	0.000000
GUESTSHOSTEDF(Y3)	15.00000	0.000000
GUESTSHOSTEDF(Y4)	18.75000	0.000000
GUESTSHOSTEDF(Y5)	8.250000	0.000000
GUESTSHOSTEDF(Y6)	11.25000	0.000000
GUESTSHOSTEDF(Y7)	10.50000	0.000000
GUESTSHOSTEDF(Y8)	10.50000	0.000000
GUESTSHOSTEDF(Y9)	23.25000	0.000000
GUESTSHOSTEDF(Y10)	6.750000	0.000000
GUESTSHOSTEDF(Y11)	9.750000	0.000000
GUESTSHOSTEDF(Y12)	24.75000	0.000000
GUESTSHOSTEDF(Y13)	8.250000	0.000000
GUESTSHOSTEDF(Y14)	2180.250	0.000000
GUESTSHOSTEDF(Y15)	16.50000	0.000000
GUESTSHOSTEDF(Y16)	15.75000	0.000000
GUESTSHOSTEDS(Y1)	9.000000	0.000000
GUESTSHOSTEDS(Y2)	2.250000	0.000000
GUESTSHOSTEDS(Y3)	3.750000	0.000000
GUESTSHOSTEDS(Y4)	4.500000	0.000000
GUESTSHOSTEDS(Y5)	2.250000	0.000000
GUESTSHOSTEDS(Y6)	3.000000	0.000000
GUESTSHOSTEDS(Y7)	3.000000	0.000000
GUESTSHOSTEDS(Y8)	3.000000	0.000000
GUESTSHOSTEDS(Y9)	6.000000	0.000000
GUESTSHOSTEDS(Y10)	1.500000	0.000000
GUESTSHOSTEDS(Y11)	2.250000	0.000000
GUESTSHOSTEDS(Y12)	6.000000	0.000000
GUESTSHOSTEDS(Y13)	2.250000	0.000000
GUESTSHOSTEDS(Y14)	513.0000	0.000000
GUESTSHOSTEDS(Y15)	4.500000	0.000000
GUESTSHOSTEDS(Y16)	3.750000	0.000000

Lingo Output Part IV

GUESTSHOSTEDK(Y1)	2.250000	0.000000
GUESTSHOSTEDK(Y2)	0.7500000	0.000000
GUESTSHOSTEDK(Y3)	1.500000	0.000000
GUESTSHOSTEDK(Y4)	1.500000	0.000000
GUESTSHOSTEDK(Y5)	0.7500000	0.000000
GUESTSHOSTEDK(Y6)	0.7500000	0.000000
GUESTSHOSTEDK(Y7)	0.7500000	0.000000
GUESTSHOSTEDK(Y8)	0.7500000	0.000000
GUESTSHOSTEDK(Y9)	1.500000	0.000000
GUESTSHOSTEDK(Y10)	0.7500000	0.000000
GUESTSHOSTEDK(Y11)	0.7500000	0.000000
GUESTSHOSTEDK(Y12)	1.500000	0.000000
GUESTSHOSTEDK(Y13)	0.7500000	0.000000
GUESTSHOSTEDK(Y14)	128.2500	0.000000
GUESTSHOSTEDK(Y15)	1.500000	0.000000
GUESTSHOSTEDK(Y16)	1.500000	0.000000
MATRIXCFR(R1, FOOD)	11.24000	0.000000
MATRIXCFR(R1, CLEANING)	2.920000	0.000000
MATRIXCFR(R1, UTILIZATION)	12.92000	0.000000
MATRIXCFR(R2, FOOD)	11.82000	0.000000
MATRIXCFR(R2, CLEANING)	2.940000	0.000000
MATRIXCFR(R2, UTILIZATION)	13.61000	0.000000
MATRIXCFR(R3, FOOD)	13.51000	0.000000
MATRIXCFR(R3, CLEANING)	2.570000	0.000000
MATRIXCFR(R3, UTILIZATION)	13.33000	0.000000
MATRIXCFR(R4, FOOD)	13.67000	0.000000
MATRIXCFR(R4, CLEANING)	2.670000	0.000000
MATRIXCFR(R4, UTILIZATION)	14.51000	0.000000
MATRIXCFR(R5, FOOD)	9.080000	0.000000
MATRIXCFR(R5, CLEANING)	2.280000	0.000000
MATRIXCFR(R5, UTILIZATION)	14.85000	0.000000
MATRIXCFR(R6, FOOD)	12.41000	0.000000
MATRIXCFR(R6, CLEANING)	2.830000	0.000000
MATRIXCFR(R6, UTILIZATION)	13.61000	0.000000
MATRIXCFR(R7, FOOD)	14.11000	0.000000
MATRIXCFR(R7, CLEANING)	2.530000	0.000000
MATRIXCFR(R7, UTILIZATION)	13.30000	0.000000
MATRIXCFR(R8, FOOD)	11.52000	0.000000
MATRIXCFR(R8, CLEANING)	2.630000	0.000000
MATRIXCFR(R8, UTILIZATION)	12.45000	0.000000
MATRIXCFR(R9, FOOD)	11.15000	0.000000
MATRIXCFR(R9, CLEANING)	2.380000	0.000000
MATRIXCFR(R9, UTILIZATION)	13.32000	0.000000

Lingo Output Part V



MATRIXCFR(R10, FOOD)	11.17000	0.000000
MATRIXCFR(R10, CLEANING)	2.020000	0.000000
MATRIXCFR(R10, UTILIZATION)	14.65000	0.000000
MATRIXCFR(R11, FOOD)	14.29000	0.000000
MATRIXCFR(R11, CLEANING)	2.990000	0.000000
MATRIXCFR(R11, UTILIZATION)	14.37000	0.000000
MATRIXCFR(R12, FOOD)	12.63000	0.000000
MATRIXCFR(R12, CLEANING)	2.140000	0.000000
MATRIXCFR(R12, UTILIZATION)	14.14000	0.000000
MATRIXCFR(R13, FOOD)	14.06000	0.000000
MATRIXCFR(R13, CLEANING)	2.530000	0.000000
MATRIXCFR(R13, UTILIZATION)	12.86000	0.000000
MATRIXCFR(R14, FOOD)	9.450000	0.000000
MATRIXCFR(R14, CLEANING)	2.330000	0.000000
MATRIXCFR(R14, UTILIZATION)	13.62000	0.000000
MATRIXCFR(R15, FOOD)	9.970000	0.000000
MATRIXCFR(R15, CLEANING)	2.560000	0.000000
MATRIXCFR(R15, UTILIZATION)	13.78000	0.000000
MATRIXCFR(R16, FOOD)	12.37000	0.000000
MATRIXCFR(R16, CLEANING)	2.000000	0.000000
MATRIXCFR(R16, UTILIZATION)	13.56000	0.000000

Lingo Output Part VI

Row	Slack or Surplus	Dual Price			
1	1360418.	1.000000	34	0.000000	-72.01466
2	12072.25	0.000000	35	0.000000	-38.96954
3	332.4456	0.000000	36	0.000000	-22.20326
4	0.000000	318.1600	37	0.000000	-40.15572
5	131957.8	0.000000	38	0.000000	-56.35109
6	44433.83	0.000000	39	0.000000	-11.35641
7	0.000000	11.45461	40	0.000000	-69.30687
8	124419.2	0.000000	41	0.000000	-52.25189
9	43926.76	0.000000	42	0.000000	-45.20113
10	0.000000	14.89122	43	0.000000	-27.97845
11	156551.2	0.000000	44	0.000000	-42.04105
12	50333.47	0.000000	45	0.000000	-48.86498
13	30684.51	0.000000	46	0.000000	-47.94000
14	0.000000	-12.88361	47	0.000000	-65.54000
15	0.000000	-29.58729	48	0.000000	-12.78000
16	823.9981	0.000000	49	0.000000	-70.94000
17	0.000000	-42.59644	50	0.000000	-88.74000
18	0.000000	-55.39101	51	0.000000	-66.32000
19	0.000000	-29.97729	52	0.000000	-47.62000
20	0.000000	-17.07636	53	0.000000	-94.72000
21	0.000000	-30.88994	54	0.000000	-99.70000
22	0.000000	-43.34545	55	754.5000	0.000000
23	0.000000	-8.730090			
24	0.000000	-53.31280	56	0.000000	-95.58000
25	0.000000	-40.18824	57	0.000000	-74.60000
26	0.000000	-34.76633	58	0.000000	-93.08000
27	0.000000	-21.52184	59	0.000000	-49.18000
28	0.000000	-32.33458	60	0.000000	-67.14000
29	0.000000	-37.58456	61	0.000000	-82.68000
30	0.000000	-16.75460			
31	0.000000	-38.46954			
32	2697.554	0.000000			
33	0.000000	-55.38164			

Lingo Output Part VII

Lingo Output Part VIII

By checking the dual prices of the variables, since our problem is maximization we can understand that the change in rows which has positive dual price value will positively effect the total revenue. That means the objective function will increase. Therefore, the reach a better solution, aim of the changes will be trying to reducing of the negative dual prices or adding a value on the related rows. Also, we can try to make changes on the slack or surplus values which has zero or negative effect on the maximimation problem that we can understand by checking their values. To understand the changes, 2 different post optimatlity checks have applied to the model. Which are:

- Changing the expense budgets of the hotel.
- Changing the percentage of visitors that belongs to the same region.

After the application of these two changes separated from each other. Cleaning and Food budgets showed zero effect on the objective function. However, increasing the Utilization budget made a huge difference on the total revenue. All two cases have inspected in further process under these two titles.

Case 1: Changing the Utilization Budget

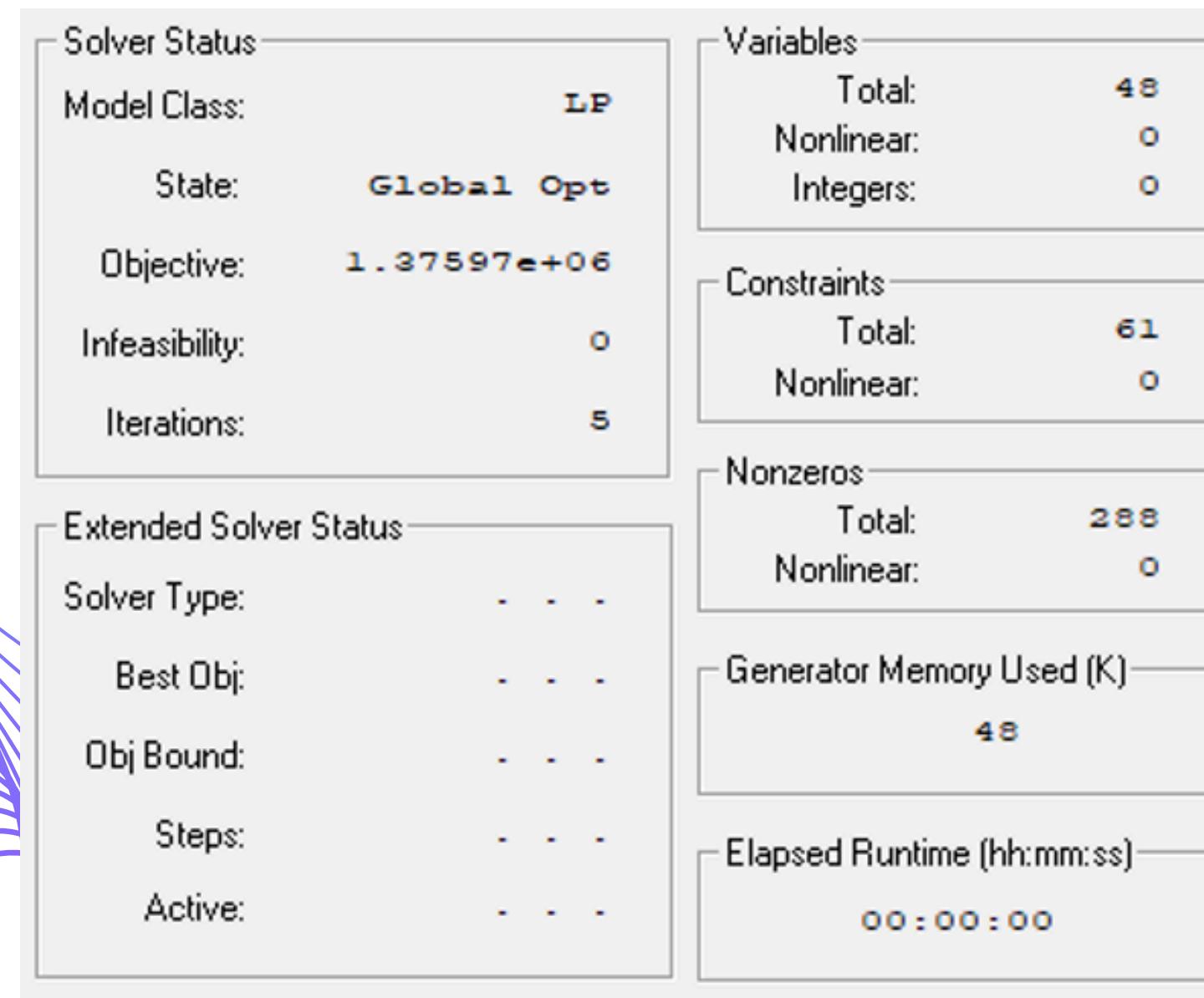
Code for the change in utilization budget will be shown in the appendix. In this part, only the output of the LINGO will be analyzed.

Solver Status	
Model Class:	LP
State:	Global Opt
Objective:	1.63804e+06
Infeasibility:	0
Iterations:	7
Extended Solver Status	
Solver Type:	...
Best Obj:	...
Obj Bound:	...
Steps:	...
Active:	...
Variables	
Total:	48
Nonlinear:	0
Integers:	0
Constraints	
Total:	61
Nonlinear:	0
Nonzeros	
Total:	288
Nonlinear:	0
Generator Memory Used (K)	
	48
Elapsed Runtime (hh:mm:ss)	
	00:00:00

After changing the Utilization Budget from 43720 to 60000, the total revenue of the hotel is changed from 1,360,420 to 1,638,040 which is 277.620 euros change in the total revenue. By considering the collected output, the Utilization Constraint can be defined as a Bottleneck Constraint that could be very much useful to increasing the budget for utilization for the hotel.

Case 2: Changing the Percentage of Expected Number of Visitors from the Same Country

Code for the change in utilization budget will be shown in the appendix. In this part, only the output of the LINGO will be analyzed.



Changing the expected ratio of the customer that visiting from the same country form 75% to 60% have changed the objective function from 1,360,420 to 1,375,970. Since the change in objective funtion is not too much. The decision of making a change on the customer type or revenue belongs to the hotel.