

Tidy Paper Report
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MAT 3310

The goal of this project is to determine how much of each paper product should be produced at each plant, on average each month, where to apply more plant storage, and what the equal percentage limitation cost is to the plant.

Information Relative to each Plant			
Plant #	Max # of Cases that can be Produced	Plant Square Footage	
1	750	1300	
2	900	1200	
3	450	500	
Information Relative to the Products			
Product	Cost per case	Sales Forecast	Required Square Footage for Storage
Toilet Paper	\$42	900	2
Hand Towels	\$36	1200	1.5
Facial Tissues	\$30	750	1.2

First, I entered all of the information into Excel. On the next page you can see how the sheet was laid out.

This is the sheet legend:

T1 (Toilet Paper at Plant 1); T2 (Toilet Paper at Plant 2); T3 (Toilet Paper at Plant 3);
H1 (Hand Towels at Plant 1); H2 (Hand Towels at Plant 2); H3 (Hand Towels at Plant 3);
F1 (Facial Tissues at Plant 1); F2 (Facial Tissues at Plant 2); F3 (Facial Tissues at Plant 3);

The Square feet constraints are listed in row 11 under Square Feet.

The Cases constraints are listed in row 16 under Cases.

The Forecast Per Month constraints are listed in row 21 under Forecast Per Month.

Table 1.1

	A	B	C	D
1	T1	516.66667		
2	T2	0		
3	T3	0		
4	H1	177.77778		
5	H2	666.66667		
6	H3	0		
7	F1	0		
8	F2	166.66667		
9	F3	416.66667		
10				
11	Square Feet			
12	plant1	1300	<=	1300
13	plant2	1200	<=	1200
14	plant3	500	<=	500
15				
16	Cases			
17	plant1	694.44444	<=	750
18	plant2	833.33333	<=	900
19	plant3	416.66667	<=	450
20				
21	Forecast Per Month			
22	plant1	516.66667	<=	900
23	plant2	844.44444	<=	1200
24	plant3	583.33333	<=	750
25				
26	Profit			
27	69600			
28				
29				
30	0 =		0	
31	0 =		0	

In order to solve for the constraints in square feet, I used the following formulas:

In cell B12, I put $=2*B1+1.5*B4+1.2*B7$

In cell B13, I put $=2*B2+1.5*B5+1.2*B8$

In cell B14, I put $=2*B3+1.5*B6+1.2*B9$

In order to solve for the constraints in cases, I used the following formulas:

In cell B17, I put $=B1+B4+B7$

In cell B18, I put $=B2+B5+B8$

In cell B19, I put $=B3+B6+B9$

In order to solve for the constraints in Forecast Per Month, I used the following formulas:

In cell B22, I put $=B1+B2+B3$

In cell B23, I put $=B4+B5+B6$

In cell B24, I put $=B7+B8+B9$

In order to solve for profit, I used the following formula:

$=42*(B1+B2+B3)+36*(B4+B5+B6)+30*(B7+B8+B9)$

This formula translates to:

$42*(\text{toilet paper total})+36*(\text{hand towel total})+30*(\text{facial tissue total})$

Once the excel sheet was setup, I used the Excel Solver to produce an Answer and Sensitivity Report. The objective of the problem was profit at a max value. The constraints are square feet, cases, and forecast per

month. This can be observed in table 1.1 from column A11-D11 through A24-D24. The equations are outlined below.

Square Feet

- Plant 1: $2 * T1 + 1.5 * H1 + 1.2 * F1 \leq 1300$
- Plant 2: $2 * T2 + 1.5 * H2 + 1.2 * F2 \leq 1200$
- Plant 3: $2 * T3 + 1.5 * H3 + 1.3 * F3 \leq 500$

Cases

- Plant 1: $T1 + H1 + F1 \leq 700$
- Plant 2: $T2 + H2 + F2 \leq 900$
- Plant 3: $T3 + H3 + F3 \leq 450$

Forecast Per Month

- Plant 1: $T1 + T2 + T3 \leq 900$
- Plant 2: $H1 + H2 + H3 \leq 1200$
- Plant 3: $F1 + F2 + F3 \leq 750$

Table 1.2 contains the Answer and Sensitivity Report, with the equal percentage limitation cost included.

Table 1.2

Objective Cell (Max)

Cell	Name	Original Value	Final Value
\$A\$27	Profit	70800	69600

Variable Cells

Cell	Name	Original Value	Final Value	Integer
\$B\$1	T1	350	516.6666667	Contin
\$B\$2	T2	0	0	Contin
\$B\$3	T3	0	0	Contin
\$B\$4	H1	400	177.7777778	Contin
\$B\$5	H2	400	666.6666667	Contin
\$B\$6	H3	133.3333333	0	Contin
\$B\$7	F1	0	0	Contin
\$B\$8	F2	500	166.6666667	Contin
\$B\$9	F3	250	416.6666667	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
\$A\$30	Profit	0	\$A\$30=\$C\$30	Binding	0
\$A\$31	Profit	0	\$A\$31=\$C\$31	Binding	0
\$B\$12	plant1	1300	\$B\$12<=\$D\$12	Binding	0
\$B\$13	plant2	1200	\$B\$13<=\$D\$13	Binding	0
\$B\$14	plant3	500	\$B\$14<=\$D\$14	Binding	0
\$B\$17	plant1	694.4444444	\$B\$17<=\$D\$17	Not Binding	55.5555556
\$B\$18	plant2	833.3333333	\$B\$18<=\$D\$18	Not Binding	66.6666667
\$B\$19	plant3	416.6666667	\$B\$19<=\$D\$19	Not Binding	33.3333333
\$B\$22	plant1	516.6666667	\$B\$22<=\$D\$22	Not Binding	383.3333333
\$B\$23	plant2	844.4444444	\$B\$23<=\$D\$23	Not Binding	355.5555556
\$B\$24	plant3	583.3333333	\$B\$24<=\$D\$24	Not Binding	166.6666667

Table 1.3 contains the Answer Report, which shows how much of each product should be produced at each plant, as well as the profit.

Table 1.3
Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
\$B\$1	T1	516.666667	0	42	4	6
\$B\$2	T2	0	-4	42	4	1E+30
\$B\$3	T3	0	-36	42	36	1E+30
\$B\$4	H1	177.777778	0	36	6	1.5
\$B\$5	H2	666.666667	0	36	6	1.5
\$B\$6	H3	0	-12	36	12	1E+30
\$B\$7	F1	0	-2.4	30	2.4	1E+30
\$B\$8	F2	166.666667	0	30	2.4	4.8
\$B\$9	F3	416.666667	0	30	1E+30	9.6

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
\$A\$30	Profit	0	0.02	0	50000	40000
\$A\$31	Profit	0	0.04666667	0	15000	15000
\$B\$12	plant1	1300	12	1300	88.8888889	177.777778
\$B\$13	plant2	1200	20	1200	50	50
\$B\$14	plant3	500	60	500	18.1818182	20
\$B\$17	plant1	694.444444	0	750	1E+30	55.5555556
\$B\$18	plant2	833.333333	0	900	1E+30	66.6666667
\$B\$19	plant3	416.666667	0	450	1E+30	33.3333333
\$B\$22	plant1	516.666667	0	900	1E+30	383.333333
\$B\$23	plant2	844.444444	0	1200	1E+30	355.555556
\$B\$24	plant3	583.333333	0	750	1E+30	166.666667

Here is the Sensitivity Report that shows the shadow prices of each product and the square footage/case allowable increase.

Objective Coefficient

The objective coefficient (cost per case) for Toilet Paper per plant is 42. For Hand Towels it is 36, and for Facial Tissues it is 30. This means that this is the number that determines the profit of each product. For example, 36 will be multiplied by the sum of the Hand Towels from the three plants, 42 multiplied by the sum of the Toilet Paper of the three plants. The numbers in the Allowable Increase and Allowable Decrease columns let you know how much the Objective Coefficient can change by without having to change the amount of materials made.

Shadow Price

The shadow price of each constraint shows the price at one unit of the cell. The shadow price is what the price should be and it tells the seller/consumer what an appropriate price is for a unit of a certain product. For the Square Feet for plant 1, the appropriate value per unit is \$12. For plant 2, \$20. For plant 3, \$60. The shadow prices for each case and forecast per month are all set to 0 because there is not much of an allowable increase to produce more. Because the allowable increase is so close to 0, the shadow price is set at 0 to encourage the producer (Tidy Paper) to not produce any more of those values (cases per plant).

With these two reports (Answer and Sensitivity), I was able to answer the three questions that I stated at the top as the project goal.

Question 1: How much of each product should be produced at each plant on average each month?

Plant 1: 750 cases (350 Toilet paper, 400 Hand towels, 0 Facial tissues)

Plant 2: 375 cases (0 Toilet paper, 300 Hand towels, 375 Facial tissues)

Plant 3: 675 cases (0 Toilet paper, 0 Hand towels, 375 Facial tissues)

These answers are shown in the answer report above.

Question 2: How much does this equal percentage limitation cost us?

Before the limitation, Tidy Paper Inc. produces a profit of \$70,800. After the limitation Tidy Paper, Inc. produces a profit of \$69,600. This is a \$1,200 difference. In order to find out the profit without the limitation included, I simply remove the limitation equations from the constraints table in the solver. The limitations equations are below, and are also in 1.1:

$$=(450*B2+450*B5+450*B8)-(900*B3+900*B6+900*B9) = 0$$

$$=(900*B1+900*B4+900*B7)-(750*B2+750*B5+750*B8) = 0$$

Question 3: If we could get more in-process storage space at one of the plants, would that help? And if so which plant?

Tidy Paper, Inc. should get more in-process storage space in Plant #3 because this plant has a shadow price of \$60 per square foot. This can be viewed in the sensitivity report (table 1. 3). As of right now, plant 3 is producing the smallest profit due to its lack of size. Increasing the side of plant 3 will increase your profit \$60 per square foot.

In this project, I assumed that the information given was concrete rather than a loose restriction. Therefore, I never tested outside of the given boundaries.