Hathaway Inc. Corporation

Business Expansion - Revenue Optimization

Summary

The Hathaway Inc. organization wants to expand its stores by a maximum of 11 stores in San Jose. The optimization model described here is for maximizing earnings at the Hathaway Inc. organization. The stores are of 3 different types each with its own set of constraints. Using the acquired data we built an optimized model with the goal of maximizing the revenue from the newly built stores. The optimization for this was then completed using Microsoft Excel and the Solver add-in. We then utilized sensitivity analysis to gain a better understanding of the model's restrictions.

After exhaustive analysis, we came to the conclusion that maximum revenue of 35$ million can be incurred with reduced constraints and with 1 convenience store, 1 supermarket store and 8 pharmaceutical stores would be the best course of action but this would be applicable only if the company is considering the drug shell life expectancy aspect. Implementing this decision would be very beneficial for the Hathaway Inc. Corporation financially and would also reduce operating expenses.

Topic/ Problem :

Revenue Optimization of Hathaway Inc. Corporation.

Hathaway Inc. Corporation plans on building a maximum of 11 new stores in a large city-San Jose. They will build these stores in one of three sizes in the selected location– a convenience store (open 24 hours), pharmaceutical store, and a supermarket- services store. The convenience store requires $4.125 million to build and 30 employees to operate. The pharmaceutical store requires $8.25 million to build and 15 employees to operate. The supermarket-services store requires $12.375

million to build and 45 employees to operate. The corporation can dedicate $82.5 million in construction capital, and 340 employees to staff the stores. In addition to this, Hathaway Inc. Corporation is not willing to build more than 2 pharmaceutical stores as it has a higher risk rate because drugs that have shelf life may become dead stock if not sold. On an average, the convenience store nets $1.2 million annually, the pharmaceutical store nets $4 million annually, and the supermarket- services store nets $2.6 million annually. How many of each should they build to maximize revenue?

If we add another constraint, the combined capital for pharmaceutical and supermarket stores cannot exceed more than 50 million.

Another constraint added is the combined employees assigned to convenience and supermarket-services stores should be at least 165.

Proposed Solution :

In this case, prescriptive analysis using **Integer Linear Programming** would best assess the ideal optimal solution to maximize revenue.

In the second case , where there were several scenarios added, like restrictions on costs invested for stores and number of employees, we did sensitivity analysis to decide on how each aspect affects the other and overall revenue of Hathaway Inc. Corporation.

Introduction

Hathaway Inc. Corporation

The Hathaway Inc. Corporation is an American multinational chain. They are primarily invested in convenience stores, pharmacies and supermarkets. The Hathaway Inc. Corporation plans on building new stores in San Jose. They can build a maximum of 11 stores, the stores can be of three different types- "Pharmacies", "Convenience Stores" and "Supermarkets". The corporation can dedicate $82.5 million in construction capital, and 340 employees to staff the stores. In addition to this, the Hathaway Inc. Corporation is not willing to build more than 2 pharmaceutical stores as it has a higher risk rate because drugs that have shelf life may become dead stock if not sold. On an average, the convenience store nets $1.2 million annually, the pharmaceutical store nets $4 million annually, and the expanded- services store nets $2.6 million annually. The cost involved in building a store and the number of employees per store according to the different types is given below.

Type	**Construction cost per Building (in million dollars)**	**No of employee**
Pharmacies	8.25	15
Convenience Stores	4.125	30
Supermarkets	$12.38	45

Appropriate analysis was performed to find the best way to get the maximum revenue from the plan of building new stores.

Main Chapter

Data Analysis

Simple lists may be organized, but the data can also be processed using advanced tools built into Excel. Excel Solver is one of these utilities and is being used here in this case. Solver uses a computer's fast processing power to subject any mathematical scenario to rapid data analysis for purposes of finding a solution to complicated formulas. The process of solving equations with a single unknown variable is relatively straightforward. However, when multiple unknowns are part of a set of multiple equations, this process gets much more time consuming and challenging. A key advantage of Solver is the ability to quickly process scenarios involving multiple unknown variables. This is often regarded as a "Integer linear optimization method". This is particularly useful when there are many unknowns, or many different sets of equations, each with its own set of unknown variables. Solver saves hours of manual algebra calculations in these circumstances.

As with linear algebra, many product development cycles are influenced by multiple factors, each of which can significantly change profit margins. Revenue generation is the key factor in this case. This is the goal of Hathaway Inc. Corporation , but there are constraints. The amount of money they have is an obvious restriction, but in addition to this they may also require a certain number of employees only. Solver can show us how to satisfy all constraints and still get the maximum revenue for the cash allowance. In this way, Solver has optimized the business plan as mentioned below in the next steps.

The following are the "**decision variables**" for the business problem.

Decision Variables		
X1=	0.0	Number of convenient stores
X2=	0.0	Number of pharmaceutical stores
X3=	0.0	Number of supermarket services stores
Total =	0.0	

Net Annually (in millions)	**Construction Costs (in millions)**	**Number of employees**
1.2	4.125	30
4	8.25	15
2.6	12.37	45
Total = 7.8	**Total = 24.745**	**Total = 90**

Here X1, X2, X3 are the number of stores. X1 represents the number of convenient stores, X2 represents the number of pharmaceutical stores and X3 represents the number of supermarket services stores. In addition to this, there are certain variables associated with the X1, X2, and X3. Convenience stores require $4.125 million to build and 30 employees to operate, pharmaceutical stores require $8.25 million to

build and 15 employees to operate and supermarket-services stores require $12.375 million to build and 45 employees to operate.

The following is the "**objective function**" for the business problem.

Objective Function	SUMPRODUCT(B2:B4*D2:D4)

Here the objective function can be mathematically represented as

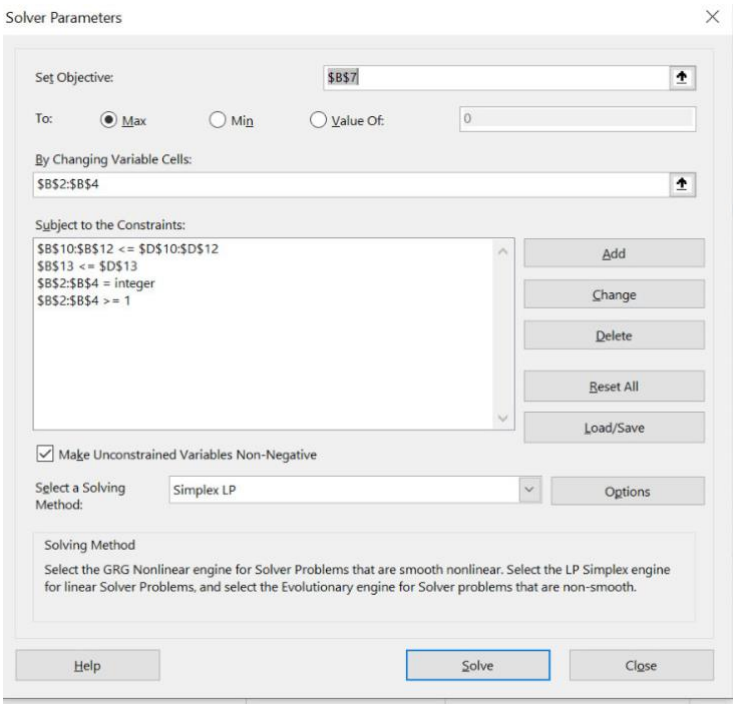
"maximum 1.2*X1 + 4*X2 + 2.6*X3"

The next table indicates the "**constraints**" for the business problem

Constraints	**LHS**		**RHS**
Total number of stores X1 + X2 + X3	0.0	<=	11
Construction Capital	0.0	<=	82.5
Number of employees	0.0	<=	340
Number of Pharmaceutical stores X2	0.0	<=	2
Number of stores X1, X2, X3 >= 1			
Number of stores = integer			

The major constraints here are, total number of stores being built cannot exceed 11, the construction capital of the entire project cannot exceed $82.5 million, number of employees to be allocated in all the stores must not exceed 340 and finally the number of pharmaceutical stores to be build cannot be more than 2 because of risk factors.

The next step from here is running the model using the solver add-in tool in Excel to find out the best optimal solution. Once we apply the solver, we must add the values in the pop up box to define the decision variable and constraints. In addition to the constraints defined in our excel worksheet, we have also added 2 additional constraints that X1, X2, X3 must be integer values and also must be greater than or equal to 1. (as shown in the table below)



After clicking on solve, it runs various series and combinations of trials to satisfy all the constraints and provide the required optimal solution. In this case our optimal solution is maximum revenue.

Below in the table we can see that all the constraints are satisfied and depicts maximum utilization of resources. Therefore, the optimal solution is maximum revenue of $23.2 million.

	A	B	C	D	E	F
1	***Decision Variables***			Net Annually (in millions)	Construction Costs (in millions)	Number of employees
2	X1=	**4.0**	Number of convenient stores	1.2	4.125	30
3	X2=	**2.0**	Number of pharmaceutical stores	4	8.25	15
4	X3=	**4.0**	Number of supermarket services stores	2.6	12.37	45
5	Total =	10.0		7.8	24.745	90
6						
7	***Objective Function***	23.2				
8						
9	***Constraints***	**LHS**		**RHS**		
10	Total number of stores X1 + X2 + X3	10.0	<=	11		
11	Construction Capital	82.48	<=	82.5		
12	Number of employees	330	<=	340		
13	Number of Pharmaceutical store X2	2.0	<=	2		
14	Number of stores X1, X2, X3 >= 1					
15	Number of stores = integer					
16						

Trying Different Scenarios for Further Analysis

#1

To further analyze the problem, our team has attempted to make variations in the constraints to check what other factors can make an impact on the revenue and increase the revenue more than how much it is at present.

One such scenario is where we have decided to remove the constraint of not building more than 2 pharmaceutical stores. This indeed has increased the revenue quite a lot. The revenue is now $35.9 million approximately.

	A	B	C	D	E	F
1	***Decision Variables***			Net Annually (in millions)	Construction Costs (in millions)	Number of employees
2	X1=	1.0	Number of convenient stores	1.2	4.125	30
3	X2=	8.0	Number of pharmaceutical stores	4	8.25	15
4	X3=	1.0	Number of expanded services stores	2.6	12.37	45
5	Total =	10.0		7.8	24.745	90
6						
7	***Objective Function***	35.80242				
8						
9	***Constraints***	**LHS**		**RHS**		
10	Total number of stores X1 + X2 + X3	10.0	<=	11		
11	Construction Capital	82.5	<=	82.5		
12	Number of employees	195.0091	<=	340		
13	Number of stores X1, X2, X3 >= 1					

Although this model gives the highest revenue, it defeats the objective of the risk factors involved in building pharmaceutical stores.

#2

In the next scenario we have added more constraints to see how it impacts the total revenue. The two additional constraints are that the combined construction capital for pharmaceuticals and supermarket stores must not exceed $50 million and the total number of employees to be allocated for convenient stores and supermarket stores should be at least 165.

	A	B	C	D	E	F
1	***Decision Variables***			Net Annually (in millions)	Construction Costs (in millions)	Number of employees
2	X1=	7.0	Number of convenient stores	1.2	4.125	30
3	X2=	2.0	Number of pharmaceutical stores	4	8.25	15
4	X3=	2.0	Number of supermarket services stores	2.6	12.37	45
5	Total =	11.0		7.8	24.745	90
6						
7	***Objective Function***	21.6				
8						
9	***Constraints***	**LHS**		**RHS**		
10	Total number of stores X1 + X2 + X3 + X4	11.0	<=	11		
11	Construction Capital	70.115	<=	82.5		
12	Number of employees	330	<=	340		
13	Number of Pharmaceutical store X2	2.0	<=	2		
14	Combined Construction capital for X2 & X3	41.2	<=	50		
15	Employees Alloted for X1 & X3	300.0	>=	165		
16	Number of stores X1, X2, X3,X4 >= 1					

By taking additional constraints into consideration the revenue now has become $21.6 million. However, the revenue has decreased by $1.6 million.

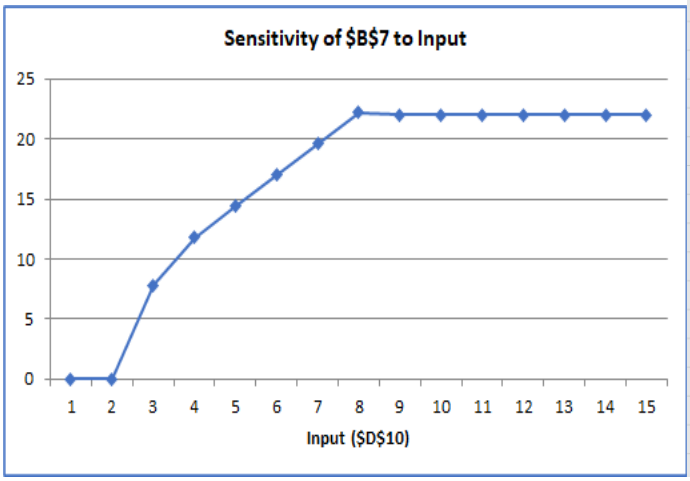
#3.1

One-way sensitivity analysis for Revenue & total number of stores

In the next three scenarios we would be analyzing how the revenue is impacted if pre-defined constraints are changed. Using one way analysis in the Solver-Table add in tool, we have taken 3 constraints of total number of stores, Construction capital and number of employees.

The **first one** is the **total number of stores.**

We have made variations to the number of stores with an increment of 1 from a minimum of 1 to a maximum of 15 stores. At 1 and 2 the optimal value is not feasible, however at 8 stores we have the maximum revenue but again a decrease from 9 to 15 stores. This implies that the total revenue is sensitive to variations made on the total number of stores and insensitive for the values 9 and above.



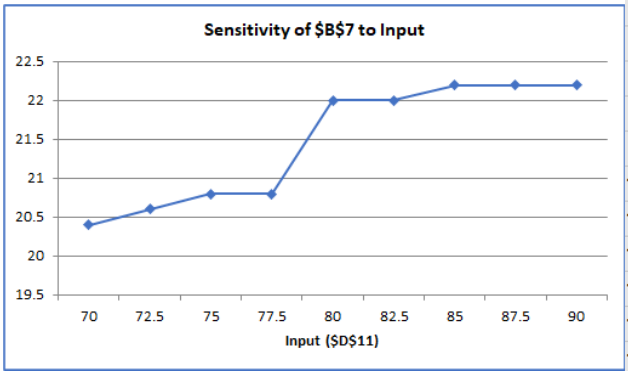
	A	B	C	D	E	F
1	**Oneway analysis for Solver model in Sheet2 worksheet**					
2						
3	Input (cell D10) values along side, output cell(s) along top					
4		B7				
5	1	Not feasible				
6	2	Not feasible				
7	3	7.8				
8	4	11.8				
9	5	14.4				
10	6	17				
11	7	19.6				
12	8	22.2				
13	9	22				
14	10	22				
15	11	22				
16	12	22				
17	13	22				
18	14	22				
19	15	22				
20						

#3.2

<u>One-way sensitivity analysis for Revenue & Construction capital</u>

Here we see the variations made on construction capital. Ranging from a minimum of $70 million to a maximum of $90 million with an increment of 2.5

In this case, the total revenue is sensitive to variation in construction capital. At $70 million the revenue is $20.4 and with further linear increments the revenue is $22.2 at $90 construction capital.

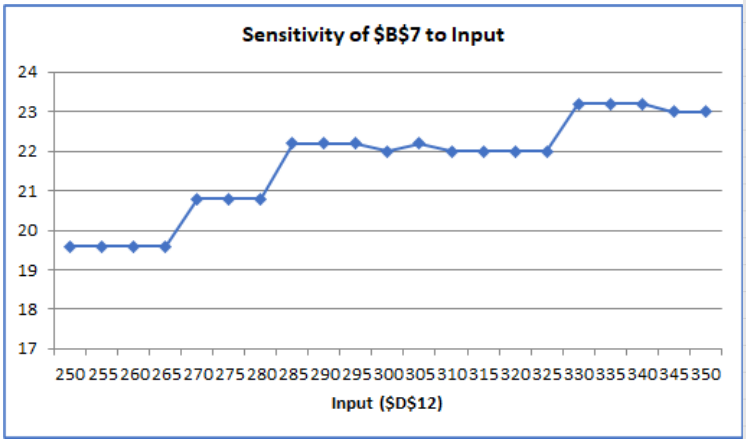


	A	B	C	D	E	F
1	Oneway analysis for Solver model in Sheet2 worksheet					
2						
3	Input (cell D11) values along side, output cell(s) along top					
4		B7				
5	70	20.4				
6	72.5	20.6				
7	75	20.8				
8	77.5	20.8				
9	80	22				
10	82.5	22				
11	85	22.2				
12	87.5	22.2				
13	90	22.2				
14						
15						

#3.3

One-way sensitivity analysis for Revenue & total number of employees

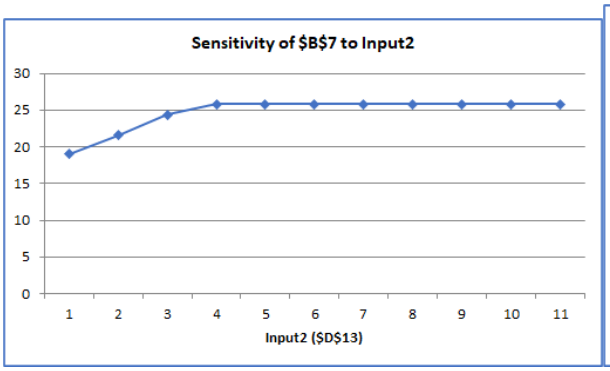
Next we are adding variations to the number of employees. Ranging from a minimum of 250 employees to a maximum of 350 employees with an increment of 5, we can see that the revenue varies from a range of $19.6 millions to $22 million from 250 to 325. And then there is a maximum revenue from 330 to 340 employees. Therefore, we can conclude that when the number of employees is from 330 to 340 the revenue is maximum.

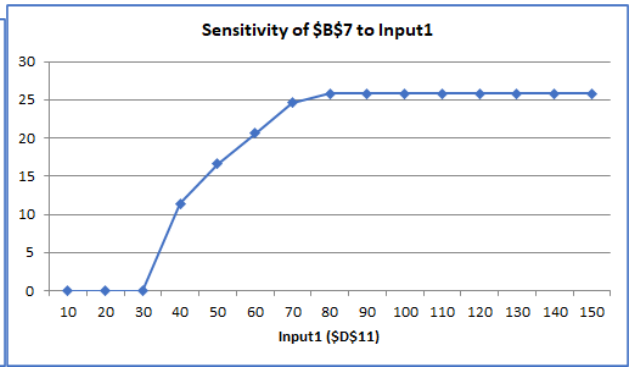


	A	B	C	D
4		B7		
5	250	19.6		
6	255	19.6		
7	260	19.6		
8	265	19.6		
9	270	20.8		
10	275	20.8		
11	280	20.8		
12	285	22.2		
13	290	22.2		
14	295	22.2		
15	300	22		
16	305	22.2		
17	310	22		
18	315	22		
19	320	22		
20	325	22		
21	330	23.2		
22	335	23.2		
23	340	23.2		
24	345	23		
25	350	23		

#4

<u>Two-way sensitivity analysis for Revenue w.r.t Construction capital and Number of Pharmaceutical stores.</u>





Overall, we can say that the revenue increases with increase in the number of pharmaceutical stores and capital invested by the company in total. From a range of 80-150$ million capital invested there is no change in revenue gained as its insensitive towards that constraint. If the number of pharmaceutical company is 4 or more it's not going to affect the overall renue, since it starts getting insensitive after 4 or more pharmaceutical stores.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	**Twoway analysis for Solver model in New added Constraint worksheet**																			
2														Output and Input1 value for chart				Output and Input2 value for chart		
3	Input1 (cell D11) values along side, Input2 (cell D13) values along top, output cell in corner													Output	Input1 value			Output	Input2 value	
4	B7	1	2	3	4	5	6	7	8	9	10	11		B7	140			B7	4	
5	10	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib		19				Not feasible		
6	20	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasible		21.6				Not feasible		
7	30	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasib	Not feasible		24.4				Not feasible		
8	40	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4		25.8				11.4		
9	50	15	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6		25.8				16.6		
10	60	17.4	19	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6		25.8				20.6		
11	70	17.8	20.4	23	24.6	24.6	24.6	24.6	24.6	24.6	24.6	24.6		25.8				24.6		
12	80	19	21.6	24.4	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8		25.8				25.8		
13	90	19	21.6	24.4	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8		25.8				25.8		
14	100	19	21.6	24.4	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8		25.8				25.8		
15	110	19	21.6	24.4	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8		25.8				25.8		
16	120	19	21.6	24.4	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8						25.8		
17	130	19	21.6	24.4	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8						25.8		
18	140	19	21.6	24.4	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8						25.8		
19	150	19	21.6	24.4	25.8	25.8	25.8	25.8	25.8	25.8	25.8	25.8						25.8		
20																				

Conclusion:

If the company is ready to invest and consider the aspect of drug shell life and to invest in pharmaceutical companies then having 1 convenience store , 8 pharmaceutical stores and 1 supermarket store would earn the company maximum revenue of 35.8$ million.

Otherwise, with the added constraint of 2 pharmaceutical stores or less, a total of 23.2$ million revenue could be earned with 4 convenience stores , 2 pharmaceutical stores and 4 supermarket stores.

With further added constraints of combined construction capital of pharmaceutical and supermarket of not more than 50$ million and total number of employees for convenience store and supermarket store at least 165 , we get a revenue of 21.6$ million.

Now depending upon further decision of the company as suggested by the Business Analyst any of these cases can be considered depending on the constraints to be considered as.


Thank you