MAXIMIZING PROFIT ANALYSIS

Shivani Vellanki

Introduction:

This project concerns a northern hardware company that intends to lease a warehouse to supply its goods to regional retailers. To maximize the company's net profit, we will run a monthly study utilizing a linear programming model. The company offers 4 goods. The products are listed below, along with their cost and selling prices.

Decision Variables	Cost Price (in $)	Selling Price (in $)
Pressure Washer	330	499.99
Go Kart	370	729.99
Generator	410	700.99
Water Pumps	127	269.99

1. **Mathematical formulation of the problem:**

We calculate the profit of each variable based on the given cost price and selling price. The quantity of products is represented by the decision variables x1, x2, x3, and x4.

Decision Variables	Decision Variables	Cost Price (in $)	Selling Price (in $)	Profit (in $)
X1	Pressure Washer	330	499.99	169.99
X2	Go Kart	370	729.99	359.99
X3	Generator	410	700.99	290.99
X4	Water Pumps	127	269.99	142.99

3.The objective of the model is to maximize the profit limiting to certain amount of budget with certain constraints like monthly budget, space, inventory requirements. The goal of this model is to maximize monthly net profits, which can be calculated as follows:

Linear Programming Formulation	
Objective	**Maximize** Z = 169.99x1 + 359.99x2 + 290.99x3 + 142.99x4
Constraints	**Monthly Budget**: 330x1 + 370x2 + 410x3 + 127x4 <= 170,000
	Space: 25x1 + 40x2 + 25x3 + 1.25x4 <= 12300
	Inventory Req 1: 25x1 + 40x2 >= 3690
	Inventory Req 2: x3 - 2x4 >= 0
	Non-Negative: x1,x2,x3,x4 >= 0

The "Monthly Budget" is calculated by summing the mathematical products of all the items and multiplying the cost price of each product by the product quantity. The sum should not be greater than $170,000. The area of each item is multiplied by the quantity to determine the "Space" constraint. The products are then added, keeping the total storage space within 12,300 square feet. The requirement that Go Karts and pressure washers account for at least 30% of the inventory is known as the "Inventory Req 1" constraint. The requirement that the corporation sell at least twice as many generators as water pumps is known as the "Inventory Req 2" constraint. The quantity cannot have a negative value, thereby imposing the non-negative constraint.

4. We determine the best solution using solver while taking the decision factors, objective, and constraints into account. The ideal number of units for each product, as well as the greatest profit that might be made, are listed below.

				Constraints			
		Quantity	Objective Paramaters	Monthly Budget	Space	Inventory Req 1	Inventory Req 2
3)	X1	0	169.99	330	25	25	0
	X2	155	359.99	370	40	40	0
	X3	238	290.99	410	25	0	1
	X4	119	142.99	127	1.25	0	-2
	Z = 169.99x1 + 359.99x2 + 290.99x3 + 142.99x4	142050.703					
			LHS	170000	12300	6207.16268	0
			Inequality	<=	<=	>=	>=
			RHS	170000	12300	3690	0

The highest profit that can be made is shown in the above figure at $142,050.703. The ideal approach has no pressure washer at all.

There are 155 Go-Karts in the ideal solution. Generator is present in 238 instances in the ideal solution. **In the ideal solution, 119 water pumps are used.**

5. The Reduced Cost for x1 is -110.07, while the Allowable Increase is 110.07, according to the Sensitivity Report mentioned below. Since the projected profit from x1 is the objective coefficient, we can raise the selling price by $110.07 to give x1 a value that is not zero.

Microsoft Excel 16.69 Sensitivity Report
Worksheet: [Book7]Sheet1
Report Created: 2/12/23 1:30:19 PM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
C17	X1 Quantity	0	-110.0715237	169.99	110.0715237	1E+30
C18	X2 Quantity	155.179067	0	359.99	205.8402439	76.73878564
C19	X3 Quantity	237.7692613	0	290.99	98.20490541	131.8664063
C20	X4 Quantity	118.8846306	0	142.99	196.4098108	89.11965734

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
E22	LHS Monthly Budget	170000	0.557648341	170000	23228.5	56225
F22	LHS Space	12300	3.841502841	12300	6078.378378	1257.086193
G22	LHS Inventory Req 1	6207.16268	0	3690	2517.16268	1E+30
H22	LHS Inventory Req 2	0	-33.68339104	0	314.5454545	974.1201949

	Quantity	Objective Paramaters	Monthly Budget	Space	Inventory Req 1	Inventory Req 2
			Constraints			
X1	434	280.0615237	330	25	25	0
X2	0	359.99	370	40	40	0
X3	56	290.99	410	25	0	1
X4	28	142.99	127	1.25	0	-2
Z = 169.99x1 + 359.99x2 + 290.99x3 + 142.99x4	142050.703					
		LHS	169736	12285	10850	0
		Inequality	<=	<=	>=	>=
		RHS	170000	12300	3690	0

We can observe from the solver output that the x1 value grows from **0 to 434 when the selling price is raised by $100.7.**

6. The Allowable increase for the "Monthly Budget Constraint LHS" is 23228.5, according to the Sensitivity analysis. To obtain the most profit, we employ solver and increase the RHS component of the budget constraint. Therefore, **the maximum profit that can be made using the $193228.5 increase in budget is $155004.03.**

6)			Constraints				
		Quantity	Objective Paramaters	Monthly Budget	Space	Inventory Req 1	Inventory Req 2
	X1	0	169.99	330	25	25	0
	X2	92	359.99	370	40	40	0
	X3	336	290.99	410	25	0	1
	X4	168	142.99	127	1.25	0	-2
	Z = 169.99x1 + 359.99x2 + 290.99x3 + 142.99x4	155004.0375					
			LHS	19322.85	12290	3680	0
			Inequality	<=	<=	>=	>=
			RHS	193228.5	12300	3690	0

7. According to the Sensitivity Report, the Allowable Decrease for the 'Space Constraint' is 1257.08. We reduce the RHS portion of the space constraint and use Solver to maximize profit. The maximum profit possible is $137,221.6, which is less than the original maximum profit of $142,050.703. As a result, it is **not advised to rent a smaller warehouse**.

		Constraints				
	Quantity	Objective Paramaters	Monthly Budget	Space	Inventory Req 1	Inventory Req 2
X1	0	169.99	330	25	25	0
X2	92	359.99	370	40	40	0
X3	287	290.99	410	25	0	1
X4	143	142.99	127	1.25	0	-2
Z = 169.99x1 + 359.99x2 + 290.99x3 + 142.99x4	137080.78					
		LHS	169871	11033.75	3680	1
	SMALLER WAREHOUSE	Inequality	<=	<=	>=	>=
		RHS	170000	11042.91381	3690	0

According to the Sensitivity Report, the Allowable increase for the 'Space Constraint' is 6078.37. To maximize profit, we increase the RHS portion of the space constraint and use Solver. - The maximum profit possible is $165400.81, which is greater than the initial maximum profit value of $142,050.703. As a result, **renting a larger space is advised.**

Conclusion:

According to the above linear programming model, the maximum profit that can be achieved with the original monthly budget of $170,000 and warehouse space of 12,300 sq ft is $142,050.703. We can estimate a $155004.03 profit increase with an increased monthly budget of $193228.5. We can estimate a maximum profit of $165400.81 with an increase in warehouse space of 18376.37 sq ft. It is recommended that the company plan for a larger warehouse to increase profits.

References:

The Organic Chemistry Tutor. (2018, February 16). *Linear Programming*. YouTube. https://www.youtube.com/watch?v=Bzzqx1F23a8

Goh, B. C., PhD. (2019, February 1). *Solve problems with linear programming and Excel*. FM Magazine. https://www.fm-magazine.com/issues/2019/feb/linear-programming-microsoft-excel.html