PROJECT REPORT

Using Linear Programming Models to maximize profits

ALY 6050 Intro to Enterprise Analytics
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Introduction:

This report offers a thorough examination of the best option for the new distribution facility for the northern hardware industry. For the facility in the southeast region, the corporation has set aside a budget of $150,000. The research focuses on figuring out the highest profit the business can make while taking into account numerous restrictions connected to product sales, space allocation, and financial restraints.

Part 1 presents the problem's mathematical formulation as well as the company's restrictions and information. The Excel solver is used to identify the best variables for each product, yielding a maximum return of $127,142.13. The analysis shows that even without selling a certain product category, like snowblowers, the company may become profitable.

The sensitivity report produced by the solution is examined in Part 2. The study focuses on the pressure washer decision variable's optimal value and calculates the lowest selling price at which this value might be changed from zero to non-zero. The restriction restricting the allocation of X1 is predicted to have a shadow price or dual value of 41.44. Based on this information, the pressure washer's lowest estimated selling price is $351.92. Part 3 of the analysis of the financial restriction finds that there is a $56.59 shortfall. This suggests that the company's budget can be increased by at least this much without impacting the best course of action. No extra investment is advised due to the budget allocation constraint of entire dollar amounts.

In Part 4, the space issue is examined, and it is found that the business would profit by renting a bigger warehouse because there is some available space. Based on the amount of space each item needs, the appropriate size of the suggested warehouse is determined. The sensitivity report does not, however, directly address the link between profit and warehouse size.

Item	Cost(in Dollars)	Selling Price(in Dollars)	Profit(in dollars)
Pressure washer(X1)	349.99	519.99	170
Lawn mower(X2)	374.99	719.99	345
Generator(X3)	399.99	699.99	300
Water pumps(X4)	131	249.99	118.99

Analysis:

Part 1:

The $150000 budget that the corporation has allocated for the new center located in the southeast region. Information about the warehouse's shelves, including how much room each product will need there, has been provided to us.

The following is the mathematical formulation that was created:

Maximize Z =	170X1 +345X2+ 300X3+ 118.99X4
Subject to:	
Budget	349.99 X1 + 374.99 X2 + 399.99 X3 +131 X4 <= 150000
Space	25X1 + 40X2 +25X3 +1.25X4 <= 12150
Allocation 1	X1+X2>= 0.36(X1+X2+X3+X4)
	0.64X1+0.64X2-0.36X3-0.36X4>=0
Allocation 2	X3>=1.8X4
	X3-1.8X4>=0
Non negativity	X1,X2,X3,X4>=0

The mathematical formulas and the limitations provided to us in the problem were used in the subsequent section. Budget, space, and product selling restrictions were involved. The variables for each product shown in the table below were discovered using the excel solver. We can obtain the company's profit using a linear programming model, which will be illuminating for us. Using the budget and marketing allocation, 36% of the generators, water pumps, pressure washers, and snowblowers are stored. 1.8 times more generators should be sold than water pumps. We were able to generate the maximum profit goal with the aid of the solver. $127142.13 is the maximum profit. These calculations show that even if the corporation didn't sell anything, it might still turn a profit.

	X1	X2	X3	X4	Maximize Z = 170X1 +345X2+ 300X3+ 118.99X4			
	0	202	157	87	127142.13			
Objective Parameters	170.00	345.00	300.00	118.99				
Constraint					Constraint LHS	Inequality	Constraint RHS	Unused Resource
Budget	349.99	374.99	399.99	131.00	149943.41	<=	150000	56.59
Space	25.00	40.00	25.00	1.25	12113.75	<=	12150	36.25
Allocation1	0.64	0.64	-0.36	-0.36	41.44	>=	0	41.44
Allocation2	0	0	1	-1.8	0.4	>=	0	0.4

We were able to produce the sensitivity report using the Excel solver. We can observe that the company's profit is maximized by the ideal quantities that can be sold. Along with the limitations imposed, we utilised the entire 12150 square feet of space allotted plus 30% of the area we purchased.

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$M$2	Profit(in dollars) Maximize Z = 170X1 +345X2+ 300X3+ 118.99X4	0	127142.13

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$I$2	Profit(in dollars) X1	0	0	Integer
$J$2	Profit(in dollars) X2	0	202	Integer
$K$2	Profit(in dollars) X3	0	157	Integer
$L$2	Profit(in dollars) X4	0	87	Integer

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$M$5	Budget Constraint LHS	149943.41	$M$5<=$O$5	Not Binding	56.59
$M$6	Space Constraint LHS	12113.75	$M$6<=$O$6	Not Binding	36.25
$M$7	Allocation1 Constraint LHS	41.44	$M$7>=$O$7	Not Binding	41.44
$M$8	Allocation2 Constraint LHS	0.4	$M$8>=$O$8	Not Binding	0.4
$I$2:$L$2=Integer					

Part 2:

It is demonstrated in the provided sensitivity report that the value of the decision variable X1 (Pressure washer) should be set to zero. We must identify the shadow price or dual value linked to the constraint that restricts the allocation of X1 in order to establish the smallest selling price for the pressure washer (X1) that would cause this optimal value to become non-zero

According to the constraint table, the constraint that affects how X1 is allocated is the "Allocation1" constraint

X1 + X2 >= 0.36 (X1 + X2 + X3 + X4) in Allocation 1.

This constraint's shadow price or dual value depicts how much an increase in the right-hand side of the constraint would affect the optimal value of the objective function. A higher allocation of X1 will result in a higher objective function value if the shadow price is positive.

According to the sensitivity report, the dual value or shadow price linked to the Allocation1 constraint is 41.44.

We may set up the following calculation to determine the Pressure washer (X1)'s minimum selling price that would cause its ideal value to become non-zero:

$0.36(X1 + X2 + X3 + X4) + 1 * \Delta X1 = 0$

Where $\Delta X1$ represents the change in the allocation of X1. We want to solve for $\Delta X1$.

Substituting the values from the sensitivity report, we have:

$0.36(0 + 202 + 157 + 87) + 1 * \Delta X1 = 0$

$0.36(446) + \Delta X1 = 0$

$\Delta X1 = -0.36(446)$

$\Delta X1 = -160.56$

We set X1 to 0 because the allocation cannot change negatively. Therefore, we would need to increase the allocation of X1 by at least 160.56 in order to shift the optimal value of X1 to a non-zero value.

Let's use the following formula to determine the Pressure washer (X1)'s lowest possible selling price:

Cost (X1) + Profit (X1) / X1 = Selling Price (X1)

The pressure washer has a $349.99 price tag, and the profit is $170.

Selling Price (X1) is 349.99 plus 170 divided by 160.56.

$351.92 is the selling price (X1).

Therefore, $351.92 is the lowest selling price for the Pressure washer (X1) that would cause a non-zero change in its optimal value.

Part 3:

The budget constraint is not legally obligatory, so the corporation should spend more funds in light of the information given. The entire cost of the things to be acquired cannot go over $150,000, according to the budgetary restriction.

Sensitivity assessment indicates that the budgetary restriction has a 56.59 percent slack. As a result, the business can raise its spending cap by at least $56.59 without compromising the best course of action. However, it would be reasonable to designate a round number because budgets are normally provided in whole dollar amounts.

We can take the cost of the items and their relative profits into account to establish the suggested further investment. The generator (X3), followed by the lawnmower (X2), pressure washer (X1), and water pumps (X4), has the biggest profit margin among the goods.

The company can deploy more funds to buy more generators (X3) or lawn mowers (X2) since they produce larger earnings given the available slack in the budget constraint and the profit margins.

Based on the available slack, let's determine the maximum number of generators (X3) or lawn mowers (X2) that can be bought:

Additional investment for generators (X3) = Slack / Cost of X3.
Rounding to the nearest whole integer, the additional investment is 56.59 / 399.99.
Additional investment equals zero because the outcome is less than one.

Regarding lawnmowers (X2):
Slack / Cost of X2 = more investment
(Rounded to the nearest full integer) Additional investment equals 56.59 / 374.99
Additional investment equals zero because the outcome is less than one.

According to the calculations, it is not possible to devote more funds for buying more things while staying within the budgetary restrictions and the available wiggle room. As a result, no additional investment is advised.
As a result, the business should anticipate that its net monthly profit will stay at $127,142 (rounded to the nearest dollar), as the purchase quantities of the items have not changed.

Part 4:

The company should hire a bigger warehouse in light of the available data. The amount of available space and the distribution of the various things would determine the appropriate size of the suggested warehouse. According to the sensitivity assessment, the corporation has some empty space because the space constraint is not legally obligatory. In order to handle additional merchandise, the company can profit from renting a bigger warehouse. We must take into account the space needs of each item to calculate the optimum warehouse size. Each item requires the following amount of space:

25 square feet per unit for pressure washer (X1)

Garden tractor (X2): 40 square feet each

Generator (X3): Each unit is 25 square feet

Water pumps (X4): 1.25 square feet per unit

From the optimal solution, we can see that the company is producing 0 units of pressure washer (X1), 202 units of lawn mower (X2), 157 units of generator (X3), and 87 units of water pumps (X4)

Therefore, the total space required in the warehouse is:

(0 units of X1 * 25 square feet) + (202 units of X2 * 40 square feet) + (157 units of X3 * 25 square feet) + (87 units of X4 * 1.25 square feet)

= 0 + 8080 + 3925 + 108.75

= 12113.75 square feet

Renting a warehouse somewhat bigger than 12113.75 square feet would be reasonable because the space constraint is not mandatory and there is some leeway in the constraint. 12120 square feet will do. Let's round up. The sensitivity report makes no mention of the direct connection between warehouse size and profit with regard to the change in warehouse size and its effect on monthly profit. As a result, the

information provided prevents us from calculating the precise proportion of the change in warehouse size to the monthly profit.

We were able to determine the company's ideal solution after putting different limitations on the solver.

Optimal benefits	127142.13
Pressure washer(X1)	0
Lawn mower(X2)	202
Generator(X3)	157
Water pumps(X4)	87

Conclusion:

In conclusion, using the excel solver and a thorough study, we have identified the best option for the new distribution center for the northern hardware company. By deploying their resources as follows: 0 units of pressure washers (X1), 202 units of lawn mowers (X2), 157 units of generators (X3), and 87 units of water pumps (X4), the company can anticipate making a maximum monthly profit of $127,142.13.

The sensitivity report has also provided us with insightful information. The corporation does not need to sell any pressure washers in order to make the most profit, as indicated by the decision variable X1's ideal value of 0, which is 0. In addition, we determined that the pressure washer's ideal value would change to a non-zero value at the cheapest selling price, which came to about $351.92.

We discovered that there is $56.59 in slack in the budget restriction, meaning that the business can increase its budget by this amount without influencing the best course of action. No extra investment is advised at this time, nevertheless, when total dollar amounts for budget allocation are taken into account. The corporation can profit from hiring a bigger warehouse because the space restriction is likewise not restrictive. It is advised for the business to take into account renting a warehouse that is a little bit bigger than 12,113.75 square feet based on the size needs of each item and the available space.

References:

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