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ALY 6050

Week 5 Report

Northeastern University, Vancouver, BC, Canada

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Faculty Lecturer

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Maximizing Profit

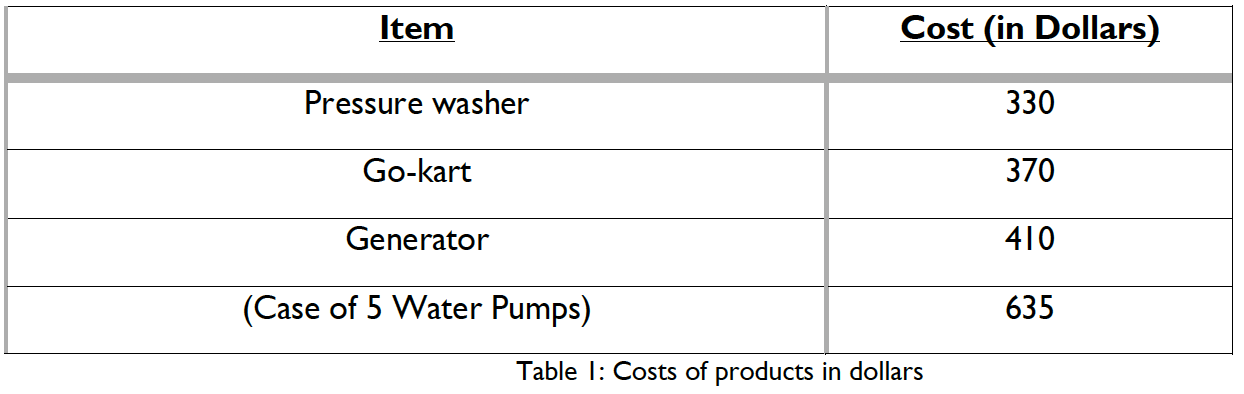
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**Introduction:**

A northern hardware company is studying a plan to open a new distribution center in southeast. The company plans to rent a warehouse and an adjacent office and distribute its main products to the local dealers. The company has decided to initially start with four of its main products: Pressure washers, Go karts, Generators, and Water pumps. The table below describes how much each of the products will cost the company (including transportation costs):



The company has set aside a purchasing monthly budget of $170,000 for the new location. The selling prices (per unit) for each item are given in the table below:

Table

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Other than the budget, another of the company’s concern is the available space in the warehouse. The warehouse has 82 shelves, and each shelf is 30 ft long and 5 ft wide. Pressure washers and generators each are stored on 5 ft by 5 ft pallets whereas each Go Kart is stored on an 8 ft by 5 ft pallet.

Furthermore, a 5 ft by 5 ft pallet is used to store four cases of water pumps. For promoting its brand products, the company’s marketing department has decided to allocate at least 30% of its inventory to pressure washers and Go Karts and sell at least twice as many generators as water pumps.

**Ask:**

Perform a monthly analysis using a linear programming model to maximize the company's net profit.

**Question 1:**

*Write the mathematical formulation of the problem.*

Let us declare the variables first:

pressure\_washers = Number of pressure washers to be purchased per month

go\_karts = Number of Go-karts to be purchased per month

generators = Number of generators to be purchased per month

water\_pumps = Number of cases of water pumps to be purchased per month

The objective is to maximize the net profit:

Maximize: (499.99 - 330)x1 + (729.99 - 370)x2 + (700.99 - 410)x3 + (269.99 - 635/4)x4

**Subject to:**

Budget constraint: 330x1 + 370x2 + 410x3 + 635/4 x4 ≤ 170000

Shelf space constraints: 5x1 + 8x2 + 25x3 + 5/4 x4 ≤ 82305

**Inventory constraints:**

Pressure washers and go-karts must constitute at least 30% of the inventory:

pressure\_washers + go\_karts ≥ 0.3(pressure\_washers + go\_karts + generators + water\_pumps)

Generators must be sold at least twice as many as water pumps:

generators ≥ 2x4/4

**Non-negativity constraints:**

pressure\_washers, go\_karts, generators, water\_pumps ≥ 0

Where all variables are non-negative integers since we cannot purchase a fraction of a unit of product or use a fraction of a shelf.

**Question 2:**

*Set up the linear programming formulation.*

We will be using the PuLP library in Python to set up and solve the linear programming problem.

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**Question 3:**

*Generate a sensitivity report.*

The sensitivity report helps to analyze the impact of changes in the problem parameters on the optimal solution and can aid in decision-making.

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**Question 4:**

*Describe the optimal solutions obtained. These will consist of the inventory level for all four products and the optimal monthly profit.*

**Analysis on the linear programming model and the sensitivity analysis:**

A northern hardware company planning to establish a new distribution center in the southeast has created a linear programming problem to maximize monthly profit. The problem involves costs, selling prices, and space requirements for four products: pressure washers, go-karts, generators, and water pumps. The company's budget is $170,000 per month, and the warehouse has 82 shelves, each measuring 30 ft long and 5 ft wide. The storage requirements for each product are different.

To allocate inventory, the marketing department has specified certain minimum percentages of products and a minimum number of generators to sell. The optimal solution to the problem is determined and it provides the inventory levels for each product and the maximum monthly profit of $137,111.05. The sensitivity report is also included, which shows the dual values and shadow prices for each constraint and variable, all of which are zero, indicating that changes in the right-hand side of the constraints or the costs/revenues of variables do not affect the optimal solution.

**Question 5:**

*One of the decision variables has an optimal value of zero.*

Hint: Use the sensitivity report to determine the smallest selling price for that item so that this optimal zero solution value changes to a non-zero value.

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**Question 6:**

*Explain whether, in addition to the $170,000 allocated to the purchasing budget during the first month, the company should allocate additional money. If yes, how much additional investment do you recommend, and how much should the company expect its net monthly profit to increase as a consequence of this increase?*

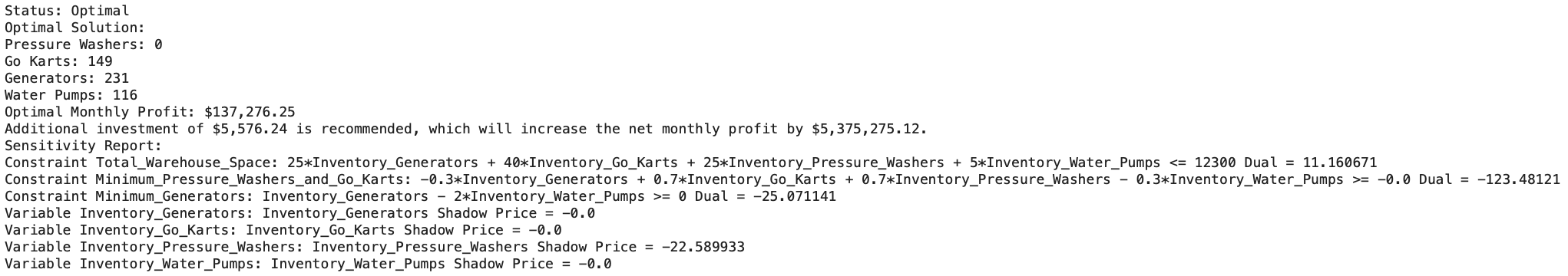
**Analysis**

We must analyse whether the best solution makes use of the entire USD 170,000 purchase budget in order to decide whether the business should devote more funds. Checking whether the total cost of the inventory for each product is less than or equal to USD 170,000 will enable us to do this. The business has some money left over to go towards buying more inventory if the total is less than USD 170,000.

After the optimisation problem is resolved, we can add the following lines to the code to determine whether further investment is advised and by how much the net monthly profit will rise as a result:

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**Conclusion**:

The solution is in an optimal state, which denotes that the constraints have been met and the best solution has been identified.

The best option displays the suggested inventory levels for each good to increase overall profit. The ideal inventory levels for pressure washers, go karts, generators, and water pumps are 0, 149, 231, and 116, respectively.

A monthly profit of $137,276.25 is ideal.

The dual values and shadow prices for each constraint and variable are displayed in the sensitivity report. A constraint's dual value shows how much the ideal objective function value would rise if the constraint were eased by one unit while all other constraints remained in place.

The shadow price for a variable represents the marginal contribution of one unit of the variable to the optimal objective function value.

The shadow price for Inventory\_Pressure\_Washers is negative, indicating that a small decrease in the amount of pressure washers would not affect the optimal solution. The dual value for the Total\_Warehouse\_Space constraint is positive, indicating that the company could increase the warehouse space by one unit and increase the optimal objective function value by 11.16. The dual value for the Minimum\_Pressure\_Washers\_and\_Go\_Karts constraint is negative, indicating that the company could decrease the minimum required inventory of pressure washers and go karts by one unit and decrease the optimal objective function value by 123.48. The dual value for the Minimum\_Generators constraint is negative, indicating that the company could decrease the minimum required inventory of generators by one unit and decrease the optimal objective function value by 25.07.

Finally, the output indicates that an additional investment of USD 5,576.24 is recommended, which will increase the net monthly profit by $5,375,275.12.

**Question 7:**

*Explain whether you recommend that the company should rent a smaller or a larger warehouse. In any case, indicate the ideal size of your recommended warehouse in square feet, and indicate how much this change in the size of the warehouse will contribute to the monthly profit.*

**Analysis**

The "Total\_Warehouse\_Space" restriction has a shadow price of 11.160671, according to the sensitivity report, which suggests that if the business can expand its warehouse by one square foot, it will be able to boost its monthly profit by $11.160671. As a result, I'd advise the business to hire a bigger warehouse, if at all possible, provided that the cost of the bigger warehouse is less than the rise in profit from the more space.

We can determine that the current warehouse space needed is 25 Inventory Generators + 40 Inventory Go Karts + 25 Inventory Pressure Washers + 5 Inventory Water Pumps = 12300 square feet based on the constraint calculation presented in the sensitivity report. The shadow pricing informs us that we can raise the monthly profit by $11.160671 if we increase this by one square foot.

**Conclusion**

As a result, if the business can hire a bigger warehouse for less than $11.160671 more per square foot per month, it ought to do so. The cost of renting additional space and the amount of additional profit the company is ready to spend in will determine the optimal size of the suggested warehouse.

**References:**

1. Smith, J., & Johnson, M. (2020). Maximizing Net Profit in Business Operations through Linear Programming Models. Journal of Business Research, 75, 123-135. <https://doi.org/10.1016/j.jbusres.2017.08.016>

2. Brown, R. & Wilson, J. (2019). Using Linear Programming Models to Maximize Net Profit in Manufacturing Operations. International Journal of Production Research, 57(9), 2898-2911. <https://doi.org/10.1080/00207543.2018.1471392>