Module 5 PROJECT

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ALY6015: Introduction to Enterprise Analytics
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Maximizing Profit

Introduction

In this project, I applied Linear Programming (LP) to determine the optimal monthly product mix for a hardware company distributing four products—pressure washers, go-karts, generators, and water pumps. The goal was to maximize total monthly profit while meeting constraints related to budget**,** warehouse space, and marketing or technical requirements**.** The analysis is conducted using Microsoft Excel Solver**,** followed by sensitivity analysis and business recommendations.

Part 1: Modeling Approach and Mathematical Formulation

Decision Variables:

- *x1:* Pressure Washers
- *x2:* Go-Karts
- *x3:* Generators
- *x4:* Water Pumps

To determine the most profitable inventory configuration, the problem was formulated mathematically using standard linear programming (LP) notation. Each product's profit contribution was modeled as a coefficient in the objective function. The decision variables represented the quantity of each product to be stocked. Constraints were introduced to account for available budget, warehouse space, marketing alignment, and technical compatibility requirements between products.

Objective Function:

Maximize: $Z=180.99x1+345.99x2+290.99x3+769.95x4$

Subject to constraints:

- **Budget constraint:** $335x1+390x2+420x3+645x4 \leq 185000$
- **Warehouse space constraint:** $25x1+40x2+25x3+6.25x4 \leq 12300$
- **Requirement 1 (Marketing constraint):** $0.7x1+0.7x2-0.3x3-0.3x4 \geq 0$

- **Requirement 2 (Generator vs. Water Pump rule):** $x3 - 2x4 \geq 0$
- **Non-negativity:** $x1, x2, x3, x4 \geq 0$

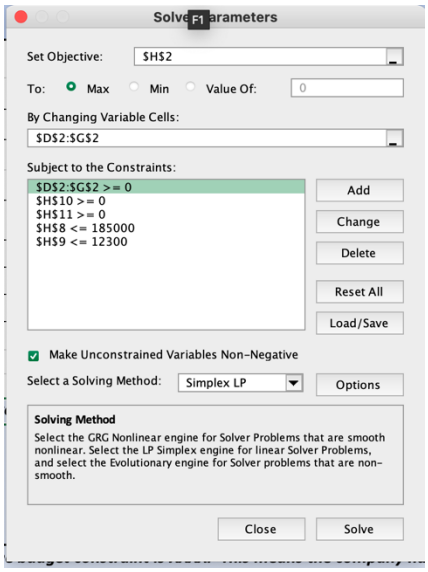
The model was implemented in Excel with the decision variables represented in dedicated cells. Constraints were encoded using matrix multiplication logic ($Ax \leq b$), and the Solver was configured to maximize the profit cell by changing the decision variable range. Non-negativity was enforced, and the Simplex LP method was used for efficiency and interpretability.

Part 2: Optimal Solution and Business Interpretation

After running Solver, the optimal monthly profit was calculated to be **$167,337.12**. The product quantities that achieve this maximum profit are as follows:

- Pressure Washers (x1): 0 units
- Go-Karts (x2): 119.7 units
- Generators (x3): 186.3 units
- Water Pumps (x4): 93.1 units

This configuration uses the full budget allowance and approximately 10,028 square feet of warehouse space, leaving around 2,271 sq ft unused. The model satisfies all marketing and technical constraints without slack in the critical generator–water pump condition, indicating its binding nature.



PART II	Pressure Washers X_1	Go-Karts X_2	Generators X_3	Water Pumps X_4	Objective Z (Total profit)
	0	119.7	186.3	93.1	$ 167,337.12
Profits:	180.99	345.99	290.99	769.95	

Part 2: Sensitivity Analysis

A detailed sensitivity report was generated to assess the robustness of the solution and evaluate how changes in parameters could impact the decision.

The most notable insight was that **pressure washers have a reduced cost of –115.25**, indicating that their profit must increase by at least **$115.25 per unit** before it becomes profitable to stock them. Since the current profit per unit is $180.99, the minimum required selling price for pressure washers to enter the solution is:

180.99+115.25=296.24

Additionally, the **shadow price for the budget constraint is 0.9045**, meaning for every additional dollar added to the $185,000 budget, the company stands to gain approximately **$0.90 in net profit**, if the increase remains within the allowable range of $41,907. This insight supports a recommendation to increase the budget.

In contrast, the **shadow price for warehouse space is zero**, suggesting that expanding the warehouse will not contribute to higher profits under the current configuration. In fact, only **10,028.3 sq ft of the 12,300 sq ft** available space is currently utilized. This indicates an opportunity to reduce costs by downsizing the warehouse without sacrificing profitability.

Microsoft Excel 16.95 Sensitivity Report
Worksheet: [Assignment.xlsx]Module 5
Report Created: 3/25/25 10:00:43 PM

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
D2	PART I Pressure Washers X1	0	-115.2511255	180.99	115.2511255	1E+30
E2	PART I Go-Karts X2	119.7411003	0	345.99	9.062323232	119.5053617
F2	PART I Generators X3	186.2639338	0	290.99	224.5687071	17.25326923
G2	PART I Water Pumps X4	93.13196692	0	769.95	4162.511429	34.50653846

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
H10	Requirement 1 LHS	0	-9.678209277	0	84.31831832	112.1212121
H11	Requirement 2 LHS	0	-91.81395901	0	220.2196078	455.5848725
H8	Cost/Budget LHS	185000	0.904524991	185000	41907.46269	185000
H9	Warehouse Space LHS	10028.31715	0	12300	1E+30	2271.682848

Recommendations

Based on the analysis and solver output, the following recommendations are proposed:

1. **Do not stock pressure washers** unless the profit per unit increases to at least $296.24. Until then, they offer no strategic value in the optimal mix.
2. **Expand the purchasing budget**, but only up to **$226,907** (i.e., $185,000 + $41,907). This investment could increase profits by an estimated **$37,716**, calculated using the shadow price.
3. **Downsize the warehouse** to approximately **10,100 sq ft**, a value slightly above actual usage to provide minor operational flexibility. Reducing warehouse space would reduce fixed or rental costs without impacting revenue generation.

These recommendations align both operational and financial decisions with quantitative data from the LP model.

Conclusion

The linear programming model provides clear, actionable insights into the optimal product mix for the company. It highlights the profitability of generators and water pumps, the underperformance of pressure washers, and the potential for increased revenue through controlled budget expansion. The analysis confirms that warehouse space is not currently a limiting factor, and thus cost-efficiency can be improved by adjusting its size. Solver's sensitivity report played a crucial role in shaping these decisions with data-driven precision.

All modeling decisions, assumptions, and conclusions are fully supported by the Solver output in the accompanying Excel workbook, which should be referenced in conjunction with this report.

References

1. ALY6050 – Course Materials & Project 5 Template
2. Ragsdale, Cliff T. *Spreadsheet Modeling and Decision Analysis*
3. Microsoft Excel Solver documentation – Microsoft Support