Guess What

SCM 518

Course Project

Optimizing Inventory for Zoyo Neighborhood Yogurt

Linear Programming Model

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Introduction

Background:

Zoyo Neighborhood Yogurt is a popular frozen yogurt shop offering a variety of flavors, smoothies, and parfaits. Its main ingredients include milk, cream, yogurt cultures, fruit, and granola, sourced from local suppliers.

Problem Statement:

During the winter season, ***customer visits decline*** significantly, reducing the demand for these products. Ordering the same quantities as in peak seasons leads to inventory surplus, storage issues, and financial losses.

Objective:

The goal is to develop an inventory optimization plan that ***minimizes procurement costs*** while ensuring sufficient stock to meet demand, staying within storage and budget constraints.

Type of Model

The Zoyo Neighborhood Yogurt problem is a ***Linear Programming*** (LP) model because it optimizes a linear objective function (minimizing cost) subject to linear constraints (demand, storage, and budget). It is a Budget Allocation problem within the broader category of Resource Allocation Models, as it involves distributing limited resources (ingredients, storage, and budget) efficiently to meet demand. This classification is due to the need to balance costs and resources while ensuring all constraints are met.

Data Collection

Key Data Points

Menu Items:

Vanilla Yogurt, Chocolate Yogurt, Strawberry Yogurt, Smoothie, Parfait.

Key Ingredients:

Milk, Cream, Yogurt Cultures, Fruit, Granola.

Constraints:

Total Budget: $450.

Total Storage Capacity: 180 sq. ft.

Ingredient Costs:

Milk: $2 per liter

Cream: $3 per liter

Yogurt Cultures: $5 per kg

Fruit: $4 per kg

Granola: $3 per kg

Storage Requirements:

Milk: 0.5 sq. ft./liter

Cream: 0.7 sq. ft./liter

Yogurt Cultures: 1.0 sq. ft./unit

Fruit: 0.8 sq. ft./unit

Granola: 0.6 sq. ft./unit

Menu/Ingredients	Milk(L/unit)	Cream(L/unit)	Yogurt cultures(kg/unit)	dry Fruit(kg/unit)	Granola(kg/unit)	Demand (units)
Vanilla Yogurt	0.8	0	0.1	0	0	50
Chocolate Yogurt	0.6	0.2	0.15	0	0	40
Strawberry Yogurt	0.7	0	0.1	0.2	0	35
Smoothie	0.4	0	0.05	0.3	0	30
Parfait	0	0	0.2	0.15	0.1	20

Mathematical Model

Objective Function

Minimize the total cost of purchasing the required ingredients:

Minimize: $\Sigma_{i \in \{1,2,3,4,5\}} C_i * X_i$

Where:

- C_i : Cost per unit of ingredient *i* (e.g., $2/liter for milk).
- X_i : Quantity of ingredient *i* to order.

Decision Variables

X_i : Quantity of each ingredient *i* to order:

- X_1 : Milk
- X_2 : Cream
- X_3 : Yogurt Cultures
- X_4 : Fruit
- X_5 : Granola

Constraints

1. **Demand Constraint**

Ensure enough ingredients are ordered to meet the demand for all menu items:

$X_i >= \Sigma_{i \in \{1,2,3,4,5\}} \Sigma_{j \in \{1,2,3,4,5\}} A_{ij} * D_j$

Where:

- A_{ij} : Amount of ingredient *i* required for one unit of menu item *j*.
- X_i : Quantity of ingredient *i* to order.

$X_1 >= 100.5$, $X_2 >= 8$, $X_3 >= 20$, $X_4 >= 19$, $X_5 >= 2$

3. **Budget Constraint**

Ensure total cost does not exceed the available budget:

$\Sigma_{i \in \{1,2,3,4,5\}} C_i * X_i <= B$

Where B = 450 (total budget)

$407 <= $450

2. **Storage Constraint**

Ensure total storage requirements do not exceed the available storage space:

$\Sigma_{i \in \{1,2,3,4,5\}} S_i * X_i <= SC$

Where:

- S_i: Storage requirement per unit of ingredient *i* (e.g., 0.5 sq. ft./liter for milk).
- SC : Total storage capacity (180 sq. ft.).

92.25 sq.ft. <= 180 sq.ft.

4. **Non-Negativity Constraint**

Quantities ordered must be non-negative:

$\Sigma_{i \in \{1,2,3,4,5\}} X_i >= 0$

Approach

<u>**Optimization Technique**</u>

Linear Programming

- The problem is formulated as a linear programming model with an objective to ***minimize ingredient costs*** while satisfying constraints for demand, storage capacity, and budget.

Key features of the model:

- Decision variables: Quantities of ingredients to order.
- Constraints: Demand satisfaction, storage, budget, and non-negativity.
- Solved using Python's Gurobi for linear programming.

<u>**Tools Used**</u>

1. **Excel**
   - Excel for data entry and constraints.
   - Solver for optimization.
2. **Python**
   - For modeling and running the optimization.

Results

Optimal Ingredient Quantities

Presenting the optimal quantities of each ingredient to order, as calculated by the linear programming model.

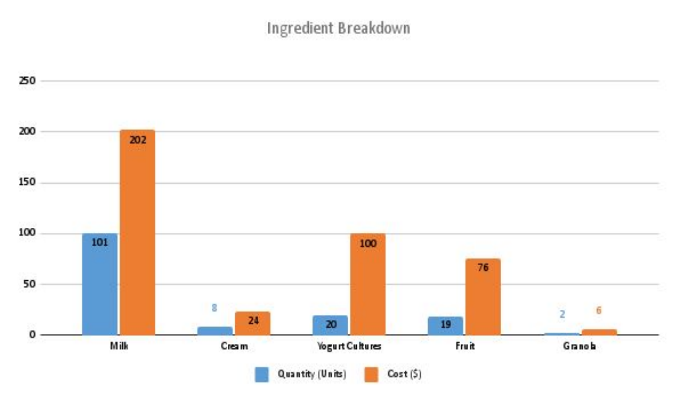
Ingredient	Optimal Quantity (units)	Cost ($)
Milk	101 L	202
Cream	8 L	24
Yogurt Cultures	20 kg	100
Fruit	19 kg	76
Granola	2 kg	6

Constraint Validation

Storage: 92.25 sq.ft. <= 180 sq.ft.

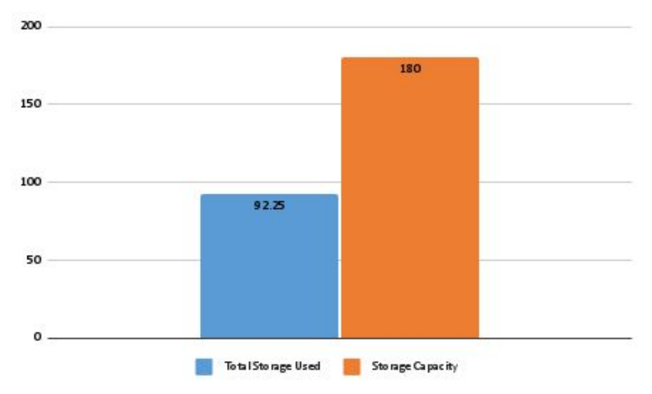
Budget: $407 <= $450

Visualization



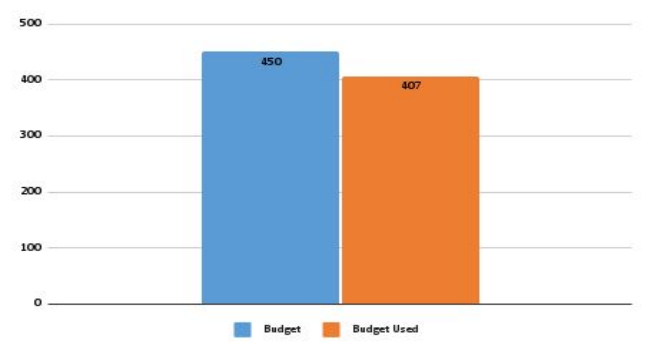
Ingredient Breakdown

Milk is the most significant contributor to both quantity (101 units) and cost ($202), highlighting its critical role in the inventory. Other ingredients have minimal contributions to cost and storage.



Storage Utilization

The total storage used (92.25 sq. ft.) is well below the storage capacity (180 sq. ft.), utilizing only about 51.25% of available space.



Budget Utilization

The budget used ($407) is well within the total budget ($450), leaving a margin of $43 for flexibility.

Insights

Key Takeaways

1. Cost Savings Achieved:

- The optimized inventory plan reduced ingredient costs to $407, saving $43 compared to the allocated budget of $450.
- Avoided overspending while ensuring sufficient stock for winter demand.

2. Efficient Use of Storage Space:

- The solution utilized 92.25 sq. ft. of the available 180 sq. ft., leaving significant space for other needs.
- Demonstrates effective use of limited storage capacity.

3. Practicality for Real-World Implementation:

- The model is adaptable for seasonal demand changes, ensuring Zoyo Neighborhood Yogurt remains competitive.
- Linear programming approach provides actionable insights for procurement planning.

Conclusion

Summary

Optimized procurement reduces costs ($407) and prevents wastage.

All constraints (demand, storage, budget) were satisfied.

Key Results

Used for initial data organization and analysis:

- Achieved a cost of $407, saving $43 under the allocated budget of $450.
- Efficiently utilized 92.25 sq. ft. of the available 180 sq. ft. storage space.
- Met projected demand for all menu items without overspending or exceeding storage limits.

Recommendations

Negotiate with suppliers for cost reductions on key ingredients like milk.

Any Questions?