Product Profit Optimization Using a Linear Programming Model:

New Chemicals Company in Tire Manufacturing Industry

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Problem Statement and Background

Use Case:
CB Corporation

Company Mission

1. Increase customer engagement for future sales by delivering on price and performance targets
2. Maximize efficiency of labor and resources to products chosen for sale and keep in line with internal sustainability targets
3. Select products that will maximize short-term profit for business

Background

CB Corporation wants to begin pilot scale production for their new R&D product formulations that they seek to sell to three prospective tire industry customers: Wheel Works, Tirevana, and Grip Gurus.

Problem

CB Corporation now needs to decide on what products are worth making and how much of the product to sell. They have a production trial week planned for the given sale period and two available sites ready for production.

Areas we explore

Research Questions

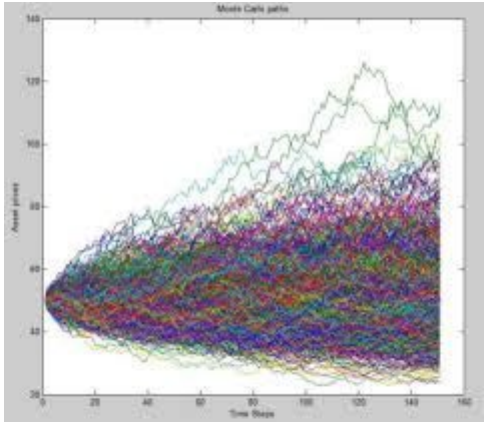
1. Will labor hours be a bigger constraint on **site choice** than inventory availability?
2. How many products will prove **unprofitable** and will not be sold due to low sale price and high raw material costs?
3. Can we **sell or trade unused raw materials** to gain more resources for profitable products?
4. What **model solving method** will be best for the decision problem?
5. How should we **allocate or forecast resources** in the future to maximize profit?
6. If we migrate this to a circular economy, how would that meet **sustainability goals** and further drive profit?

Literature Review: Similar Approaches

- Product Mix Optimization
    - Model Simplicity vs Complexity
- Advantages and Disadvantages of Literature Approaches

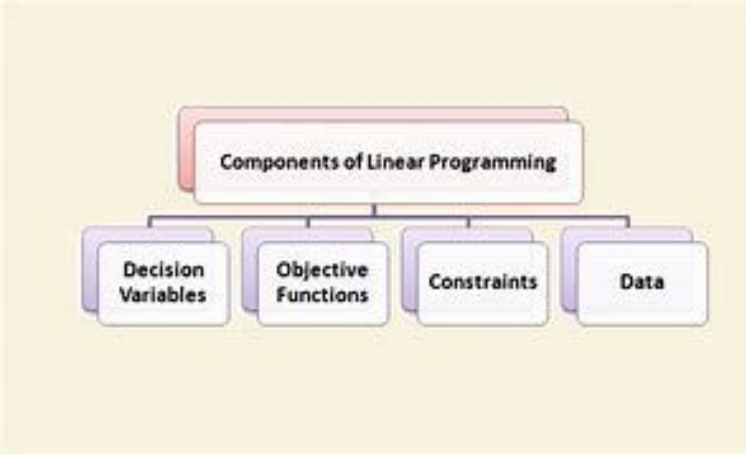
Literature Review: Alternative Approaches

- Deterministic vs Stochastic Models
    - Linear Programming
    - Monte Carlo
    - Simulated Annealing



Literature Review: Model Applications

- Complexity of Linear Programming Models
- Interdependencies
- Real-World Application



Model Implementation and Assumptions

- 168 hour constraint on labor per site
- Material availability constraint max per site
- Objective Function

$$P = \sum_{j=1}^{2} \sum_{i=1}^{9} (R_i x_{i,j} - C_i x_{i,j})$$

- R_i = Revenue (Product Sales Price) per Batch Unit of Product *i* (equiv. 15 kg)
- C_i = Raw Material Cost per Batch Unit of Product *i* (equiv. 15 kg)

$$= 15 * \sum_{i=1}^{9} (V_m * M_{m,i})$$

- *i* = {P1, P2, P8*, P3, P4, P4*, P10, P6, P9}
- *j* = {Site 1, Site 2}
- *m* = {RSXX, STYY, CBAA, CBZZ, SBRXL, SLSM, C10, C20, C30, C40, C60}

Methodology and Challenges

- Cross-product calculated profitability of each material per product (cost is material level)
  - And then the profitability per product
  - Factors in an array of labor to produce each product
- Factors in labor constraint per site
- Solved utilizing GLPK

$$c = \begin{vmatrix} i & j & k \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{vmatrix}$$

$$c = \begin{array}{l} [(a_2 \times b_3) - (a_3 \times b_2)]\, i \;+ \\ [(a_3 \times b_1) - (a_1 \times b_3)]\, j \;+ \\ [(a_1 \times b_2) - (a_2 \times b_1)]\, k \end{array}$$

Computational Experiments and Results

1. Optimal Value
2. Trade Offs
3. Raw Material Use
4. Sensitivity Analysis
5. Unused Materials
6. Production System

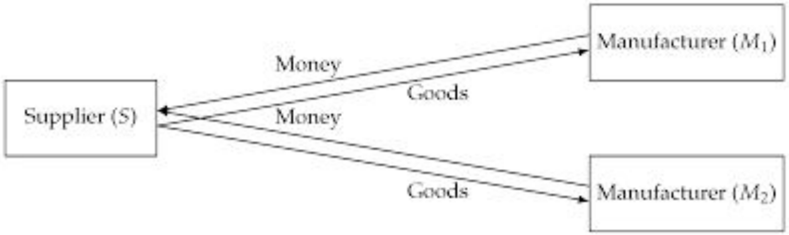
Total Maximized Profit Across Site 1 and Site 2: $75, 203.05

	Optimal Product Value at Site 1		Optimal Product Value at Site 2	
Product	**Value (Batch)**	**Profit ($)**	**Value (Batch)**	**Profit ($)**
Product 1	0.000	0.00	170.756	6,813.16
Product 2	0.000	0.00	0.000	0.00
Product 8B*	88.610	4,092.43	0.000	0.00
Product 3	238.689	9,398.37	0.000	0.00
Product 4	0.000	0.00	0.000	0.00
Product 4*	0.000	0.00	0.000	0.00
Product 10	156.863	19,894.14	128.205	16,259.60
Product 6	152.381	7,965.71	152.381	7,965.71
Product 9	0.000	0.00	28.657	2,813.88
	Total	41,350.68	**Total**	33,852.37

Model Limitations and Areas for Future Work

- Circular Economy
  - Recycle
  - Waste Reduction
  - Cost Reduction

- Resource Management
  - Forecasting
  - Storage and Transportation



Research Question Answers

1. Will labor hours be a bigger constraint on **site choice** than inventory availability?
    - *The biggest constraint on site choice appears to be inventory availability*
2. How many products will prove **unprofitable** and will not be sold due to low sale price and high raw material costs?
    - *There are 3 products: Products 2, 4, and 4**
3. Can we **sell or trade unused raw materials** to gain more resources for profitable products?
    - *Yes, including certain materials in the production plan contributes to suboptimality*
4. What **model solving method** will be best for the decision problem?
    - *Linear Programming Model*
5. How should we **allocate or forecast resources** in the future to maximize profit?
    - *Historical data should be used to forecast resource acquisition and allocation through quantitative models such as linear regression*
6. If we migrate this to a circular economy, how would that meet **sustainability goals** and further drive profit?
    - *By selling unused raw materials to other companies that need it*