Using Python

1. Value of Additional Pounds of Each Raw Material

The shadow prices indicate the potential increase in total profit if the company could acquire more raw materials:

- Material X: The shadow price is $0.85, meaning each additional pound of Material X would increase total profit by $0.85, assuming all else remains constant.
- Material Y: The shadow price is $2.40, which is significantly higher than Material X. This suggests that Material Y is the more constrained and valuable resource—securing additional Material Y would have a greater impact on improving profitability. This makes sense as the primary product is still the most profitable and with the 7500 of X and 9000 of Y, we have a surplus of X compared to a deficit of Y.
- Waste Balance: The shadow price of $0.25 indicates that each additional unit of waste that can be disposed of or treated effectively contributes $0.25 to total profit.

Recommendation: If possible, Smith-Brown Industrial Chemicals Inc. should prioritize securing additional Material Y over Material X, as it has a higher profit contribution per unit.

2. Sensitivity Analysis of Objective Function Coefficients

The sensitivity analysis on the primary product price suggests that profit is highly responsive to changes in the selling price of the primary product:

- If the price drops to $5.50, profit decreases to $26,175.
- If the price increases to $5.90, profit increases to $27,975.
- This highlights that pricing strategy plays a crucial role in overall profitability.

Additionally, the Reduced Costs reveal the following insights:

- Product M has a reduced cost of -$1.60, meaning that for it to become part of the optimal solution, its price must increase by at least $1.60 per pound to break even.
- Product K has a reduced cost of 0, suggesting that it is part of the current optimal solution (or very close to being profitable).

3. Accountant's Recommendation on Eliminating Product K

The accountant suggested eliminating Product K, believing it to be unprofitable. However, based on the sensitivity analysis:

- Product K has a reduced cost of $0.00, meaning it is either profitable or very close to the break-even point in the current model.

- Eliminating Product K would force more waste into either special treatment (which incurs a cost of $0.25 per pound) or production of Product M, which is significantly less profitable due to a -$1.60 reduced cost.

If Product K were eliminated, the optimal solution would likely shift more weight toward:

1. Producing more Product M, despite its high reduced cost.
2. Treating more waste, which would reduce overall profit.

Thus, removing Product K may not be the best decision. Instead, a better approach might be to reassess whether Product K's production cost can be reduced or its selling price increased slightly to improve its profitability.

With Solver

The sensitivity analysis indicates that Material Y is the most valuable resource, with a shadow price of $2.30 per pound, making it the top priority for securing additional supply. Product K remains viable, as its reduced cost is $0, meaning it contributes positively to profit, whereas Product M is currently unprofitable with a reduced cost of -$1.50, requiring a price increase to at least $2.05 to become viable. The primary product remains stable, as price fluctuations above $2.70 do not affect its optimal production. Waste treatment is necessary but should be carefully managed since its cost can rise to $0.60 before the optimal solution changes. Eliminating Product K, as suggested by the accountant, would be detrimental, as it would shift more waste into costly treatment or force production of Product M, which is not currently viable. Instead, the company should continue producing Product K, prioritize securing more Material Y, and monitor waste treatment costs carefully to maintain profitability.

Recommendation

1. Continue Producing Product K – Since Product K has a reduced cost of $0, it contributes positively to profit. Eliminating it, as suggested by the accountant, would increase waste treatment costs or force the production of Product M, which is currently unprofitable (-$1.50 reduced cost).
2. Do Not Produce Product M Unless Its Price Increases – Product M is not part of the optimal solution, and its selling price must increase to at least $2.05 for it to be viable.
3. Keep Primary Product Pricing Above $2.70 – The primary product remains stable unless its price drops below $2.70, at which point profitability would be impacted.

Reflection

This project required a combination of accounting knowledge, mathematical optimization, and computational tools to determine the most cost-effective method for handling liquid waste in a chemical manufacturing process. I already had experience with accounting principles and equation maximization, including calculus-based derivations to find maxima and minima. However, to effectively solve this problem, I needed to learn new tools such as PuLP in Python and Excel Solver, both of which are essential for formulating and solving linear optimization problems.

One of the biggest challenges in completing this project was that it did not involve traditional data analysis but instead required applying optimization techniques to an accounting-style problem. Unlike standard data science tasks that focus on large datasets, pattern recognition, or predictive modeling, this project required structuring constraints, defining an objective function, and interpreting sensitivity analysis results. Learning how to properly set up constraints in Excel Solver and formulate an optimization problem in PuLP took time but ultimately helped in achieving a structured and analytical approach to decision-making.

Overall, this experience reinforced my understanding of optimization and decision science while introducing me to new computational tools that will be useful for similar analytical challenges in the future. It also highlighted the importance of adapting data science techniques to real-world business problems, even when they do not involve traditional datasets.