**Title: Optimizing Production and Transportation Costs for a Diverse Product Line**

**Problem Statement**: In a competitive market, managing production and transportation costs while maintaining stock levels and meeting sales targets is crucial for maximizing profitability. Efficiently allocating resources across various products can significantly impact a company's bottom line. Given the complexity of managing multiple product types with distinct production and logistical requirements, a methodical approach is necessary to optimize costs and resource allocation.

**Project Objective**: Utilize the Simplex Method to minimize the total costs associated with manufacturing and transporting a range of products, taking into account constraints like stock levels, sales targets, lead times, and quality control.

**Dataset Link**: <https://www.kaggle.com/datasets/amirmotefaker/supply-chain-dataset>

**Overview of the Dataset**: The dataset includes multiple attributes for a variety of products, such as manufacturing costs, transportation costs, stock levels, sales volumes, and defect rates. Each product is identified by a unique SKU, and additional details like lead times and product availability are provided to simulate realistic operational constraints.

**Goals**:

1. Minimize Total Costs: Reduce the sum of manufacturing and transportation costs across all products.
2. Comply with Stock Constraints: Ensure that production volumes do not exceed available stock levels to prevent overproduction and potential wastage.
3. Meet Sales Targets: Achieve or exceed minimum sales volumes to ensure market presence and customer satisfaction.
4. Adhere to Lead Times: Manage production and transportation schedules to meet lead times, ensuring timely delivery of products.

**Project Plan**:

1. Define the Objective Function: The objective function will sum the product of quantities produced and the associated costs (manufacturing plus transportation) for each product.
2. Set Constraints: Constraints will include inequalities for stock levels and sales targets, and possibly other operational constraints derived from the dataset.
3. Optimization Tool: GNU Octave will be used along with the GLPK package to implement and solve the linear programming problem using the Simplex Method.

**Expected Outcomes**: Determination of optimal production quantities for each product that minimize total costs while satisfying all constraints.

**Probable Objective Function**: We aim to minimize the total costs, which include manufacturing and transportation costs

: Minimize 𝑍=∑(𝑥𝑖⋅Manufacturing costs𝑖+𝑥𝑖⋅Transportation costs𝑖)

Where 𝑥 𝑖 is the quantity of product i to be produced and transported.

**Constraints:**

1. **Stock Level Constraint**: The production should not exceed the stock levels to avoid overstocking. 𝑥𝑖≤Stock levels
2. **Sales Volume Constraint**: Ensure that the number of products sold meets a minimum sales target to maintain market presence. 𝑥𝑖≥Minimum sales target
3. **Lead Time Constraint**: Production and shipping must be completed within the lead time constraints to ensure timely delivery. Manufacturing lead time + Lead times≤Maximum allowable lead time
4. **Defect Rate Constraint**: Maintain defect rates below a certain threshold to ensure quality. Defect rates≤Maximum allowable defect rate

We need to find out the values of

Stock levels

Minimum sales target

Maximum allowable lead time

Maximum allowable defect rate

1. Stock Levels

For setting Minimum and Maximum Stock Levels, you need to analyze historical stock data:

Minimum Stock Level: Calculate the lowest historical stock level but consider increasing it slightly to avoid stockouts.

Maximum Stock Level: Determine the highest historical stock level but adjust it down to avoid excessive inventory holding costs.

Formulas:

Minimum Stock Level = percentile of historical stock levels (e.g., 10th percentile)

Maximum Stock Level = percentile of historical stock levels (e.g., 90th percentile)

2. Minimum Sales Target

Analyze historical sales data to set realistic sales targets:

Calculate the average sales over a chosen historical period.

Adjust based on trends: If there is a growth trend, you might want to set targets above the historical average.

Formula:

Minimum Sales Target = average historical sales

3. Maximum Allowable Lead Time

This refers to the longest acceptable period from order to delivery:

Analyze the historical lead time data from your dataset.

Set the maximum based on the upper range of historical data, perhaps using a high percentile to ensure you cover most scenarios without overestimating.

Formula:

Maximum Allowable Lead Time = a high percentile (e.g., 95th percentile) of historical lead times

4. Maximum Allowable Defect Rate

Determine acceptable quality levels by analyzing defect rates:

Calculate the average defect rate from historical quality data.

Consider setting a threshold that is slightly above the average but low enough to maintain quality standards.

Formula:

Maximum Allowable Defect Rate = average defect rate + standard deviation (to provide a buffer)

The python code to find

Stock levels

Minimum sales target

Maximum allowable lead time

Maximum allowable defect rate

Is given below

import pandas as pd

import numpy as np

# Load your dataset

df = pd.read\_csv(‘')

# Calculate stock levels

min\_stock\_level = np.percentile(df['Stock levels'], 10)

max\_stock\_level = np.percentile(df['Stock levels'], 90)

# Calculate minimum sales target

min\_sales\_target = df['Number of products sold'].mean()

# Calculate maximum allowable lead time

max\_allowable\_lead\_time = np.percentile(df['Lead times'], 95)

# Calculate maximum allowable defect rate

max\_allowable\_defect\_rate = df['Defect rates'].mean() + df['Defect rates'].std()

# Print results

print("Minimum Stock Level:", min\_stock\_level)

print("Maximum Stock Level:", max\_stock\_level)

print("Minimum Sales Target:", min\_sales\_target)

print("Maximum Allowable Lead Time:", max\_allowable\_lead\_time)

print("Maximum Allowable Defect Rate:", max\_allowable\_defect\_rate)