**Summary of the Acme Case Study**

This document outlines a structured approach to analyzing and optimizing sales and margin growth for a company dealing with beauty and cosmetic products. The case study involves **data generation, optimization techniques, revenue and margin maximization, and predictive modeling** to achieve business objectives.

**Step 1: Synthetic Dataset Creation**

* A **synthetic dataset** was generated using feature engineering.
* The dataset contains **1000 records** across various brands, product categories, geographies, and portfolios.
* Random values were assigned to key metrics like **revenue, margin, trends, and contribution percentages**.
* The dataset was saved as a CSV file.

**Step 2: Sales Maximization**

* **Constraints were generated** at three levels:
  + **Global constraints** (e.g., max growth of 15%, max margin of 30%).
  + **Branch-level constraints** (region-specific growth/margin caps).
  + **Unit-level constraints** (growth and margin tied to product characteristics).
* A function was implemented to:
  + **Calculate the maximum possible sales** based on growth constraints.
  + **Compute profitability** by multiplying sales with margin.
  + Identify whether **requested growth targets are achievable**.

**Step 3: Margin Maximization**

* **Margin optimization** was performed by:
  + **Applying growth constraints** to margins.
  + Computing **new contribution values** for revenue growth.
  + Checking whether **requested margin increases are achievable**.

**Step 4: Hitting a Sales Target While Maximizing Margin**

* A function was designed to:
  + **Sort products by margin** (highest first).
  + **Cumulatively add sales** until the target is reached.
  + **Adjust contributions** dynamically.
  + **Check if the target is realistically achievable**.

**Step 5: Hitting a Margin Target While Maximizing Sales**

* A similar approach was used as in Step 4:
  + **Products were sorted by revenue** (highest first).
  + **Cumulative margin growth was calculated**.
  + The function determined whether the **target margin was reached**.

**Step 6: 5-Year Projections**

* **Revenue and margin were projected** over 5 years.
* Constraints like:
  + **Max growth per year** (default 5%).
  + **Max margins increase per year** (default 2%).
  + **Trend influence** (impact of market trends on sales).
* The function computed:
  + **Total projected revenue** over 5 years.
  + **Total projected contribution** over 5 years.

**Exploratory Data Analysis (EDA)**

* **Summary statistics** and **missing values check** were performed.
* **Visualization techniques included**:
  + **Histograms** for revenue, margin, trends.
  + **Correlation heatmaps** to understand relationships.
  + **Box plots** for outlier detection.

**Hypothesis Testing**

* **Shapiro-Wilk and Kolmogorov-Smirnov tests** showed that revenue data **does not follow a normal distribution**.
* **Histograms and Q-Q plots** confirmed the non-normality of revenue distribution.

**Machine Learning Model for Revenue Prediction**

1. **Data Preparation:**
   * Created a **binary target** (High/Low Revenue).
   * Selected features: **Margin, Max Trend, Max Contribution**.
   * Splitting into **training (80%) and testing (20%) datasets**.
2. **K-Nearest Neighbors (KNN) Classifier:**
   * **Hyperparameter tuning** was performed using **GridSearchCV**.
   * Best parameters: **11 neighbors, Manhattan distance, weighted model**.
3. **Model Performance:**
   * **Accuracy: 54%** (not very high).
   * **AUC (ROC curve): 55%** (indicating weak classification ability).
4. **Visualization:**
   * **ROC Curve** plotted to evaluate classification performance.

**Key Takeaways**

1. **Sales and margin can be optimized** using linear programming and constraints.
2. **Not all growth/margin targets are achievable** due to real-world limitations.
3. **Revenue does not follow a normal distribution**, affecting statistical assumptions.
4. **Machine learning (KNN) struggled** to classify high vs. low revenue products, indicating the need for better features or models.

**Business Insights from the Acme Case Study**

This case study is centered around optimizing **sales growth, margin maximization, and long-term revenue forecasting** in the beauty and cosmetics industry. It provides a **data-driven approach** to improving business performance using **analytics, optimization, and machine learning**. Below are key takeaways from a **business perspective**:

**1. Sales Growth Strategy: Unlocking Revenue Potential**

* The study shows how **growth constraints (market conditions, brand positioning, and product trends)** impact revenue.
* By identifying **high-growth segments**, companies can **prioritize investment in products with the highest potential**.
* **Key Business Insight:**
  + Instead of a **one-size-fits-all** growth strategy, businesses should adopt a **regional and product-specific** strategy.
  + **Example:** If "Luxury Fragrances in North America" has a **higher growth trend**, marketing efforts should focus on **expanding distribution and premium pricing** in this segment.

**2. Margin Optimization: Enhancing Profitability**

* The analysis identifies **the maximum achievable margin** for different products and regions.
* **High-margin products should be prioritized** in pricing and promotional strategies to **increase profitability**.
* **Key Business Insight:**
  + Instead of focusing solely on revenue growth, businesses should **balance volume and profitability**.
  + **Example:** If "Aveda Foundation" has a **low margin but high sales volume**, the company should **adjust pricing or cost structure** to improve profitability.

**3. Achieving Target Sales with Smart Pricing & Promotions**

* The study highlights **how businesses can hit revenue targets** while optimizing profitability.
* **Sorting products by margin and prioritizing high-margin items** ensures that **sales growth does not come at the cost of profit erosion**.
* **Key Business Insight:**
  + Businesses often focus on increasing revenue, but **blindly pushing sales can dilute margins**.
  + **Example:** If a company needs to reach **$50 million in sales**, it should **promote high-margin products first** instead of offering excessive discounts on low-margin items.

**4. Sustainable Margin Growth & Cost Management**

* Businesses aiming for **higher profitability should optimize product mix** rather than just increasing volume.
* The study shows how **cumulative margin growth is achieved through targeted pricing strategies**.
* **Key Business Insight:**
  + Instead of setting arbitrary profit goals, businesses should **leverage data to set achievable margin targets**.
  + **Example:** If the target margin increase is **$10 million**, the company should **prioritize high margin products** and **negotiate better supplier contracts** to reduce costs.

**5. Long-Term Business Forecasting: 5-Year Revenue Projection**

* The study projects **revenue and margin growth over 5 years**, providing **a roadmap for strategic decision-making**.
* By applying **market trends and business constraints**, the company can forecast **realistic growth scenarios**.
* **Key Business Insight:**
  + Instead of **reacting to market changes**, businesses should **use predictive analytics** to **proactively plan investments, expansions, and cost-cutting strategies**.
  + **Example:** If the forecast shows **5% annual growth in skincare**, the company can **expand production, invest in R&D, and secure supplier contracts early** to meet demand.

**6. Data-Driven Decision Making in Revenue Strategy**

* The study highlights **correlations between revenue, margin, and product trends**.
* Machine learning was used to **predict high-revenue products**, but accuracy was low (54%), showing **a need for better data models**.
* **Key Business Insight:**
  + **Relying on traditional intuition-based decisions is no longer effective.** Businesses must invest in **AI-driven demand forecasting** for better accuracy.
  + **Example:** If machine learning struggles to predict high-revenue products, the company should **improve data collection** and **incorporate external factors like market demand and competitor pricing**.

**7. Identifying Market Opportunities & Risks**

* The study confirms that **revenue distribution is not normal**, meaning some brands outperform others significantly.
* **High-revenue segments should receive focused investment**, while underperforming segments need reevaluation.
* **Key Business Insight:**
  + Instead of spreading marketing budgets **equally across all products**, focus on **high-growth categories**.
  + **Example:** If "Luxury Skincare in Europe" has the **highest revenue potential**, invest in **premium branding, influencer partnerships, and exclusive distribution**.

**8. Optimizing Customer Acquisition & Retention Strategies**

* The study suggests that businesses should **analyze profitability before running aggressive sales campaigns**.
* Instead of **blindly increasing discounts**, pricing should be **dynamic and based on demand elasticity**.
* **Key Business Insight:**
  + **Discounting should be strategic.** Run promotions on **high-margin or low-cost-acquisition products** while maintaining premium pricing on in-demand items.
  + **Example:** If "Lipsticks in North America" have **a high contribution margin**, a **Buy One, Get One** (BOGO) offer can drive volume without hurting profits.

**Final Business Recommendations**

* **Revenue growth should be driven by data insights, not assumptions.**  
  🡪 Focus on **high-growth geographies and categories**.
* **Maximizing sales is not enough; margins must be optimized.**  
  🡪 Prioritize **high-margin products** over volume-driven revenue increases.
* **Long-term forecasting is essential for sustainable business growth.**  
  🡪 Use **predictive models to plan for market shifts and expansion opportunities**.
* **Machine learning can enhance decision-making, but data quality is key.**  
  🡪 Improve **data collection on consumer behavior, market trends, and competitor pricing**.
* **Strategic pricing and promotions should balance volume and profitability.**  
  🡪 Avoid **over-discounting**, and instead, **use targeted offers on high-margin products**.
* **Market leaders leverage AI-driven forecasting for a competitive edge.**  
  🡪 Invest in **advanced analytics and AI models** to stay ahead of competitors.