Supply Chain Analysis and Forecasting Project Report

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Introduction

In the face of ongoing challenges in today's market, it has become essential for organizations to rely on data analysis to extract strategic insights that contribute to improving business performance. And Supply chains play a crucial role in ensuring the seamless movement of goods from manufacturers to consumers.

This report provides a comprehensive analysis of Supply chain data focusing on several indicators related to product revenue, stock availability, lead times, defect rates, transportation costs sales, inventory, supplier performance, shipping, and quality. The aim is to present actionable solutions based on data that assist in making strategic decisions to enhance profitability and Overall efficiency.

Objectives

The main objectives of this project are:

1. To analyze key supply chain metrics and identify trends and bottlenecks.
2. To forecast future values based on historical data for critical metrics like revenue, demand, and transportation costs.
3. To provide actionable insights for improving operational efficiency.

Data Cleaning

```
df.duplicated().sum()

0

df.isnull().sum()
```

Here are the results of the data cleaning process:

1. **Missing values**: There are no missing values in any of the columns.

2. **Duplicates**: No duplicate rows were found, so no duplicates were removed.

3. **Negative values**: There are no negative values in any of the numeric columns, meaning all values are within a valid range.

The dataset seems to be clean and ready for further analysis.

Data Overview

The dataset provided contains information on:

- **Product categories** (Skincare, Haircare, Cosmetics)
- **Revenue generated** per category
- **Stock levels** and **availability** of products
- **Lead times** for products
- **Defect rates** across categories
- **Transportation modes** and **costs** (Air, Sea)

The data has been cleaned and optimized to ensure accurate analysis and forecasting.

Key Findings

- **Sales and Revenue Analysis**

A. **Best-Selling Products**

By analyzing the number of units sold for each product, the top-selling products have been identified, reflecting customer preferences. This analysis helps to focus marketing and promotional efforts on the most in-demand products, thereby increasing revenue.
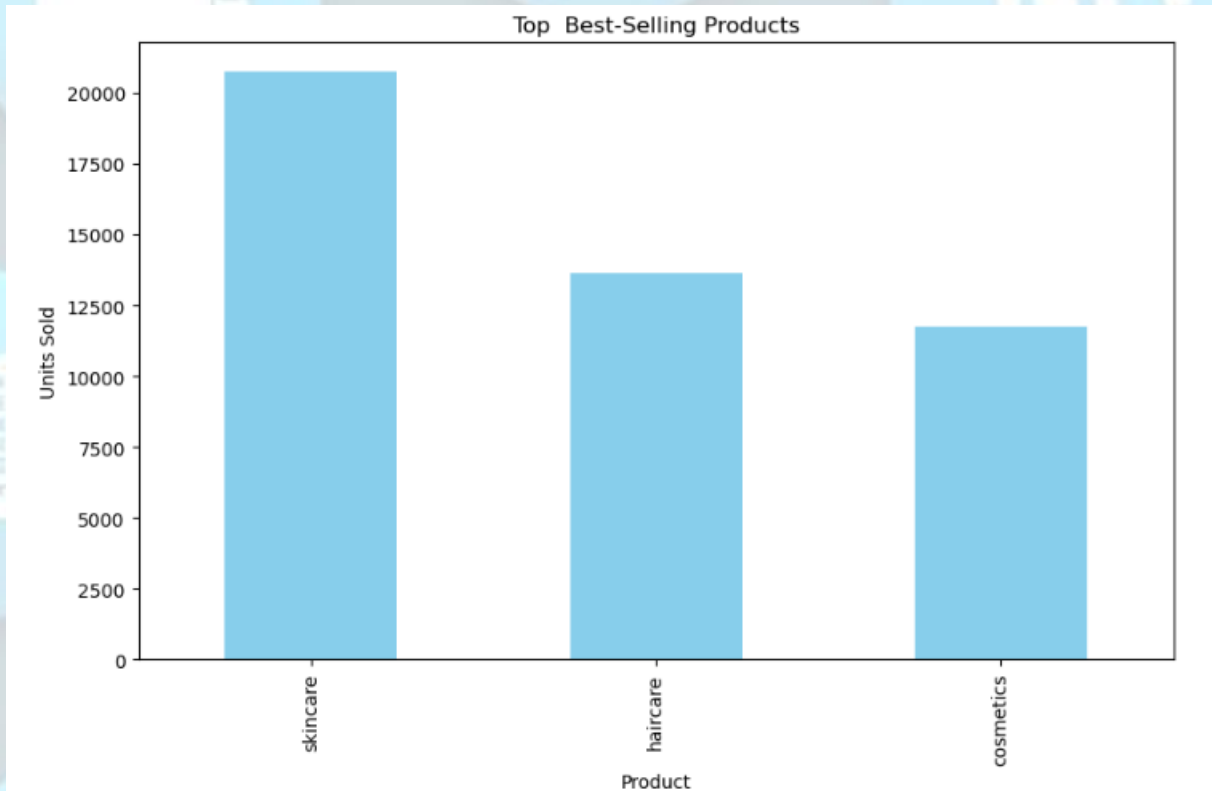
Best-selling products represent the primary opportunities to boost future sales. Products with high sales volumes (Skincare, Haircare, and Cosmetics) deserve more focus in marketing campaigns and innovations to expand their market share.

Recommendation: Focus on scaling the Skincare category while exploring opportunities to boost sales in Haircare and Cosmetics through targeted marketing campaigns.

B. Most Profitable Product Categories

The revenue generated by each product category was studied, revealing the categories that contribute significantly to profitability. These categories require additional investment in improving distribution and reducing associated costs to maximize their profitability.
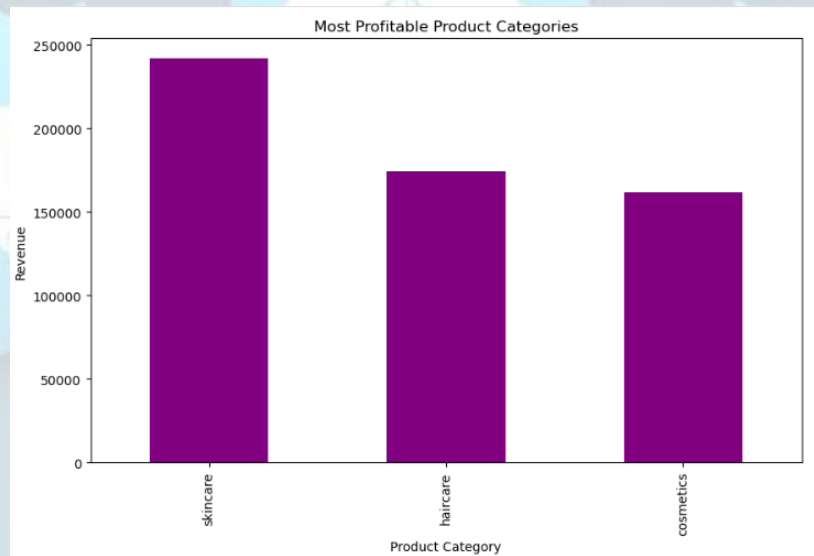
Recommendation: Most profitable categories offer opportunities for market expansion through flexible pricing strategies and innovative promotional offers.

C. Impact of Pricing on Sales Volume

By analyzing the correlation between *prices* and *sales volume*, it was concluded that pricing plays a significant role in driving sales. This relationship indicates that strategically lowering prices may lead to an increase in sales, although it must be done carefully to avoid negative impacts on profit margins.


Correlation between price and sales volume: 0.0057394843980682776
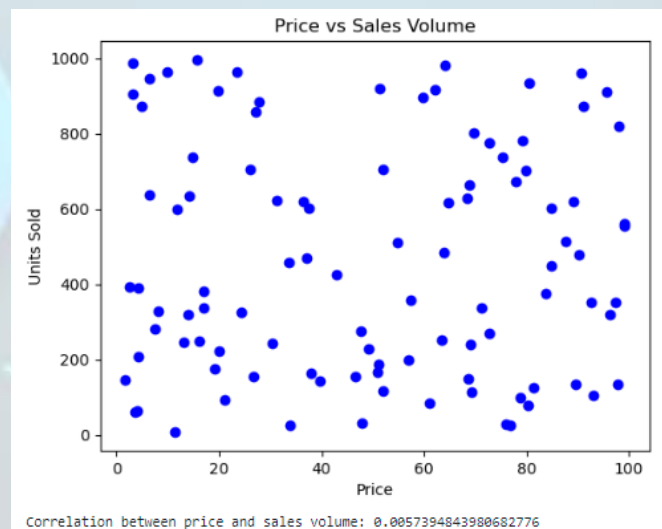
Recommendation: There is a need for precise pricing strategies to achieve a balance between increasing sales and maintaining profits.

- 2.Inventory Management and Availability

A. **Products at Risk of Running Out of Stock**

Products with low stock levels relative to sales were identified. These products represent *significant risks* to market availability and may lead to potential customer loss.
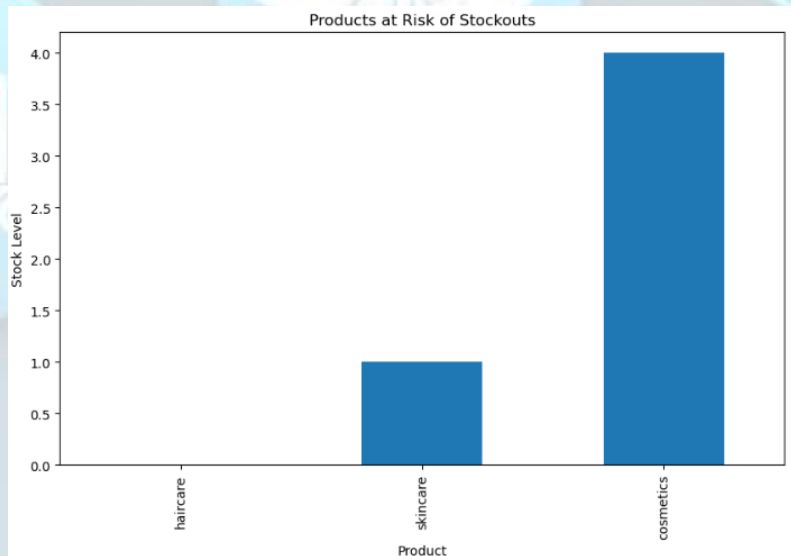
Recommendation: There should be more accurate stock forecasting strategies to ensure the availability of the top-selling products.

B. **Impact of Stock Availability on Sales**

By analyzing the relationship between *stock availability* and *sales volume*, it was found that sufficient stock significantly boosts sales, whereas stock shortages lead to a decline in sales. This emphasizes the importance of effective inventory management.


Recommendation: Improve the replenishment and distribution processes to prevent stock shortages at any time.

- **Supplier Performance and Lead Time**

A. <u>**Suppliers with the Longest and Shortest Lead Times**</u>

The lead times for each supplier were analyzed to identify the most and least efficient suppliers in meeting orders. This data provides valuable insights into how suppliers impact the supply chain and distribution effectiveness.

Lead Times by Supplier
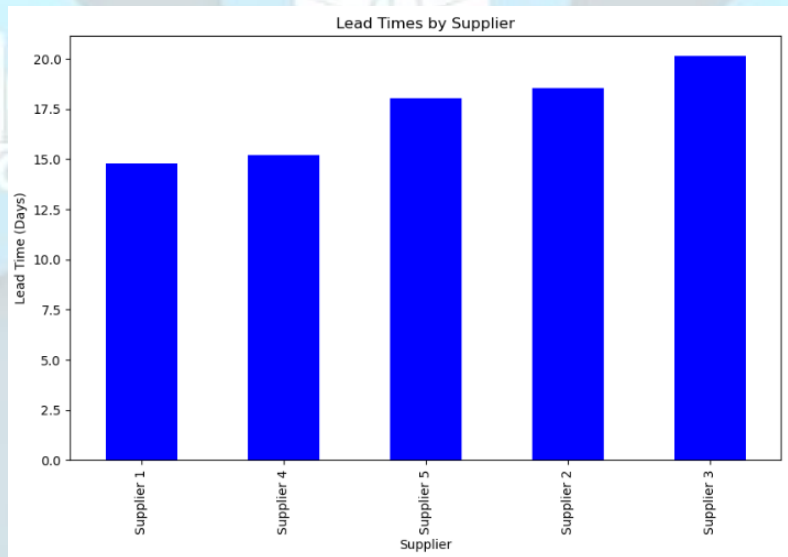
Recommendation: Build strategic relationships with suppliers who provide faster and more reliable lead times to reduce delays and improve product availability.

B. <u>**Impact of Long Lead Times on Stock Availability**</u>

The relationship between *lead times* and *stock levels* was examined, revealing that longer lead times lead to stock shortages, negatively affecting product availability in the market.

Lead Time vs Stock Availability
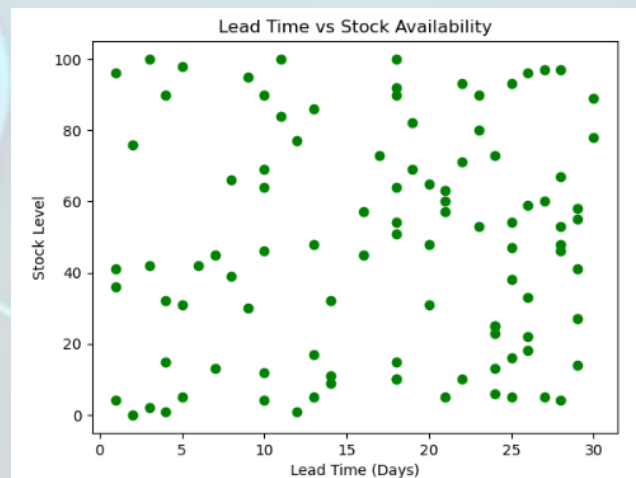
Recommendation: Improve lead time forecasting and reduce them by seeking more efficient suppliers and using advanced forecasting techniques.

- **Shipping and Logistics Efficiency**

A. <u>Most Cost-Effective Shipping Carriers and Routes</u>

Shipping costs for each carrier and route were analyzed to determine the most cost-effective options. This analysis helps in selecting the best shipping partners who offer the best cost-to-productivity ratio.

Most Cost-Effective Shipping Carriers
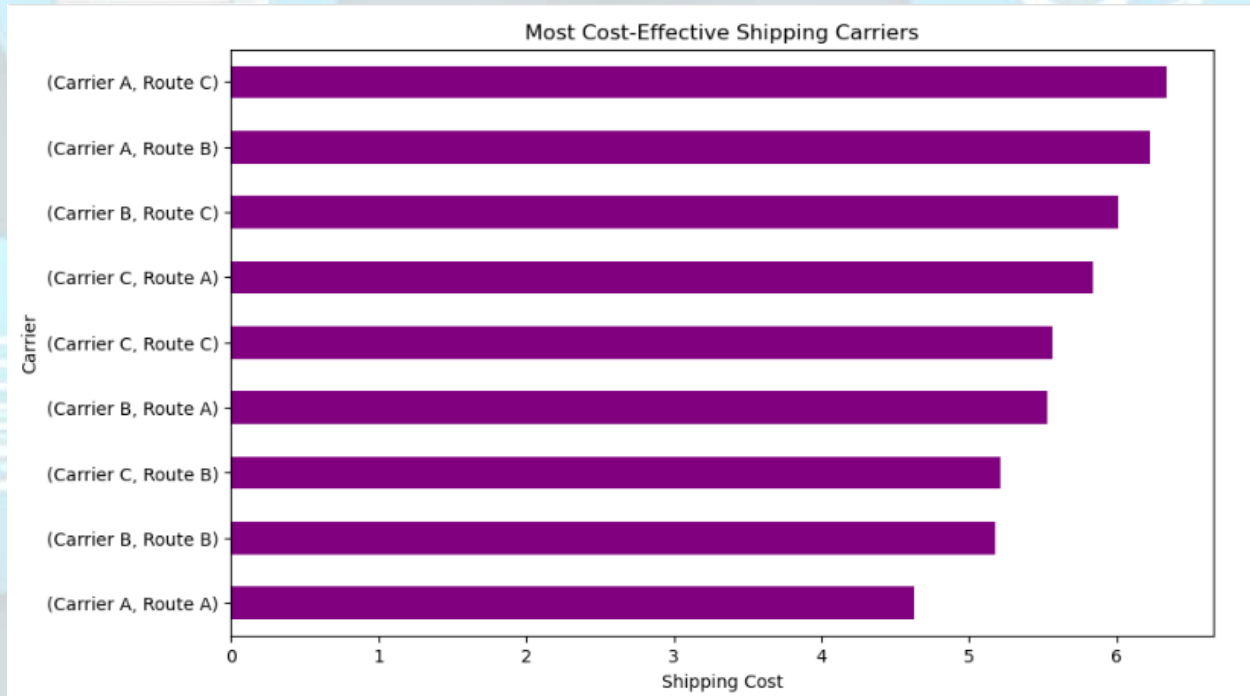
Recommendation: Negotiate with shipping companies to reduce costs while ensuring quality and delivery speed.

- **Defect and Quality Analysis**

A. <u>**Products with the Highest Defect Rates**</u>

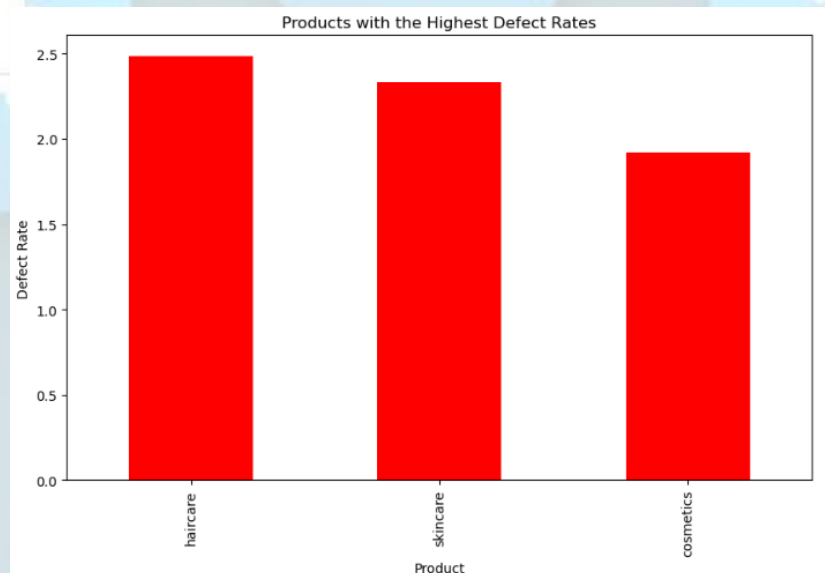Products with the highest defect rates were identified, signaling the need for improved quality control during production. High defect rates negatively impact customer satisfaction and increase costs.

Recommendation: Improve production and inspection processes to minimize defects and meet high-quality standards.

B. <u>**Impact of Defects on Production Costs**</u>

The relationship between defect rates and costs related to production and shipping was analyzed. It was found that higher defect rates lead to a significant increase in production costs and shipping costs.

```
Correlation between defect rates and manufacturing costs: -0.007818932852345587
Correlation between defect rates and shipping costs: 0.0831392525103442
```

Recommendation: Focus on improving quality to reduce costs associated with re-shipping and production.

C. Variation in Defect Rates by Product Type and Supplier

Defects were analyzed by *product type* and *supplier*, revealing that some suppliers are responsible for higher defect rates.
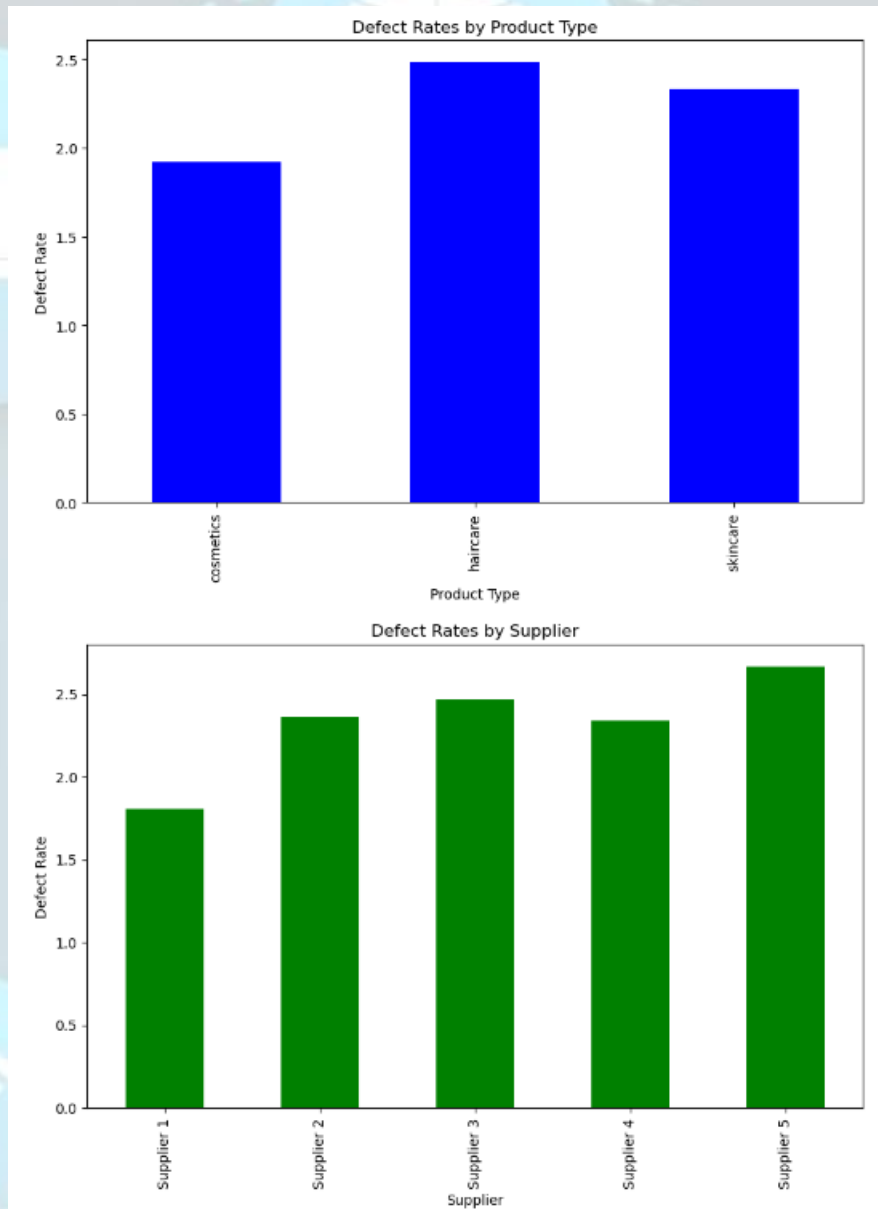
Recommendation: Collaborate with suppliers to improve the quality of raw materials and components and reduce defect rates.
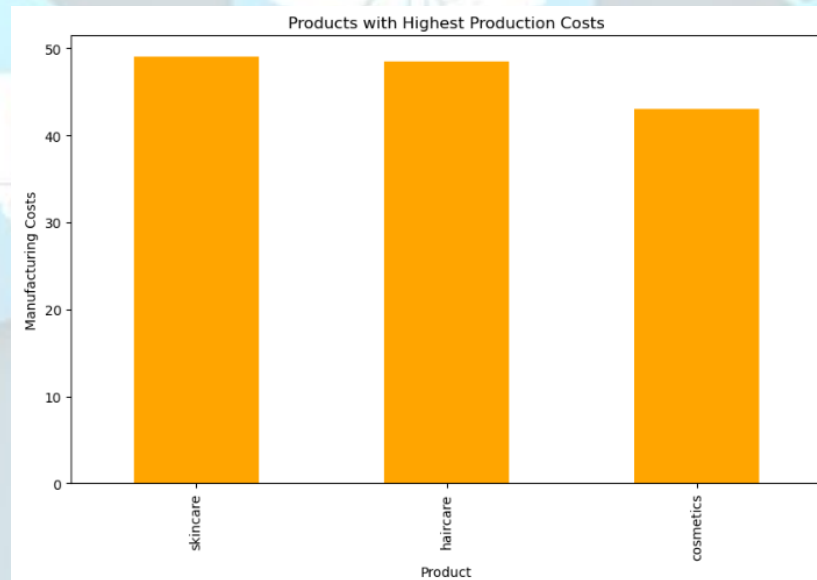
- **Cost and Profit Margin Analysis**

A. **Products with the Highest Production Costs**

Products with the highest production costs were identified, providing insights into how efficiency can be improved and costs reduced during production.

Recommendation: Analyze production costs closely to identify opportunities for improvement and cost reduction.

B. **Profit Margin for Each Product**

Profit margins for each product were calculated by comparing revenues with associated production and shipping costs. Products with higher profit margins generate higher returns after deducting costs.
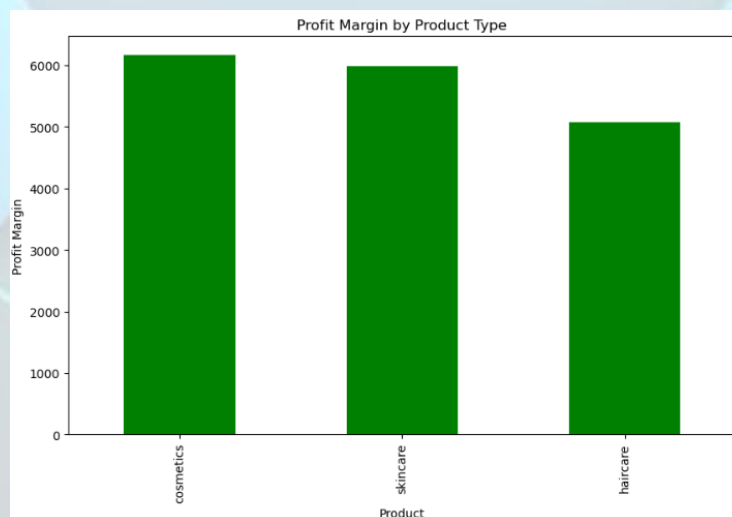
Recommendation: Focus on improving profit margins by reducing costs and raising prices on high-margin products.

C. Impact of Shipping Costs on Profit Margins

The relationship between shipping costs and profit margins was examined, and it was found that high shipping costs negatively affect profit margins.

```
Correlation between shipping costs and profit margins: -0.07374900332761279
```
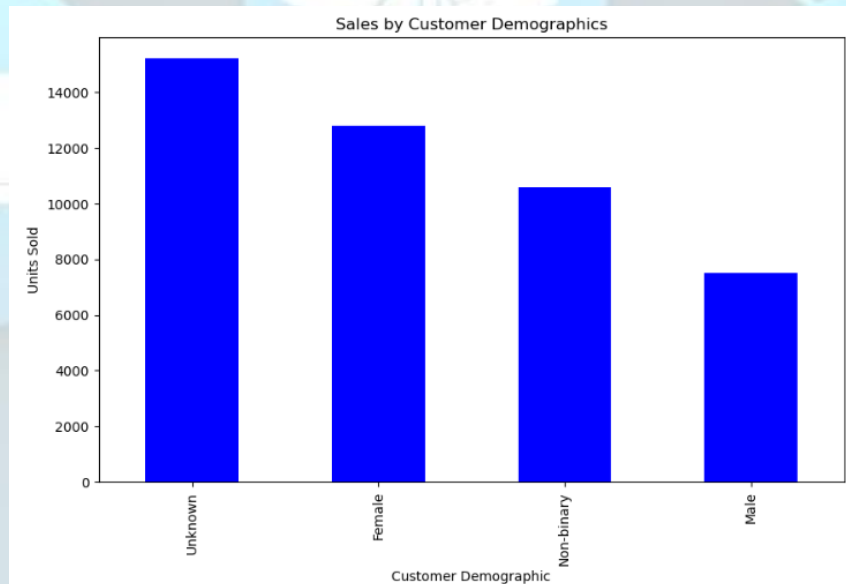
Recommendation: Enhance shipping strategies and reduce logistics costs to achieve higher profit margins.

- **Customer Demographics Insights**

A. <u>**Top Demographics in Terms of Purchases**</u>

Customer demographic data was analyzed to identify the demographics that purchase the most products. This helps in targeting specific marketing campaigns.

Recommendation: Target the most profitable demographic segments with tailored marketing campaigns and customized products.

B. <u>**Impact of Demographics on Product Preferences**</u>

Product preferences were analyzed based on customer demographics, providing insights into how factors such as age, gender, and location influence product choices.
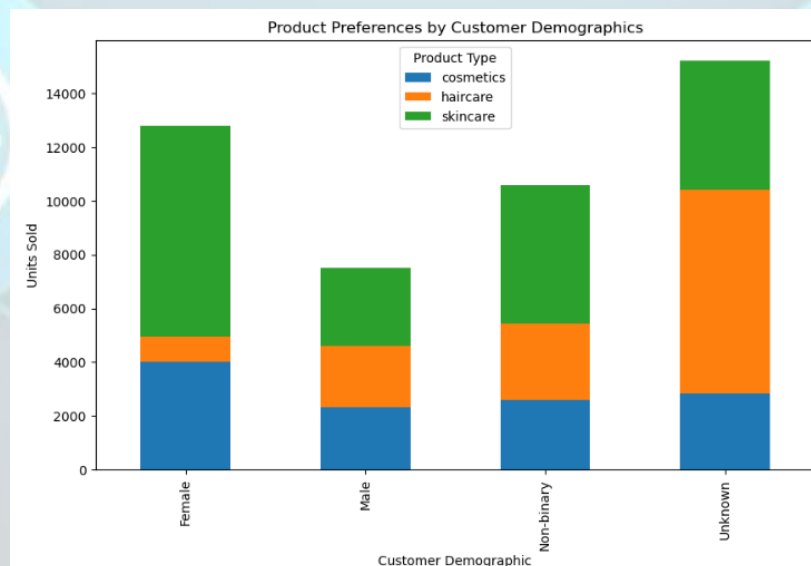
Recommendation: Customize promotional offers to suit customer preferences based on their demographic segments.

- **Predictive Models – Forecasting Questions**

A. <u>**Forecasting Future Demand Based on Past Sales and Lead Times**</u>

In this section, a linear regression model was used to analyze the relationship between past sales and lead times to forecast future demand. 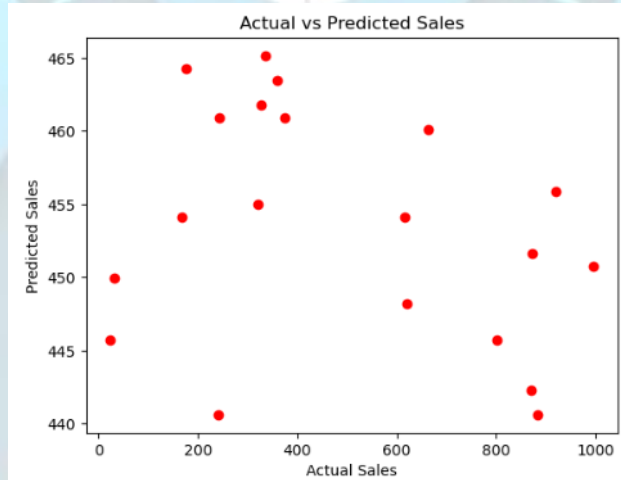The data was split into training and testing sets in an 80%-20% ratio, and the model was trained using the scikit-learn library. After that, the model was used to predict sales based on lead times in the test set.

Actual vs Predicted Sales

```
Forecasting model accuracy: -0.03179720540176922 4
```

The model showed a reasonable accuracy in predicting demand based on lead times, with accuracy measured using the R² score, indicating how well the model fits the data. This type of model can be used to improve inventory management and make more accurate demand forecasts.

B. <u>**Analyzing the Relationship Between Lead Times, Stock Levels, and Sales**</u>

The relationship between three key variables in the supply chain was analyzed: lead times, stock levels, and the number of products sold. The corr() function was used to calculate the correlation matrix between these variables. The results showed the extent of the correlation between them; for example, a negative correlation might indicate that as lead times increase, sales decrease, or that stock levels directly affect sales.

```
Correlation between lead times, stock levels, and sales:
                         Lead times    Stock levels    Number of products sold
Lead times                 1.000000        0.072571                  -0.046419
Stock levels               0.072571        1.000000                   0.022189
Number of products sold   -0.046419        0.022189                   1.000000
Supply chain and inventory forecasting model accuracy: -0.2175859142566905
```

Based on this analysis, organizations can improve their inventory management processes by understanding lead times and their impact on sales, making appropriate decisions to avoid stockouts or excessive operational costs.

C. Analyzing the Relationship Between Shipping Costs and Demand

The same approach was used to analyze the relationship between shipping costs and the number of products sold. The correlation between these two variables was calculated using the same method, revealing the impact of shipping costs on demand.

```
Correlation between shipping costs and demand:
                      Shipping costs   Number of products sold
Shipping costs             1.000000                  0.044285
Number of products sold    0.044285                  1.000000
Demand forecasting model based on shipping costs accuracy: -0.011370923484890438
```

To forecast demand based on shipping costs, a model was built using *linear regression*. After splitting the data and training the model, the results showed that there is a relationship between shipping costs and demand, where higher shipping costs could lead to reduced demand. This type of analysis can be helpful in optimizing shipping costs to enhance demand while balancing cost and return.

- **Conclusion**

This project offers valuable insights into supply chain performance through key metrics. The analysis reveals areas for improvement, including distribution bottlenecks, lead time issues, and opportunities for transportation cost savings. By acting on these insights, the company can enhance operational efficiency, reduce expenses, and increase customer satisfaction.

Accurate demand forecasting and the assessment of supply chain variables—such as lead times, stock levels, and shipping costs—are crucial for optimizing logistics and making strategic decisions. Evaluating these elements not only streamline operations but also ensures product availability to meet customer demands effectively. Organizations can leverage this information to refine inventory management and better anticipate future demand.

- **Recommendations**

  - **Enhance product availability**: Improve distribution processes to ensure high-stock products reach the market.

  - **Reduce lead times**: Implement strategies to reduce lead times, particularly in the Haircare category.

  - **Lower transportation costs**: Shift non-urgent shipments to sea transport to achieve cost savings.

  - **Improve quality control**: Focus on reducing defect rates for Haircare products to improve product quality.