**Summary**

Celestial Charm Beauty Co., known for its luxurious lipstick line "Luxe Lips," faced challenges due to seasonal demand fluctuations, impacting sales and distribution efficiency. To counter these challenges, the company embarked on a strategic initiative focusing on advanced forecasting and inventory management to optimize its supply chain and minimize costs.

Utilizing historical sales data from 2016 to 2020, the company analyzed the quantitative relationship between lipstick production and its key ingredients: pigments, additives, waxes, and fragrances. This analysis aimed to accurately forecast demand by identifying seasonality patterns, which would then inform raw material procurement and inventory levels.

The forecasting revealed insights into seasonal demand, enabling Celestial Charm Beauty Co. to tailor its inventory strategy, thereby reducing production and stockout costs. A critical examination of the costs associated with ordering raw materials and how ordered quantities affected overall expenses was conducted using solver table. The objective was to ascertain the optimal ordering quantity that met operational needs while minimizing procurement costs.

By aligning inventory management and production with forecasted demand, Celestial Charm Beauty Co. sought to maintain its reputation for delivering high-quality, glamorous products. This strategic approach significantly enhanced operational efficiency and cost-effectiveness without compromising the brand's commitment to sophistication and quality.

**Introduction**

**Company**

Celestial Charm Beauty Co , a cosmetic company operating out of the Milan, Italy, commenced its operations in 2010. Founded by entrepreneur Bella Paul, this company was initially started as a small business of cosmetic products. Over time, it evolved into a manufacturing unit, driven by its commitment to adaptability to evolving beauty trends.

The core competitiveness of Celestial Charm Beauty Co lies in its ability to cater to the diverse tastes and preferences of its customers. It began as a modest trading business of cosmetic products, gradually expanding into a manufacturing unit. With its headquarters in Milan, boasts ten depots and collaborates with 45 authorized global retailers, supported by a dedicated sales force of 1000 individuals, extending its reach to various countries globally.

**Challenges:**

Challenges arose for them, when they introduced their premium lipstick line, "Luxe Lips," packaged in sets of 10 lipsticks per bundle, further organized into crates containing 25 bundles each. Maintaining high-quality standards while managing inventory levels became essential. However, seasonal variations in demand posed challenges for distributors, impacting sales and distribution channels. Given the delicate nature of lipstick products and the lead time of 30 days for sourcing ingredients, careful handling during transportation and storage was crucial to preserve product integrity. Additionally, each procurement incurred an ordering cost of 10000 pounds, while the monthly carrying cost for crates amounted to 3% of the cost of goods, with each crate priced at 1400 pounds.

**Objective**

The primary objective was to minimize the annual cost of procurement by determining the optimal quantity that satisfied all operational requirements of the company. Furthermore, the company sought to assess the short-term and long-term implications of these quantitative decisions on inventory management, ensuring the effectiveness and sustainability of its operations.

By strategically managing inventory and aligning production with demand, they aimed to uphold their reputation as a leader in lipstick production, delivering unparalleled glamour and sophistication to its clientele while optimizing operational efficiency and minimizing costs.

**Historic Data:**

Below table shows the historical demand for lipsticks in crates from 2016 to 2020.

| **Year** | **2016** | **2017** | **2018** | **2019** | **2020** |
| --- | --- | --- | --- | --- | --- |
| Jan | 453 | 639 | 1069 | 1143 | 1258 |
| Feb | 388 | 721 | 996 | 1200 | 1231 |
| Mar | 467 | 773 | 907 | 1021 | 1256 |
| Apr | 509 | 920 | 1049 | 1231 | 1385 |
| May | 721 | 1050 | 1106 | 1245 | 1456 |
| Jun | 856 | 1134 | 1256 | 1321 | 1598 |
| Jul | 898 | 1236 | 1301 | 1439 | 1710 |
| Aug | 1007 | 1250 | 1398 | 1503 | 1599 |
| Sep | 1100 | 1295 | 1460 | 1621 | 1538 |
| Oct | 1151 | 1298 | 1471 | 1588 | 1498 |
| Nov | 1165 | 1323 | 1395 | 1537 | 1500 |
| Dec | 587 | 1195 | 1380 | 1421 | 1400 |

Each Crate can hold 200 bundles and each bundle has 10 lipstick which sums up to 2000 lipsticks per Crate.

The following tables display the ingredients necessary for manufacturing chocolate bars, which are linked to the available data prior to advancing with the model.

1. Pigments

| **Ingredient** | **Pigments** | |
| --- | --- | --- |
| **Holding cost** | 0.4% | |
| **Ordering cost** | 1250 | |
|  | ***Quantity*** | ***Price*** |
|  | 1 to 2000 | 78.3 |
|  | 2001 to 4000 | 78.2 |
|  | 4001 to 6000 | 78 |
|  | >6000 | 77.8 |
| **Weight per crate** | 9 | |

2. Additives

| **Ingredient** | **Additives** | |
| --- | --- | --- |
| **Holding cost** | 0.3% | |
| **Ordering cost** | 1500 | |
|  | ***Quantity*** | ***Price*** |
|  | 1 to 1000 | 55.4 |
|  | 1001 to 2000 | 55.3 |
|  | 2001 to 3000 | 55.2 |
|  | >3000 | 55 |
| **Weight per crate** | 12 | |

3. Waxes

| **Ingredient** | **Waxes** | |
| --- | --- | --- |
| **Holding cost** | 0.35% | |
| **ordering cost** | 2500 | |
|  | ***Quantity*** | ***Price*** |
|  | 1 to 1250 | 21.7 |
|  | 1251 to 2500 | 21.6 |
|  | 2501 to 3750 | 21.5 |
|  | >3750 | 21.3 |
| **Weight per crate** | 30 | |

4. Fragrances

| **Ingredient** | **Fragrance** | |
| --- | --- | --- |
| **Holding cost** | 0.3% | |
| **ordering cost** | 1200 | |
|  | ***Quantity*** | ***Price*** |
|  | 1 to 2500 | 145.08 |
|  | 2501 to 5000 | 145 |
|  | 5001 to 7500 | 144.9 |
|  | >7500 | 144.8 |
| **Weight per crate** | 3 | |

**Model Formulation:**

The main objective is to minimize the total costs. As the inventory must always be greater than demand. The costs are the sum of any order made in a month, plus the monthly cost of the inventory and the holding cost for the inventory. The inventory includes all four ingredients for the chocolate bar.

**Demand Forecasting:**

To enhance our inventory management, we engaged in demand forecasting, a process where future demand is predicted based on past data. In this scenario, demand forecasting involved analyzing five years of demand data (2016-2020) to anticipate future needs. A critical part of our analysis was calculating the seasonality index, which quantifies how demand fluctuates at different times of the year based on historical patterns. This index helped us project demand for the forthcoming 24 months. We visualized these patterns by creating a scatter plot, overlaying it with a linear regression line to highlight the overall trend. The linear regression line serves as a statistical tool, indicating the general direction in which our data points, and thus demand, are moving over time. This approach allowed us to align our inventory levels more closely with anticipated market demand, streamlining operations and reducing inefficiencies.

| **Year** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** |
| --- | --- | --- | --- | --- | --- | --- |
| Jan | 453 | 639 | 1069 | 1143 | 1258 | 1268 |
| Feb | 388 | 721 | 996 | 1200 | 1231 | 1272 |
| Mar | 467 | 773 | 907 | 1021 | 1256 | 1252 |
| Apr | 509 | 920 | 1049 | 1231 | 1385 | 1455 |
| May | 721 | 1050 | 1106 | 1245 | 1456 | 1607 |
| Jun | 856 | 1134 | 1256 | 1321 | 1598 | 1792 |
| Jul | 898 | 1236 | 1301 | 1439 | 1710 | 1931 |
| Aug | 1007 | 1250 | 1398 | 1503 | 1599 | 1999 |
| Sep | 1100 | 1295 | 1460 | 1621 | 1538 | 2093 |
| Oct | 1151 | 1298 | 1471 | 1588 | 1498 | 2108 |
| Nov | 1165 | 1323 | 1395 | 1537 | 1500 | 2100 |
| Dec | 587 | 1195 | 1380 | 1421 | 1400 | 1831 |

**Non-Linear Programming:**

Our NLP model encompasses various critical components, all centered on predicting the demand for lipsticks. The objective of our model is to estimate the monthly demand for each ingredient in kilograms. This is achieved by calculating the amount of each ingredient contained in a lipstick and then multiplying it by the projected demand.

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After forecasting the demand, our next crucial step is to calculate the total costs. The total cost is derived from the aggregation of two specific columns: Cost per Order and Holding Cost. The Cost per Order encompasses expenses related to order placement, the cost per kilogram of each ingredient, and the total quantity ordered. Meanwhile, the Holding Cost is calculated by multiplying the existing inventory levels by the holding cost rate for each ingredient, expressed as a percentage of its weight.

Below table shows the ordering costs and holding costs of individual ingredient

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Moving on to the next segment of our NLP model, we will establish the constraints section. The sole purpose is ensuring the availability of each ingredient to satisfy monthly demand. This is achieved by guaranteeing that the inventory level for every ingredient remains non-negative, and the Supply (the quantity ordered) does not exceed the demand. By adhering to these guidelines, we ensure a consistent availability of ingredients to meet demand requirements.

The procurement of ingredients is carried out with consideration given to holding expenses.

Analysis with Solver table:

Analysis with EOQ:

Results and Recommendations:

Conclusions:

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