Improving Inventory Management and Operational Efficiency for a Fertilizer and Pesticide Business

Mid-term report for the BDM capstone

Project Submitted by

Name: Abhishek

Roll number: 22f3000978

IITM Online BS Degree Program,

Indian Institute of Technology, Madras,

Chennai Tamil Nadu, India, 600036

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Declaration Statement

I am working on a Project Title "**Improving Inventory Management and Operational Efficiency for a Fertilizer and Pesticide Business**". I extend my appreciation to **Jyoti Trading Company**, for providing the necessary resources that enabled me to conduct my project.

I hereby assert that the data presented and assessed in this project report is genuine and precise to the utmost extent of my knowledge and capabilities. The data has been gathered through primary sources and carefully analyzed to assure its reliability.

Additionally, I affirm that all procedures employed for the purpose of data collection and analysis have been duly explained in this report. The outcomes and inferences derived from the data are an accurate depiction of the findings acquired through thorough analytical procedures.

I am dedicated to adhering to the information of academic honesty and integrity, and I am receptive to any additional examination or validation of the data contained in this project report.

I understand that the execution of this project is intended for individual completion and is not to be undertaken collectively. I thus affirm that I am not engaged in any form of collaboration with other individuals, and that all the work undertaken has been solely conducted by me. In the event that plagiarism is detected in the report at any stage of the project's completion, I am fully aware and prepared to accept disciplinary measures imposed by the relevant authority.

I agree that all the recommendations are business-specific and limited to this project exclusively, and cannot be utilized for any other purpose with an IIT Madras tag. I understand that IIT Madras does not endorse this.

Signature of Candidate: (**Digital Signature**)

Name: Abhishek

Date: 5 September, 2024

1. Executive Summary and Title

Title: Improving Inventory Management and Operational Efficiency for a Fertilizer and Pesticide Business

This project aims to enhance inventory management and operational efficiency for Jyoti Trading Company, a small fertilizer and pesticide business. The focus is on resolving inventory mismanagement issues, such as overstocking and stockouts, which strain finances and hinder operations. Through analyzing historical sales data and conducting an ABC analysis, key findings revealed that 52% of sales come from a small number of high-priority products (Category A), emphasizing the need for focused inventory management.

Future plans include collecting additional of six months more to refine forecasting models and enhance inventory practices further. The expected outcomes are cost reduction, improved product availability for customers, and greater financial stability for the business, positioning Jyoti Trading Company for sustainable growth.

2. Proof of originality of the Data

Link - Google Drive

3. Metadata

1. Dataset Overview:

- **Source**: Data collected from Jyoti Trading Company's historical records over two seasons (April 2024 to September 2024).
- **Variables**: The dataset comprises the following columns:
- **Product**: Name of the product.
- **Month**: Time period of the record.
- **Stocked**: Quantity of the product stocked.
- **Sold**: Quantity of the product sold.
- **Purchase Cost**: Cost incurred to purchase the product.
- **Selling Price**: Revenue earned from selling the product.
- **Leadtime**: Time taken to replenish stock.

2. Data type:

Each column in the dataset is of specific data types (e.g., categorical for Product and Month, numerical for Stocked, Sold, Purchase Cost, Selling Price, and Leadtime).

3. Data Collection Method:

Data was manually entered from physical records into a digital format, ensuring that the historical context and specific details are preserved for accurate analysis.

The primary problem faced by Jyoti Trading Company involves **inventory management** challenges, particularly optimizing stock levels to meet demand while managing limited storage space. To address these challenges, the dataset includes key attributes such as **Product**, **Month**, **Stocked**, **Sold**, **Purchase Cost**, **Selling Price**, and **Leadtime**. Each column is essential for establishing a comprehensive understanding of the dataset's structure and for analyzing inventory dynamics. The **Product** and **Month** columns allow for tracking sales trends over time, while **Stocked** and **Sold** provide insights into inventory turnover, helping identify patterns related to stockouts and overstocking. Additionally, **Purchase Cost** and **Selling Price** facilitate financial analysis, enabling the company to assess profitability and pricing strategies. The inclusion of **Leadtime** is critical for optimizing reorder points, ensuring that stock levels align with customer demand.

4. Descriptive Statistics

1. **Central Tendency:**
    - **The mean number of units sold** helps understand average demand, guiding future stock levels.
    - **The mean purchase cost and selling price** provide insight into average costs and revenues, which are essential for pricing strategy evaluation.
2. **Dispersion:**
    - **Standard deviation** of units sold indicates the level of variability in product sales, which is key to identifying inconsistent demand.
    - **Range** in stocked units across months provides insight into stock variability, aiding in identifying periods of high or low inventory.
3. **Correlations:**
    - **Stocked vs. Sold units:** Understanding how well stocked levels align with sales is critical in ensuring sufficient product availability without incurring excess storage costs.
    - **Purchase Cost vs. Selling Price**: By calculating margins between the two, you can assess profitability, which is essential in optimizing pricing and cost management strategies.

The descriptive statistics generated in the notebook help address Jyoti Trading Company's key issue—optimizing inventory management. By analyzing the average sales (demand) and stock levels, you can better forecast future stock requirements. The variability in sales, captured by the standard deviation, helps in identifying the potential for stockouts or overstocking, which directly links to managing limited storage space. The relationships between stock, sales, and lead times provide actionable insights into reorder points and the timing of future stock purchases. Finally, by analyzing purchase and selling prices, you can evaluate financial performance and inform future pricing strategies.

5. Detailed Explanation of Analysis Process

1. **Demand Forecasting:**
    - **The ARIMA** (AutoRegressive Integrated Moving Average) model is used for time series forecasting, which is appropriate for predicting future demand based on historical sales data. ARIMA can account for trends, seasonality, and cycles in the data, making it more suitable for the dataset's monthly structure.
    - **Justification:** ARIMA is a popular choice for time series data as it adapts well to the seasonal and cyclic patterns that inventory and sales data tend to exhibit. It provides flexibility by combining autoregressive, moving average, and differencing terms to fit the historical patterns in the data, giving it an edge over basic methods like linear regression. Moreover, ARIMA is supported by Python's statsmodels library, making it easily implementable and validated using performance metrics such as AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion).
    - **Model Validation:**
        - **AIC** and **BIC** are essential tools for comparing models. They allow you to select the best-fitting model with the least complexity by penalizing models with more parameters, ensuring a balance between goodness-of-fit and model complexity.
        - **Justification:** These criteria help avoid overfitting, which is crucial given the limited data available. Using these metrics ensures that the chosen model is both efficient and accurate in predicting demand, making ARIMA preferable to simpler methods like moving averages when trends and seasonality are significant.
2. **ABC Analysis:**
    - **ABC Analysis** classifies products into A, B, and C categories based on their contribution to sales revenue and inventory costs:
        - **A Items:** High-value, low-volume products that generate the majority of revenue but require close monitoring.
        - **B Items:** Moderate-value, moderate-volume items with consistent sales.
        - **C Items:** Low-value, high-volume products that require less attention.
    - **Justification**: ABC analysis is a strategic method to prioritize resources and focus management attention on the most critical inventory items. A Items, which have the most significant impact on profitability, require strict oversight, while C Items are managed more routinely. This method allows for differentiated management, ensuring that inventory management efforts are appropriately focused, minimizing effort on less important items. Python allows for quick, efficient computation of the ABC categorization, making this method more effective than simply treating all products equally.

3. **Inventory Optimization:**

- **Reorder Points & Safety Stock:**
    - The calculation of reorder points ensures that stock is replenished just in time before it runs out. Safety stock accounts for variability in demand or lead time, ensuring that unexpected surges in demand or delays in delivery do not result in stockouts.
    - Justification: This is a highly relevant technique for managing limited storage space and avoiding excess inventory costs. By calculating reorder points and safety stock levels, Jyoti Trading Company can maintain an optimal balance between avoiding stockouts and overstocking, which is directly tied to profitability and customer satisfaction. The use of Python for these calculations allows for real-time updates and adjustments as new data becomes available, offering an advantage over traditional manual approaches.
- **Economic Order Quantity (EOQ):**
    - The EOQ model determines the ideal order size that minimizes the total costs of ordering, holding, and stockouts. This model considers the balance between fixed costs per order and holding costs per unit, helping optimize order sizes.
    - Justification: EOQ is especially relevant for Jyoti Trading Company as it balances holding costs (important due to limited storage) and ordering costs. Given that the business faces the challenge of stockouts and high holding costs, EOQ ensures that orders are placed in the most cost-effective size. Python's computational power allows for quick EOQ calculations, which helps in making timely, data-driven decisions about order quantities, minimizing inventory-related costs.

6. Results and Findings

1. **Seasonal Trends in Sales:**

- **Increase in Sales During Sowing Season:** The analysis shows a significant increase in the number of fertilizers and pesticides sold during the sowing season. This aligns with typical agricultural patterns, where farmers purchase inputs just before planting crops.
- **Off-season Sales:** The data indicates a notable drop in sales during the off-season. This pattern is expected as demand for fertilizers and pesticides decreases when crops are growing and less input is required.

2. ABC Analysis:

	Product	Total_Sales_Value	Cumulative_Percentage	Category
2	Azoxystrobin 11% & Tebuconazole 18.3%	167400	0.12	A
0	Amistar Top	160000	0.24	A
9	Fipronil 0.3% GR	134960	0.34	A
7	Chlorpyriphos 50% + Cypermethrin 5% EC	128800	0.43	A
6	Chlorantraniliprole 0.4% GR	117120	0.52	A
11	Mycorrhizal Biofertilizer	96000	0.59	A
14	Pymetrozine 50% WG	84000	0.65	A
13	Pretilachlor 37% EW	66120	0.70	A
5	Carbendazim 12% + Mancozeb 63% WP	58500	0.74	B
3	Bifenthrin 10% EC	55800	0.78	B
15	Sulphur 80% WDG	55500	0.82	B
16	Thiamethoxam 30% FS	55000	0.86	B
4	Bispyribac Sodium 10% SC	42000	0.89	B
8	Emamectin benzoate 5% SG	40500	0.92	C
10	Glyphosate 41% SL	38800	0.95	C
18	Zinc 12%	28800	0.97	C
17	Thiophanate Methyl 70% WP	25200	0.99	C
12	Paraquat Dichloride 24% SL	7200	1.00	C
1	Ammonium Salt of Glyphosate 71% SG	5400	1.00	C

Figure 1- ABC Analysis

The ABC analysis classified the products into three categories based on their total sales value:

- **Category A (High Priority):** Comprises 8 products, contributing 52% of total sales. Key products include Azoxystrobin 11% & Tebuconazole 18.3% ($167,400) and Amistar Top ($160,000), requiring close inventory management.
- **Category B (Medium Priority):** Contains 5 products, accounting for 11% of total sales. Notable items include Carbendazim 12% + Mancozeb 63% WP ($58,500) and Bifenthrin 10% EC ($55,800), needing moderate inventory attention.
- **Category C (Low Priority):** Includes 6 products, making up 3% of total sales. Examples are Emamectin benzoate 5% SG ($40,500) and Glyphosate 41% SL ($38,800), allowing for more flexible inventory management.

3. ARIMA Model Performance:

Figure 2- ARIMA model working fine with most products

- **Current Model Limitations:**

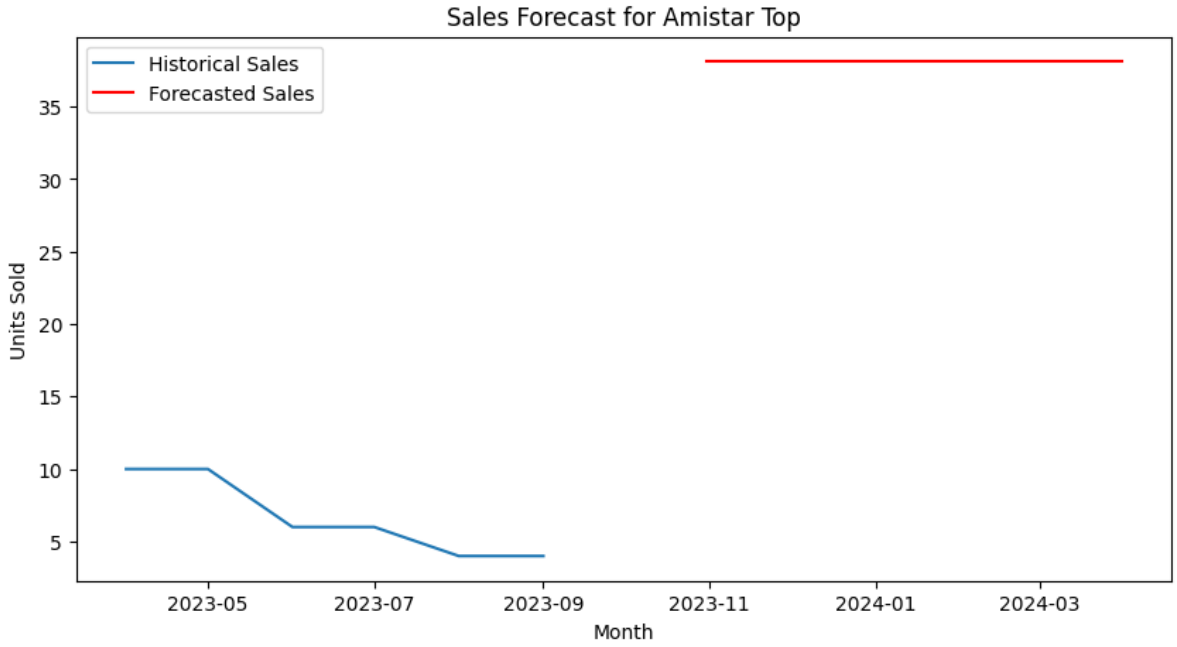

Figure 3- shows incoorect predition because of lack of data

- The ARIMA model applied to forecast future sales did not perform as expected. This could be attributed to the limited amount of historical data available, leading to inaccurate predictions.
- **Future Improvements:** By collecting six more months of data, the model's accuracy can be improved, allowing it to better capture seasonal trends and cyclic patterns. With a longer time frame, the model will have more data to understand recurring sales cycles.

4. **Future Steps:**
    - **Data Collection:** Extending the dataset to include more recent sales data will allow for better forecasting accuracy and trend analysis.
    - **Model Refinement:** Recalibrating the ARIMA model after adding more data points will help in fine-tuning the prediction of sales trends, particularly during transitional periods between seasons.
    - **Exploring External Factors:** Including external factors such as weather patterns, government policies on agriculture, and global fertilizer prices could enhance the model's predictive power.