BUSINESS DATA MANAGEMENT

Capstone Project End Term

Optimizing Inventory and Operations for Sustainable Growth in a Family-Run Grocery Business

Submitted By :-

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Content :

Executive Summary :

Jai Maa Jhandewali Store, a family-run grocery business located in Pitampura, Delhi, serves daily essentials like dairy, FMCG products, and groceries. Established two years ago, the store has steadily grown and now operates profitably under the management of Mr. Satyam Prakash, who balances his studies with running the shop. Despite its success, the store faces three key challenges: inventory management issues, limited storage space, and restricted business growth due to reliance on manual operations and family-run management.

To address these challenges, we conducted a comprehensive data-driven analysis using historical sales data. The analysis included trend analysis, correlation analysis, ABC classification, and sales prediction through machine learning. Trend analysis revealed that dairy products, particularly milk, have fluctuating but high sales, especially during specific months like March, June, October, and December, linked to seasonal and festival demand. FMCG sales are driven by bread, which shows similar seasonal trends to milk. Grocery sales are steady, with pulses contributing the highest. Correlation analysis highlighted interdependencies among SKUs, with closely related sales patterns within categories like rice, wheat, and pulses. ABC classification identified key products like milk, bread, and chips as "A" category items, contributing the most to revenue. Sales prediction through linear regression demonstrated the feasibility of forecasting demand, helping to plan optimal stock levels for perishable and high-demand items.

Based on the findings, we recommend adopting automated inventory management tools to maintain optimal stock levels and reduce wastage. Temporary staffing during peak months like March and October will allow Mr. Satyam to balance his academic responsibilities. Expanding into home delivery services and implementing targeted seasonal marketing campaigns will improve customer satisfaction and drive sales. Additionally, optimizing the storage layout to prioritize high-demand items and removing slow-moving products can address space constraints.

These measures will enable Jai Maa Jhandewali Store to streamline operations, improve profitability, and scale sustainably while balancing Mr. Satyam’s academic commitments.

Detailed Explanation of Analysis Method :

1. Trend Analysis

We are using trend analysis to understand the patterns and behaviors in sales data over time, which is critical for effective inventory management and business planning at Maa Jhandewali Store. Given the store's location in Delhi and the seasonal nature of its operations, sales are influenced by factors such as festivals (Diwali, Christmas) and weather conditions (cold winters affecting footfall). By analyzing trends, we can identify peak demand periods and prepare inventory accordingly, avoiding stockouts or overstocking during slow-moving months. Trend analysis also helps in recognizing growth opportunities, such as identifying consistent increases in demand for certain product categories like FMCG or Dairy, allowing Mr. Satyam to make informed decisions on stocking and space allocation. Furthermore, it provides insights into recurring patterns, such as weekly or monthly variations, and helps align marketing strategies, like discounts or promotions, with these cycles to maximize sales.

Steps to Perform:

- **Data Preprocessing:**
    - Organize sales data by Date and categorize into Dairy, FMCG, and Groceries.
    - Aggregate daily sales into monthly totals for each SKU and category.
- **Visualize Trends:**
    - Plot line charts for overall and category-wise monthly sales to observe seasonality and growth trends.
    - Use decomposition methods to separate components (trend, seasonality, residuals) using libraries like statsmodels.
- **Smooth Trends:**
    - Apply moving averages to smooth fluctuations. For instance:

$$S_t = \frac{1}{n} \sum_{i=0}^{n-1} D_{t-i}$$

where St is the smoothed trend, Dt is daily sales, and n is the window size.

- **Identify Seasonal Peaks:**
    - Highlight periods with sharp increases or decreases, such as Diwali or chilled winters, using annotations.
- **Expected Outcome:** A clear understanding of sales patterns over time will enable Mr. Satyam to prepare for high-demand periods and prevent overstocking during slow months. Trend analysis is expected to facilitate a proactive approach to inventory and sales management, improving operational efficiency and enhancing customer satisfaction through timely availability of products.

2. Sales Prediction Using Machine Learning (ML)

We are using machine learning (ML) techniques at Maa Jhandewali Store to enhance decision-making by leveraging the predictive power of advanced analytics. Unlike traditional methods, ML can uncover complex patterns and relationships in the store's sales data that might not be immediately apparent. This capability is particularly crucial for inventory management, where accurate predictions of future sales trends can significantly reduce wastage, avoid stockouts, and optimize stock levels.

For example, ML algorithms like Linear Regression or ARIMA can forecast sales of perishable items like Dairy (Milk and Butter) or fast-moving FMCG products (Chips, Biscuits) based on historical sales data, seasonal trends, and external factors like holidays or weather. This predictive insight enables Mr. Satyam to order stock in alignment with expected demand, reducing holding costs and improving cash flow.

Additionally, ML models can analyze the correlation between different SKUs and customer preferences, identifying cross-selling opportunities or gaps in the product mix. For example, clustering algorithms could reveal which items are frequently purchased together, guiding decisions on new SKU introductions or targeted promotions.

Steps to Perform:

- **Data Preparation:**
  - Convert Date into numerical features like month, day of the week, and year.
  - Split data into training and testing sets (e.g., 80:20 split).
- **Model Selection:**
  - Use regression models like Random Forest or time-series models like ARIMA or LSTM.
- **Feature Engineering:**
  - Include Month, Day of Week, Category, and lagged sales as predictors.
- **Model Training and Evaluation:**
  - Train the model on the training set and validate using RMSE (Root Mean Square Error):

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

- **Forecast Sales:**
  - Generate future predictions for 1–3 months to prepare stock levels.
- **Expected Outcome:** Accurate sales forecasts will help Mr. Satyam aligns inventory with demand, avoiding overstocking and wastage. ML is expected to reduce stockouts, minimize holding costs, and enhance decision-making for SKU selection and business expansion, ensuring sustainable growth for the store.

3. ABC Analysis

ABC analysis is a crucial inventory management tool for Maa Jhandewali Store, as it helps categorize products based on their contribution to overall sales or revenue. In a space-constrained setup like this store, optimizing inventory is essential to ensure that high-priority SKUs (Category A) are always in stock, while lower-priority items (Categories B and C) are managed

more conservatively. For example, fast-moving products like milk and soft drinks are likely to fall under Category A, necessitating consistent availability. At the same time, slow-moving items like specific spices may be categorized as B or C, allowing for better allocation of shelf space. ABC analysis also helps identify opportunities to streamline inventory by removing or replacing underperforming SKUs, ensuring that valuable space is utilized effectively to drive sales and customer satisfaction.

Steps to Perform:

- **Rank SKUs by Sales or Revenue:**
  - Calculate total sales or revenue for each SKU.
- **Calculate Cumulative Contribution:**
  - Sort SKUs in descending order and calculate their cumulative percentage contribution.
- **Categorize SKUs:**
  - Assign A to items contributing to 80% of sales, B to the next 15%, and C to the remaining 5%.
- **Visualize Results:**
  - Create Pareto charts to represent category contributions.
- **Expected Outcome:** ABC analysis can reveal potential gaps in the product mix, guiding the introduction of new SKUs that align with customer preferences and boost revenue. The store will achieve a more efficient inventory system, better space management, and enhanced profitability.

4. Correlation Analysis

Correlation analysis is a powerful statistical method to examine the relationships between different SKUs at Maa Jhandewali Store. Understanding these relationships helps uncover patterns in sales and customer buying behavior. For instance, if sales of chips strongly correlate with soft drinks, it indicates that customers often buy them together, highlighting cross-selling opportunities. Conversely, a weak or negative correlation between certain products may suggest

independent purchasing behavior, allowing better segmentation of inventory. Given the store's space constraints, identifying such associations ensures that complementary products are strategically placed to maximize sales and enhance customer convenience. Additionally, correlation can help identify seasonal dependencies or external factors influencing sales, aiding better forecasting and inventory decisions.

Steps to Perform:

- **Calculate Correlation:**
    - Use the Pearson correlation formula:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

- **Interpret Results:**
    - Positive correlations indicate complementary products, while negative correlations suggest substitutable items.
- **Visualize Relationships:**
    - Plot a heatmap for SKU categories like Dairy, FMCG, and Groceries.
- **Expected Outcome:** understanding sales dependencies across categories like Dairy, FMCG, and Groceries will enable the store to anticipate demand shifts and adjust inventory levels accordingly, minimizing wastage and stockouts. Correlation analysis will drive smarter inventory and marketing strategies, ultimately increasing profitability and customer satisfaction.

Results and Findings :

Based on the trend analysis and category-specific insights, we observe distinct sales patterns that provide valuable information for inventory management, sales strategies, and overall business planning for Jai Maa Jhandewali Store.

Within the Dairy category, Milk is the primary driver of sales, exhibiting a highly fluctuating trend. This is likely due to the product's short shelf life, which makes it more susceptible to overstocking and wastage if not managed properly. Butter, while part of the same category, has more consistent but lower sales, showing a steady demand over time. The higher sales for Milk in months like March, June, October, and December can be attributed to specific factors:

- March sees an uptick due to festivals like Holi and the increased consumption of dairy products during this period, particularly in residential areas where early morning snacks are popular.
- June aligns with the summer holidays, where demand for dairy-based products like milk and curd increases, especially among students and families.

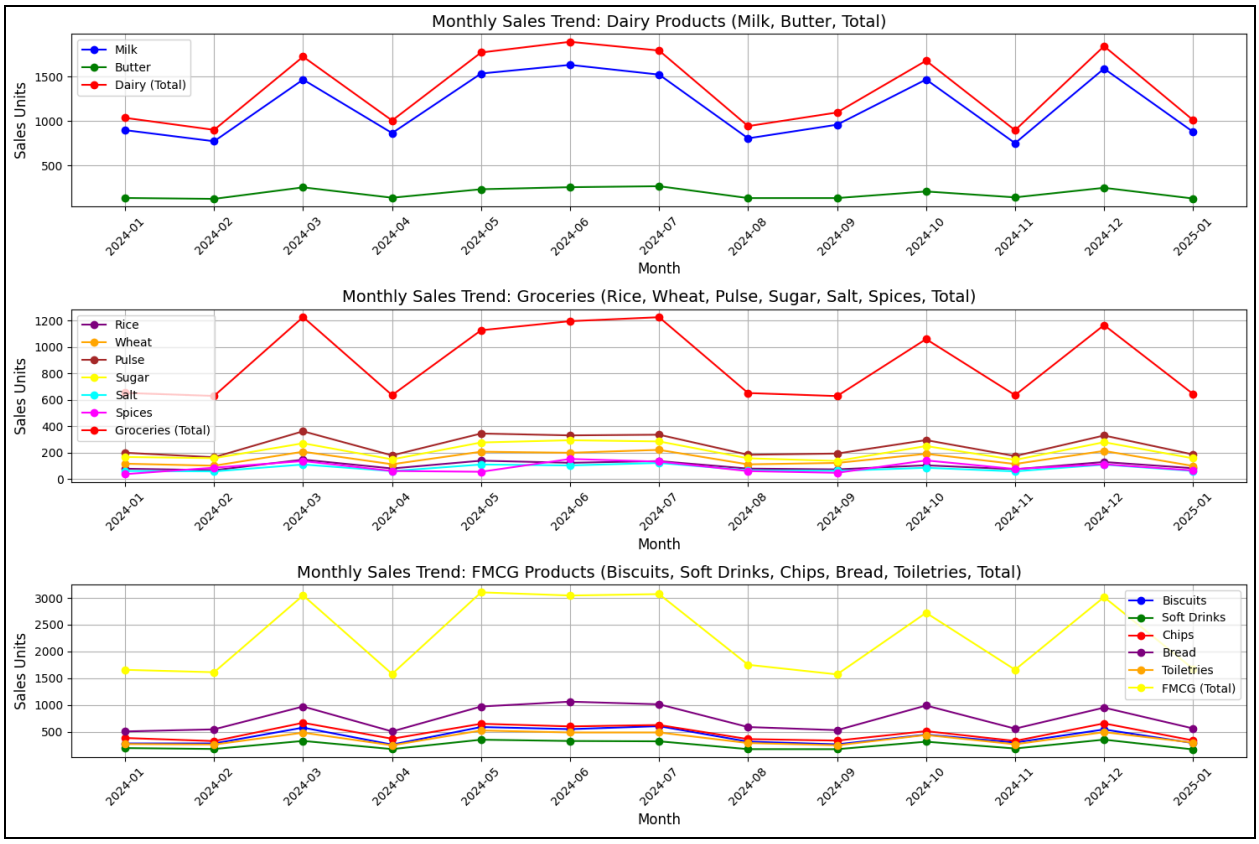

Image 1 : 3 Line charts showing category wise sales trends

- October is marked by the Navratri and Diwali festivals, where dairy consumption generally rises due to sweets and special preparations.
- December, being one of the coldest months, also sees a boost in dairy sales, partly due to the consumption of dairy in warm, comforting foods and festive treats like Christmas sweets. This pattern highlights the need for careful inventory management in the dairy category, especially for Milk, ensuring that stock levels align with the demand spikes during these months without leading to excess stock, which can result in spoilage.

In the **FMCG** category, **Bread** emerges as the top performer, showing a similar pattern to **Milk** in terms of fluctuating sales. Bread sales typically rise during the festivals or holiday seasons, with consumers seeking more staple products for family meals and gatherings. This aligns with the patterns seen for Milk, indicating that bread might be a high-demand product during festive months like **October** (Navratri/Diwali) and **December** (Christmas and New Year celebrations). The seasonal spike in sales of these essential products is critical for Mr. Satyam to consider when managing inventory for **bread**.

In the **Grocery** category, sales appear to be more **consistent** throughout the year, with **Pulse** being the highest-selling SKU. The stable demand in this category could be due to pulses being a staple in daily diets, particularly in households that focus on traditional meals. However, since the grocery category shows a more **steady** pattern, it may not experience the same high variability as dairy or FMCG products, which means that overstocking in grocery items like pulses and rice might not be as risky, but managing space for slow-moving products can help optimize shelf usage.

By using **Machine Learning** and **Linear Regression**, we have successfully predicted the future sales of **Milk** based on historical data. This approach leverages past sales trends to forecast demand for the upcoming period, allowing for a more accurate estimation of required inventory. This technique not only helps in predicting the sales of **Milk**, which has fluctuating demand due to its perishable nature, but it can also be applied to other categories in **Jai Maa Jhandewali Store** like **FMCG** and **Grocery**.

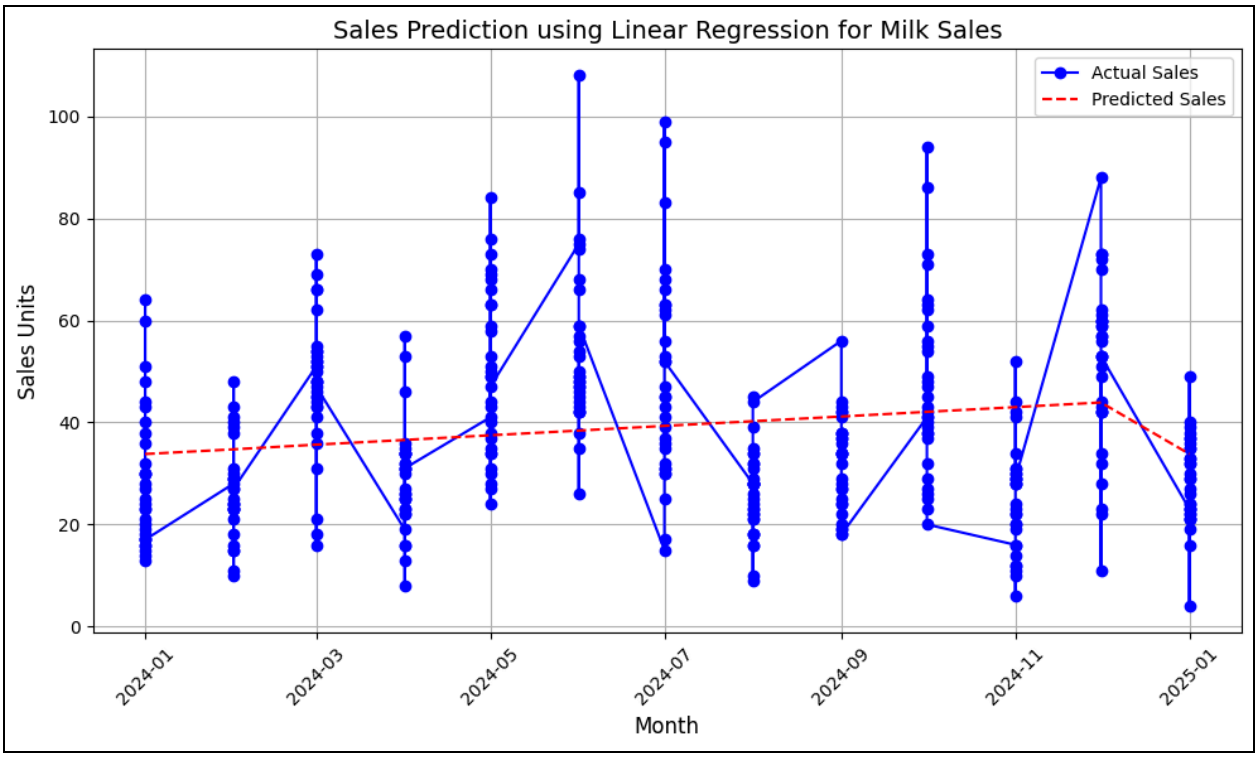

Image 2 : Chart where blue shows actual sales of Milk and red line shows future predictions

Based on the **ABC Classification** analysis, which categorizes the products based on their total sales and cumulative sales percentages, the findings highlight which products contribute the most to the store's overall sales, and help in prioritizing inventory management strategies.

1. **Category A (High Priority)**:

    - Products classified under **Category A** are the highest contributors to the store's total sales. These products account for **70.59% of total sales**. In this category, we have products such as **Milk**, **Bread**, **Chips**, **Biscuits**, **Toiletries**, and **Soft Drinks**.
    - **Milk** leads with a total sales value of **15,148 units**, contributing around **25.85%** of the store's total sales.
    - **Bread** follows closely with **9,801 units** (approximately **16.77%** of total sales).
    - **Chips**, **Biscuits**, and **Toiletries** also show high sales volumes and are critical for the store's overall revenue.

- Products in this category should receive **high attention** in terms of **stocking levels**, **supply chain management**, and **promotions** due to their significant impact on sales.

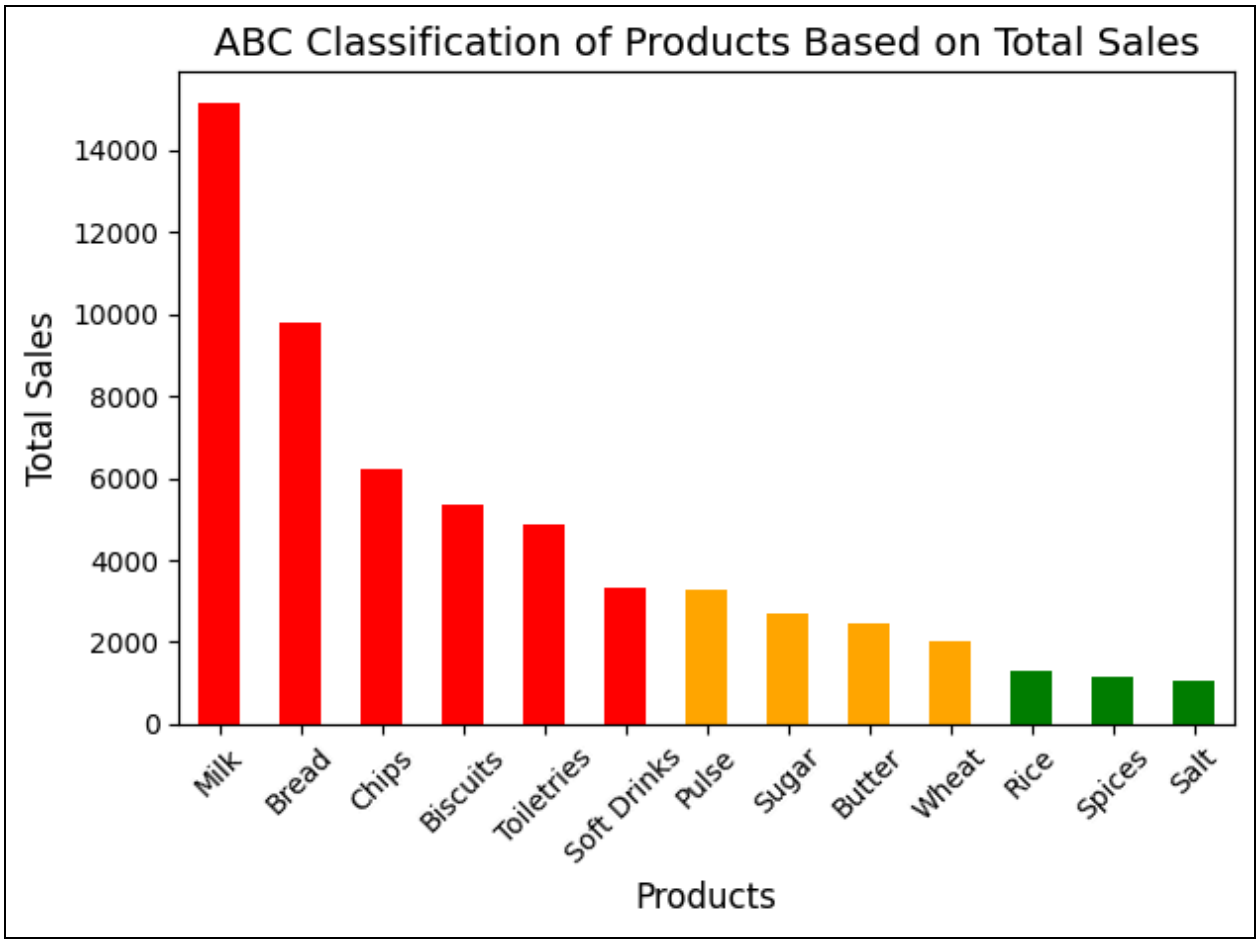

Image 3 : Bar graph showing Category A in red, B in Orange and C in Green

2. **Category B (Medium Priority)**:

- Products in **Category B** account for the next 20% of sales, contributing a cumulative total of **16.59%**. These products are still important but don't have as high a sales volume as those in Category A.
- **Pulse**, **Sugar**, **Butter**, and **Wheat** are the products in this group.
- For instance, **Pulse** with **3,266 units** (approx **5.94%** of total sales) and **Sugar** with **2,713 units** (approx **4.92%**) contribute to stable but lower revenue.

- **Category B products** should be stocked regularly but do not require as much attention as **Category A products**. Monitoring demand patterns can help ensure these items are available when required without overstocking.

3. **Category C (Low Priority)**:

   - Products classified under **Category C** are those with the lowest contribution to overall sales, representing **approximately 3.75%** of total sales. These products include **Rice**, **Spices**, and **Salt**.
   - For example, **Rice** shows sales of **1,298 units**, contributing to **2.35%** of total sales, while **Spices** and **Salt** are the least performing products.
   - Products in **Category C** should be monitored for slow-moving sales and possibly reduced in stock. They could be considered for **promotions** or **discounts** to move excess stock.
   - These products may also be considered for **discontinuation** or **consolidation** in favor of faster-moving products in **Category A and B**.

The correlation heatmap provides valuable insights into the relationships between the sales of various products in the store. Here's a breakdown of key observations based on the correlation coefficients:

High Correlations:

1. **Pulse and Wheat (0.729)**: A strong positive correlation indicates that the sales of **Pulse** and **Wheat** often move together. These products may have a shared demand due to their complementary nature in grocery shopping.
2. **Pulse and Rice (0.691)**: A significant correlation suggests that customers buying **Pulse** are also likely to purchase **Rice**. This trend could indicate that these items are staples for most households.
3. **Rice and Wheat (0.629)**: Another strong correlation between these two grocery staples reinforces their complementary demand.

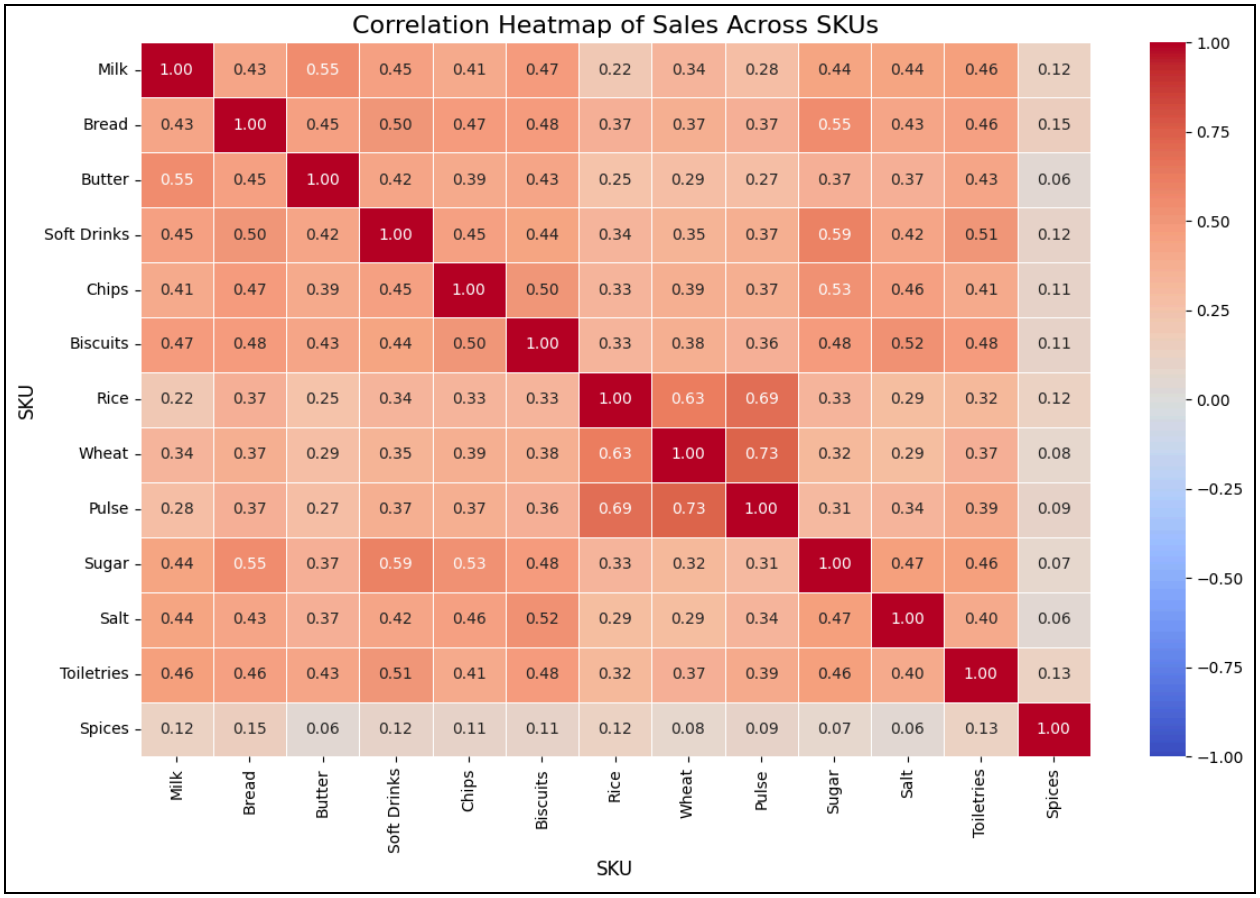

Image 4 : Correlation Heatmap

Moderate Correlations:

1. **Soft Drinks and Sugar (0.595)**: The positive correlation indicates a potential relationship, possibly due to sugar's use in beverages or as a complementary product with soft drinks.
2. **Milk and Butter (0.546)**: A moderate correlation implies that customers buying **Milk** may also purchase **Butter**, aligning with their complementary use in breakfast or cooking.
3. **Bread and Sugar (0.550)**: A moderately high correlation suggests that customers buying **Bread** are also likely to purchase **Sugar**, which could be attributed to their use together in breakfast or snacks.
4. **Milk and Bread (0.431)**: The correlation reflects the likelihood of these two breakfast essentials being purchased together.

5. **Chips and Biscuits (0.499)**: Indicates a preference for these snack items to be purchased together, which could be useful for bundling or promotional strategies.

Low and Negligible Correlations:

1. **Spices with all SKUs (< 0.2)**: The consistently low correlation of **Spices** with other products suggests that it is purchased independently of other items and doesn't show a strong relationship with sales patterns.
2. **Milk and Spices (0.119)**: Highlights a lack of connection between these items, confirming that they belong to entirely different consumption categories.

Interpretation of Results and Recommendation :

Problem 1: Inventory Management Issues

Interpretation:

- **Milk** shows the highest sales in the dairy category, but its sales fluctuate significantly, especially during festive months like March, October, and December. Overstocking perishable items like milk leads to wastage, while understocking risks missed sales opportunities.
- **Butter**, despite having low but stable demand, occupies inventory space without contributing significantly to fluctuations.
- ABC classification highlights that fast-moving products like **Milk, Bread, and Chips** (A-category) contribute 76% of total sales, indicating these should be prioritized for stock optimization.
- Machine learning sales predictions can guide stocking levels for perishable and seasonal products to balance demand and supply effectively.

Recommendations:

1. **Data-Driven Inventory Optimization**:
    - Use sales predictions to adjust inventory levels for high-demand months, especially for perishable products like milk.
    - Implement a just-in-time inventory system for A-category products to minimize wastage while meeting demand.
2. **Seasonal Planning**:
    - Plan inventory spikes for products like milk and bread during festive months and school vacations, leveraging sales trends to avoid overstocking.
3. **Supplier Coordination**:
    - Establish strong communication with suppliers for faster replenishment cycles, ensuring that stock levels match expected demand.
4. **Wastage Reduction Initiatives**:
    - Offer discounts on near-expiry products to encourage sales and minimize spoilage.
    - Explore partnerships with local NGOs to donate unsold perishables, enhancing goodwill.

Problem 2: Space Constraints

Interpretation:

- Limited space impacts the ability to stock a wide range of products effectively.
- ABC classification reveals that **C-category items** like spices, salt, and rice contribute minimally to sales while occupying valuable shelf space.

- Correlation analysis shows strong relationships between certain products (e.g., **Milk and Bread**, **Pulse and Wheat**), indicating opportunities to streamline product placement and bundling.

Recommendations:

1. **Focus on High-Contributing Products**:
    - Prioritize stocking A-category items like **Milk, Bread, and Chips**, which drive the majority of revenue.
    - Reduce storage for C-category products, offering them on-demand or through pre-orders.
2. **Product Placement Optimization**:
    - Position high-correlation products like **Milk and Bread** or **Pulse and Wheat** together to encourage bulk purchases.
3. **Leveraging Vertical Storage**:
    - Invest in space-efficient storage solutions such as vertical shelves to maximize available storage area.
4. **E-Commerce Collaboration**:
    - Partner with local e-commerce platforms to list slow-moving products, reducing the need for physical storage.

Problem 3: Limited Business Growth

Interpretation:

- Mr. Satyam's dual role as a student and business owner creates operational bottlenecks, particularly during peak sales months like March and October, which coincide with exam periods.
- High demand in March and October indicates seasonal trends, making these periods critical for business performance.
- The lack of dedicated support during these busy times could lead to missed sales opportunities and operational inefficiencies.
- Providing home delivery could address customer convenience and expand the store's reach, especially during peak demand.

Recommendations:

1. **Automate Sales and Inventory Management**:
    - Install a point-of-sale (POS) system for efficient sales tracking and inventory monitoring.
    - Utilize automated tools to generate demand forecasts, helping prepare for high-demand periods.
2. **Hire Temporary Support**:
    - Employ a part-time or temporary worker during March and October to manage store operations, allowing Mr. Satyam to focus on his studies.
    - Assign responsibilities like billing, inventory restocking, and customer handling to the temporary staff.
3. **Expand Service Offerings with Home Delivery**:

- Introduce home delivery services, particularly for regular customers, to enhance customer convenience and satisfaction.
- Use local delivery methods like bicycles or scooters to manage delivery costs efficiently.

4. **Seasonal Marketing Campaigns**:
   - Offer bundle deals and discounts during peak months to boost sales.
   - Advertise home delivery services through local WhatsApp groups and social media platforms to attract a broader customer base.
5. **Streamline Operations During Exams**:
   - Pre-plan inventory for March and October using sales trends and ABC classification to avoid last-minute stocking issues.
   - Establish a backup operational plan where family members or the temporary employee take full charge during Mr. Satyam’s exams.