Improving Operational Efficiency through Data Analysis: A Case Study on Bharat Kirana Store

A Mid-Term Report for the BDM capstone project

Submitted By:

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EXECUTIVE SUMMARY

This project focuses on optimising demand forecasting and inventory management for Bharat Kirana, a grocery store in Patna, Bihar. Established in 1940 and modernised in 2010, Bharat Kirana serves around 150 customers daily, offering a wide range of household items and packaged goods. Despite having data management software, the store faces challenges in efficient inventory management, stock procurement, and customer transactions.

To address these issues, we collected historical sales data from April 2023 to April 2024 and performed data cleaning. Exploratory data analysis revealed significant seasonal trends, with sales peaks during Diwali and Holi, and higher sales on weekends and during promotions. Weather analysis showed higher sales during moderate temperatures and dry days.

Advanced predictive modelling and clustering analysis was used to forecast future sales trends, optimise stock replenishment and segment customers based on buying behaviour. Initial results suggest that inventory should be evaluated frequently and coordination should be better to avoid stockouts and overstocking.

The models will help Bharat Kirana to optimise inventory levels, reduce stockouts, and increase customer happiness for the business's profit. By implementing these data driven strategies, the store will be able to streamline operations, improve customer satisfaction and grow business.

Initial results show that demand varies across product categories and seasonality needs to be considered while forecasting demand. To ensure products are stocked on time and efficiently the analysis suggests the shop should evaluate inventory more frequently and department wise.

PROOF OF ORIGINALITY

- BUSINESS FRONT WITH MANAGER AND THE STUDENT Storefront.jpeg
- BUSINESS MANAGER AND THE STUDENT: store manager photo.png

- VIDEO OF THE STUDENT DISCUSSING PROJECT DETAILS WITH BUSINESS MANAGER: BDM Video.mp4
- (RAW) SALES DETAIL REPORT (DATA) (APR-23 TO APR-24) PROVIDED BY BUSINESS: Sales Detail Report 23-24.xls
- (RAW) SALES AND STOCK DETAILED DATA (APR-23 TO APR-24) PROVIDED BY BUSINESS: Sales And Stock (Detail) .xlsx
- BHARAT KIRANA STORE'S CONTACT INFORMATION: Store Contact.jpeg
- LETTER OF AUTHENTICATION FROM BHARAT KIRANA auth_stamp.pdf
- All Data related to this project (Incl. Meteorological data of city) : BDM Project

METADATA

To design a demand forecasting and inventory management optimization model for Bharat Kirana, we collected historical sales data from the previous year, including sales volume, revenue, and product categories. We also gathered inventory levels and stock reports for each product category for the same period.

Descriptive statistics revealed sales variability with peaks during Diwali (October, November) and Holi (March, April), indicating the need for an adaptable inventory management system.

Using histograms, box plots, and time series analysis, we identified sales trends and patterns. Festive periods significantly impact the demand for certain products, such as oil and atta, while products like bread and milk maintain consistent demand year-round.

Our review of the store's current inventory management system revealed that it does not account for demand trends, leading to surplus inventory for some products and stockouts for others. A more advanced system considering historical sales data, seasonal trends, and planned promotions will benefit the store.

Stock-to-sales ratio analysis showed significant variation across products, with some being overstocked and others understocked, leading to stockouts and lost sales.

These insights will be used to construct a demand forecasting and inventory management optimization model, forming a basis for ongoing improvements and strategic planning to achieve long-term operational efficiency.

DESCRIPTIVE STATISTICS

Descriptive statistics give an overall view of the current demands, inventory levels and sales statistics of the grocery store for the period from April 2023 to April 2024.

Sales Statistics:

	Received Amount	Credit Amount	Cheque Amount	Card Amount	Net Amount
count	358.0	358.0	358.0	358.0	358.0
mean	141445.35754	4.6927374	0.0	6.3687150	141456.41899
std	58751.249395	63.234838	0.0	120.18404	58745.885245
min	23656.0	0.0	0.0	0.0	23656.0
25%	99636.75	0.0	0.0	0.0	99636.75
50%	133532.5	0.0	0.0	0.0	133532.5
75%	173480.25	0.0	0.0	0.0	173480.25
max	366229.0	950.0	0.0	2274.0	366229.0

Mean Net Amount: Average daily sales amount is **₹141,456.42**.

Median Net Amount: Middle value of daily sales amount is **₹133,532.50**.

Standard Deviation of Net Amount: Sales amount variability is **₹58,745.89**.

Minimum Net Amount: Lowest daily sales amount is **₹23,656.00**.

Maximum Net Amount: Highest daily sales amount is **₹366,229.00**.

Stock Statistics:

	Tax Rate	Prod MRP	ProdSale Rate	OpStock	OpRate	PurchaseQty	PurchaseRate	PurchaseValue	SalesReturnRate	In Stock	In Stock Rate	In Stock Value	SalesQty	Sales Rate	SalesValue	Shortage StockRate	Out Stock	Out Stock Rate	Out Stock Value
count	13170	13170	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170.0	13170	13170.0	13170.0
mean	12.7148	175.48	157.804	685.59	50.1271	10679.753	105.13660	3615.0391	13.830288	11216.004	118.99116	3731.744	9892.8245	128.7594	3472.048	60.5984	11096.71	146.3343	4029.522
std	6.647	504.81	482.860	14147.1	257.58	204012.	1514.32	18666.9	123.3442	206003	1518.3	19111	195586	1962	18236.	300.1189	204830	1953.184	19626.81
25%	5.0	50.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	12.1075	83.6125	1.0	13.3	62.72	0.0	2.0	35.792500	165.6
50%	18.0	99.0	91.0	0.0	0.0	6.0	43.65	396.49	0.0	6.0	54.235	439.29	4.0	59.25500	360.24	0.0	6.0	73.875	518.79
75%	18.0	199.75	181.0	3.0	52.297	24.0	110.0	1519.52	0.0	24.0	122.55	1584.	20.0	133.3	1419.3	65.0	25.0	150.0725	1801.350

					5			5			75	6		4	75			0	0
max	28.0	11000.	11000.0	598800.0	26000.0	114834 00.0	170000.0	523526.23	9260.0	115392 85.0	17000 0.0	52352 6.23	118357 58	2200 00.0	500504 .35	26000.0	118552 55.0	220000.0	530285.17

Mean Product MRP: Average product MRP is **₹175.48**.

Median Product MRP: Middle value of product MRP is **₹99.00**.

Standard Deviation of Product MRP: Product MRP variability is **₹504.82**.

Maximum Product MRP: Highest product MRP is **₹11,000.00**.

DETAILED EXPLANATION OF ANALYSIS PROCESS

To develop a Trend Analysis and inventory management optimization model for the grocery store we needed a systematic and data driven approach which involved the following steps:

DATA COLLECTION: The initial step was to gather historical sales and inventory data from Bharat Kirana. This data included detailed records of sales transactions, inventory levels, and other relevant metrics over the period from April 2023 to April 2024.

DATA SELECTION: We carefully selected relevant data attributes necessary for the analysis. Key attributes were product names, manufacturing companies, MRP, sale rates, opening and closing stock values, purchase quantities, and sales amounts.

DATA CLEANING: In this stage, we focused on cleaning the historical sales data by:

- Removing duplicates to make each entry unique.
- Addressing inconsistencies to standardise data formats and values.
- Identifying and handling outliers that could skew the results.
- Using extensive data cleaning techniques, we verified the data accuracy and reliability, reduced the noise and formatted the data for accurate analysis.

DATA PREPROCESSING: After cleaning, we preprocessed the data to prepare it for analysis:

- Converting data into a suitable format for analysis tools.
- Handling missing values appropriately.
- Normalising and scaling data where necessary to make it consistent across all metrics.

EXPLORATORY DATA ANALYSIS (EDA): With the cleaned data, we did Exploratory Data Analysis to understand its basic characteristics, find patterns, and detect anomalies:

- Histograms and box plots to visualise data distribution.
- Time series analysis to find seasonality, trends and outliers.

EDA helped us gain insights into the underlying data and understand how factors like seasonality, holidays and weather affect sales.

TREND ANALYSIS: Based on the insights gathered from EDA, we did trend analysis to understand the long-term movement in sales data, as shown in (Fig-1).

This involved:

- Fitting a trend line to the sales data to see if sales were increasing or decreasing over time.
- Identifying any long-term shifts in demand for specific products or categories.

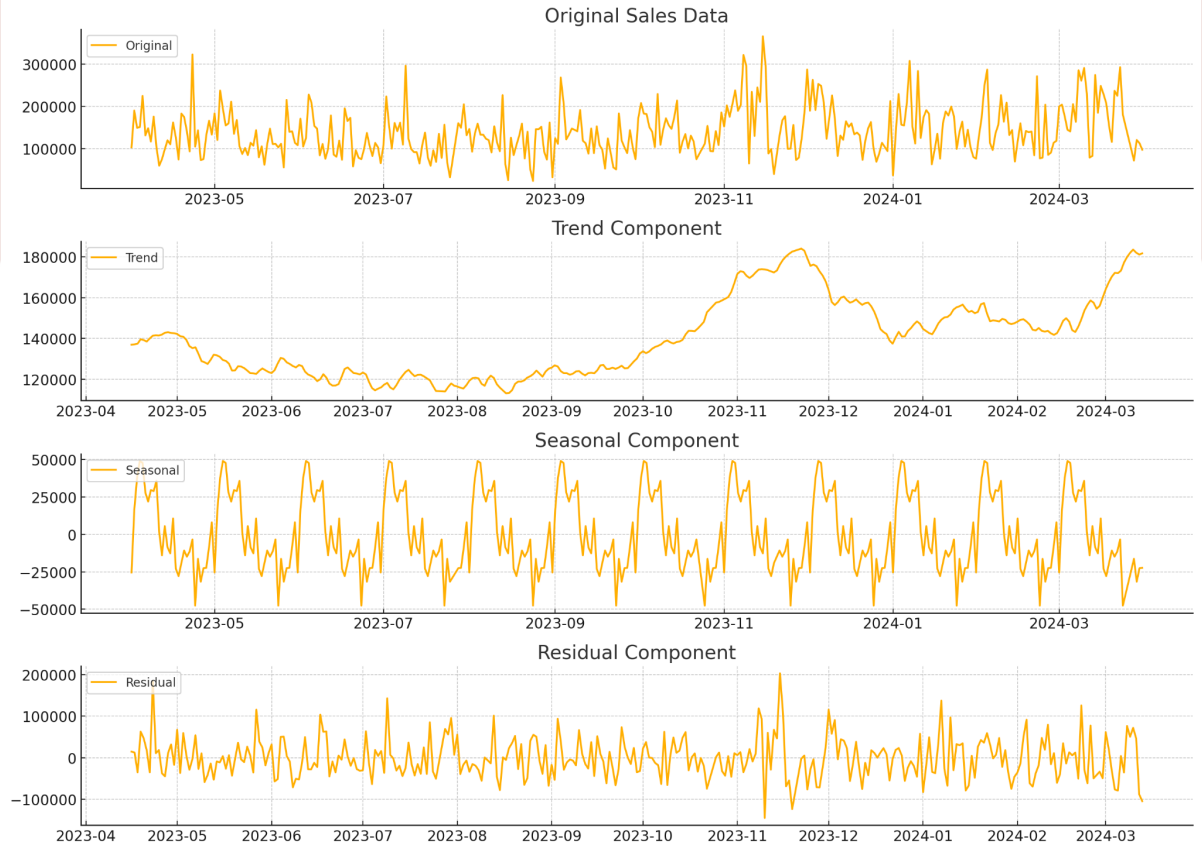

Fig 1

SEASONALITY AND FESTIVE ANALYSIS: We performed seasonal decomposition of the sales data to identify clear seasonal patterns.(also shown in Fig-1) This involved:

- Analysing periodic changes in sales data within a year.
- Using techniques like seasonal decomposition to extract the seasonal component from the trend and other components.
- Identifying peak seasons for specific products or categories.

PROMOTION ANALYSIS: To understand the impact of promotions on sales, we did promotion analysis by:

- Comparing sales data from promotional periods to non-promotional periods.
- Finding out the effectiveness of different promotions.

WEATHER ANALYSIS: We ran weather analysis to assess the impact of weather on sales. This involved:

- Comparing sales data to meteorological data.
- Identifying correlations between weather conditions and sales performance.

INVENTORY MANAGEMENT OPTIMIZATION: We did stock-to-sales ratio analysis to identify inefficiencies in inventory management. This helped in:

- Identifying overstocked and understocked products.
- Proactively managing inventory during high demand periods, especially festive months.

DEMAND FORECAST ANALYSIS : The forecast indicated continued variability in sales, with expected peaks during the next festive seasons.
We can use these forecasts for inventory planning and demand management.

QUANTITY VS DENSITY ANALYSIS : We analysed sales quantities using a quantity vs. density plot to understand typical customer buying habits and identify common sales ranges.

SWOT ANALYSIS:

Strengths:

- Strong Supplier Relationships: Products are supplied consistently.
- Wide Product Range: Variety of products available for customers.
- High Sales Figures: Robust sales performance with significant revenue.

Weaknesses:

- Inventory Management: Variability in stock levels, including stockouts and overstock situations.
- Cost Efficiency: High operational costs due to inefficiencies in inventory management.

Opportunities

- Customer Buying Patterns: Leveraging data analytics to optimize product demand variation.
- Supplier Management: Improving relationships and purchasing practices to reduce costs and increase product availability.

Threats

- Market Competition: Competitors offering better prices or services could impact sales.
- Supply Chain Disruptions: Potential delays or issues in the supply chain may impact stock availability and customer satisfaction.

Our analysis process included data collection, cleaning, preprocessing, EDA, trend analysis, seasonality and festivity analysis, promotion analysis, weather analysis, quantity vs. density analysis, demand forecasting, and inventory management optimization. By integrating various data sources and techniques, we developed a robust model to optimize inventory, reduce stockouts, and enhance customer satisfaction for profitable operations.

RESULTS AND FINDINGS

Our preliminary examination of historical sales data revealed several key trends for developing our demand forecasting and inventory management model:

Seasonality and Festivity:

Peak Sales During Festivals: Seasonal decomposition of the sales data showed a clear seasonal pattern, sales were higher during the festive months of November and March, coinciding with Diwali and Holi. These periods see a huge surge in customer buying, hence there is strong seasonality due to festive celebrations.

Higher Weekend Sales: Sales were higher on weekends compared to weekdays, suggesting customers prefer shopping on weekends due to more free time, as shown in the bar graph (Fig-2).

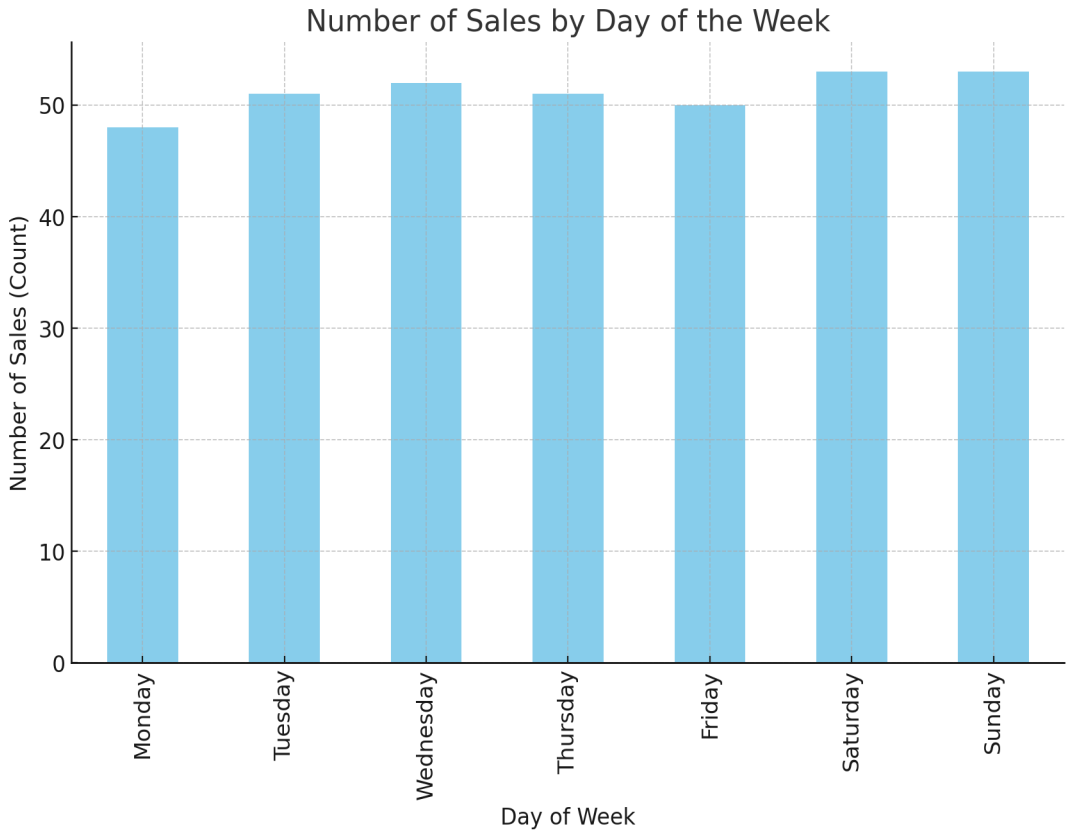

Fig-2

Effectiveness of Promotions: Promotional activities have a considerable impact on sales. Our data shows that sales are notably higher during promotions. Among various promotions, "buy one get one free" offers have proven to be particularly effective in boosting sales.

Weather Influence:

Sales and Weather Conditions: Weather conditions play a significant role in influencing sales. Our analysis shows that sales of certain items such as sunscreen and cold drinks tend to be higher in hot and sunny weather conditions.

Optimal Conditions for Sales: Sales data correlated with weather conditions shows higher sales in moderate temperatures (25°C to 35°C) and no precipitation. Customers shop more in these ideal weather conditions, which should be considered in demand forecasting. The plot of Sales v/s Temperature and Sales v/s Precipitation are depicted in (Fig-3 and Fig-4).

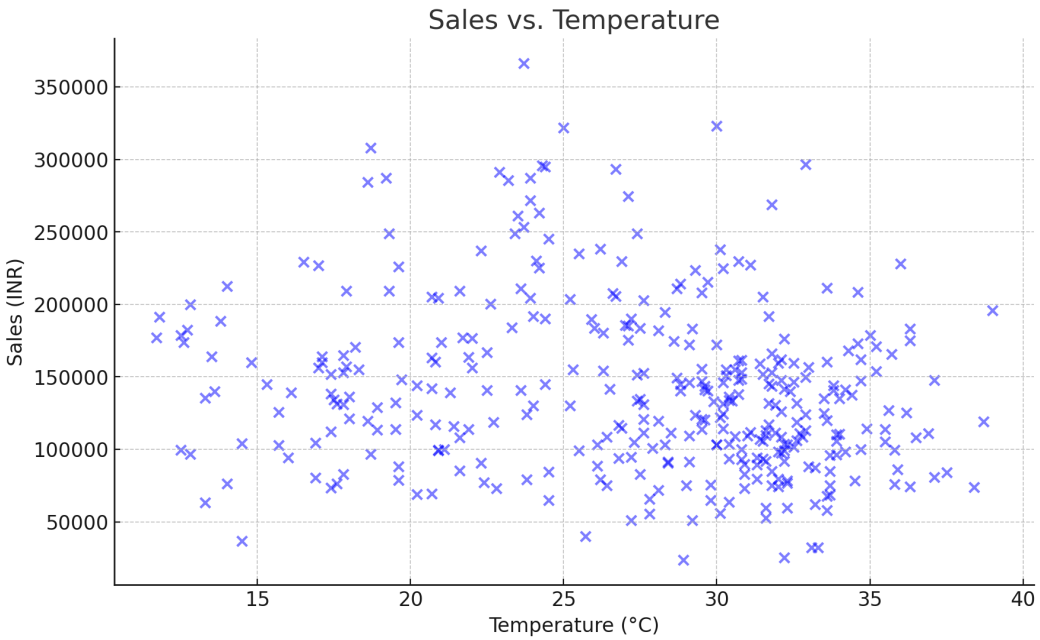

Fig-3

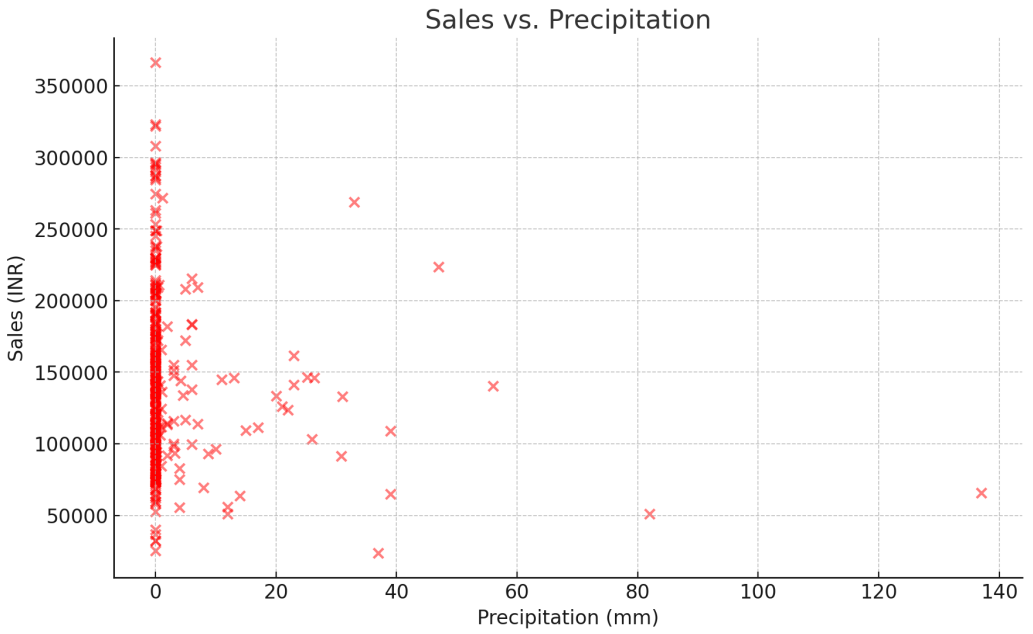

Fig-4

Stock Management: The stock-to-sales ratio analysis identified several products with inventory management inefficiencies:

Overstocked Products: Items such as *Makka Sabut 500 GM* and *Rakesh Gulal Red 100 G* had high stock-to-sales ratios, indicating overstocking.

Understocked Products: Products like *MP Bag Piper Wheat Loose (1000 GMS)* and *Maida Loose (1000 GM)* were frequently understocked, leading to potential stockouts and lost sales.

Quantity v/s Density: A quantity vs. density plot (Fig-5) showed sales transactions clustering around specific quantity ranges, indicating typical customer buying behaviour.

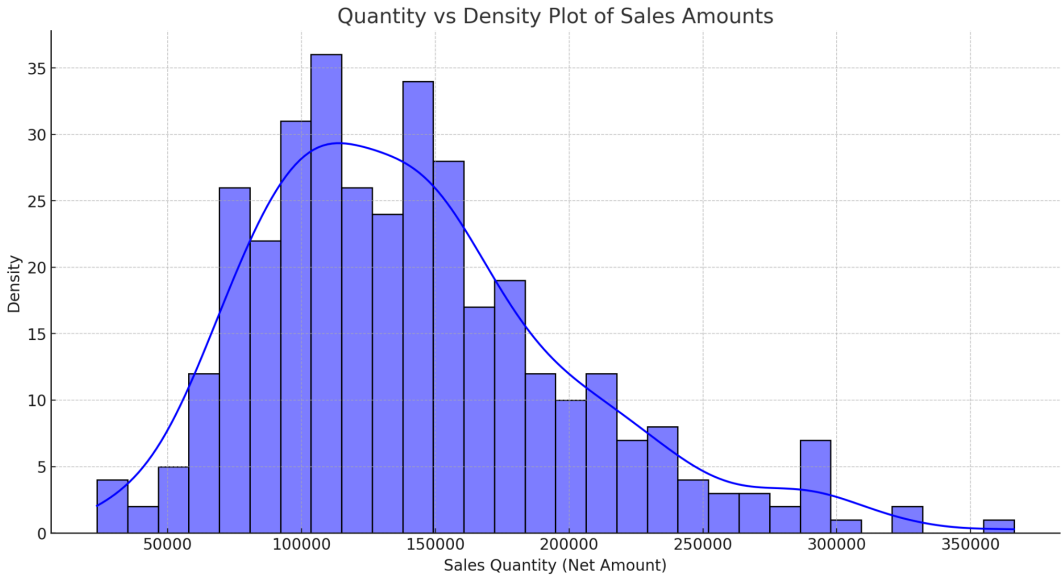

Fig-5

While creating the demand forecasting and inventory management optimization model, This will be considered to improve understock and overstock conditions.

We may offer some initial suggestions for the demand forecasting and inventory management optimization model based on these preliminary observations and outcomes. The Store should adjust inventory based on seasonal demand pattern for high demand products during festive months. For understocked products, we advise raising inventory levels. For weather sensitive products, we suggest creating successful sales boosting campaigns and making sure inventory is optimal. In order to ensure that inventory levels are updated to suit the expanding demand for the grocery store's products, we also advise that the trend in sales be taken into account while creating the demand forecasting model.

As a result of our preliminary analysis of the data, we have found some key trends and insights which will help us to build a strong demand forecasting and inventory management model for the grocery store. By incorporating factors such as seasonality, promotional impact, weather conditions, and stock levels, the store can optimise inventory, reduce stockouts, and enhance customer satisfaction, ensuring profitability and operational efficiency year-round.