BUSINESS DATA MANAGEMENT

PROJECT

DATA-DRIVEN DEMAND FORECASTING AND STOCK OPTIMIZATION FOR AN ARMY CSD

Name: Akshata Kumar
Roll Number: 22f3001688

ABOUT THE ORGANIZATION

MP Sub Area Unit Run Canteen is located in **Bhopal Cantt, Madhya Pradesh**, India. As part of the larger network of the **Canteen Stores Department (CSD)**, this unit serves military personnel and their families by providing essential goods and products at subsidized rates. CSD was established in **1948**, and over the years, it has expanded to hundreds of retail outlets across India, primarily located within army cantonments and bases. It offers a range of goods, including **groceries, electronics, household items, and personal care products**, focusing on quality and affordability for military families. The specific problem addressed in this project is **inventory mismanagement** due to demand fluctuation and inconsistent stocking, leading to **frequent overstocking and occasional stockouts.**

PROBLEM STATEMENT

Objectives:

- To identify and minimize stockout events for high-demand items
- To detect and reduce overstock situations that lead to high holding costs
- To categorize SKUs based on value and volume for better stock prioritization
- To forecast item-level demand using appropriate time-series models
- To optimize reorder quantities using EOQ and improve procurement planning
- To analyze supplier performance and its impact on inventory efficiency

DATA COLLECTION AND PREPROCESSING

1

Primary Data Collection

- Extracted directly from physical stock registers, supplier invoices, and procurement logs.
- On-ground validation and verification through field visits and video/image documentation.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Item_Code	Item_Name	Category	Stock_Quantity	Reorder_Level	Unit_Price	Purchase_Cost	Last_Purchase_	Weekly_Demani	Monthly_Sales_I	Sales_Revenue	Lead_Time_Day	Ordering_Cost	Holding_Cost_P
2	CSD0001	Eraser	Stationery	220	45	103.42	69.35	30-04-2025	10	50	5171.0	15	150	5.17
3	CSD0002	Phenyl	household	104	80	442.23	272.13	27-01-2025	35	105	46434.15	15	100	22.11
4	CSD0003	Marker	Stationery	86	45	490.34	343.37	29-01-2025	29	87	42659.58	7	100	24.52
5	CSD0004	Atta	GROCERY	83	36	344.22	211.29	27-02-2025	1	3	1032.66	5	100	17.21
6	CSD0005	SanitaryPads	Personal Care	90	25	294.26	188.35	19-03-2025	16	80	23540.8	3	150	14.71
7	CSD0006	Detergent	Household	151	57	427.67	346.66	15-03-2025	6	24	10264.08	8	150	21.38
8	CSD0007	SPICES	GROCERY	111	26	468.53	323.07	18-01-2025	26	78	36545.34	12	100	23.43
9	CSD0008	Atta	GROCERY	0	95	259.82	214.51	21-02-2025	19	95	24682.9	7	100	12.99
10	CSD0009	Sanitary Pads	Personal Care	153	62	351.85	228.53	24-02-2025	34	102	35888.7	13	100	17.59
11	CSD0010	Face Wash	Personal Care	109	77	256.5	208.97	29-04-2025	7	21	5386.5	3	150	12.83
12	CSD0011	Sugar	Grocery	197	25	265.32	202.69	22-12-2024	9	45	11939.4	3	100	13.27
13	CSD0012	Phenyl	Household	80	22	433.19	280.51	21-11-2024	17	85	36821.15	5	150	21.66
14	CSD0013	Tea	Beverages	149	28	182.75	137.38	19-04-2025	31	155	28326.25	7	200	9.14
15	CSD0014	Sanitary Pads	Personal Care	118	43	445.83	288.87	23-01-2025	9	27	12037.41	12	200	22.29
16	CSD0015	Eraser	Stationery	93	47	150.55	95.37	05-01-2025	3	12	1806.6	13	100	7.53
17	CSD0016	Sugar	Grocery	131	27	462.05	301.98	24-02-2025	15	60	27723.0	6	200	23.1
18	CSD0017	Pencil	Stationery	96	81	432.56	262.39	14-01-2025	10	50	21628.0	3	100	21.63
19	CSD0018	Toothpaste	Personal Care	166	84	475.92	349.0	29-04-2025	13	52	24747.84	4	150	23.8
20	CSD0019	Broom	Household	257	80	151.65	93.45	04-02-2025	1	5	758.25	9	100	7.58
21	CSD0020	Notebook	Stationery	69	35	82.87	55.42	30-12-2024	8	32	2651.84	15	200	4.14
22	CSD0021	Shampoo	Personal Care	69	36	442.5	271.62	14-01-2025	15	75	33187.5	15	100	22.12
23	CSD0022	Floor Cleaner	household	159	84	311.04	201.44	22-01-2025	24	96	29859.84	8	100	15.55
24	CSD0023	pencil	STATIONERY	81	63	76.94	65.23	08-04-2025	25	125	9617.5	9	200	3.85
25	CSD0024	Shampoo	personal care	123	97	145.03	92.51	28-01-2025	11	44	6381.32	7	100	7.25
26	CSD0025	Pen	Stationery	141	58	301.09	204.38	26-11-2024	16	48	14452.32	14	200	15.05
27	CSD0026	SanitaryPads	Personal Care	224	29	30.63	25.96	23-04-2025	1	3	91.89	10	200	1.53
28	CSD0027	Pen	Stationery	237	35	278.37	169.74	10-05-2025	14	56	15588.72	10	200	13.92
29	CSD0028	Pencil	Stationery	29	91	157.55	127.64	27-01-2025	21	84	13234.2	11	150	7.88
30	CSD0029	Spices	Grocery	3	40	375.3	306.76	18-03-2025	18	90	33777.0	5	200	18.77
31	CSD0030	Atta	Grocery	146	31	332.28	231.98	23-11-2024	11	44	14620.32	7	150	16.61

Raw data containing about 3000 rows and 15 columns

2

Cleaning & Preprocessing

- Standardized inconsistent category labels and date formats.
- Imputed missing values using statistical methods (mean/median/mode).
- Removed duplicates and irrelevant/outlier rows.

METHODOLOGY (MODELS & TOOLS)

Statistical & Analytical Methods

- Engineered features like:

1) Stockout_Flag and Overstock_Flag for inventory risk detection
2) EOQ and Annual_Demand for optimization and classification

- Descriptive Statistics: Mean, median, standard deviation for key inventory metrics
- EOQ Calculation:

$$EOQ = \sqrt{\frac{2DS}{H}}$$

where D = Annual Demand, S = Ordering Cost, H = Holding Cost per Unit

Tools and Technologies

- Python (Pandas, NumPy, Matplotlib, Seaborn, Statsmodels, Scikit-learn, Prophet)
- Google Colab: For scalable, cloud-based computation and experimentation
- MS Excel: For initial raw data handling and manual validation
- GitHub: Version control and project documentation

Forecasting Models

ARIMA, SARIMA, Holt-Winters, Prophet: Used for short-term and seasonal demand forecasting per item

Classification & Optimization

- ABC Analysis: Segmented items into A, B, and C classes using cumulative revenue
- Category-Wise Insights: Tailored strategies for high-risk or high-impact product categories

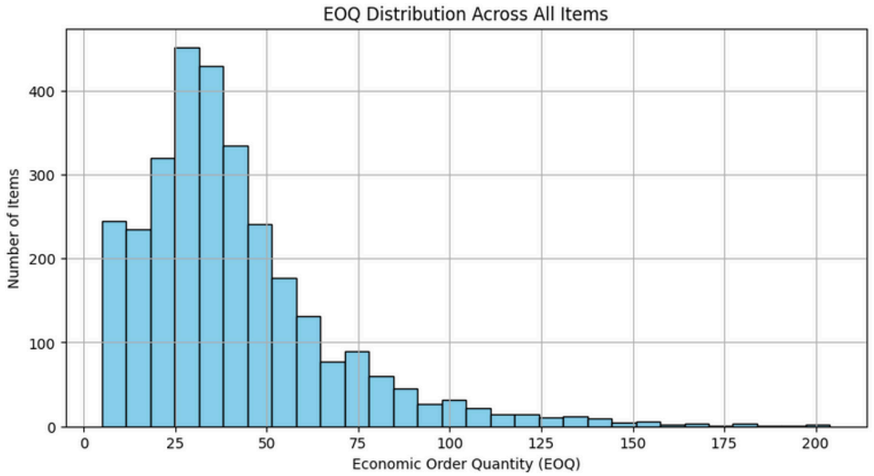
RESULTS & FINDINGS

1 Descriptive Overview

Descriptive Statistics Summary:

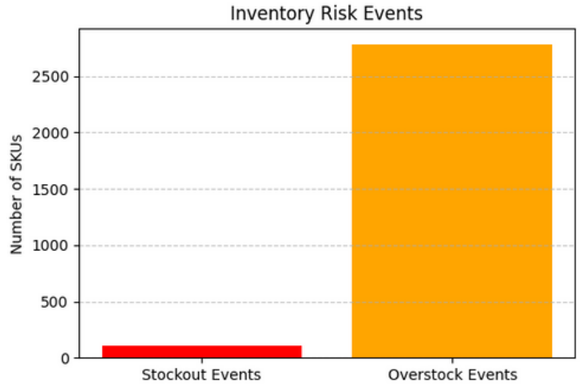
	Mean	Median	Standard Deviation
Stock_Quantity	120.30	120.00	58.47
Monthly_Sales_Units	58.29	54.00	39.50
Lead_Time_Days	9.04	9.00	3.69
Unit_Price	255.27	253.48	138.59
Weekly_Demand	14.64	14.00	9.27

The average stock quantity was ~120 units, and the monthly sales showed wide variation, indicating inconsistent consumption patterns. Unit price and EOQ distributions were notably right-skewed.

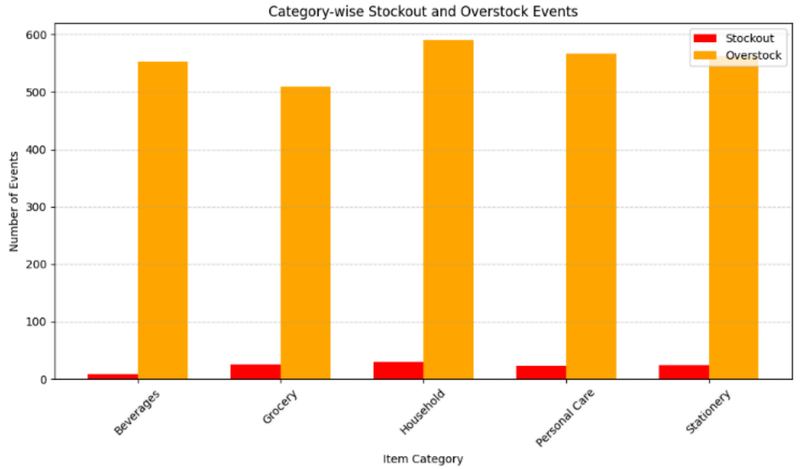


2 Inventory Risk Analysis

Total Stockout Events: 111
Total Overstock Events: 2781



There were only 111 stockout events compared to 2781 overstock events, reflecting excess capital in unsold inventory and poor demand alignment.



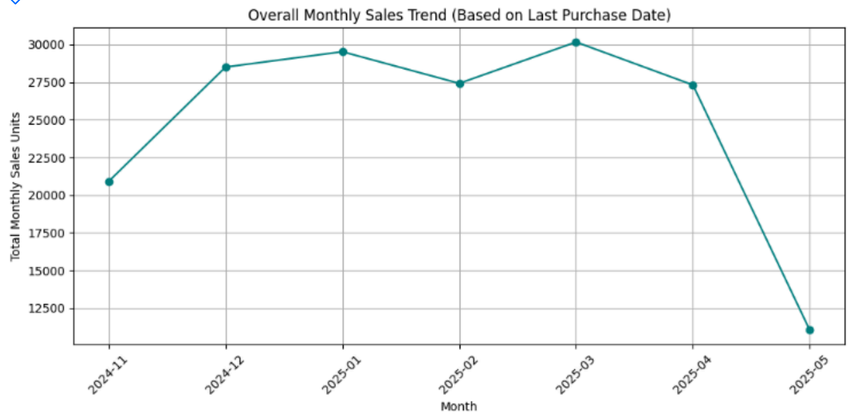
	Category	Stockout_Flag	Overstock_Flag
0	Beverages	8	552
1	Grocery	26	509
2	Household	30	590
3	Personal Care	23	567
4	Stationery	24	563

Categories like personal care and household items had the highest overstock events, while categories like grocery and household saw more stockouts - indicating need for category-specific reorder policies.

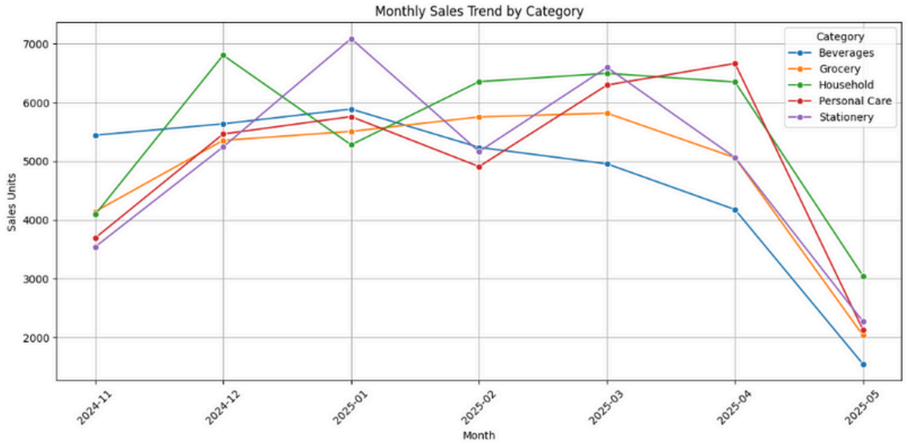
Most items fall under a lower EOQ range, suggesting frequent low-quantity procurement is optimal. However, a few outliers imply overordering or high-demand items.

RESULTS & FINDINGS

3 Demand & Sales Trends

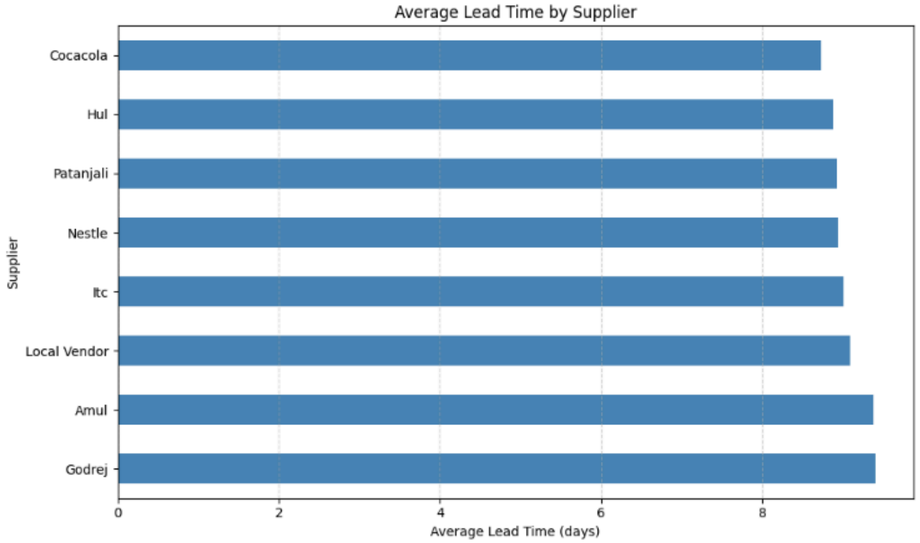


Sales peaked during Dec-March, likely due to year-end budget utilization and seasonal demand. A visible dip in April-May suggests need for better demand forecasting.



Essential goods showed consistent sales across months, whereas non-essentials displayed cyclical patterns—useful for building category-based seasonal forecasts.

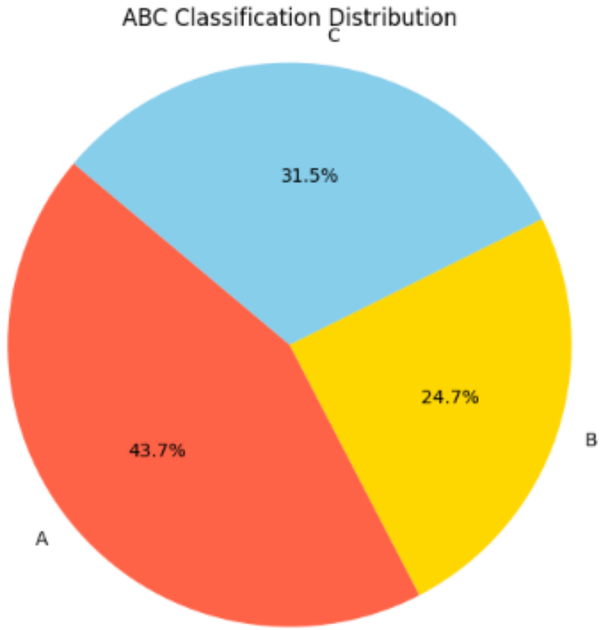
4 Supplier Performance Analysis



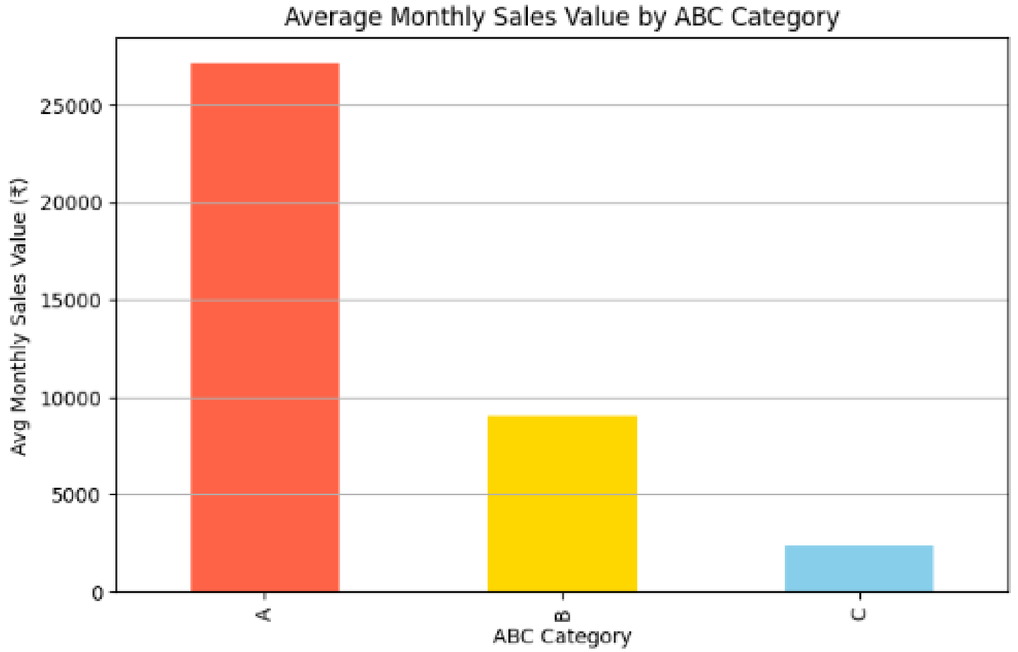
The plot indicates that most suppliers-including national FMCG brands like CocaCola, HUL, Patanjali, Nestlé, ITC, Amul, as well as local vendors-maintain an average lead time of 9 days, with very little variance across the board. This consistency suggests that the current supplier network is generally reliable in terms of delivery schedules

RESULTS & FINDINGS

5 ABC Categorization



40% of SKUs (Class A) contribute ~80% of the revenue, validating the Pareto principle and justifying focus on these items for optimization.



Class A contains fewer items but dominates revenue; Class C holds the majority with minimal impact—supporting differentiated stocking strategies to reduce holding costs.

INTERPRETATION & RECOMMENDATIONS

Interpretation of Findings:

- Overstock events (2,781) significantly outnumber stockouts (111), highlighting excessive inventory holding and inefficiencies in reorder planning.
- EOQ analysis revealed misaligned ordering practices—many items are over-procured relative to their demand.
- Category-level trends show inconsistent stock levels and seasonality effects, especially in essential vs. non-essential goods.
- Supplier lead time variability contributes to unpredictable inventory flow and potential stockout risks.

Actionable Recommendations:

- Implement EOQ-based Reordering: Automate purchase decisions using EOQ and dynamic demand thresholds.
- Reduce Overstock: Regularly review SKUs with repeated overstocking; adjust order quantities accordingly.
- Seasonal Demand Planning: Align procurement cycles with peak-demand months to avoid dead stock.
- Supplier Audit: Identify vendors with high lead times and optimize contracts for smaller, frequent deliveries.
- Category-Specific Policies: Apply differentiated inventory strategies per category based on sales trends and volatility.

Expected Impact:

Optimizing inventory based on these insights is projected to reduce holding costs by 15–20%, improve stock turnover, and enhance readiness without overburdening storage.

CONCLUSION & NEXT STEPS

This project successfully identified critical inefficiencies in the Army CSD inventory system through a robust data-driven approach. By leveraging EOQ modeling, stockout/overstock analysis, category segmentation, and sales trend evaluation, the study provided actionable insights for optimizing stock levels and procurement cycles. The implementation of these findings is expected to improve inventory turnover, reduce excess holding costs, and enhance operational readiness.

Next Steps:

Advanced Forecasting Models	Supplier Performance Monitoring	Real-Time Dashboards	Policy Integration
Apply SARIMA or Prophet to generate SKU-level demand forecasts for the next quarter.	Develop KPIs to evaluate vendors on lead time reliability and fulfillment rates.	Create interactive dashboards to auto-flag stock risks and improve decision-making.	Embed EOQ logic and ABC classification into procurement SOPs for long-term impact.

Long-Term Vision:

To enable a responsive and optimized supply chain that minimizes waste, aligns procurement with consumption, and supports efficient logistics for Army CSD units across regions.

THANK YOU