Project Report

Stochastic Inventory Modeling

Submitted in the partial fulfilment of the requirements of ME F320(Engineering Optimization)

By

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ACKNOWLEDGMENTS

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INTRODUCTION

The following report analyses the Stochastic Inventory Modelling done for the local Amul vendor at BITS Pilani, Hyderabad Campus. The study is based on the data collected on the sale of 12 different product categories over the year. The report focuses on variations in Demand and Lead Time over the year and various methods to reduce their effect while maintaining a minimum amount of Safety Stock in the inventory. Probabilistic Inventory modelling techniques such as Newsvendor Model and S-s Policy have been implemented to overcome the challenges. Overall, the report aims to provide insights into effective inventory management strategies that can be applied to similar retail stores in the industry.

Stochastic Inventory

Stochastic inventory refers to a type of inventory management that takes into account the random and uncertain nature of demand and lead times for inventory items. In stochastic inventory models, demand and lead time are treated as random variables, and inventory policies are designed to balance the cost of holding inventory with the cost of stockouts. This approach to inventory management is particularly useful in industries where demand and lead times are variable and difficult to predict with a high degree of accuracy. By using stochastic inventory models, businesses can optimize their inventory levels and minimize the risk of stockouts while minimizing the cost of holding inventory.

Terminology

Holding cost: the cost of holding or carrying inventory over a certain period of time. It includes costs such as warehousing, insurance, interest on capital, and depreciation.

For our study, we have considered holding costs separately for refrigerated and non-refrigerated products

Lead time: the time it takes to receive an order after it has been placed. It includes the time required for processing, production, and transportation.

Storage cost: the cost associated with storing inventory. It includes the cost of the physical space, utilities, and maintenance.

Safety stock: extra inventory that is held to protect against unexpected variations in demand or lead time.

Reorder point: the inventory level at which an order is triggered to replenish inventory. It is typically set where the expected demand during the lead time plus the safety stock equals the reorder point.

Capacity: the maximum amount of inventory that can be held or produced within a given period of time.

Setup cost: the cost associated with preparing a production or inventory system to produce a new batch of items.

Stockout cost: the cost associated with not having enough inventory to meet demand. It includes the cost of lost sales, backorders, and potential damage to customer relationships.

<u>Factors</u>:

Demand Variation

The store caters to a community of 5000+ people residing on the campus for their daily needs. Also, it has to deal with various variations in demand such as seasonal holidays during summer and winter break when the majority of the student body isn't present on campus, as well as demand variations based on events happening on campus without going stock out.

To cater to such an immense demand variation with limited storage and cooling capacity is a challenge which can be overcome by using proper inventory management strategies.

<u>Input Data</u>:

	Amul Buttermilk	Amul Lassi	Amul Stick Ice-Creams	Amul Ice-Cream Cones	Flavoured Milk	Cold Drinks(250ml)	Cold Drinks(500ml)	Sting	Kulfi	PaperBoat	Ice-Cream Sandwich	Chocolates
Jan	1550	400	400	950	2800	500	800	1800	1200	1800	1400	1400
Feb	1600	500	420	1200	3000	600	890	1880	1300	1800	1450	1400
Mar	1800	500	500	1500	3200	650	900	1900	1400	1800	1550	1500
Apr	1890	800	560	1580	3400	660	960	1900	1440	1950	1600	1560
May	2000	900	600	1600	3600	700	1000	2000	1600	2000	1600	1560
Jun	800	100	150	825	2500	200	500	1000	700	1000	700	800
Jul	800	100	120	800	2450	220	400	1000	700	1000	750	800
Aug	1600	460	580	1400	3200	680	950	1800	1500	1800	1550	1600
Sep	1550	390	500	1350	3300	600	930	1880	1450	1800	1500	1500
Oct	1400	380	440	1000	3250	550	900	1880	1350	1800	1450	1445
Nov	1000	310	360	1000	3000	560	860	1900	1200	1800	1450	1540
Dec	900	300	300	900	2950	550	800	2000	1000	1800	1400	1500

Lead Time Variation

Lead time variation is a term used to describe how uncertain or unpredictable it is for a product to move through the supply chain. In other words, lead time variance means how much actual lead times deviate from planned or anticipated lead times. Some things, including unforeseen events, manufacturing problems, supplier delays, and transportation concerns, can bring this on. In our case, lead time completely depends on whether the supplier has an inventory of the product we want and whether transportation is available when we want delivery. If the inventory is not available with the supplier, it can increase the lead time a lot which will completely depend on when the supplier is receiving products. It will take more time if the supplies are still in production.

<u>Input Data</u>:

	Amul Buttermilk	Amul Lassi	Amul Stick Ice-Creams	Amul Ice-Cream Cones	Flavoured Milk	Cold Drinks(250ml)	Cold Drinks(500ml)	Sting	Kulfi	PaperBoat	Ice-Cream Sandwich	Chocolates
January	1550.00	400.00	400.00	950.00	2800.00	500.00	800.00	1800.00	1200.00	1800.00	1400.00	1400.00
February	1600.00	500.00	420.00	1200.00	3000.00	600.00	890.00	1880.00	1300.00	1800.00	1450.00	1400.00
March	1800.00	500.00	500.00	1500.00	3200.00	650.00	900.00	1900.00	1400.00	1800.00	1550.00	1500.00
April	1890.00	800.00	560.00	1580.00	3400.00	660.00	960.00	1900.00	1440.00	1950.00	1600.00	1560.00
May	2000.00	900.00	600.00	1600.00	3600.00	700.00	1000.00	2000.00	1600.00	2000.00	1600.00	1560.00
June	800.00	100.00	150.00	825.00	2500.00	200.00	500.00	1000.00	700.00	1000.00	700.00	800.00
July	800.00	100.00	120.00	800.00	2450.00	220.00	400.00	1000.00	700.00	1000.00	750.00	800.00
August	1600.00	460.00	580.00	1400.00	3200.00	680.00	950.00	1800.00	1500.00	1800.00	1550.00	1600.00
September	1550.00	390.00	500.00	1350.00	3300.00	600.00	930.00	1880.00	1450.00	1800.00	1500.00	1500.00
October	1400.00	380.00	440.00	1000.00	3250.00	550.00	900.00	1880.00	1350.00	1800.00	1450.00	1445.00
November	1000.00	310.00	360.00	1000.00	3000.00	560.00	860.00	1900.00	1200.00	1800.00	1450.00	1540.00
December	900.00	300.00	300.00	900.00	2950.00	550.00	800.00	2000.00	1000.00	1800.00	1400.00	1500.00

Stockout

A stockout occurs when a company cannot satisfy customer demand for a specific product because it has run out of that product's inventory. Stockouts can happen for several reasons, including unforeseen demand increases, supply chain delays, production problems, or poor inventory management. Stockouts can hurt businesses in a big way, resulting in lost sales, lower customer satisfaction, and reputational harm.

Demand Prediction

Inventory demand prediction is a process of forecasting the expected demand for a product or item over a given period of time. One way to perform this task is by using machine learning algorithms, which can be implemented in Python using the sci-kit-learn library.

Using this, we can make informed decisions about inventory management, such as determining optimal reorder points, safety stock levels, and production quantities. This can help businesses improve their supply chain efficiency and reduce costs.

Safety Stock

Safety stock is to be maintained to tackle such issues. We are giving input of a safety stock based on monthly demand variation, with the highest safety stock in the month of April and May at 20% and the lowest during June and July at 5%.

Methodology

To get the desired results, we will be doing multiple regression. Our goal is to maximize profits, find optimal order quantity, and optimal safety stock, and predict future demand with the help of the present data set. For doing multiple regression of data, we have we have created a Python code.

Step 1: Taking data input: -

Firstly we will take a number of products we have and data related to it with help of running multiple loops. Data we will need for it will be

1. Product name
2. Purchase cost
3. Selling price
4. Holding cost
5. Shortage cost
6. Mean lead time for product
7. Standard deviation of lead time
8. Storage capacity
9. Reorder point
10. Safety stock
11. Mean demand
12. Standard deviation of demand

Step 2: Demand prediction

It will be done by analysing past demand data for 12 months and using the Scikit-learn Python library, running a linear regression analysis to predict the demand for the upcoming season.

Step 3: Calculating margins for each unit sold using the formula.

Profit = selling price – purchase cost

Step 4: Calculating optimal order quantity for each safety stock

First calculating the reorder point for each safety stock = reorder point + safety stock. It will be calculated for all safety stock given as input

Then calculating expected demand during lead time = predicted demand x mean lead time

And now we will calculate optimal order quantity = expected demand lead time – capacity + reorder point with safety stock.

Step 5: Calculating profit for different safety stock level

It will be done through calculating reorder point then optimal order quantity. After this we will be calculating probability of stock out. Then profit will be calculated using

= expected sales – purchase cost – expected holding cost – expected shortage cost

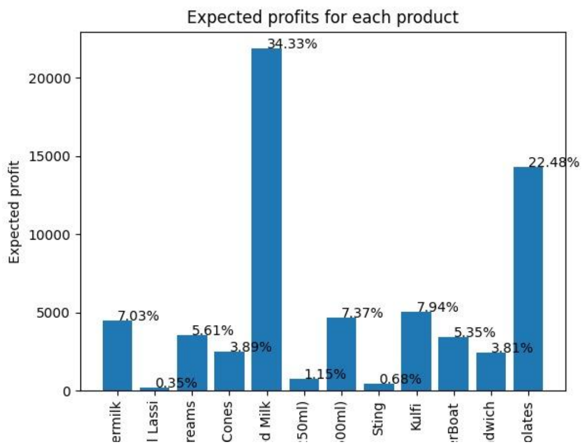
Step 6: Calculation of the safety stock:

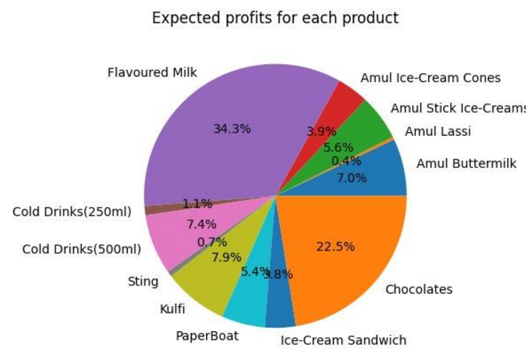
For the calculation of the safety stock, we are giving input for the various safety stock depending on the historical values and we are taking the input as an array argument and then it would calculate the optimal safety stock by iterating again and again by calculating the expected profit for each product and it would give the result as the optimal safety stock for which the expected profit would be maximum

Result

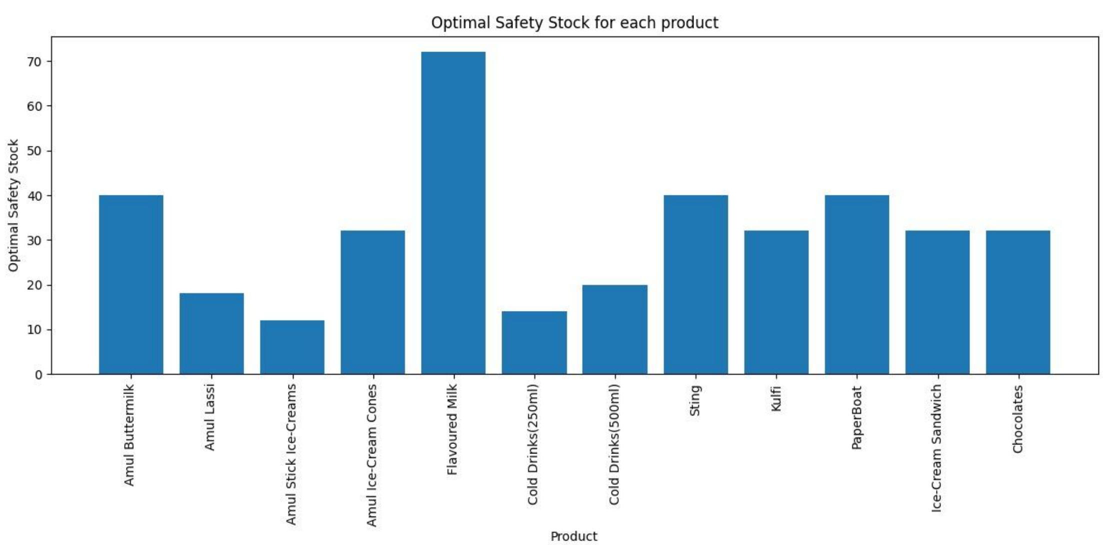
The study gives the following results:

1. Expected Profit for the period would be: **₹63,728**

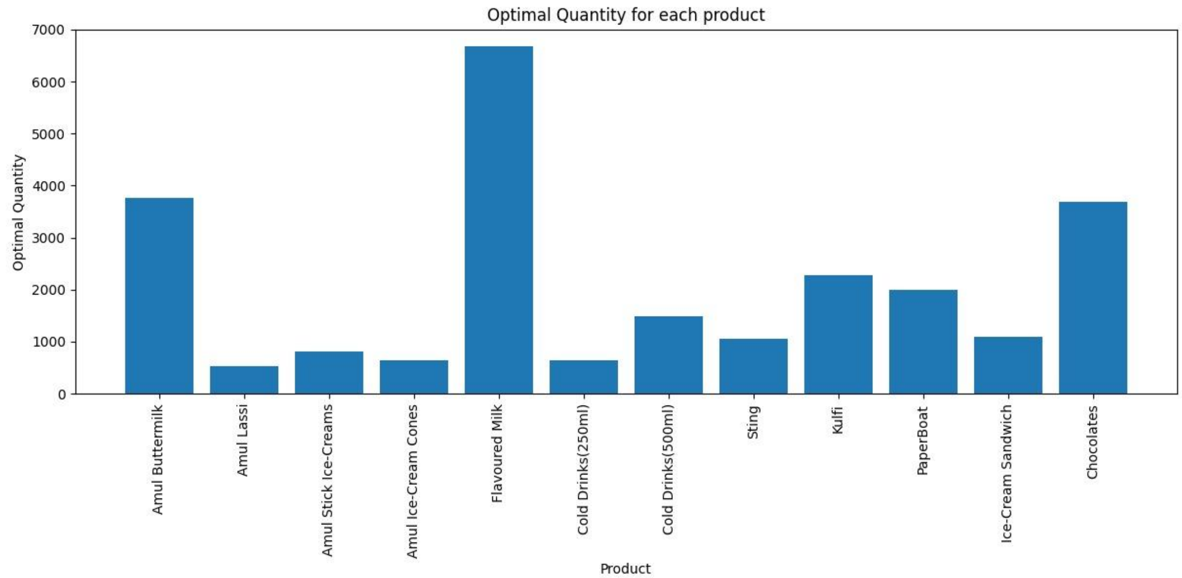




2. Optimal Safety Stock:



3. Optimal Order Quantity:



REFRENCES

1. "Supply Chain Mangement- Strategy, Planning and Operation" by Sunil Chopra,Peter Meindel
2. "Operations Research" by R. VEERACHAMY & V. RAVI KUMAR

Appendix

https://manaskumar111.github.io/Stochastic_Inventory/

https://github.com/ManasKumar111/Stochastic_Inventory/blob/master/InventoryLatest.py