Developing the Inventory Policies with the application of ABC Categorization: The case of Footware Industry

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Abstract

This research article leads to developing the strategy for creating inventory policies that is based on the ABC categorization of inventories. A popular technique for classifying inventory items according to their value is the ABC categorization. Organizations can prioritise the resources they devote to managing each sort of inventory by dividing it into categories A, B, and C. With the application of ABC technique, the amount tied up with the inventory holding cost can be significantly reduced while keeping high-value items accessible. With the aim of reducing holding costs while ensuring the availability of high-value items chosen on the basis of ABC cateagorization, this strategy is frequently used to prioritise the resources that an organisation spends managing its inventory. Researchers in the past suggest that using the ABC categorization can be an effective way to find out which products are high-demanding. The problem unders study is the shoe company in Pakistan. Application of ABC analysis with inventory policies according to the A categorization inventory (Min/Max) policy. B-categorization inventory with Q and R policies and C-categorization inventory with periodic review policies. Implementing inventory policies led to a considerable decrease in holding costs, stock-out costs, and overall expenses based on the ABC categorization of inventories. Particularly, costs associated with keeping inventory were reduced by 30%, costs associated with running out of stock were reduced by 45%, and overall expenditures were reduced by 31%. These improvements show how applying the ABC categorization system and the implementation of realistic inventory policies can minimise costs and maintain availability.

Keywords: Holding cost, stockout, ABC Analysis, Inventory policies.

1. Introduction

Inventory management plays a significant role in the supply chain by ordering, storing and supply the inventory according to the demand. This include the management of raw material being used or being ready for sale as a finished good.

One of a company's most valuable assets is its inventory. A company's inputs and finished products are the heart of its business in retail, manufacturing, food services, and other inventory-intensive industries. A lack of inventory when and where it is needed can be disastrous. At the same time, inventory can be considered a liability (if not in an accounting sense). A large inventory is vulnerable to spoilage, theft, damage, or changes in demand. Inventory must be insured, and if it is not sold in a timely manner, it may be salvaged or simply destroyed. (Lwiki et al., 2013)

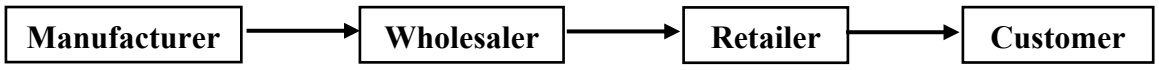
1.1 Aim of Inventory Management

Inventory management aims to

(i) Boost business profitability through better inventory control
(ii) Anticipate how corporate policies can affect stock levels
(iii) Reduce overall logistical costs while still providing for consumer needs.

1.2 Inventory Flow

The passage of goods from manufacturers to warehouses and from distribution centres to retail locations is guided by inventory management as a component. Controlling inventory refers to the efficient administration of supplies, raw materials, semi-finished goods, and final goods.(Ganeshan et al., 2001) To do this there must be a categorization of inventories.



1.3 ABC Analysis

ABC Analysis helps in sectioning inventory into most important to least important sections. A small number of goods account for the majority of yearly material uses. Some of these parts are referred to as "A" parts and play a crucial role in the company. There are many objects with the name "B" and "C," but they are not very important. All materials are divided into three categories for this examination: A, B, and C. based on yearly usage. This enables the Management & Organizations to concentrate on the primary inventory. (D. Annie Rose Nirmala, 2022)

The goal of using ABC-analysis is to rank the positions under consideration and identify those whose contributions to the overall result are the most significant. Positions are classified into three categories: A, B, and C.(Nuzhna et al., 2019) The ABC analysis boils down to the following: The Pareto principle (20/80) is applied, which is commonly stated as "20% of the effort yields 80% of the result" ("vital few and trivial many"). The method allows you to divide the list under study into three groups based on their importance; in other words, the ABC analysis allows you to choose the positions that have the greatest impact on the outcome.(Kvon et al., 2018)

1.4 Inventory Policies

The Inventory Policies define the reorder point of the Inventory. That point may be according to the time or the quantity on hand. It defines when Inventory will be reordered again for fulfilling the demand of the customers. An inventory management system's primary goal is to maintain the stock so that it is neither overstocked nor understocked. Understock will cause operations to cease, and overstock will slow down other manufacturing processes.(Tayur et al., 2012) Inventory management has both operational and economic goals. By using the Inventory Policies, many problems of Inventory can be solved out.

These Policies are used in this Project:

- Continuous Review:
    - Q/R policy based on order quantity and reorder point.
    - Min/Max policy based on minimum and maximum inventory levels
- Periodic Review:
    - T/S policy based on time period and standard order quantity.

1.5 Related Work

Author(s)	Industry	Methodology	Conclusions & Findings
(Kumar, 2017)	Hospitality Sector	ABC Analysis	Liquor, Beverages & Tobacco Inventory was categorized by the ABC Analysis and after that some steps were taken to maintain the Inventory according to the Revenue.
(Jiapeng Liu, 2016)	Universal For All Industries	ABC Analysis; Simulated annealing algorithm	The ABC analysis is frequently used in inventory management and can assist businesses in classifying

			inventory items according to various evaluation criteria.
(S. Nallusamy, 2017)	Automotive Manufacturing Industry	ABC Analysis, Inventory Review Policy	It was discovered that by managing the inventory level for a year, the developed periodic review policy reduced the inventory turnover ratio from 3.15 to 2.13.
(D. Annie Rose Nirmala, 2022)	SRI DEVI SNACKS	ABC Analysis, VED Analysis, EOQ Model	Based on the price and volume of items purchased, an ABC analysis is performed. The Vital, Essential, and Desirable (VED) analysis gives a clear picture of how items are divided into these three categories. The production's Economic Order Quantity was determined by EOQ Model.
(Stanisław Ambroszkiewicz, 2022)	Universal For All Industries	SM-v-Policies	The SM-v policies can outperform policies found as solutions to the severely confined situation, where the maximum vendor's inventory level is equal to the maximum achievable space limit.
(Peter Berling, 2022)	Ecommerce & Mainly Retail Industry	(R, Q) Policies	The computationally effective algorithms that are made to deal with the highly variable customer order sizes, (R, Q) policies at all stock points in real-world one warehouse many retailer inventory systems.
(Abdo Abouelrous, 2022)	Retail Industry	Good–Turing sampling and Linear Programming	In comparison to other Algorithms, the suggested algorithm achieves an average cost reduction of 7.56% in comparison with that are produced at random. Short time horizons and a sizable share of consumers who are in-store benefit greatly from the proposed algorithm.

(Jun-Yeon Lee, 2009)	Universal For All Industries	Periodic Review Inventory System	The challenge of controlling stochastic demand for replenishment in periodic-review inventory systems, where a replenishment order may be fulfilled right away or one period later, based on the likelihood of an extensive endeavour.
(D. Kim, 2022)	Semiconductor Industry	Arena Software Usage & Order-up-to policy	By adopting the order-up-to policy, inventory models may be directly applied to the industrial sector, and they look at how a die bank can be utilized to decrease completed product inventory and boost customer's satisfaction.

1.6 Research Gap

In all Articles, there are inventory Characterization in the past and that is solely based on the Dollar volume which represent the worth of inventory. Moving from single criteria to multiple criteria helps in finding an optimal solution to fulfil multiple objectives. By putting stockout cost and holding cost as an additional cost with the dollar volume helps in maintaining the availability as well reducing the holding cost.

By using this not only the profit will be maximised but also the customer experience will be maximised as it will lower the stockout cost. By using Categorization and policy making side by side helps the inventory manager to track the Stock more effectively.

1.7 Problem Statement

This practical examination of the Pakistani shoe industry is reflected in this paper. The working method in the sector is "make to stock." This industry bases on the storage of materials on the principles of purchasing raw materials and storing them. It ensures the availability but there is overstocking in the storage causing higher inventory cost. There is demand forecasting, but inventory is not being used properly. The more space-consuming inventory is kept in storage. However, it is increasing the industry's holding costs.

1.8 Our Work

In this article, ABC analysis applied on the forecasted demand and inventory policies are developed. In addition, the most important level of inventory having higher profits is handled with care and stockout is minimised for it while the least important type of inventory referred

This thing makes the Min/Max policy relatively more dynamic and can handle the worthy products where the stockout is not acceptable at all.

The Quantity to be ordered after the on hand inventory goes below is equal to :

$$Order\ Quantity = (Min_{limit} - On\ hand\ inventory) + (Max_{limit} - Min_{limit})$$

Where the Reorder point can be estimated in both cases as :

$$Reorder\ point = D * L + ss$$

Where SS is the safety stock one can kept and DL is the demand during lead time.

The policy by category is shown below:

	Dollar Volume	Stockout Risk	Holding Cost	Suggested policy	Reviewed
Category A	High	Risk to Business Safety stock must	Percentage of Inventory price	Min/Max Policy	Continuously
Category B	Medium	Low Risk to business	-	Q R policy	Continuously
Category C	Low	No Risk to Business	-	T S policy	periodically

After assigning all the policies its time to check how much these policies helps in reducing the cost therefore stochastic demand that is obtained by demand forecasting is used. The issue here is to model the weekly demand

2.5 Modelling the inventory Consumption

The inventory consumption is being modelled in MATLAB for 52 weeks (A whole year) where the weekly demand is modelled as a normal distribution.

2.5.1 Why Normal Distribution

This issue in inventory control is the statistical description of total demand during the time between placing and receiving an order. Because both demand per unit time and lead time are random variables, the lead time demand distribution is formulated as a mixture. In practise, despite their nonnegativity, one or both components of the mixture are frequently assumed to be normally distributed.(Radasanu, 2016) In practise, this assumption implies that a normal curve truncated at zero is a valid description. Several approximations to the true tail area probabilities are investigated (given truncation). As a result, an improved and simpler expression for the normal-gamma mixture is obtained. There are also some numerical results presented.(J. K. Ord, 2006)

In many Inventory Control system, the demand per unit time is modelled as a normal distribution that can be shown as N(μ , σ) where the μ is the mean demand per unit time while the uncertainties in demand can be shown as σ . Because of its convenient mathematical

properties, the normal distribution is frequently used to model demand. In practise, however, actual customer demand for some products may be better represented by an asymmetric, or skewed, probability distribution. The goal of this paper is to determine the best inventory order quantity and reorder point policies when demand follows a typical PDF. (Cobb, 2013)

The weekly consumption is thus modelled as normal distribution in MATLAB.

$$Weekly\ Demad = N(\mu, \sigma)$$

where

$$\mu = \text{Average Weekly demand} = \frac{\text{Yearly Demand}}{52}$$

$$\sigma = \text{Uncertainty in demand}$$

After modelling the weekly demand a simulation is run for 52 weeks(an year) to check the advantage in the form of cost maintaining the availability.

The pseudo Codes for this policies(Simulation) is shown below:

2.5.2 Pseudo Code of Modelling periodic Vs Continuous Review

Periodic review Algorithm
procedure

YD ← Yearly Demand

PQD ← planned Quarter demand

QOH ← Quantity on hand Initially

LT ← Lead Time to manufacture LOT

WWY ← Working Weeks in year (52)

Initialize YD, PQD, QOH, LT and WWY

FOR weeks in year

QOH ← QOH – N(Average Week Demand , Demand Uncertainty)

Weekday++ % Update the weeks For Quarter

IF Quarter Reached

Order Quantity ← PQD - QOH

QOH(week +LT) ← QOH + Ordered Quantity

Weekday = 1 % Reset the quarter

END

END

Plot QOH Vs Weeks

END PROCEDURE

Continuous Review (QR policy) Algorithm

PROCEDURE

$QOH \leftarrow Quantity\ on\ hand\ initialy$

$SS \leftarrow Safety\ Sotck$

$OQ \leftarrow Order\ Quantity$

$YD \leftarrow Yearly\ Demand$

$LT \leftarrow lead\ time$

$WW \leftarrow Working\ weeks$

$Q \leftarrow Fixed\ Order\ Quantity$

Initialize LT, SS, QOH, YD, OQ, Q

$ROP \leftarrow SS + LT * Expected\ demand\ in\ lead\ time$

While $I <= WW$

QOH ← QOH – N(Average Week Demand , Demand Uncertainty)

$I++$

IF QOH goes below ROP

QOH($I+LT$) ← QOH + Q

END

END

Plot QOH Vs Weeks

END PROCEDURE

Continuous Review MIN/ MAX Algorithm
PROCEDURE

$QOH \leftarrow Quantity\ on\ hand\ initialy$

$SS \leftarrow Safety\ Sotck$

$OQ \leftarrow Order\ Quantity$

$YD \leftarrow Yearly\ Demand$

$LT \leftarrow lead\ time$

$WW \leftarrow Working\ weeks$

$Q \leftarrow Variable\ Order\ Quantity$

$MIN \leftarrow SS + LT * Expected\ demand\ in\ lead\ time$

$MAX \leftarrow Maximum\ Order\ Quantity$

Initialize LT, SS, QOH, YD, OQ, Q,MIN,MAX

While $I <= WW$

QOH ← QOH – N(Average Week Demand , Demand Uncertainty)

$I++$

IF QOH goes below MIN

Q = MAX - QOH

QOH($I+LT$) ← QOH + Q

END

END

Plot QOH Vs Weeks

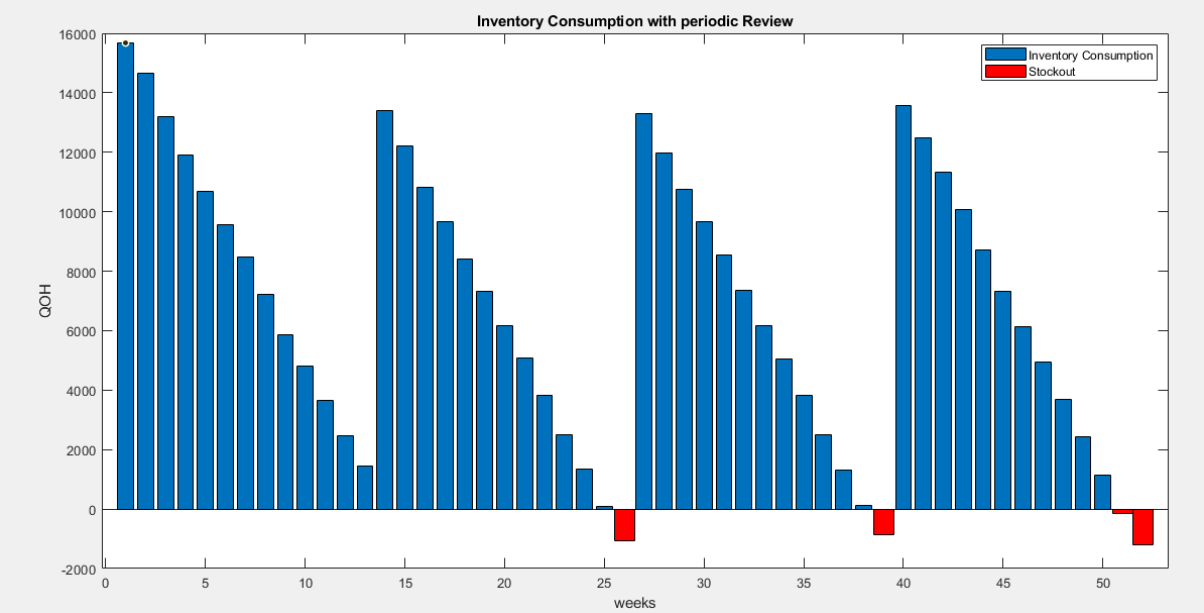
END PROCEDURE

Applying the inventory policies without the above ABC characterization and using the manager perspective leads abnormalities in the system causing the overstocking, losing business, pay less attention to the most valued inventories and vice versa and customer unsatisfaction. These problems will arrive if policies are not applied on categories.

3.Results

3.1 Current Scenario

The Current scenario is all about taking inventory as a single Category and handling it as a periodic review. This thing might make the stockout minimum but may impose a high holding cost to the firm making the profit of the firm less.



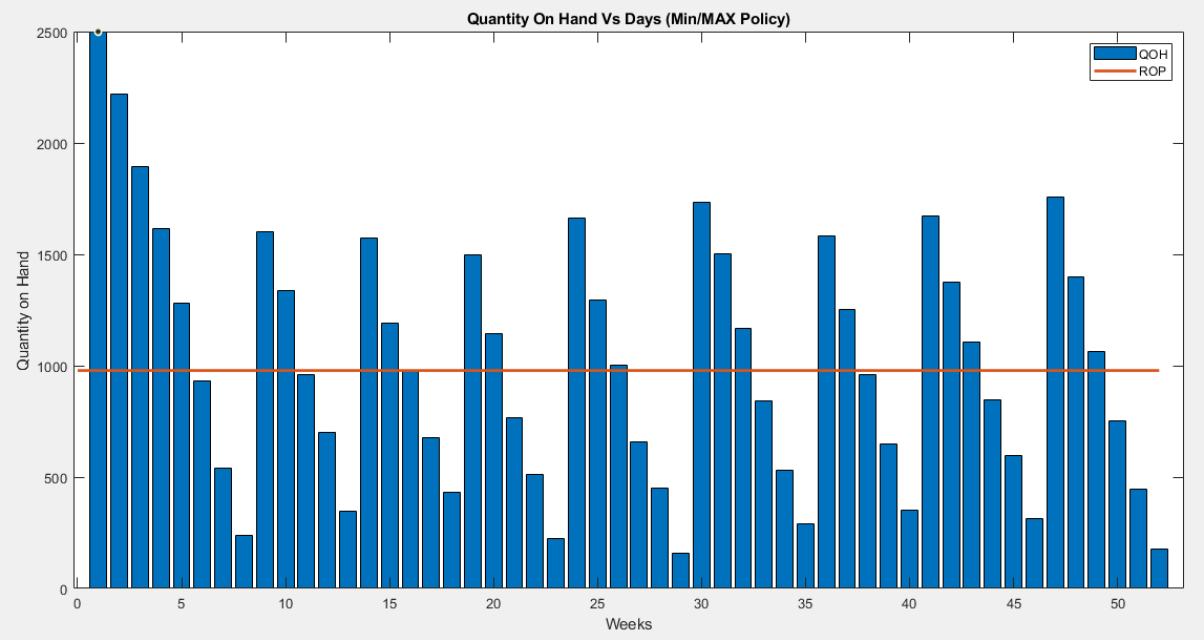
The Goal is to minimize the holding cost keeping the availability as high as possible and restrict the periodic review policy to the less important inventory that is characterized as Category C while the other two categories (A & B) is handled with continuous review policy with an optimal value of QR or Min Max parameter that makes the stockout zero.

3.2 Devised Scenario

The suggested scenario based on categorization and related policies according to the table and there corresponding consumption.

3.2.1 Category A Inventory consumption

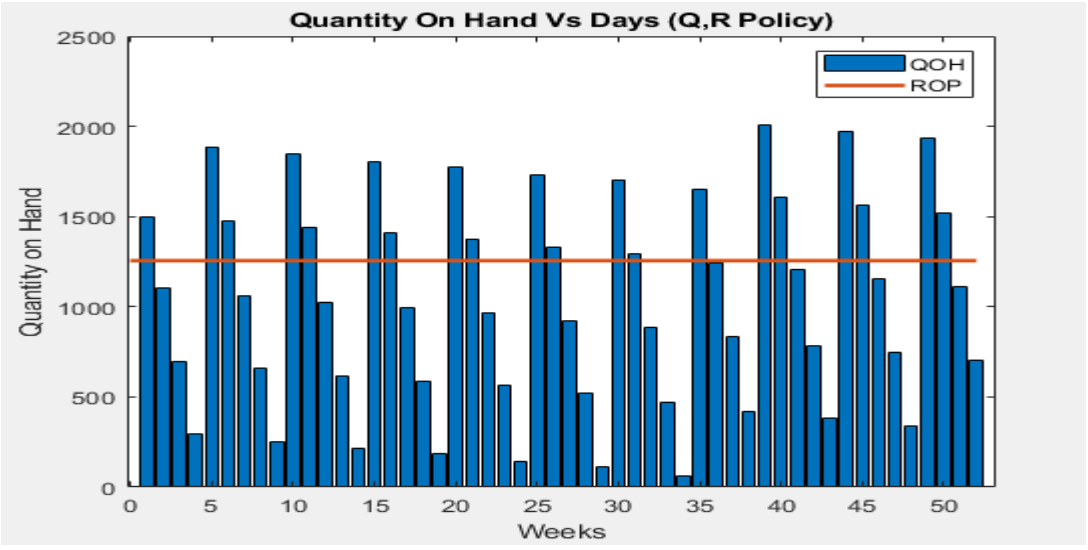
To Determine the inventory Holding cost It is required to estimate the presence of inventories in warehouse for year where weekly demand is estimated with a normal distribution such that mean demand is known for a week but variance shows how uncertain the demand will be and it is shown by MATLAB below:



The graph shows the Quantity on hand vs weeks. Because the cycle time for making new inventory is 3 weeks, whenever inventory falls below the ROP, it will be ordered and restocked after 3 weeks. The graph shows no stockouts, but they could occur if there is an unexpectedly high demand. This is encountered, however, by taking a sufficient variance in weekly demand.

3.2.2 Category B Inventory Consumption

For Category B inventories the process is similar to the Min/Max except the order quantity is not random but fixed. The Weekly demand is normally distributed with mean equal to the estimated yearly demand divided by the number of working years. The Consumption of inventories is shown with the help of MATLAB below:

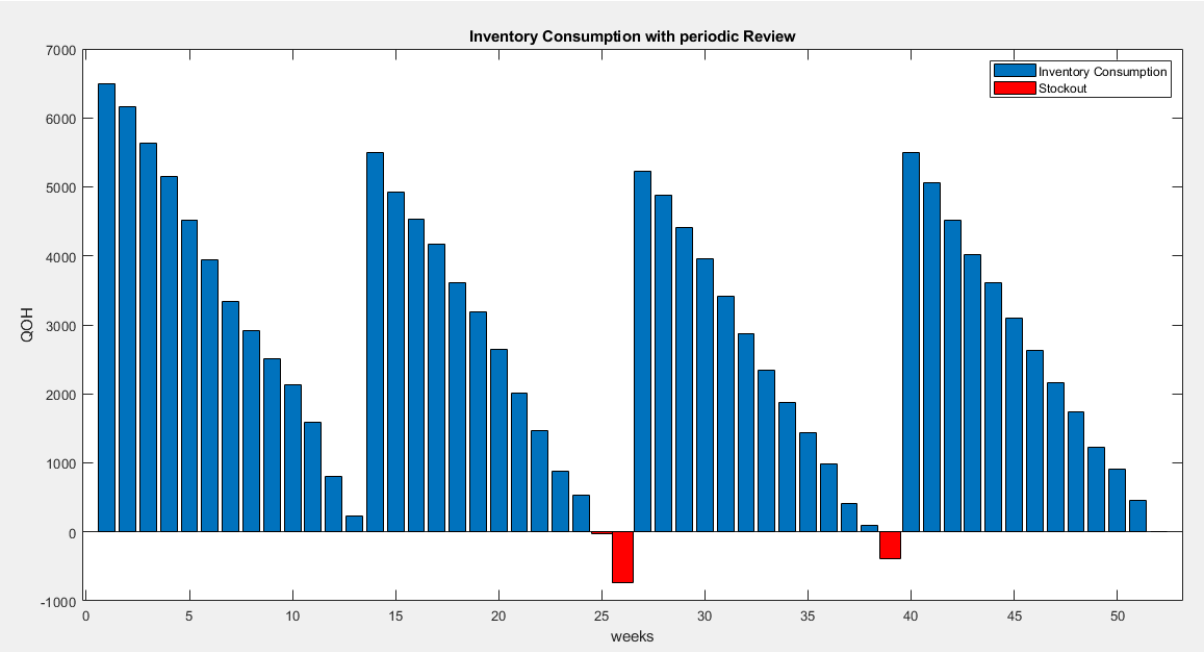


The Graph shows how the inventories are continuously reviewed and if it is found the quantity goes below it is ordered. Because the cycle time for making new inventory is 3 weeks, whenever inventory falls below the ROP, it will be ordered and restocked after 3 weeks. The graph shows no stockouts, but they could occur if there is an unexpectedly high demand. This is encountered, however, by taking a sufficient variance in weekly demand.

3.2.3 Category C Inventory Consumption

The Inventories in Category C is less important so it goes with the periodic review as it is handled previously. The period selected is the quarter or somehow near 13 weeks. This Inventory consumption may show some stockout but it can be manageable as the dollar volume is less for it

However, this project will give more benefit in term of saving holding cost while the stock out cost is not so significant.



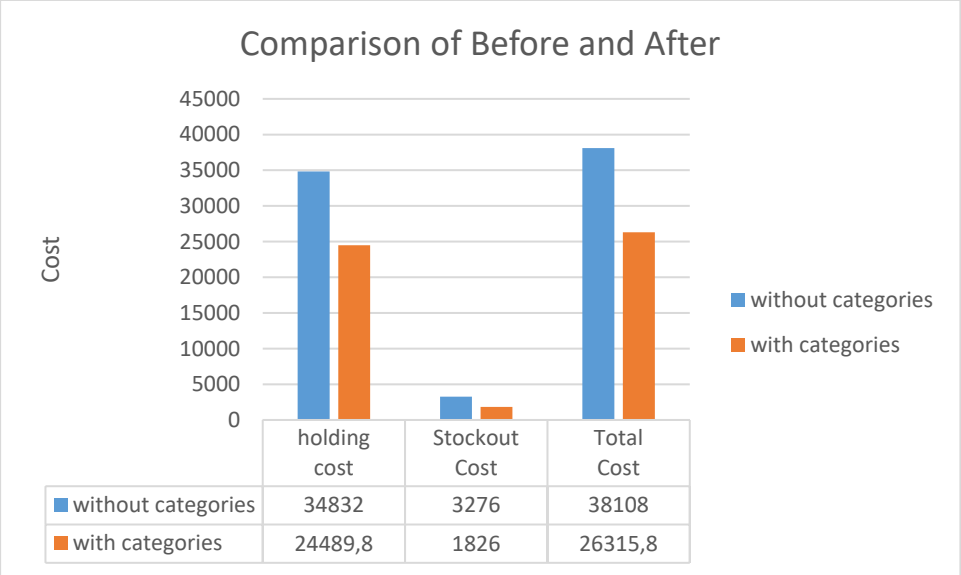
The Stockout here is less significant and it is shown by red colour however it will be more significant if this type of review is done for Category A and B inventories.

3.3 Comparison

The Inventory Holding is sufficiently reduced and how it is different with categories is shown below:

	Inventory Holding Cost	Category	Category Wise cost
Before	34832 $	Single	34832 $
After	24489 $	A	5151.1 $
		B	5553.7 $
		C	13785 $

The comparison of before and after is shown below:



4.Conclusion

The Data for the current year is forecasted with the help of previous two years data for the 21 shoes types. On the bases of dollar Volume, Holding cost and Stockout cost. Based on this criteria Inventories are classified into three categories. Every Category Consumption with periodic as well as continuous review policy is being modelled in MATLAB and it is shown above. Categorization of Inventories helps in reducing inventory holding cost by 30 percent and stockout cost to approximately 45 percent. Moving from Periodic review to Continuous Review policy for Top two categories causes the total inventory related cost to cut by 31 percent Maintaining the availability of inventory. New policies can handle uncertain demand more effectively rather the previous one Such that continuous review policies respond more effectively to change in demand.

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