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A STUDY ON MINIMIZE THE WASTAGE OF PERISHABLE PRODUCTS

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Abstract:

The present paper deals with a supermarket, where perishable and Non-perishable products are available in high variety and stock. For high variety and stock there is a need of purchasing more quantities in each products depends on their demand. The excess amount of purchasing leads to more wastage and high amount of quantity returns to the vendor. In our study, the fruits have more losses due to wastages and quantities returned to vendor about 4.52% in the total sales. From that, which fruits contributing more losses (orange, grapes, sapodilla and sweet lime)about 66% in the total losses are extracted from the HML analysis and the demand has been forecasted using the three types of forecasting techniques: Linear Regression, Simple Moving Average, Simple Exponential Smoothing. Based on forecasted demand the EOQ was calculated and the profit of two types of inventory models were analyzed such as fixed order quantity (Q-System) and fixed Review Period (P-System). The best model was selected based on the profit of each model and selected inventory model applied and which reduces the losses from 66.37% to 42.56%.

Key Words: Inventory, Demand Forecasting, EOQ, P-system, Q-System & Perishables.

1. Introduction:

In a supermarket, where perishable and Non-perishable products are available in high variety and stock. For high variety and stock there is a need of purchasing more quantities in each products depends on their demand. The excess amount of purchasing leads to more wastage and high amount of quantity returns to the vendor inventory is a stock of any item or resource used in an organization. An inventory system is the set of policies and controls that monitors levels of inventory and determines what levels should be maintained, when stock should be replenished, and how large orders should be. By convention, manufacturing inventory generally refers to items that contribute to or become part of a firm's product output. Manufacturing inventory is typically classified into a materials, finished products, component parts, supplies, and work in process. In services, inventory generally refers to the tangible goods to be sold and the supplies necessary to administer the service. The basic purpose of inventory analysis in manufacturing and stock keeping services is to specify when items should be ordered and how large the order should be. Many firms are tending to enter into longer-term relationships with vendors to supply their needs for perhaps the entire year. This changes the "when" and "how much to deliver". Perishable products are the products which is likely to decay very quickly if it is not refrigerated. The main difference between perishables and non-perishables is the 'Shelf Life'. The shelf life of a product is measured in days, counting from the day it is produced until the product becomes unacceptable for consumption or obsolete. This end date has a strict relation to the date mentioned on the product. Clearly, perishables are items with a short shelf life and non-perishables are items with a long shelf life.In a supermarket or retail store, there is a large number of products kept for sale. This store contains both perishable and non-perishable products. In this problem, the more wastes occurs in perishable products especially in fruits. The total wastages and losses due to some quantities returned to vendors are reasonable to less profit. The objective of this paper is to minimize the

wastage and quantities returned to vendor. This has been minimized by solving the root cause analysis problems. This paper is structured as follows: In section II, the literature review on the problem and solutions presented. Section III contains problem description and identification is discussed, IV, different models and techniques used to solve the problem discussed. In section V, Results of each model were discussed. In Section VI, results of wastages and quantities returned to vendors discussed. Section VII contains some concluding remarks, direction for future work, and reference.

2. Literature Review:

Chen F.L. et al (2009) have developed a gray relation analysis and multilayer functional link network sales forecasting model for perishable food in convenience store. Initially they have identified the factors which are influencing demand. The forecasting model was selected based on the factors and univariate and multivariate analysis. The forecasted results selected based on the mean absolute deviation (MAD). **Mattias Eriksson et al (2012)** have taken for their analysis six Swedish retail stores food losses. They analyzed the flow of fruits and vegetables at all retail stores with the recorded data and by performing physical measurements. They analyzed the correlation between in and out store wastage. The flow of fruits and vegetables from the start to end was analyzed to reduce wastages. Finally they have identified the retail chain need to focus on the pre store waste management. **Serkan Gunpinar et al (2014)** have developed stochastic integer programming models for reducing wastages and shortages of blood products at hospitals. Using this model he has minimized the total cost, shortage and wastage levels of blood products at a hospital within a planning horizon. The stochastic and deterministic models included consider uncertain demand rate, demand for two types of patients, and cross match-to-transfusion ratio and results shows wastage rates decreasing from 19.9% to 2.57% on average. **Van K. Donselaar et al (2006)** have studied the performance and inventory management of perishable products in supermarkets. The aim of this paper is to understand the product, sales and supply characteristics of perishables and to define and operationalize relevant concepts in controlling the inventories of perishables and to investigate how the intelligence in ASO systems have been developed mainly for perishables. Finally they have developed a new strategy in ASO system to manage perishable products.

3. Problem Description:

In a supermarket or retail store, there is a large number of products kept for sale. These stores contain both perishable and non-perishable products. In this problem, the more wastes occurs in perishable products especially in fruits. The total wastages and losses due to some quantities returned to vendors are reasonable to less profit. In the total loss in fruits, four fruits such as orange, grapes, sapodilla and sweet lime are contributing more losses (about 66%). This is because of the seller may not know the exact demand, how much to order and which inventory model is can be adapted to increases the profit.

Table 3.1 Fruits Sales Loss Data

Fruits	Order Quantity/Week In Kgs	Quantities Returned to Vendors In Kgs	Sales Loss in Rs.	Wasted Quantities In Kgs	Wastage Cost In Rs.
Orange	1750	121	4356	97	5820
Grapes	1400	119	2856	86	6296
Sapodilla	1300	93	2232	79	3160
Sweet lime	1800	87	2088	67	2680

4. Models and Techniques:

4.1 Assumption:

- Purchasing and selling prices are known.
- Wastages and quantities to be returned to the vendor are unknown.
- Service level to the customer is 95%.
- The demand for the products are normally distributed.
- Lead time is constant.
- Quantities returned to vendor at 60% discount.

4.2 Forecasting Model:

4.2.1 Simple Moving Average:

$$M_t = 1/n(D_{t-(n-1)}+D_{t-(n-2)}+\ldots+D_{t-2}+D_{t-1}+D_t)$$

Where, M_t = simple moving average at the end period t (It is to be used as a forecast for period t+1)

D_t = Actual Demand in period t.

n = number of periods included in each average.

4.2.2 Simple Exponential Smoothing:

$$F_t = F_{t-1}+\alpha(D_{t-1}+F_{t-1})$$

Where, F_t = smoothed average forecast for period t.

F_{t-1} = Previous period forecast

α = smoothing constant, weight given to previous data ($0 \leq \alpha \leq 1$)

D_{t-1} = Previous period demand

4.2.3 Linear Regression:

$$Y = a+bx$$

Where, Y – Response (demand)

a – Intercept

b – Slope

x – Independent variable (weeks)

y – Demand per week

S – Standard Error

n – Number of weeks

a = y bar + b*x bar

b = $(\sum xy - n*x\ bar)/(\sum x^2 - n*(x\ bar)^2)$

$$S = \sqrt{\sum_{i=1}^{12} \frac{(y_i - Y_i)}{n-2}}$$

4.3 Verification of selected forecasting Technique:

The selected forecasted method is verified using moving range chart.

Determine the parameter: Moving Range (MR), Average Moving Range (AMR), Upper control limit 'UCL' and Lower control limit 'LCL'.

$$MR = |(D_t - F_t) - (D_{t-1} - F_{t-1})|$$

AMR = $\sum$MR/(n-1)

UCL = 2.66*AMR

LCL = -2.66*AMR

4.4 EOQ Model:

$$EOQ = \sqrt{(2DS/H)}$$

Where, D = Demand per week

S = Ordering cost per order

H = Inventory Holding Cost per week per Kg

4.5 Inventory Model:

4.5.1 Fixed Review Period Model:

SS = z * standard deviation of demand over the review and lead time

Q = D + SS

E(z) = (dT(1-P))/ standard deviation of demand over the review and lead time

Where, D – Demand per week in Kgs

SS – Safety stock per week Kgs

Q – Order quantity per week in Kgs

E(z) – Expected number of units short from the normalized table

P – Service level desired expressed as a fraction

T – Review period

d – Daily demand in Kgs

4.5.2 Fixed Order Quantity Model:

d = (weekly demand/n)

EOQ = $\sqrt{}$(2DS/H)

R = dL

Where, n – Number of days

D – Demand per week

S – Ordering cost/order

H – Holding cost/week/kg

R – Reorder Point

d – Average Daily Demand

L – Lead Time

4.6 Methodology Description:

According to data collection and literature review, the problem has been identified. The HML analysis has been done to identify most wastage fruits. The demand has been forecasted using the previous week sales data and the three types of methods such as simple moving average, simple exponential smoothing and linear regression. The better result was selected based on which model possess the minimum error. The selected forecasting verified using moving range chart (MR). With the forecasted demand economic order quantity has calculated. Using the order quantity the inventory models such as fixed order and fixed review period models are analyzed and the best model was selected based on their profit. The wastage and quantity returned to vendor predicted based on the previous order quantities.

4.7 HML Analysis:

In HML analysis, the products were classified into three groups. These are based on the wastages incorporated with the Fruits.

Sales Loss in Percentage:

-High (<70%)

-Medium (<20%)

-Low (<10%)

H (66.37%)	**M (23.92%)**	**L(9.71)**
Orange (25.36)	Apple (Fuji) (6.29)	Pomegranate (5.43)
Grapes (15.69)	Apple (Simla) (6.04)	Guava (4.13)
Sapodilla (13.44)	Others (banana, lime, etc.) (6.14)	Watermelon (0.15)
Sweet Lime (11.88)	Papaya (5.45)	

5. Discussion on the Proposed Work:

5.1 Root Cause Analysis (RCA):

RCA is used to brainstorm and identify the root causes of the problems. Root causes can be identified by asking "why" multiple times

	Problem	Possible Solutions
Why more wastages?	Inventory is high	Best Inventory model
Why inventory is high?	Excess amount of quantities purchased	Optimal order quantity
Why excess amount of quantities purchased?	More variation in the demand	Demand forecasting

5.2 Demand Forecasting:

The demand forecast gives the expected level of demand for goods or services. This is the basic input for business planning and control. Hence, the decisions for all the functions of any corporate house are influenced by the demand forecast.

Table 5.2.1 Forecasted Results (Minitab software)

Fruits	Forecasting Results		
	Simple moving average	Exponential Smoothing	Linear Regression
Orange	1574	1610	1707
Grapes	1232	1266	1203
Sapodilla	1093	1067	1057
Sweet lime	1213	1578	1759

Table 5.2.3 Selected Results Using Error Estimation (MAD)

Fruits	**Forecasted demand/week**	**Appropriate method**
Orange	1610	Simple Exponential smoothing
Grapes	1266	Simple exponential smoothing
Sapodilla	1067	Simple exponential smoothing
Sweet Lime	1578	Simple exponential smoothing

Table 5.2 Verification of Forecasting Technique

Fruits	AMR	UCL	LCL
Orange	163.9	435.99	-435.99
Grapes	116.09	308.8	-308.8
Sapodilla	87.5	232.87	-232.87
Sweet Lime	162	430.92	-430.92

The table shows that the Average Moving Range values are lies between the Upper Control Limit and Lower Control Limit.

Table 5.3 EOQ Results

Fruits	**Forecasted Demand Per Week in Kgs**	**Holding Cost/ Week/kg in Rs.**	**EOQ in kgs**
Orange	1610	0.015	1770
Grapes	1266	0.03	1380

Sapodilla	1067	0.032	1130
Sweet Lime	1578	0.035	1670

Table 5.4 Fixed Review Period Model Results

Fruits	**Forecasted Demand/week in Kgs**	**Safety Stock/week in Kgs**	**Order Quantity/week in kgs**	**Profit in Rs.**
Orange	1610	77	1700	5210
Grapes	1275	60	1340	2727
Sapodilla	1065	47	1120	2430
Sweet Lime	1596	77	1680	3446

Table 5.5 Fixed Order Quantity Model results

Fruits	Forecasted Demand/week	EOQ in Kgs	Avg Daily Demand in Kgs	Reorder Point in Kgs	purchase cost/order in Rs	selling cost/order in Rs.	profit/order in Rs.
Orange	1610	1770	230	230	95580	96600	1020
Grapes	1274	1380	182	182	49680	50960	1280
Sapodilla	1065	1130	152	152	40680	42600	1920
Sweet Lime	1596	1670	228	230	60120	63840	3720

6. Results:

6.1 Existing Model:

Table 6.1 Losses Percentage in the Ordered Quantitiesof Existing Model

Fruits	Order Quantity/week in kg	Quantities returned to vendor in kg	% returns to the vendor	Wasted Quantities in kg	% wastages
Orange	1750	121	6.9	97	5.54
Grapes	1400	119	8.5	86	6.14
Sapodilla	1300	93	7.15	79	6.07
Sweet Lime	1800	87	4.8	67	3.72

The wastages and quantities returned to vendors are predicted based on the percentage losses contribution in the forecasted order quantity.

6.2 Proposed Model:

Table 6.2 Losses Percentage in the Order Quantities of Proposed Model

Fruits	Optimal order quantities per week in Kg	% returns to the vendor	Quantities returned to vendor in kgs	Losses due to returned quantities in Rs.	% wastages	Wastage quantities in Kgs	Losses due to wastages in Rs.	Total losses in Rs.
Orange	1700	6.9	94	3045	5.54	75	4050	7095
Grapes	1340	8.5	85	1836	6.14	64	2304	4140
Sapodilla	1120	7.15	67	1447	6.07	45	1620	3067
Sweet Lime	1680	4.8	65	1404	3.72	38	1368	2772

7. Conclusion:

In the proposed work, the demand for the next period has been forecasted using three types of forecasting methods and the best results were selected based on the error estimated on three forecasting techniques. The economic order quantity has been identified based on the ordering and holding cost has calculated based on the total expenses in the supermarket. The profit of inventory model such as fixed order quantity and fixed review period models are analyzed and thebest inventory model by comparing their profit. The wastage has been reduced from 66% to 42.56%. Further research can be carried out by identifying the factors affecting demand and forecasting can give the more accurate results.

8. References:

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