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Requirement Prediction of Retailer/Dealer Dairy Produces

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***Abstract* -** General public has become more sensible about the health issues, it is often noticed the demand for fresh items, efficient and effective inventory management is the need of the hour while considering the minimization of losses due to decay in freshness. The demand for product is dependent on price, stock in hand, freshness condition of commodity, goods. The suggested inventory model decides the most favourable price, the replenishment cycle period, and the inventory order quantity, for calculation of maximum profit.

Keywords : *inventory, freshness, price, stock*

INTRODUCTION

Milk dairy organization comprises dairy farming, processing of milk to produce dairy products, storage and marketing to consumer through distributors. It is a complex process. Being milk is perishable in nature, the market price of dairy products may vary as per the remaining shelf life of product.

Satisfaction levels for the service rendered by the dairy plants based on the season and fulfilment of orders of consumers will make the organization sustainable. The production and distribution issue in a milk organization for obtaining profit considering various cost constraints is resolved using multi-objective mixed integer programming method.

The dairy supply chain considered comprises multiple production centres, multiple distribution centres including many consumers. Milk product generation will create greenhouse effect in the process of generation and consumption and poses environmental risk

The model aims to couple conflicting objectives: such as maximizing economical advantage by taking into account the shelf life of dairy items, maximizing the satisfactory services levels to consumers in terms of orders Of late, consumers are showing keen interest in health than earlier, and the requirement of clean fresh items has increased. Effective and valuable inventory controlling of unpreserved and decaying items is required to prevent unnecessary losses because of natural decaying .Requirement of goods is swayed by various aspects like price, stock, and freshness condition etc. Requirement for consumable products is a multivariate function of cost, current stock quantity, and freshness condition. 6 cost dependent requirement functions are generally applied: linear, exponential, logarithmic, and polynomial. The Results exhibit that increasing cost of shelf items influences in increase in cost, inventory period time, amount ordered, including gains that are obtained for all cost requirement models. Sensitivity analysis is conducted, and various managerial suggestions are made. lifetime to food produce before it reaches deterioration point and suffers its bazaar cost is identified as shelf life. Some constituents in item produce determine its shelf life.

As per . Robertson[1],shelf life for edible goods can be segregatedinto3 categories: perishable, semi-perishable, non-perishable at room temperature. Short-shelf life goods encounters problems for SCM due to several alternatives, strong identification needs ,requirement estimation, short shelf-life of goods, and requirement for thermal control, and large capacity of items asper Meulstee et[2].Upgraded requirement prediction exhibit a role in determining the procurement for shelf life goods. However, as per author Shukla, &Jharkdaysa[3] a precise and complete requirement prediction for small shelf life goods is a prospecting area of research. In requirement prediction of short-shelf life food goods for wholesalers, various issues on nature and quantity of goods that are crossing through SCM on a suitable periodicity (e.g. every day) is a prospective area.

It deals on routine requirement variation associated with wholesalers and classifies variability factors causing requirement.

LITERATURE SURVEY

Since long most of food marketers are planning to have accurate predictions with a view of planning. Services, amenities and goods are clustered as accountability of a organisation , anticipation of upcoming requirement is important tSmith et al [4]. Prediction allows organizations to predict the requirements resource, raw material, planned maintenance, etc. in advance, in extremely changing situations. Various approaches, thoughts , models and techniques are **studied in** determining requirement by considering resources like people jia et al [5], Goods and materials Menget al and xu at al [6,7] etc. Consumer requirement is principle generator of gain for any firmGuo et al [8]. Eatable items sellers are concerned and worried regarding requirement, due to goods' special characteristics say decaying rate, quality and random consumer requirement (specifically every day requirement). Short-shelf life eatables goods (i.e. ripened Fruits and fresh vegetables) can be marketed in a controlled time interval , thus causing plentiful or scant inventory might turn into spoilage or loosing order/unconditional met consumer, looses gain levels.

Investigating Requirement for Short-shelf Life FoodLiu et al &Doganis et al [9,10]. It investigates main changeable factors causing requirement prediction and also prevailing methods proposed by researchers in food supply chain. The literature regarding optimization of milk processing in the dairy industry is very scant. some authors have conducted research on production of considering on milk products such as textured yogurt, curd, flavoured ice cream etc. supply chain organization can be sorted as per the variations in the problem and the offered solving techniques. The variations in the problem found due to different decision layers, supply chain systems, many product varieties, different dairy production techniques, perishability, operation time and changeover, process shutdowns. The offered solution techniques are MILP, Constrained Program stochastic chance programming and discrete simulation. mathematical quantitative techniques for the optimization of milk organization were applied generally]. The dairy organization issues start from allocating the products to the respective milk production canters and fixing the target of stock limit product wise at processing canters and distributions /dispatch location, satisfying constraints such as product cost

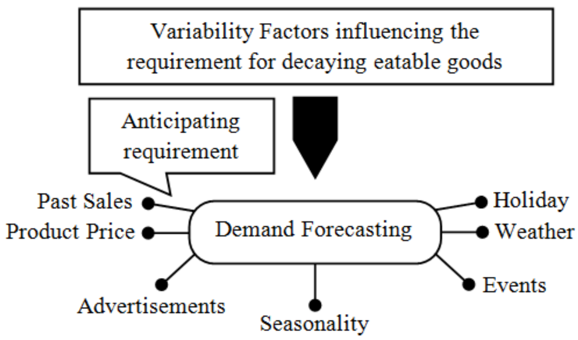

Fig. 1: Variability factors

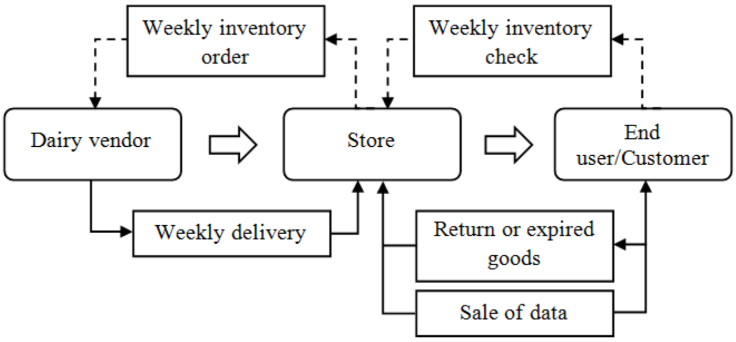

Fig. 2: The inventory cycle of goods

Misra et al. (2016detected gain in predicted items quantity ordered by consumers with sales prediction, and found effects on production. Ping 2016 planed to determine subsequent handling volume established on regression technique of Yangtze River port by means of prediction. Sugiarto et al. 2016applied sales and distribution software model to ease procedure of vending to consumers as per liking of consumers for goods sold including services rendered, make it is simple to inspect sale of goods and delivery of goods, and help consumers.

As per Tratar and Strmčnik(2016) when mistake happens resulted by production of estimated production requirement ,it will influence the procedure of goods sale to consumers, and prediction of requirement may be considered for evading of surplus / deficiency of goods supply in storehouse. Gupta (2015) &Sarno and Herdiyanti (2010) authored on prediction of ready made food item requirement using mathematical techniques and felt prediction of requirement as normal feature found in a manufacturing concern..

Harsoor and Patil (2015) mentioned retail vendor merchandize driving factors by going through market trade sale information of Walmart store which is geographically placed at different sites and market estimates. Hassan et al.suggested method for latest product market prediction includes monitoring of prediction based on accusation, evaluation, and option of subjective prediction forwarded by staff for new products without any past data. Mor et al. (2015, 2017) identified that agri-food supply chains are maintained by novelty, supply chain cooperation, removal of uncertainties. Zhou et al. (2015) discovered a dependable inventory forecast limits excess stock of production with lessening of maintenance charge, and suggested 2_step dynamic prediction technique . it is accomplished to know stock out situations in time series. García et al. (2014)stressed on strategic implications to perform with packaging technique being one factor of competitive advantages in SCM as per Procter .

Patushi and Kume (2014) proposed development of cluster as a means for enhancing competitiveness in marketing & a means of operational use of strength of dairy business in the course of policy guidance includes administration to face obstacles. Veiga et al. (2014) planned to evaluate execution ARIMA& Holt–Winters (H-W) method son decaying perishable items and studied with interfaces of prices relating to different marketing levels with attention on milk powder. Assis et al. (2013)suggestedusing6 Requirement Prediction ofShort-Lifecycle Dairy Products. Spicka (2013) suggested vertical business dealings within dairy scm in dairy industry by analysis of competitive advantage and established it is a weak link.

Amorim et al. (2013) discovered risk eversion models for reducing the amount of expired products by proper production and considering shelf life .Taylor (2011) found that capable SCM relies on correct requirement prediction. Jraisatet al. (2013) demonstrated for an organisation to remain in selling with proper marketing, however it shall possess good sales arm including fast delivery of goods in economical way. Ghosh (2008) demonstrated univariate time-series methods like multiplicative, seasonal,, integrated, moving mean, autoregressive ,exponential smoothing to predict 30days peak requirement of electric power. Dhahri and Chabchoub (2007) depended on ARIMA technique for predicting sugarcane productions for a year data. Vaida (2008) considered with theoretical issues of sales requirement techniques , collection criteria and application in formulating of furniture requirement estimation..

A. Factors Initiating Requirement

Variability factors considered in effect of presence of goods and disbursement days incudes with 3 normal factors; previous sales, cost and non_business days and also deliberated by Sivilloand .Reilly[12]]. Authors [Aburto, and R. ber]11] has considered similar issues apart from considering one year temperature data in place of non_business days . a review of past studies (Fig1) has stressed factors particularly to a single produce or a business type.

B. Prevailing Prediction Methods

Various linear, non-linear and hybrid methods are applied for forecasting requirement. Autoregressive–moving mean model (ARMA) technique is one of the main linear technique which joins auto-regression of past data and moving mean model of estimation errorsBox[14].

The linear model is Holt-Winters . exponential smoothing is applied on past data [Chatfield [15Linear auto-regression and moving mean technique were substituted, separately or jointly, with non-linear techniques such as neural network. Linear based technique give more inaccurate forecasting system of wholesalers is mentioned here with.

a) Previous sales

b) Producecost

c) Advertisements

d) Seasonality ofproduce

e) Holidays

f) Year

g) Price of product

Table-1: Different dairy products

list.	key item	By-product	technique	Final Items
A.	Milk Cream	Skimmed milk	Pasteurizing	Flavoured colour milk
			Sterilisation	Sterilized flavoured colour milk
			Fermenting	Cultured hygienic buttermilk
			Fermenting and absorption	Concentrated skim milk
			Concentration	Plain and sweetened skim milk
			aeration	Dried skim milk /Non Fat Dry Milk (NFDM)
			solidification	Cottage cheese, edible casein
B.	Butter	Butter milk	Fermentation	Condensed buttermilk
			Concentration	dehydrated buttermilk
			Coagulation	Soft cheese
C.	Milk Cheese Casein Channa Panneer	Whey	Fermentation	Whey beverage, yeast whey
			Concentration	Plain and sweetened condensed whey, whey protein concentrate, whey paste, lactose
			aeration	Dried whey
			solidification	Ricotta cheese
D	Processed Ghee	Ghee residue	Drying and centrifuging	sweet paste

Temperature, offdays and financial aspects have an influence on requirement Aburto, &ber[12]. Author also stressed the importance that produce readiness has also to be considered while stating to past data to correctly estimate future requirement past milk sales are taken into consideration to assess the future requirement and inferred on-systematic variation to holidays and consumer trends as in demand Aburto, &ber[11],forecasts among all prediction methods Doganis, et al [10]. Non-linear models are superior to linear models, particularly depends to find association among market requirement and variability aspects in place of moving mean error in marketing requirement.

Non-linear models; GA for variable selection and adaptive Radial Basis Function(RBF) artificial neural network are used to model association between variables and market volume demand Aburto, &ber [11. A model combining linear and nonlinear models [11], ARIMA was meant linear auto regression and Neural Network for demonstrating of prediction moving mean Errors. The model produced faults by 29 percent %; hover, in comparison with [other technique exhibited correct results (i.e. 9.3 %%) which can be associated to milk business(milkDoganis, et al [10], and edible oil]); whom re also researching milk requirement prediction, applied a hybrid non-linear model consisting of Gray relationship analysis for variable selection and artificial neural network.

C. Restriction

Prediction variable inaccuracy is lessened using nonlinear RBF technique to 5 percent taking into account other small no. of factors Doganis, et al [10]; factors (e.g. cost) can enhance correctness of technique prediction of error can be compared to business sector which can Date: taken into account 'past sales' as variable in capturing forth coming consumer requirement. This association slowly decreases by increasing of time (e.g. last year sales are more appropriate than years before)

1. Business Category: for studying pattern of the goods for various business categories (e.g., hotels, inn, schools etc.,), business types for various short-shelf life goods.
2. Goods: less -shelf life food goods classified mainly 4classes (i.e.MILK, GHEE, POWDERS,DAIRY and ICE CREAMS) therefore one item representing each category is selected.
3. Site: site has its own population, events etc., to analyses effect of the aspects on market prediction data recollected from various localities.

Data recollected for various less_ shelf life goods and services types in business of organisation. Sales requirement of lesser shelf life goods are influenced by fluctuations in no. of consumers from year after year. It is influenced by major requirement ; which make estimation of requirement using present sales requirement not accurate. The move is applied before beginning analysis, to determine where is any trend in real sales. ,sales move requirement is attuned by below described method

Normalisation of order quantity: sales requirement is normalised dependent on Back Lagged orders: it is related with examining the effect of time on requirement. orders are delayed on day to day ,or week to week (time window)basis to examine if estimated variable has an effect on requirement.

D. Examining of Various Variability Factors Causing demand prediction

There are normal factors and also specifically factor on behalf of requirement vacillation has an consequence on each produce, as deviations in sales requirement are determined by cost change, discounts, rebates food custom etc., in addition to seasonal changes, current festivals and functions . various aspects causing short-shelf life food goods are recognized. In addition to identified factors from literature, some more factors are also found . such Identified factors are previous sales requirement' and 'Holidays' are extended into many sub-levels taking into account the consequences (i.e. conditions). new factor 'Events', 'Seasons' and few or sub levels for prevailing aspects are are taken into consideration

Table-1demonstratesvariability factors collected from different sources. Additionally gathered data contains noise as changing frequently, Prediction of Daily/wekly Requirement:

1. Mean of week Days
2. Week Mean of 2/3

E. Lessening of Variability Factors

The move looks at identifying requirement trend of lesser shelf life goods check if factors can be lessened using Principle Component Analysis (PCA)model. Product Requirement trend is studied from one year based on daily, weekly and 30days orders.

2.1 Literature Gap

Identification of various factors and as the demand is influenced predominantly by price. The prediction of demand based on price using as well as optimising the profit in determining the order quantity based on the forecasted demand is the gap noticed in the literature.

METHODOLOGY ADOPTED

1. Preparation of price dependent equation using ANN technique
2. Solving the equation for optimum profit

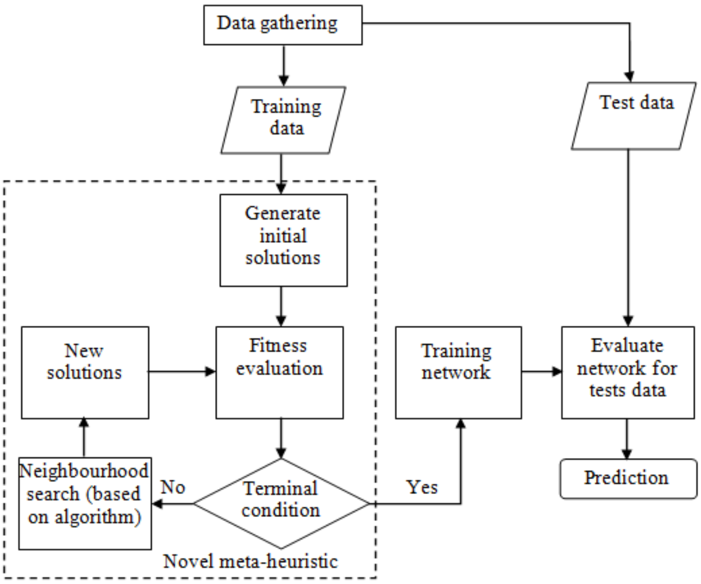

Fig.3: Flow chart for ANN technique

Quality data is a requisite to implement any data mining procedure and requires to be formulated ie to transform the data into a suitable format required and also to express with detail information for the purpose of modelling the data.

1. Total market for each good weekly *t* buckets to take care of with high improbability and variations in trade outlines.
2. Assort by deleting return sales for consumer revenues.

Normalise sales volume of all goods in a marketing period to allow evaluation among time series of goods of various sales volumes, normalised sales at time i, y_i, is calculated by division of sale of time i x_i, by total sales in particular period : $y_i = x_i / \sum n x_k$, (n = no. of. periods.)

3.1 Model for profit optimization

Organisation accomplishes a produce which possess essential perishability, and product is subject to physical and cleanness decaying has a partial shelf-life, after which it is not saleable, stock cycle period is not more than product 's shelf-life. Because of item nature ,requirement relates on cost, present stock, and its freshness. Inventory target at inventory cycle period end. Recovery cost and decaying cost are also considered for decayed items for inventory cycle. At start of stock cycle t0,seller accepts a lot size of Q units, and inventory level instantaneously starts to lessen because requirement &decaying, until store level reaches units at t.

Table-2: Notations

Parameters	Description
s	Recover price of depreciated item
c	Buying price()
c_d	Deterioration price ()
h	Inventory holding cost
h_1	Inventory holding cost 1 week
h_2	Inventory holding cost 2 nd week
K	Ordering cost (/per cycle)
n	Shelf-life
	From stockage (unit of time)
W	Maximum shelf place
η	Recover factor (0 ≤η≤ 1)
θ	Deterioration rate (0 ≤θ≤ 1)
ω	Sensitivity parameter top resent inventory limit
$K2$	Scale factor cost-dependent requirement
a	Sensitivity factor for cost-dependent requirement
Functions	
$D(p)$	Cost-dependent requirement
$In(t)$	Store level at time t(units)
$D(\mathrm{r}p, I(\mathrm{n}t), t)$	Cost-, stock-, and age-dependent requirement on time basis
$H(t)$	Quadratic holding cost function
$\pi_c(pr, T)$	gain per cycle()
$\pi(pr, T)$	l gain per unit time()
t	stock age, time taken since previous replacement()
Variables	
p	produce selling cost ()
T	Replenishment cycle length ()
Q	quantity Ordered

$d(pi) = a - b*p,$ 0 <=p≤1a1/b(linear requirement),

$d(pi) = a - a*p^{-b},$ $0 \leq p \leq \infty$ (iso-elastic requirement),

$d(pi) = a - a*e^{-bp},$ $0 \leq p \leq \infty$ (exponential requirement),

$d(\mathrm{i}p) = \frac{a}{1+e^{bp}},$ $0 \leq p \leq \infty$ (logit requirement),

(1)

requirement functions used, depend on cost, sufficiently model scenario where requirement improves as cost decreases.

By taking into account all assumptions, on-hand inventory level I (t) is

$$\frac{dInv(t)}{dt}=\frac{ni-t}{n}d(pi)-\omega Inv(t)-\theta Inv(t) \quad , \qquad 0\le t\le T \quad (2)$$

Such that

$Inv(T) = 0.$ (3)

For stock cycle $[0,T]$,on-hand stock decays at a constant rate (θ), with loosening its freshness requirement hinge on cost, stock, and age, as :

$$D(pi, Inv(t), t)=\frac{n-t}{ni}d(pi)+\omega Inv(t), \quad n>0,\ \omega\ge 0,\ t\le n, \qquad (4)$$

where part of requirement that is dependent on cost ($d(p)$):

By solving Eq.(3),$In(vt)$ is:

$$I(nvt)=\frac{d(pt)}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}\right)\left(e^{(\omega+\theta)(T-t)}-1\right)-\frac{d(p)}{n(\omega+\theta)}\left(Te^{(\omega+\theta)(T-t)}-t\right),$$

$0\le t\le T.$(5)

1) Order quantity Q,

$$Q=\frac{d(pi)}{(\omega+\theta)}\left(-1-\frac{1}{n(\omega+\theta)}\right)+\frac{d(pi)e^{(\omega+\theta)T}}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\le W. \qquad (6)$$

2) Sales Revenue

$$SR=p\int_0^T\left[d(pi)\left(1-\frac{t}{n}\right)+\omega I(t)\right]dt$$

$$=d(pi)T\left[1-\frac{T}{2n}\right]-\frac{\omega d(pi)T}{(\omega+\theta)}\left[1-\frac{T}{2n}+\frac{1}{n(\omega+\theta)}\right]$$

$$+\frac{\omega d(pi)}{(\omega+\theta)}\frac{(e^{(\omega+\theta)T}-1}{(\omega+\theta)}\left[1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right] \qquad (7)$$

3) Recovery cost per cycle (SV) of deteriorated items.

$SV = s\eta$ (Deteriorated units per cycle).

$$SV = s\eta\left(Q-\int_0^T\left(d(pi)\left(1-\frac{t}{n}\right)+\omega I(t)\right)dt\right),$$

$$SV = s\eta\left\{\frac{d(pi)}{(\omega+\theta)}\left[-1-\frac{1}{n(\omega+\theta)}+\frac{d(pi)e^{(\omega+\theta)T}}{(\omega+\theta)}\left[1+\frac{1}{n*(\omega+\theta)}\right]\right.\right.$$

$$-\left[d(p)*T*\left(1-\frac{T}{2n}\right)-\frac{\omega*d(pi)T}{(\omega+\theta)}\left(1-\frac{T}{2n}+\frac{1}{n*(\omega+\theta)}\right)\right.$$

$$\left.\left.+\frac{e^{(\omega+\theta)*T}-1}{(\omega+\theta)}\left(\frac{\omega d(pi)}{(\omega+\theta)}\right)\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]\right\} \quad (8)$$

$\pi_c =$ revenue + salvage cost - ordering cost - holding cost - buying cost – decaying cost-defcost

$\pi_c =$ SR + Salvage V – OrderC – HoldingC – PurC – DeplC-defcost.

defcost, =(1-alpha)q

Hence,total gain per time unit is formulated below :

$$\pi(pi,T)=\frac{1}{T}\left\{d(pi)T\left[1-\frac{T}{2n}\right]-\frac{\omega d(pi)T}{(\omega+\theta)}\left[1-\frac{T}{2n}+\frac{1}{n(\omega+\theta)}\right]\right.$$

$$+\frac{\omega(pi)}{(\omega+\theta)}\frac{(e^{(\omega+\theta)T}-1)}{(\omega+\theta)}\left[1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right]+s\eta\left\{\frac{d(pi)}{(\omega+\theta)}\left[-1-\frac{1}{n(\omega+\theta)}\right]\right.$$

$$+\frac{d(pi)e^{(\omega+\theta)T}}{(\omega+\theta)}\left[1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right]-\left[d(pi)T\left(1-\frac{T}{2n}\right)-\frac{\omega d(pi)T}{(\omega+\theta)}\left(1-\frac{T}{2n}\right.\right.$$

$$\left.\left.\left.\left.+\frac{1}{n(\omega+\theta)}\right)+\frac{e^{(\omega+\theta)T}-1}{(\omega+\theta)}\left(\frac{\omega(pi)}{(\omega+\theta)}\right)\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]\right\}\right\}$$

$$-\left\{h*\left\{\frac{d(pi)*T}{(\omega+\theta)}\left[-1+\frac{T}{2n}-\frac{1}{n(\omega+\theta)}\right]+\left[\frac{e^{(\omega+\theta)*T}-1}{(\omega+\theta)}\right]\left[\frac{d(pi)}{(\omega+\theta)}\left(1+\frac{1}{n*(\omega+\theta)}\right)-\frac{T}{n}\right]\right\}\right.$$

$$+h_1\left\{\frac{d(pi)T^2}{(\omega+\theta)}\left[-\frac{1}{2}+\frac{T}{3n}-\frac{1}{2n(\omega+\theta)}\right]\right.$$

$$\left.+\left[\frac{e^{(\omega+\theta)T}-(\omega+\theta)T-1}{(\omega+\theta)^2}\right]\left[\frac{d(pi)}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]\right\} \quad (9)$$

$$h_2\left\{\frac{d(pi)T*^3}{(\omega+\theta)}\left[-\frac{1}{3}+\frac{T}{4n}-\frac{1}{3*n*(\omega+\theta)}\right]\right.$$

$$\left.+\left[\frac{2e^{(\omega+\theta)T}-[(\omega+\theta)(T(\omega+\theta)+2)]}{(\omega+\theta)^3}\right]\left[\frac{d(pi)}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]\right\}$$

$$-c\left[\frac{d(pi)}{(\omega+\theta)}\left(-1-\frac{1}{n(\omega+\theta)}\right)+\frac{d(pi)e^{(\omega+\theta)T}}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]$$

$$-\left\{c_d\left\{\frac{d(pi)}{(\omega+\theta)}\left[-1-\frac{1}{n(\omega+\theta)}\right]+\frac{d(pi)e^{(\omega+\theta)T}}{(\omega+\theta)}\left[1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right]\right.\right.$$

$$-\left[d(pi)T\left(1-\frac{T}{2n}\right)-\frac{\omega d(pi)T}{(\omega+\theta)}\left(1-\frac{T}{2n}+\frac{1}{n(\omega+\theta)}\right)\right.$$

$$\left.\left.\left.+\frac{e^{(\omega+\theta)T}-1}{(\omega+\theta)}\left(\frac{\omega d(pi)}{(\omega+\theta)}\right)\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]\right\}\right\}$$

4) Ordering cost

$OC = K.$ (10)

5) Carryingcost (Cc) per cycle:

$$Cc=\int_0^T H(t)Inv(t)\,dt=\int_0^T (h+h_1t+h_2t^2)I(t)$$

$$Cc=\int_0^T H(t)Inv(t)dt=h\left\{\frac{d(pi)T}{(\omega+\theta)}\left[-1+\frac{Ti}{2n}-\frac{1}{n((\omega+\theta)}\right]\right.$$

$$\left.+\left[\frac{e^{(\omega+\theta)T}-1}{(\omega+\theta)}\right]\left[\frac{d(pi)}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]\right\}$$

$$+h_1\left\{\frac{d(pi)T^2}{(\omega+\theta)}\left[-\frac{1}{2}+\frac{T}{3n}-\frac{1}{2n(\omega+\theta)}\right]\right.$$

$$\left.+\left[\frac{e^{(\omega+\theta)T}-(\omega+\theta)T-1}{(\omega+\theta)^2}\right]\left[\frac{d(pi)}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]\right\}$$

$$+h_2\left\{\frac{d(pi)T^3}{(\omega+\theta)}\left[-\frac{1}{3}+\frac{T}{4n}-\frac{1}{3n(\omega+\theta)}\right]+\left[\frac{2e^{(\omega+\theta)T}-[T(\omega+\theta)(T(\omega+\theta)+2)]}{(\omega+\theta)^3}\right]\right.$$

$$\left.\cdot\frac{d(p)}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right\} \quad (11)$$

6)Acquisition cost (PC)

$$piC=c\left[\frac{d(pi)}{(\omega+\theta)}\left(-1-\frac{1}{n(\omega+\theta)}\right)+\frac{d(pi)e^{(\omega+\theta)T}}{(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right] \quad (12)$$

7) cycle Decaying cost (DC) per cycle.

$$iDiC=c_d\left(Q-\int_0^T d(pi)\left(1-\frac{t}{n}\right)+\omega I(t)\right),$$

$$DiC=c_d\left\{\frac{d(pi)}{(\omega+\theta)}\left[-1-\frac{1}{n(\omega+\theta)}\right]+\frac{d(pi)e^{(\omega+\theta)T}}{(\omega+\theta)}\left[1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right]\right.$$

$$-\left[d(pi)T\left(1-\frac{T}{2n}\right)-\frac{\omega d(pi)T}{(\omega+\theta)}\left[1-\frac{T}{2n}+\frac{1}{n(\omega+\theta)}\right]\right.$$

$$\left.\left.+\frac{e^{(\omega+\theta)T}-1}{(\omega+\theta)}\left(\frac{\omega d(pi)}{(\omega+\theta)}\right)\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\right]\right\} \quad (13)$$

therefore, total gain per cycle is,optimization problem expressed

$\text{Max}_{p,T}\pi(ip,T)$

Subject to $c\leq p\leq p_{\max}$ and $T\leq n$. (14)

Gain per unit of time function () denotes that it is nonlinear in selling cost (pi)& replenishment cycle time (T). Hence computation of a close form for decision variables is impossible. Optimal values p&T are determined by an optimization method untraditional conditions for optimality.

Gain per unit time $\pi(p,T)$ to

$$\frac{\partial\pi(pi,T)}{\partial p}=0 \quad (15)$$

$$\frac{\partial \pi(pi,T)}{\partial T} = 0 \qquad (16)$$

8) Total gain per unit time $\pi(\underline{p},T)$ is concave, constraints to be satisfied follows:

$$\frac{\partial^2 \pi(pi,T)}{\partial p^2} < 0 \qquad (17)$$

$$\frac{\partial \pi(pi,T)}{\partial T} = \left\{ p\left[\frac{d(pi)}{2n}\left(\frac{\omega}{\omega+\theta}-1\right)+\frac{\omega d(pi)}{(\omega+\theta)}\left(\frac{(e^{(\omega+\theta)T}(\omega T+\theta T-1)+1}{(\omega+\theta)T^2}\right)\left(1+\frac{1}{n((\omega+\theta)}\right)\right.\right.$$

$$\left. -\frac{\omega d(pi)e^{(\omega+\theta)T}}{n(\omega+\theta)}\right] + \left[s\eta\left(\frac{d(p)}{(\omega+\theta)T^2}\left(1+\frac{1}{n(\omega+\theta)}\right)\right.\right.$$

$$+\frac{d(p)}{(\omega+\theta)a}\left(\frac{(e^{(\omega+\theta)T}(\omega T+\theta T))+1}{T^2}\right)\left(1+\frac{1}{n(\omega+\theta)}\right)$$

$$-\frac{d(p)}{n(\omega+\theta)}(\omega+\theta)e^{(\omega+\theta)T}+\frac{d(p)}{2n}\left(1-\frac{\omega}{(\omega+\theta)}\right)$$

$$\left.\left. -\frac{\omega d(pi)}{(\omega+\theta)}\left(\frac{(e^{(\omega+\theta)T}(\omega T+\theta T))+1}{(\omega+\theta)T^2}\right)\left(1+\frac{1}{n(\omega+\theta)}\right)+\frac{\omega(pi)}{n(\omega+\theta)}e^{(\omega+\theta)T}\right)\right]$$

$$+\left[\frac{K}{T^2}\right]-\left[\left(h\left(\frac{d(pi)}{2n(\omega+\theta)}+\frac{d(pi)}{(\omega+\theta)}\left(\frac{(e^{(\omega+\theta)T}(\omega T+\theta T-1))+1}{(\omega+\theta)T^2}\right)\left(1+\frac{1}{n(\omega+\theta)}\right)i\right.\right.\right.$$

$$\left.\left. +\frac{d(pi)}{(\omega+\theta)}\left(\frac{\omega Te^{(\omega+\theta)T}+\theta Te^{(\omega+\theta)T}-e^{(\omega+\theta)T}+1}{(\omega+\theta)^2T^2}\right)-\frac{d(pi)}{n(\omega+\theta)}\left(\frac{e^{(\omega+\theta)T}-1}{(\omega+\theta)}\right)\right)\right)$$

$$+\left(h_2\left(-\frac{2d(pi)T}{3(\omega+\theta)}+\frac{3d(pi)T^2}{4n(\omega+\theta)}-\frac{2d(pi)T}{3n(\omega+\theta)}\right.\right.$$

$$+\frac{d(p)}{(\omega+\theta)}\left(-\frac{\theta^2T^2+2\omega\theta T^2-2\theta Te^{(\omega+\theta)T}-2\omega Te^{(\omega+\theta)T}+2e^{(\omega+\theta)T}+\omega^2T^2-2}{(\omega+\theta)^3T^2}\right)$$

$$\left.\left.\left. .\left(1+\frac{1}{n(\omega+\theta)}\right)-\frac{d(p)}{n(\omega+\theta)}\left(\frac{2e^{(\omega+\theta)T}(\omega T+\theta T)-1}{T^2}\right)\right)\right)\right]$$

$$-\left[c\left(\frac{d(pi)}{(\omega+\theta)T^2}\left(1+\frac{1}{n(\omega+\theta)}\right)+\frac{d(pi)}{(\omega+\theta)}\left(\frac{e^{(\omega+\theta)T}(\omega T+\theta T)-1}{T^2}\right)\left(1+\frac{1}{n(\omega+\theta)}\right)\right.\right.$$

$$\left.\left. -\frac{d(p)}{n*(\omega+\theta)}(\omega+\theta)e^{(\omega+\theta)T}\right)\right]-\left[c_d*\left(\frac{d(p)}{(\omega+\theta)*T^2}\left(1+\frac{1}{n*(\omega+\theta)}\right)\right.\right.$$

$$+\frac{d(p)}{(\omega+\theta)}\left(\frac{(e^{(\omega+\theta)T}(\omega T+\theta T-1))}{T^2}\right)\left(1+\frac{1}{n(\omega+\theta)}\right)$$

$$-\frac{d(p)}{n(\omega+\theta)}(\omega+\theta)e^{(\omega+\theta)T}+\frac{d(p)}{2n}\left(1-\frac{\omega}{(\omega+\theta)}\right)$$

$$-\frac{\omega d(p)}{(\omega+\theta)}\left(\frac{(e^{(\omega+\theta)T}(\omega T+\theta T-1))}{(\omega+\theta)T^2}\right)\left(1+\frac{1}{n(\omega+\theta)}\right)+\frac{\omega d(p)}{n(\omega+\theta)}e^{(\omega+\theta)}\Bigg)\Bigg]\Bigg\}=0$$

(18)

Algorithm-determining optimal result

Move 1. Input inventory parameters.
Move 2. Calculate $p_{\max}$.
Move 3. Resolve simultaneously equations (to obtain costs for *pi* and *T*.
Move 4. If (19)-(22) are condition met, results optimal, and proceed to move 5.
Otherwise, infeasible, and move to 14.
Move 5. If $c \le p \le p_{\max}$&$T \le n$ are condition met, n consider $p^* = p, TI = T$, and proceed to move 11.
Otherwise, proceed to move 6.
Move 6. If *p* less than or equal to *c* and T is less than or equal to *n* are, met, n consider $p^* = c, TI = T$, and perform move 11.
Otherwise, proceed to move 7.
Move 7. If $p \le c$&$T > n$ are condition met, n consider $p^* = c, TI = n$, and go to move 11.
Otherwise, proceed to move 8.
Move 8. If $p > p_{\max}$&$T < n$ are condition met, n consider $p^* = p_{\max}$ and $TI = T$, & proceed to 11.
otherwise, move to 9.
Move 9. If $p \le p_{\max}$&$T > n$ are condition met, n conside r$p^* = p$ and $TI = n$, and proceed otherwise 11.
Else, perfrorm move 10.
Move 10. Consider$p = p_{\max}$, $TI = n$.
Move 11. Compute lot size QU^*as per equation six.
Move 12. Calculate gain per unit time π^* (p^*,T^*) as per h equation fifteen
Move 13. Ideal result π^* (p^*,T^*), p^*, *TI* & Q^*.
Move 14. End.

$$\frac{\partial\pi(pi,T)}{\partial p}=\Big\{[-bp+d(p)]\Big[1-\frac{T}{*2*n}+\frac{\omega}{(\omega+\theta)}\Big(-1+\frac{T}{2n}-\frac{1}{n*(\omega+\theta)}\Big)\Big]$$

$$+\left(\frac{\omega}{T(*\omega+\theta)}\right)\left(\frac{e^{(\omega+\theta)*T}-1}{(\omega+\theta)}\right)\left(1+\frac{1}{n(\omega+\theta)}\right)-\left(\frac{\omega}{Tn(\omega+\theta)}\right)\left(\frac{T(e^{(\omega+\theta)T}-1}{(\omega+\theta)}\right)\Big]$$

$$+[s\eta(-b)]\Bigg[\frac{1}{T(\omega+\theta)}\left(-1-\frac{1}{n(\omega+\theta)}\right)+\frac{e^{(\omega+\theta)T}}{T(\omega+\theta)}\left(1+\frac{1}{n(\omega+\theta)}\right)-1$$

$$+\frac{T}{2*n}+\frac{\omega}{(\omega+\theta)}\left(1-\frac{T}{2*n}+\frac{1}{n*(\omega+\theta)}\right)+\frac{\omega}{T(\omega+\theta)}\left(\frac{e^{(\omega+\theta)T}-1}{(\omega+\theta)}\right)\left(-1-\frac{1}{n(\omega+\theta)}+\frac{T}{n}\right)\Big]$$

$$-\Bigg[(-hb)\left(\frac{1}{(\omega+\theta)}\left(-1+\frac{T}{2n}-\frac{1}{n(\omega+\theta)}\right)+\frac{1}{T(\omega+\theta)}\left(\frac{e^{(\omega+\theta)T}-1}{(\omega+\theta)}\right)\right.$$

(19)

$$.\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\Bigg)+(-h_1 b)\left(\frac{T}{(\omega+\theta)}\left(\frac{T}{3n}-\frac{1}{2}-\frac{1}{2n(\omega+\theta)}\right)\right.$$

$$+\frac{1}{T(\omega+\theta)}\left(\frac{e^{(\omega+\theta)T}-T(\omega+\theta)-1}{(\omega+\theta)^2}\right)\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\Bigg)$$

$$+(-h_2 b)\left(\frac{T^2}{(\omega+\theta)}\left(\frac{T}{4n}-\frac{1}{3}-\frac{1}{T(\omega+\theta)}\right)\right.$$

$$+\frac{1}{T(\omega+\theta)}\left(\frac{2e^{(\omega+\theta)T}-T((\omega+\theta)(T(\omega+\theta)+2)-2}{(\omega+\theta)^3}\right)\left(1+\frac{1}{n(\omega+\theta)}-\frac{T}{n}\right)\Bigg]$$

$$+\left[(-cb)\left(\frac{1}{T+(\omega+\theta)}\left(1+\frac{1}{n*(\omega+\theta)}\right)+\frac{e^{(\omega+\theta)T}}{T*(\omega+\theta)}*\left(-1-\frac{1}{n*(\omega+\theta)}+\frac{T}{n}\right)\right)\right]$$

$$-[c_d(-b)]\left[\frac{1}{T*(\omega+\theta)}\left(-1-\frac{1}{n*(\omega+\theta)}\right)+\frac{e^{(\omega+\theta)*T}}{T*(\omega+\theta)}\left(1+\frac{1}{n*(\omega+\theta)}-\frac{T}{n}\right)\right.$$

$$-1+\frac{T}{2*n}+\frac{\omega}{(\omega+\theta)}\left(1-\frac{T}{2*n}+\frac{1}{n*(\omega+\theta)}\right)$$

$$+\left(\frac{\omega}{T(\omega+\theta)}\right)\left(\frac{e^{(\omega+\theta)T}-1}{(\omega+\theta)}\right)\left(-1-\frac{1}{n(\omega+\theta)}+\frac{Tn}{}\right)\Bigg]\Bigg]\Bigg\}=0$$

CASE STUDY

Assume that the price dependent element of the demand for the new item islinear as explained : $d(p) = 500 - 30p$ (i.e., $a = 500$ &$b = 30$). shelf-life of the new item is $n = 7$ days. Isa maximum shelf place of $W = 400$ measuring units. Unit cost of placement of an order to the vendor is $K = 25000$rupees,the procurement unit price $c = 500$ rupees, and the recoverable value of the decayed item is $s = 400$ rupees per unit. -sensitivity coefficient $\omega = 0.45$, and the stock deterioration rate is $\theta = 0.06$. unit holding cost per week $h = 170$ rupees, unit price per next 7 days $h_1 = 16$rupees, and unit price for subsequent next 7 days $h_2 = 26$ rupees. unit decaying cost of the item $cd = 2$ rupees, and the salvage coefficient is $\eta = 0.75$. Since $n = 1$ week, the replenishment cycle period be $T \leq 7$ days . the upper limit is $p$max=(a/b) = (500/30) =17. -is means that the price must satisfy$5 \leq p \leq 17$.

The opimum value p∗ 1769 rupees per unit, Time of cycle =3 days, Quantity ==95 units, and profit = 204900.903 euros per week.

Table-3: sensitive analysis

Parameter	value	*p*	*T*	*Q*	Profit
n	0.6	17.52065	0.3895503	54.51395	145700.327
	1	17.59124	0.4395922	94.42941	204900.903
	1.3	17.73165	0.6284379	118.4082	224400.032
	1.4	17.74546	0.6591541	126.7715	229700.187
K	250	17.59124	0.4395922	94.42941	204900.903
	350	17.71696	0.6101394	106.0448	183900.465
	500	17.74562	0.6955007	118.4688	156800.368
ω	0.35	17.58249	0.4095219	84.91483	192000.088
	0.35	17.5858	0.4207697	88.45035	197000.198

Parameter	value	*p*	*T*	*Q*	Profit
	0.6	17.59124	0.4395922	94.42941	204900.903
θ	0.03	17.58352	0.4399946	94.1671	205200.615
	0.05	17.59124	0.4395922	94.42941	204900.903
	0.06	17.5951	0.4393881	94.6602	204800.693
c	4	17.18122	0.4256198	95.76367	226900.809
	5	17.59124	0.4395922	94.42941	204900.903
	6	18.30186	0.4546421	93.02275	184000.193
s	3.5	17.59273	0.439444	94.39203	204900.342
	4	17.59124	0.439592	94.42941	204900.903
	4.4	17.58974	0.439739	94.4668	205000.665
h, h_1, h_2	1.54, 0.05, 0.15	17.58038	0.440920	94.74612	205400.729
	1.74, 0.15, 0.35	17.59124	0.439592	94.42941	204900.903
	1.84, 0.35, 0.35	17.70203	0.438271	94.11458	204500.093
c_d	1	17.58655	0.440052	94.64633	205100.972
	2	17.59124	0.439592	94.42941	204900.903
	3	17.59592	0.439132	94.31266	204700.837
η	0.5	17.59498	0.439224	94.33599	204800.35
	0.8	17.59124	0.439592	94.42941	204900.903
	1	17.58748	0.439960	94.62293	205100.658
a, b fixed	360	11.79361	0.770094	69.96747	23100.0563
	600	17.59124	0.439592	94.42941	204900.903
	840	23.54165	0.314190	105.6754	532800.862
b, a fixed	5	62.50045	0.317419	58.93376	1432900.36
	20	17.59124	0.439592	94.42941	204900.903
	30	12.73633	0.666856	101.7333	84700.1779

RESULTS AND CONCLUSIONS

The optimum value p∗ 1769 rupees per unit, Time of cycle = 3 days, Quantity == 95 units, and profit = 204900.903 euros per week

Tables 3 depicts the sensitivity of the input parameters on the ideal solution .the ordering cost *K* have the similar influence on the inventory policy and total profit in price demand. A lengthier product's maximum shelf-life (*n*)results in a increased optimal price, a quantity, which implies a fresh product with enhanced life span (it takes longer to lose its attractiveness) permits the marketer to propose it at a larger price.

The price and inventory cycle period rise with lower profits when ordering cost K rises

FUTURE SCOPE OF THE STUDY

Decision makers shall formulate appropriate techniques to reduce the ordering costs in order to get more profits. shortages with full or limited backlogging can be considered in the model as a future scope , the costs and benefits of spending on preservation techniques for the goods can be explored. Fuzzy costs can be considered as a future case study

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