Supply Chain of Perishable Items

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Abstract—Supply chain forms a very important aspect of a firm's operations. The rules of supply chain management change significantly while dealing with perishable items. Perishable products forms a large portion of total inventory and include virtually all foodstuffs, dairy products, pharmaceuticals, fashion goods, electronic items, periodicals (newspapers/magazines), dig- ital goods (computer software, video games, DVD) and many more. There are many goods that either deteriorate and/or become obsolete in the course of time. This paper presents the relation between reserve inventory & deterioration rate on profit. The methodology relaxes with the condition of zero stock (make to order) at the end of cycle & maintains reserve stock. Under Standard assumptions of single product, instantaneous replenishment with zero lead time, and constant deterioration rate. Study says that profit decreases with reserve inventory; deterioration rate has pronounced impact on order quantity and profit as compared to inventory dependent demand factor.

Index Terms—Supply Chain, Perishable product, Demands

I. INTRODUCTION

A supply chain is two or more parties linked by a flow of materials, information and money. If all the players act coherently, they can maximize their profits and the profit of the supply chain as a whole. But, it is difficult to put this ideal action into practice as the supply chain involve several decision-makers pursuing different objectives which are generally conflicting in nature. A number of incentive compatible coordination mechanisms known as supply chain contracts have been developed to encourage coordination by which the objectives of different members of a supply chain can be aligned and the system performance can be improved. Supply chain contracts have been suggested as a coordination mechanism that provide incentives to all supply chain members so that the decentralized and uncoordinated supply chain behaves nearly or exactly the same as an integrated one. However, short life-cycle products such as fashion apparel, electronic goods, personal computers, toys, and books which are characterized by uncertain demand, short selling season and long lead times have been posing many challenges to the supply chain members as the supply chains are operating under highly uncertain and competitive environment.

Perishable products constitute a large portion of the world economy and include virtually all foodstuffs, pharmaceuticals, fashion goods, electronic items, periodicals, digital goods and many more as they lose value with time due to deterioration and/or obsolescence. Retailers dealing with perishable goods have to consider the factors of short shelf life and the dependency of sales volume on the amount of inventory displayed in determining optimal procurement policy. Perishable goods can be broadly classified into two main categories based on: (i) Deterioration (ii) Obsolescence.

Deterioration refers to damage, spoilage, vaporization, depletion, decay (e.g. radioactive substances), degradation (e.g. electronic components) and loss of potency (e.g. pharmaceuticals and chemicals) of goods. Obsolescence is loss of value of a product due arrival of new and better product [1]. Perishable goods have continuous or discrete loss of utility and therefore can have either fixed life or random life. Fixed life perishable products have a deterministic, known and definite shelf life and examples of such goods are pharmaceuticals, consumer packed goods and photographic films. On the other hand, random life perishable products have a shelf life that is not known in advance and variable depending on variety factors including storage atmosphere. Items are discarded when they spoil and the time to spoilage is uncertain. For example, fruits, vegetables, dairy products, bakery products etc., have random life [2]. Perishable products provide extra challenges to the supply chain due to their limited shelf-life. As such, storing these goods for more than their designated shelf-time leads to expiry and they must be discarded. Hence, quantities delivered to retailers are limited by the shelf-life of goods as well as the retailer's holding capacity.

II. LITERATURE REVIEW

Constant demand rate is not always suitable to many inventory items (e.g. electric goods, fashionable clothes, tasty foods, etc.) as they experience fluctuations in the demand rate. In the last few years, the inventory lot-sizing models with time-varying demand and deterioration have received considerable attention. Dave and Patel [3] first considered the inventory models for deteriorating items with linear increasing demand. The consideration of exponentially decreasing demand for deteriorating items was first analyzed by Hollier and Malc [6]. Haringa and Benkherouf [7] generalized Hollier and Macs [6] model taking into account both exponentially growing and declining markets. Haiping and Wang [4] developed An economic ordering policy model for deteriorating items with time proportional demand. H. Xu [9] proposed, Optimal inventory policy for perishable items with time proportional demand. Benkherouf and Mahmoud [5] developed an inventory model

with deterioration and increasing time-varying demand and shortages. Silver [8] proposed a Simple inventory object replenishment decision rule for a linear trend in demand. We know that the shortages in inventory systems are either completely backlogged or totally lost.

On inventory management, Chen et al. [10] studied a two-echelon distribution system. Yang and Wee [11] analyzed an integrated single-vendor multi-buyers inventory system of a deteriorating item. Wee and Yang [12] presented a single-producer, multi-distributors and multi-retailers inventory system. Furthermore, Axsater et al. [13] considered two-level inventory with one warehouse and multiple retailers. Supply chains with perishable products have been studied in different lines of research. Some researchers extended the economic order quantity (EOQ) policy for inventory models which include perishable products. For example, Giri and Chaudhuri [1998] proposed an inventory model for a perishable product where the demand rate is a function of the on-hand inventory, and the holding cost is nonlinear. Moreover, Padmanabhan and Vrat [1995] proposed stock-dependent selling rate model where the backlogging function was assumed to be dependent on the amount of demand backlogged.

III. METHODOLOGY

Notations

The Following notations are used:

R_i Reserve Inventory

P Profit

Q Order Quantity

e Time invariant deterioration rate

Assumptions:

1. We assume some assumption like-the inventory planning horizon is infinite and the inventory system deals with one product along with one stocking point.

2. The deterioration (Shelf life) of product is continuous and a constant fraction of the on-hand inventory deteriorates per unit time. Deterioration rate is deterministic, known and constant. There is no replenishment or repair of deteriorating items during the inventory cycle.

3. The demand is on hand inventory dependent, deterministic and time invariant.

4. The order quantity, inventory level and demand are treated as continuous variable while the number of replenishments is treated as discrete variable.

The inventory level decreases rapidly at the beginning of each inventory cycle because both demand rate and deterioration rate are greater due to higher level of inventory. The profit, order quantity and cycle length decreases with deterioration rate The effect of deterioration is more pronounced on profit and order quantity.

$$P = \frac{Q}{R_i * e} \quad (1)$$

A. Effect on profit due to reserve inventory

From the study it has been noticed that the relationship between profit and reserve inventory or stock show negative linear graph in simple words more inventory less profit.

TABLE I

Ri	0	100	200	300	400	500	600
P	30	25	20	15	10	5	0
Q	3	4	5	6	7	8	9

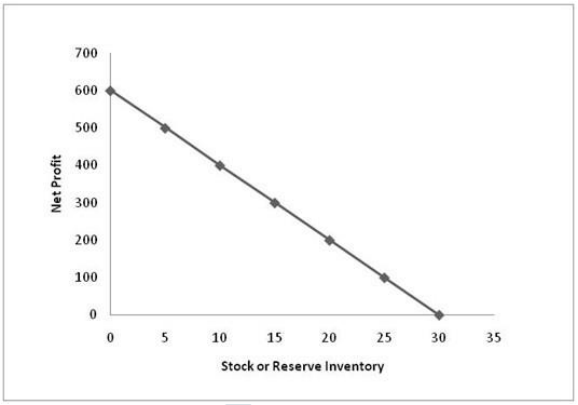

Fig. 1. Negative linear relationship between Profit and Stock or Reserve Inventory

B. Effect of deterioration rate on profit and order quantity

The deterioration rate is assumed fixed for a particular stock or inventory. If we compare between deterioration and net profit, it is expected that there is a loss and if it is with order size then it will be minimizes, it shows a convex relation as shown in Fig 2 and Fig 3.

TABLE II

e	0	.2	.4	.6	.8	1.0
P	500	400	300	200	100	0
Q	9	8	7	6	5	4

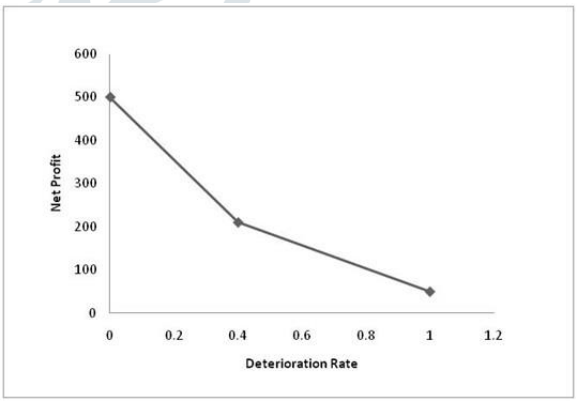

Fig. 2. Effect of deterioration rate on profit

IV. CONCLUSION

This paper explains about various conditions for a single perishable product. In Perishable supply chain demand is to be considered stock dependent, in which stock is deteriorating

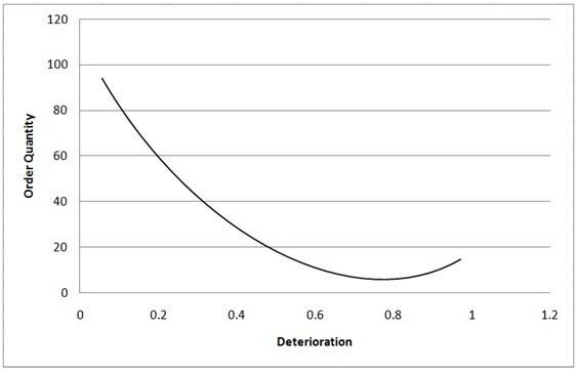

Fig. 3. Effect of deterioration rate on order quantity

goods having random shelf life. Which result the reserve inventory or stock eat into profit and have negative linear relationship with profit. If we plot a graph for profit and quantity with stock or inventory it would be expected to increase. Further, profit is deeply impacted by deterioration rate and followed by stock or inventory. This model can be used in determining optimal inventory policy for continuously deteriorating goods or perishable products such as fruits and vegetables, milk and milk products, bakery products which are mainly sold through supermarket, grocery shops.

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