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EFFECT OF TRADE CREDIT FINANCING UNDER THE WAREHOUSE CAPACITY ONSTRAINT IN A BULK RELEASE PATTERN

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ABSTRACT: Time has affected the business senses of organizations. Every businessman strives to increases his profits, his goodwill, and his customer base. To achieve this, supplier provides a concessions or credit limits for a retailer to stimulate the demand, boost market share or decrease inventories of certain items. In framing the traditional inventory model, it was assumed that the payment must be made to the supplier for the items immediately after receiving the consignment. However, in practice, for encouraging the retailer to buy more, the supplier allows a certain fixed period for settling the account and does not charge any interest from the retailer on the amount owed during this period. The traditional economic ordering quantity model considers that the retailer pays the purchasing cost for the product as soon as the products are received; but in reality, the supplier usually offers different delay period, known as trade credit period or deferred payment period, sometimes with different price discounts to encourage the retailer to order more quantity.

KEYWORDS*:* Inventory model, price discount

INTRODUCTION

Inflation plays a very interesting and significant role: it increases the cost of goods. To safeguard from the rising prices, during the inflation regime, the organization prefers to keep a higher inventory, thereby increasing the aggregate demand. The effect of time value of money is very important and should be reflected in the development of inventory models. In the present days' market scenario of explosion of choice due to cut-throat competition, no company can bear a stock-out situation as a large number of alternative products are available with additional features. Furthermore, there is no cut-and- dried formula by means of which one can determine the demand exactly. Despite having considerable cost, firms have to keep an inventory of the various types of goods for their smooth functioning mainly due to geographical specialization, periodic variation and gap in demand and supply. When a firm needs an inventory, it must be stored in such a way that the physical attributes of inventory items can be preserved as well as protected. Thus, inventory produces the need for warehousing.

In practical inventory management, there exist many factors like an attracted price discount for bulk purchase, etc. to make retailers buy goods more than the capacity of their owned warehouse. In this case, retailers will need to rent other warehouses or to rebuild a new warehouse. However, from economical point of views, they usually choose to rent other warehouses. Sometimes supplier may have been influenced by an offer of a discounted price for the stock if he buys a minimum of a certain amount. Or it may be that he foresees a season of large sale ahead, and he wants to be prepared in advance, lest he loses out on the opportunity to make large profit. Supplier may wish to prepare himself for that time by buying more than he immediately needs. All this stock may ultimately prove to be more than he can actually store in his own warehouse. Under such circumstances, he is compelled to rent another warehouse to stock the excess items. It also becomes imperative that he finds the other warehouse in either close proximity to the first one, or that this new warehouse is located at a place from where he can subsequently sell off his goods conveniently. At such time, he also has to consider the mode of transportation from his owned warehouse to the rented one. This cost should also be bearable; otherwise the whole point of renting extra warehouse is beaten. But since he has to pay the rent of the warehouse in addition to other costs, hence the effective holding costs in a rented warehouse (RW) comes out to be more than that of owned warehouse (OW). Obviously the supplier would want to empty the rented warehouse as soon as possible. Selecting the location and the layout of the warehouse contributes greatly to the productivity of the venture and its efficiency.

REVIEW OF LITERATURE

Goyal (1985) explored a single item EOQ model under permissible delay in payments. In real life situations, there are products like volatile liquids, medicines, and materials, etc. in which the rate of deterioration is very large. Therefore, the loss due to deterioration should not be ignored. Goswami and Chaudhuri (1992) developed the model with or without shortages by assuming that the demand varies over time with linearly increasing trend and that the transportation cost from RW to OW depends on the quantity being transported. However, deterioration phenomenon was not considered in all these models. Pakkala and Achary (1992) further considered the two-warehouse model for deteriorating items with finite replenishment rate and shortages. In all these models, the demand was assumed to be constant and the cost of transporting items from RW to OW was not taken into account. Motivated by the trade credit policy given by supplier, first time Shah and Shah (1992) developed a deterministic inventory model under the permissible delay in payment with two storage facilities. In that model, the items were considered non-deteriorating without shortage and the time horizon was infinite. Hariga (1994) studied the effects of inflation and time value of money on the replenishment policies of items with time continuous non-stationary demand over a finite planning horizon with shortages. Hwang and Shinn (1997) developed the optimal pricing and lot sizing for the retailer under the condition of permissible delay in payments. Bhunia and Maiti (1998) developed a two warehouse model for deteriorating items with linearly increasing demand and shortages during the infinite period under continuous transportation pattern. In another paper, Zhou (1998) presented a two-warehouse model for deteriorating items with time varying demand and shortages during the finite-planning horizon. Chen (1998) developed a model in which the demand rate was assumed to be time-proportional, shortages are allowed and completely backordered and the effects of inflation and time-value of money are taken into consideration. Sarker *et. al.* (2000) addressed the ordering policy for a retailer of a perishable product, where the decision is influenced by the time value of money and inflation, and allowable shortage and the retailer is allowed a delay period to pay back the dues for the products purchased. Liao *et al.* (2000) proposed an inventory model for initial-stock-dependent consumption rate when a delay in payment is permissible. In the inventory model, shortages were not allowed and the effect of the inflation rate, deterioration rate and delay in payment were discussed. Chung et. al. (2011) derived an inventory model for deteriorating items with the demand of linear trend and shortages during the finite planning horizon considering the time value of money under the permissible delay in payments. Kar *et al.* (2011) studied a two-warehouse inventory model for items by considering lot-size dependent replenishment cost, linearly time-dependent demand and finite time horizon. Chang *et al.* (2012) put a varying deterioration rate, time-value of money and the condition of permissible delay in payments used in conjunction with the EOQ model as the focus of discussion. Deterministic economic order quantity models with partial backlogging were formulated by Teng and Yang (2014*)*. Chang (2014) proposed an inventory model in an inflationary environment under a situation in which the supplier provides the purchaser a permissible delay of payments if the purchaser orders a quantity larger than a predetermined quantity. Teng *et al.* (2015) considered optimal pricing and ordering policy under permissible delay in payments. Moon *et al.* (2015) made an effort to incorporate the two opposite physical characteristics of amelioration and deterioration of stored items into inventory model. They developed models for time-varying demand pattern over a finite planning horizon, taking into account the effects of inflation and time value of money. Zhou and Yang (2015) developed a two-warehouse inventory model for items with stock-level-dependent demand rate. Ouyang *et al.* (2006) developed an inventory model for deteriorating items with permissible delay in payments. Chung and Huang (2007) presented a two-warehouse inventory model for deteriorating items under trade credit financing. In that model, shortages were not allowed and time horizon was infinite. Liao (2007) presented a note on an EOQ model for deteriorating items under supplier credit linked to ordering quantity. Singh et al. (2008) presented a two-warehouse inventory model for deteriorating items with constant demand rate where shortages were allowed and partially backlogged. An inventory lot-size model for deteriorating items with partial backlogging was formulated by Chern et al. (2008). Chung (2009) established a solution procedure for deteriorating items with permissible delay in payment. Geetha and Uthayakumar (2010) developed an Economic Order Quantity (EOQ) model for deteriorating items with permissible delay in payments and single storage facility.

The following assumptions have been adopted for the proposed model to be discussed.

- The demand R(t) is exponentially increasing with time: $R(t) = ae^{bt}$, $a > 0$, $1 > b > 0$.
- Deterioration of the item follows a two parameter Weibull distribution.
- Single item inventory is considered.
- Holding cost is taken as linear increasing function of time.
- Inflation and time value of money are considered.
- Product transactions are followed by instantaneous cash-flow.
- The transfer of stocks from RW to OW follows a bulk-release rule.
- Capacity of OW is finite while that of RW is infinite.
- Lead time is zero.
- There are highest credit between the firm and the supplier, so during the credit period, the firm makes payment to the supplier immediately after the use of the materials. On the last day of the credit period, the firm pays the remaining balance.

- Shortages, if any, are allowed and partially backlogged and the demand rate R(t) is given by $R(t) = ae^{bt}$, Where some of the unsatisfied demand is backlogged, and the fraction of shortages backordered is $1/(1+\delta x)$, where x is the waiting time up to the next replenishment and δ is a positive constant.

In addition, the following notations are defined and will be used throughput the paper:

f(t): Two parameter probability density function for the rate of deterioration $f(t) = \alpha\beta t^{\beta-1} e^{-\alpha t^{\beta}}$ or $ght^{h-1} e^{-gt^{h}}$, where α, g are the scale parameter (α, g > 0) and β, h are the shape parameter (β, h >0).

$\theta_1(t)$: Weibull instantaneous rate function for the stocked item in OW, $\theta_1(t) = f(t)/ e^{-\alpha t^{\beta}} = \alpha\beta t^{\beta-1}$.

$\theta_2(t)$: Weibull instantaneous rate function for the stocked item in RW, $\theta_2(t) = f(t)/ e^{-gt^{h}} = ght^{h-1}$.

W: Capacity of OW.

I_r: Amount of goods stored in RW.

r: Constant representing the difference between the discount rate and inflation rate.

c_0: Setup cost per cycle

c: Purchasing cost per unit item.

p: Selling price per unit item.

$(C_{h1} + \phi t)$: Inventory holding cost per unit item per unit item in OW.

$(C_{h2} + \varphi t)$: Inventory holding cost per unit item per unit item in RW.

c_b: Shortage cost per unit item per unit time.

c_1: Shortage cost for lost sales per unit.

T: Length of the cycle.

n: Number of times stocks are transfered from RW to OW.

I_0 (t): Inventory level in OW at any time t.

$I_r(t)$: Inventory level in RW at any time t.

Ic The capital opportunity cost in stock per dollar per year.

Ie The interest earned per dollar per year

M: Trade credit period

K Transported units rom RW to OW

FORMULATION AND SOLUTION

It is assumed that the management owns a warehouse with a fixed capacity of W units and any quantity exceeding this should be stored in a rented warehouse, is assumed to be available with abundant space. i.e., we assume that a company purchases Q (Q > W) units out of which W units are kept in OW and (Q–W) = I_r units are kept in RW. Initially, the demands are not using the stocks of OW until the stock level drops to (W–K) units at the end of T_1 then a lot is released from the RW to replenish the stock level back to W in OW. Hence at time T_1, first lot is released from RW. Up to this time the stocks in RW were being depleted due to decay only. As a result, the stock level of OW again becomes W and the stocks of OW are used to meet further demands. The stock level in OW depletes due to both demand and deterioration. This process is continued until the stock in RW is fully exhausted. After the last shipment, only W units are used to satisfy the demand during the time interval $[T_{n-1}, T_n]$ and then the shortages occur and partially backlogged during the time interval $[T_n,T]$. The graphical representation of the whole process is shown in the figures 1.1 and 1.2. The inventory level at RW and OW are governed by the following differential equations:

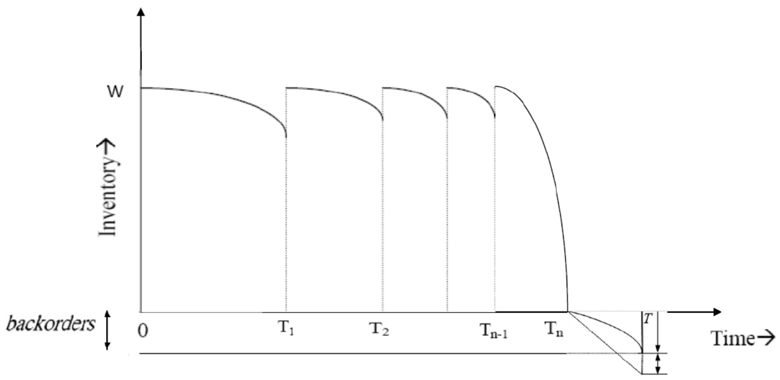

Fig 1.1: Graphical representation of inventory system for own warehouse

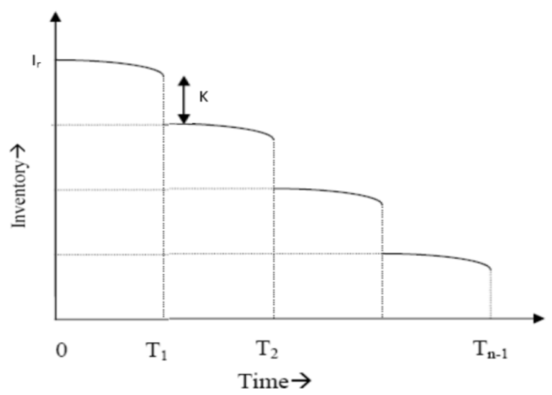

Fig 1.2: Graphical representation of inventory system for rented warehouse

For Own warehouse

$$\frac{dI_0(t)}{dt}+\alpha\beta t^{\beta-1}I_0(t)dt=-ae^{bt}, \qquad T_i \le t \le T_{i+1} \qquad \dots (1.1)$$

With the boundary condition $I_0(T_i) = W$, I = 0, 1, 2….n-1 and i = n, $I_0(T_i) = 0$ also $T_0 = 0$

For Rented Warehouse

$$\frac{dI_r(t)}{dt}+ght^{h-1}I_r(t)dt=0, \qquad T_i \le t \le T_{i+1} \qquad \dots (1.2)$$

With the boundary condition $I_r(0) = I_r$, for $0 \le t \le T_1$ and $I_r(T_{i+1}) = I_r(T_i)$-K for $T_i \le t \le T_{i+1}$, i = 1,2,…n-2.
Using the boundary conditions, we arrive at the following results for the own warehouse

$$I_0(t) = ae^{-\alpha t^{\beta}} \begin{bmatrix} (T_i - t) + \frac{b}{2}(T_i^2 - t^2) + \frac{\alpha}{\beta+1}(T_i^{\beta+1} - t^{\beta+1}) + \\ \frac{b^2}{6}(T_i^3 - t^3) + \frac{\alpha^2}{2(2\beta+1)}(T_i^{2\beta+1} - t^{2\beta+1}) \end{bmatrix} + We^{\alpha(T_i^{\beta} - t^{\beta})}$$

…(1.3)

$$I_0(t) = ae^{-\alpha t^{\beta}}\left[(T_n - t) + \frac{b}{2}(T_n^2 - t^2) + \frac{\alpha}{\beta+1}(T_n^{\beta+1} - t^{\beta+1}) + \frac{b^2}{6}(T_n^3 - t^3) + \frac{\alpha^2}{2(2\beta+1)}(T_n^{2\beta+1} - t^{2\beta+1})\right]$$

…(1.4)

$$I_r(t) = I_r e^{-gt^h}, \quad 0 \le t \le T_1 \quad \text{… (1.5)}$$

$$I_r(t) = [I_r(T_i) - K]e^{g(T_{i+1}^h - t^h)}, \quad T_i \le t \le T_{i+1},\ i = 1,2,\ldots n-2 \quad \text{…(1.6)}$$

During the time interval $[T_n, T]$

$$\frac{dI_s(t)}{dt} = -\frac{ae^{bt}}{1+\delta(T-t)}, \quad T_n \le t \le T \quad \text{… (1.7)}$$

With the boundary condition $I_0(T_n) = 0$, solution of the equation (1.7)

$$I_0(t) = a\left[(1-\delta T)(T_n - t) + \frac{1}{2}(b - b\delta T + \delta)(T_n^2 - t^2) + \frac{b\delta}{3}(T_n^3 - t^3)\right] \quad \text{… (1.8)}$$

These equations clearly show the variation of inventory in the prescribed time period in both the OW and the RW.

Present worth Set-up Cost

Order is placed at the beginning of each cycle and hence for every cycle,

$$SPC = C_0 \quad \text{… (1.9)}$$

Present worth Item Cost

Inventory is bought at the beginning of the cycle and stored separately at the two warehouses. Hence

$$IC = c\,(I_r + W) \quad \text{…(1.10)}$$

Present worth Holding Cost in OW

Inventory is available during $T_i \le t \le T_{i+1}$, $i = 0,1,2,\ldots n-1$.

Hence the holding cost needs to be computed during these time periods

$$HC_{OW} = \sum_{i=0}^{n-1} e^{-rT_i}\int_{T_i}^{T_{i+1}} I_0(t)(C_{h1} + \phi t)e^{-rt}dt$$

$$= \sum_{i=0}^{n-2} e^{-rT_i}\int_{T_i}^{T_{i+1}} (C_{h1} + \phi t)I_0(t)e^{-rt}dt + e^{-rT_{n-1}}\int_{T_{n-1}}^{T_n}(C_{h1} + \phi t)I_0(t)e^{-rt}dt \quad \text{… (1.11)}$$

Present worth holding cost in RW

Inventory is available during $0 \le t \le T_1$ and $T_i \le t \le T_{i+1}$, $i = 1, 2,\ldots n-2$.

Hence the holding cost needs to be computed during these time periods

$$HC_{OW} = \sum_{i=0}^{n-2} e^{-rT_i}\int_{T_i}^{T_{i+1}} I_r(t)(C_{h2} + \varphi t)e^{-rt}dt$$

$$= \int_0^{T_1} I_r(t)(C_{h2} + \varphi t)e^{-rt}dt + \sum_{i=1}^{n-2} e^{-rT_i}\int_{T_i}^{T_{i+1}} I_r(t)(C_{h2} + \varphi t)e^{-rt}dt \quad \text{… (1.12)}$$

Present worth Shortage cost or backorder cost

Shortages occur during $T_n \le t \le T$, Hence the shortage cost needs to be computed during this time period

$$SC = C_b e^{-rT_n}\int_{T_n}^{T}[-I_s(t)]e^{-rt}dt$$

…(1.13)

Present worth Opportunity Cost

Opportunity cost needs to be computed during the time period T_n t T.

$$OC = C_1 e^{-rT_n} \int_{T_n}^{T} ae^{bt} \left[1 - \frac{1}{1+\delta(T-t)} \right] e^{-rt} dt \qquad \ldots (1.14)$$

Present worth Transportation Cost

$$TRC = T_C \sum_{i=1}^{n-1} e^{-rT_i} \qquad \ldots (1.15)$$

Interest payable

When the end point of credit period is shorter then or equal to the length of period with positive inventory stock o the item ($M \leq T_n$), payment for goods is settled and the retailer starts paying he capital opportunity cost for the items in stock with rate I_p. Thus, the opportunity cost per cycle (Interest payable) is given below.

Case 1.1: M > T_n

$$IP_1 = cI_c e^{-rM} \int_{M}^{T_n} I_0(t) e^{-rt} dt \qquad \ldots. (1.16)$$

Case 1.2: M > T_n

In this case there is no opportunity cost.

Therefore $IP_2 = 0$ … (1.17)

Interest Earned from sales Revenue

There are many different ways to tackle the interest earned. Here we assume that during the time when the account is not settled, the retailer sells the goods and continues to accumulate sales revenue and earns the interest with rate I_e.

Therefore interest earned per cycle for two different cases is given below

Case 1.1: M >T_n

$$IE_1 = pI_e \left\{ \sum_{i=0}^{n-1} e^{-rT_i} \int_{T_i}^{T_{i+1}} \left(ae^{bt} \right) te^{-rt} dt \right\} \qquad \ldots (1.18)$$

Case 1. 2: M > T_n

$$IE_2 = pI_e \left[\sum_{i=0}^{n-1} e^{-rT_i} \int_{T_i}^{T_{i+1}} \left(ae^{bt} \right) te^{-rt} dt + \left(M - T_n \right) \left\{ \sum_{i=0}^{n-1} e^{-rT_i} \int_{T_i}^{T_{i+1}} \left(ae^{bt} \right) e^{-rt} dt \right\} \right] \qquad \ldots (1.19)$$

NUMERICAL ILLUSTRATION

The model developed above is illustrated by the following numerical example. Numerical data is based on the previous study in standard units.

Example: For Case 1.1. ($T_{n-1} \leq\leq M \leq\leq T_n$) and Case 2. ($T_n \leq\leq M \leq\leq T$)

$\alpha = 0.05$,	$\beta = 2$,	$g = 0.02$,	$h = 2$,	$r = 0.06$,
$W = 500$,	$C_0 = 100$,	$p = 10$,	$T_C = 50$,	$C_1 = 10$,
$C_{h1} = 5$,	$C_{h2} = 7$,	$C_b = 8$,	$I_c = 0.12$,	$I_e = 0.15$,
$M = 1.5$,	$\delta = 0.5$,	$a = 10$,	$b = 0.2$,	$T = 10$,
$T_0 = 0$,	$I_r = 2500$,	$K = 200$,	$\varphi = 0.004$	$\phi = 0.05$

Table 1.1: For Case 1 $T_{n-1} \leq\leq M \leq\leq T_n$ Optimal Values of Time and Total cost for different number of cycles

N	T_1	T_2	T_3	T_4	T_5	T_6	T_7	Total Cost (TC)
3	2.9526	1.9052	7.2211	-	-	-	-	21221.8
4	1.9932	1.9864	1.9796	7.2341	-	-	-	23529.5
5	1.5500	1.1000	4.6500	6.2000	7.2889	-	-	27091.3
6	1.1836	2.3672	1.5508	4.7344	1.9180	7.2239	-	23262.0
7	0.9887	1.9774	2.9661	1.9548	4.9435	1.9322	7.2255	23478.0

Here, we observe that as the number of cycles increases, the total cost increases from cycle 3 to 5, but the total cost per unit time is found to be minimum for n =3 and it is observed that the total cost for number of cycle 6,7 is greater than that of number of cycle of 1. Optimal values of time are decrease for increasing the number of cycles respectively.

Table 1.2: For Case 1.2 $T_n \leq\leq M \leq\leq T$ Optimal Values of Time and Total cost for different number of cycles

N	T_1	T_2	T_3	T_4	T_5	T_6	T_7	Total Cost (TC)
3	2.9527	1.9055	6.4965	-	-	-	-	21181.8
4	1.7135	1.4270	1.1405	6.7451	-	-	-	24010.7
5	1.5503	1.1006	4.6509	6.2012	6.9987	-	-	27027.7
6	1.1847	2.3694	1.5541	4.7388	1.9238	6.1082	-	23474.0
7	0.9887	1.9774	2.9661	1.9548	4.9435	1.9322	6.9892	23377.7

Here, it is also observe that the optimal number of cycle is 1 as we observe that as the number of cycles increases, the total cost increases from cycle 3 to 5, but the total cost per unit time is found to be minimum for n =3 and it is observed that the total cost for number of cycle 6,7 is greater than that of number of cycle of 1. Optimal values of time are decrease for increasing the number of cycles respectively.

CONCLUSION

The impact of bulk release pattern on an order-level inventory model with two levels of storage for an item subject to Weibull distribution decays in inflationary environment has been considered. Trade credit policy plays an important role in the business of many products and it serves the interests of both the supplier and retailer. The supplier usually expects the profit to increase since rising sales volumes compensate the capital losses incurred during the credit period. Also, the supplier finds an effective means of price discrimination which circumvents anti-trust measures. On the contrary, the retailer earns an interest by investing the sale proceeds earned during the credit period.

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