Trade Credit in Supply Chains for Deteriorating Items

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Abstract

Trade credit is an invaluable promotional tool for the suppliers to increase profit through stimulating more sales and a unique opportunity for the retailers to reduce demand uncertainty and its associated risks. It is a regular component of market transactions and constitutes a major source of short-term financing. Its nature has predominantly been an area of inquiry for researchers from the disciplines of finance, marketing, and economics. This is especially remarkable for operational management since financial flows are considered a key element of purchasing and supply chain management. In this review article, an attempt is made to present a complete up-to-date survey of published inventory literature under trade credit for deteriorating items. Compared with the extant reviews (Chang et al 2008; Soni et al 2010), this paper covers the studies from a different perspective. First, this paper proposes some key factors which should be considered in the inventory studies of deteriorating items under trade credit; then, from the perspective of study scope, the literatures are distinguished into different categories with other factors like shortages, price discount, limited storage space, inflation and the time value of money with trade credit and types of trade credit. The literature review framework in this paper provides a clear overview of the inventory models under trade credit for deteriorating items, which can be used as a starting point for further study.

Keywords: Inventory, Trade Credits, Deteriorating Rate, Factors Related To Trade Credits

1. Introduction :

From past few years, many researchers have studied inventory models for deteriorating Items. In general, almost all products deteriorate over time. Sometimes the rate of deterioration is too low, for items such as steel, hardware, glassware and toys, to cause consideration of deterioration in the determination of economic lot sizes. However, some items have a significant rate of deterioration, such as blood, fish, strawberry, alcohol, gasoline, radioactive chemicals, medicine, and food grains that deteriorate rapidly over time, which cannot be ignored in the decision making process of production lot size.

In the traditional economic order quantities (EOQ) model, it is assumed that the retailer must pay to the supplier for the items as soon as the items are received. Today, in practice, the supplier is willing to offer the retailer a certain credit period without interest during the permissible delay period to promote market competition. Before the end of the trade credit period, the retailer can sell the goods and accumulate revenue and earn interest. A higher interest is charged if the payment is not settled by the end of the trade credit period.

This type of model was first discussed by Haley and Higgins (1973). Goyal (1985) explored a single-item EOQ model under permissible delay in payments. Jaggi and Aggarwal (1994) presented the economic ordering policies of deteriorating items in the presence of trade credit.

Based on our record, there were about 71 inventory lot-size articles related to trade credits for deteriorating items since 1994. Our record shows that there were only 13 publications in the first decade (i.e., from 1994 to 2004). By contrast, there were over 50 publications in the next decade (i.e., from 2005 to 2015). It is obvious that there is a growing research interest in this area. Consequently, in this paper, we present a review of the advances of the inventory lot-size models under trade credits for deteriorating items. For simplicity, we classify the inventory lot-size models related to trade credits into 4 categories by considering different deteriorating rate.

2. Inventory models with constant deteriorating rate :

Jaggi and Aggarwal (1994) presented the economic ordering policies of deteriorating items in the presence of trade credit using a discounted cash-flows (DCF) approach. A DCF approach permits a proper recognition of the financial implication of the opportunity cost and out-of-pocket costs in inventory analysis. It also permits an explicit recognition of the exact timing of cash-flows associated with an inventory system. They also made an attempt to obtain optimum order quantity of deteriorating items under a permissible delay payment in 1995 which showed that as the credit period increases, there is marginal increase in cycle length and order quantity for less deteriorating items and total cost decreases significantly. Hwang and Shinn (1997) developed the joint price and lot size determination problem for an exponentially deteriorating product when the supplier offers a certain fixed credit period. They expressed the retail demand rate of the product with a constant price elasticity function. Jamal et al. (1997) developed a model for an optimal ordering policy for deteriorating items with allowable shortage and permissible delay in payment. Chu et al. (1998) investigated the properties of the convexity of the total variable cost function of the inventory model of the deteriorating items under a permissible delay in payments. Sarkar et al. (2000) developed Supply chain models for perishable products under inflation and permissible delay in payment. Further Liao et al. (2000) presented an inventory model for initial-stock-dependent consumption rate when a delay in payment is permissible under inflation. Chung et al. (2001) developed the cycle time determination problem for an exponentially deteriorating product when the supplier offers a certain fixed credit period. Chang et al. (2003), Chung and Liao (2004) presented an EOQ model for deteriorating items when supplier credits linked to order quantity. Ouyang et al. (2005) provided the optimal policy for the customer to obtain its minimum cost when the supplier offers not only a permissible delay but also a cash discount. Teng et al. (2005) developed an algorithm for a retailer to determine its optimal price and lot size simultaneously when the supplier offers a permissible delay in payments by considering the difference between the selling price and the purchase cost. Chung and Liao (2006) presented an inventory system for deteriorating items under the conditions of using the discounted cash-flows (DCF) approach to the permissible to delay payment related to order quantity to generalize Jaggi and Aggarwal (1994). Chung (2006), Chung and Huang (2007) and Teng et al. (2009) developed the optimal cycle time for deteriorating items with limited storage capacity under permissible delay in payments by considering two warehouse inventory. Chen and Ouyang (2006) extended Jamal et al.(1997) model by fuzzifying the carrying cost rate, interest paid rate and interest earned rate simultaneously, based on the interval- valued fuzzy numbers and triangular fuzzy number to fit the real world. Liao (2008)

study focused on an exponentially deteriorating item under the conditions of the retailer receiving the supplier trade credit and providing the customer trade credit simultaneously so as to minimize the average total cost (two level trade credit). Huang and Liao (2008) explored an economic lot sizing model that incorporates a realistic feature such as the deterioration rate following an exponential distribution, making a broader application scope of Chang and Teng (2004). Tsao and Sheen (2008) adopted a price- and time-dependent demand function to model the finite time horizon inventory for deteriorating items. De and Goswami (2008) developed a probabilistic inventory model for items that deteriorate at a constant rate and the demand is a random variable under trade credit financing. Thangman and Uthayakumar (2009) characterized a profitable decision policy between a supplier and the retailers by an agreement on the trade credit scenario such as permissible delay in payments (two echelon trade credit financing) for perishable items in a supply chain when demand depends on selling price and credit period.

Thangam and Uthayakumar (2010) developed an economic-order-quantity-based model with perishable items and two storage facility as a profit maximization problem under retailer's partial trade credit policy and price dependent demand. Further Chang et al. (2010) established optimal ordering policies for deteriorating items using a discounted cash-flow analysis when a trade credit is linked to order quantity. Shah (2010) made an attempt to formulate the mathematical model for a customer to determine optimal special cycle time when the supplier offers the special extended credit period for one time only during a special period. Dye and Ouyang (2011) done a particle swarm optimization for solving joint pricing and lot-sizing problem with fluctuating demand and trade credit financing for deteriorating items. Roy and Samanta (2011) developed a continuous production control inventory model for deteriorating items without shortage in which two different rates of productions are present and where it is possible that production started with one rate and after some time changed to another rate. Chung and Lin (2011) simplified the procedure of finding optimum solution of Jaggi and Aggarwal's (1994) economic ordering policies of deteriorating items in the presence of trade credit using a discounted cash-flows (DCF) approach. Further Khanra et al. (2011) developed an EOQ model for a deteriorating item with time dependent quadratic demand under permissible delay in payment. Teng et al. (2011) made a comprehensive extension of optimal ordering policy for stock-dependent demand under progressive payment scheme. Sing (2011) discussed an economic order quantity model for items having linear demand under inflation and permissible delay. Mahata (2012) investigated the optimal retailer's replenishment decisions for deteriorating items under two levels of trade credit policy to reflect supply chain management situation within the economic production quantity (EPQ) framework. Liao et al. (2012) made attempts to determine economic order quantity for deteriorating items with two-storage facilities where trade credit is linked to order quantity. Dye (2012) considered a finite horizon deteriorating inventory model with two-phase pricing and time-varying demand and cost under trade credit financing using particle swarm optimization. Further Thangam (2012) developed optimal price discounting and lot-sizing policies for perishable items in a supply chain under advance payment scheme and two-echelon trade credits. Hou and Lin (2012) extended economic order quantity model for deteriorating items under inflation and permissible delay in payments where demand rate is a linear function of price and decreases negative exponentially with time. Singh and Pattanayak (2012) designed an EOQ model for a deteriorating item with time dependent exponentially declining demand under permissible delay in payment

A two-warehouse inventory model for deteriorating item with stock and selling price dependent demand under partial credit period was developed by Guchhait et al. (2013). Das

et al. (2013) developed Integrated supply chain model for a deteriorating item with procurement cost dependent credit period. Yang and Chang (2013) incorporated a two-warehouse partial backlogging inventory model for deteriorating items with permissible delay in payment under inflation. Chung et al. (2014) developed the inventory models for deteriorating items in the discounted cash-flows approach under conditional trade credit and cash discount in a supply chain system. Next Chen et al. (2014) developed economic production quantity models for deteriorating items with up-stream full trade credit and down-stream partial trade credit. Swami et al. (2015) considered an economic ordered quantity model for deteriorating item with stock dependent demand and holding cost per unit time was considered as a function of two factors: deterioration and storage period. Shortages were allowed and partial backordering was taken into account in this study. Mahata (2015) proposed an economic order quantity model for the retailer where (1) the supplier provides an up-stream trade credit and the retailer also offers a down-stream trade credit, (2) the retailer's down-stream trade credit to the buyer not only increases sales and revenue but also opportunity cost and default risk. Under these conditions, he modelled the retailer's inventory system as a profit maximization problem to determine the retailer's optimal replenishment decisions under the supply chain management.

3. Inventory models with Weibull distributed deteriorating rate :

Chang and Dye (2001) dealt with an inventory model with a varying rate of deterioration (two parameter Weibull distribution) and partial backlogging rate under the condition of permissible delay in payments. Basu and Sinha (2007) developed an inflationary inventory model with time dependent demand with Weibull distribution deterioration and partial backlogging under permissible delay in payments. Shah and Raykundaliya (2010) formulated retailer's pricing and ordering strategy for Weibull distribution deterioration under trade credit in declining market. Misra et al. (2011) derived an optimal inventory replenishment policy for two parameters Weibull deteriorating items with a permissible delay in payment under inflation over finite planning horizon.Tripathy and Pradhan (2011) dealt with development of an optimal pricing and ordering policy for items with three parameter Weibull deterioration where the supplier offers a delay in payments. Recently Singh (2013) studied an EOQ model for a deteriorating item with time dependent quadratic demand and variable deterioration under permissible delay in payment, which was the extension of author's earlier paper having quadratic demand pattern constant rate of deterioration. Kumar and Rajput (2013) developed an inflationary inventory model for Weibull deteriorating items with constant demand and partial backlogging under permissible delay in payments. Patel and Patel (2013) derived EOQ model for Weibull deteriorating items with imperfect quality, shortages and time varying holding cost under permissible delay in payments.

4. Inventory models with deteriorating rate is other function of time :

Singh and Singh (2010) developed a stock dependent economic order quantity model for perishable items under inflationary conditions by considering variable rate of deterioration. Tripathy and Pradhan (2011) formulated an integrated partial backlogging inventory model having Weibull demand and variable deterioration rate with the effect of trade credit. Kumar et al. (2013) derived a deterministic inventory model for deterioraing items with selling price dependent demand and parabolic time varying holding cost under trade credit. Here in both the above models deterioration rate was time varying i.e.

$\theta(t) = \theta * t$. Annadurai (2013) formulated integrated inventory model for deteriorating items with price-dependent demand under quantity-dependent trade credit by

considering variable deteriorating rate. Recently Wang et al. (2014) built an EOQ model for the seller to obtain its optimal credit period and cycle time by incorporating the following important and relevant facts: (1) deteriorating products not only deteriorate continuously but also have their maximum lifetime, and (2) credit period increases not only demand but also default risk. Then they had derived the necessary conditions, and then characterized the seller's optimal credit period and cycle time. Here the physical significance of the deterioration rate was the rate to be closed to 1when time is approaching to the maximum lifetime m i.e. $\theta(t) = \frac{1}{1+m-t}$. Mahata and Mahata (2014) developed a finite replenishment model with trade credit and variable deterioration for fixed lifetime products. Here deterioration rate was time dependent $\theta(t) = \frac{1}{1+m-t^2}$. Yadav et al. (2015) developed manufacturing inventory model for deteriorating items with maximum lifetime under two-level trade credit financing

5. Inventory models with non-instantaneous deteriorating rate

Wu et al. (2006) considered a problem of determining the optimal replenishment policy for non-instantaneous deteriorating items with stock-dependent demand. In the model, shortages were allowed and the backlogging rate was variable and dependent on the waiting time for the next replenishment. An appropriate inventory model for non-instantaneous deteriorating items with permissible delay in payments was considered by Ouyang et al. (2006). This mathematical model was a general framework that comprises numerous previous models such as in Ghare and Schrader (1963), Goyal (1985), and Teng (2002) as special cases. A complete proof on the solution procedure for non-instantaneous deteriorating items with permissible delay in payment was given by Chung (2009). Soni (2013) derived optimal replenishment policies for non-instantaneous deteriorating items with price and stock sensitive demand under permissible delay in payment . Wu et al. (2014) complemented Soni (2013) model's shortcomings by (i) selling those ending inventory as salvages, and (ii) considering all possible replenishment cycle time, which may be shorter than the period of non-deterioration. With these modifications the repeatability of the replenishment cycle was ensured and the applicability of Soni's model was strengthened.

6. Conclusion

In this paper, we have provided an up-to-date review of inventory lot-size models under trade credit for deteriorating items since Jaggi and Aggrawal established the economic ordering policies of deteriorating items in the presence of trade credit using a discounted cash-flows (DCF) approach in 1994. We then have classified all related relevant models into four categories, and briefly discussed pertinent information regarding model developments based on their incorporated factors in the last two decades. Deteriorating rate is major key factor in the study of deteriorating items inventory under trade credit and there are also several kinds of deteriorating rate in the present study, such as constant deteriorating rate, deteriorating rate is a function of time, deteriorating rate is two- parameter Weibull distributed, deteriorating rate is three-parameter Weibull distributed and non- instantenious deteriorating rate. Among them, constant deteriorating rate is the easiest one and commonly used and the three-parameter Weibull distribution deteriorating rate is more complex.

The literature review presented in this research shows that although many researches have been conducted in this area of science, it has still great potential to be further extended.

This can be considered as the major infrastructure for the inventory models of deteriorating items with delay in payment.

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