



A lot-sizing model with backordering under hybrid linked-to-order multiple advance payments and delayed payment



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ABSTRACT

An economic order quantity model with backordering is investigated under a hybrid payment scheme. The payment scheme, which is also linked to order quantity, involves multiple advance payments as well as delayed payment. Incorporating this payment scheme can efficiently stimulate sales due to applying delayed payment; besides it provides the benefits of advance payment such as controlling the risk of cash flow. The developed model seeks to optimize the order and shortage quantities. Theoretical results are developed to determine the conditions of existence and uniqueness of the optimal solutions. Numerical examples illustrate the proposed model and solution method.

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1. Introduction and literature review

Inventory management is one of the most challenging activities for any organization (Cárdenas-Barrón et al., 2014). It is among major operations of supply chain (Gürler et al., 2014) and making right inventory decisions play a key role in success of different firms (Zolfagharinia et al., 2014). There are diverse varieties of factors which influence order quantity of an inventory system, among which timing of payment plays a key role. In this regard, three basic payment strategies are possible: (i) Delivery time payment, (ii) delayed payment and (iii) advance payment. A combination of these is also possible (Taleizadeh, 2014). In the classic inventory management problems, which have been introduced by Harris (1990), it is implicitly assumed that purchasing cost is paid right after delivering orders. However, it does not always hold in reality.

In the competitive environment of business, which has made success and survival of firms a challenging target, delayed payment is considered as an influential means to stimulate sales. On the contrary, advance payment is incorporated by firms to either control the risk of cancelling orders or finance the procurement of material (Zhang et al., 2014).

The literature body of the problem investigates three broad areas including delayed payment, advance payment and hybrid advance and delayed payments, each of which will be studied briefly in the following subsections.

1.1. Delayed payment

Delayed payment, as one of the common components of commercial transactions, has been investigated by large number of researches. Goyal (1985) proposed the first classical delayed payment model. Teng (2002), Shinn and Hwang (2003), Yang (2004), Jaggi et al. (2007) and Soni and Shah (2008) are pretty early and worth mentioning studies in this area.

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Nomenclature

Parameters

A	fixed order cost
P	unit selling price
C	unit purchasing cost
D	demand per period
h_c	unit holding cost per period excluding capital cost
h	unit holding cost per period including capital cost
I_k	capital interest charge per unit per period
I_e	interest rate which can be earned per year
π	backorder cost per unit per period
W	the pre-determined quantity at which partial advance partial delayed payment is permitted per order
T_w	the time interval that W units are depleted to zero
T_0	the time interval that αQ units are depleted to zero
n	the number of equally spaced advance payments
L	the length of time during which the buyer will pay the advance payment
M	the length of trade credit period
α	the fraction of purchasing cost that must be paid as multiple advance payments

Variables

F	percentage of demand that will be filled from stock (decision variable)
T	the length of inventory cycle (decision variable)
Q	the order quantity (decision variable)
TP^I	the identical total annual profit
CC	total annual capital cost
IE	total annual interest earned
$TP(F, T)$	total annual profit

Huang and Hsu (2008) investigated two-level trade credit financing to reflect the supply chain management situation. The supplier incorporated full delay in payments, while the retailer offered his customers a partial trade credit payment scheme. Teng and Chang (2009) analyzed a retailer who receives full trade credit from its supplier and offers full trade credit to “good” and partial trade credit to “bad” customers. Sarkar (2012a,b), Sarkar et al. (2013), Sarkar et al. (2014a) and Wu et al. (2014) are other papers which investigated the impact of trade credit financing in different inventory contexts. Taleizadeh et al. (2013a), Guria et al. (2013), Wu and Chan (2014) and Guchhait et al. (2014) studied partial delayed payment in EOQ model, while in Soni and Patel (2012), Mahata (2012), Sarkar et al. (2014) and Pan (2014) partial trade credit was investigated in EPQ model.

Linking delayed payment to order quantity was first studied by Khouja and Mehrez (1996). In their model, only if the order quantity was greater than a specified threshold, delayed payment was offered to the retailer. Huang (2007) extended the previous models such that if the order quantity is lower than a specific quantity, partial trade credit will be possible. Chung et al. (2013) extended Huang (2007) by assuming that interest charged in stocks is not necessarily greater than interest earned on investment. Ouyang et al. (2009) investigated an economic order quantity model for deteriorating items under partially permissible delay in payments which was considered to be linked to order quantity as well. Chang et al. (2009) proposed a model to determine the optimal strategy for an integrated vendor–buyer inventory system under the condition of trade credit linked to the order quantity, where the demand rate is considered to be a decreasing function of the retail price. Chang et al. (2010), Annadurai and Uthayakumar (2012), Teng et al. (2013), Chung (2013), Yang et al. (2013), Ouyang et al. (2013), Chen et al. (2014) and Shah and Cárdenas-Barrón (2015) are other studies which investigated linked-to-order trade credit financing.

1.2. Advance payment

Although advance payment is incorporated by many firms in practice, its impact on inventory control policies is rarely studied in the literature. Maiti et al. (2009) studied the effect of advanced payment for price-dependent demand in a stochastic environment. Gupta et al. (2009) extended this by treating the cost parameters as interval, rather than fixed values. Taleizadeh et al. (2011) developed a multiproduct, multi-constraint inventory control problem to import raw material from another country for which a fraction of purchasing cost should be paid as advance payment. Taleizadeh et al. (2013b) developed an EOQ model with multiple payments under three conditions of no shortage, full backordering and partial backordering. In Taleizadeh (2014) the previous model was extended for an evaporating item.

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