ARTICLE IN PRESS

Applied Mathematical Modelling xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Applied Mathematical Modelling

journal homepage: www.elsevier.com/locate/apm

On the conditional and partial trade credit policy with capital constraints: A Stackelberg model ☆

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ARTICLE INFO

Article history:
Received 16 March 2013
Received in revised form 22 March 2015
Accepted 17 April 2015
Available online xxxx

Keywords:
Trade credit
Stackelberg game model
Capital constraints
Price discount
Order policy

ABSTRACT

For the two-echelon supply chain with stable market demand, by taking the supplier's capital constraint into consideration, we establish a conditional and partial trade credit model, which actually is a Stackelberg model with the supplier being a leader in the game. By analyzing two parties' optimal decisions in the game, we provide the supplier with a threshold for setting the model. The model can not only stimulate the retailer to make a larger order at each replenishment cycle, but also incite the retailer to make a partial payment when he is in a good financial condition. Hence, the supplier's financial pressure is marginally relieved in this model. On the other hand, the retailer's benefit in the traditional trade credit model does not decrease. Thus, the new model makes the supply chain more stable and a win–win outcome can be realized. We illustrate the validity of the model via a set of numerical experiments. The sensitivity and the Pareto optimality of the model are also discussed in this paper.

1. Introduction

In classical economic order quantity model, the retailer generally pays for all the items ordered from a supplier upon completion of transaction. To stimulate the retailer to make a larger order at each replenishment cycle and thus decrease the order processing cost from the perspective of the supplier, many enterprises usually provide a trade credit policy to their retailers, that is, retailers are allowed to defer their payment for their order for some period, see, e.g., Haley and Higgins [1], Jamal et al. [2], Jaggi et al. [3]. Nowadays, this strategy becomes more and more popular in developed and developing countries as shown in Chen and Wang [4] and Arkan and Hejazi [5] Blasio [6], Paul and Boden [7]. As a research topic, the trade credit policy receives much attention of researchers, e.g., Arcelus and Srinivasan [8], Kim et al. [9], Huang [10,11], Goyal [12], Chung [13], Teng [14], Huang [15] and Chung [16] consider the effect of trade credit on the retailer's ordering behavior, while Jaber and Osman [17] and Zhou and Zhou [18] consider the setting of the trade credit policy.

For the effect on the retailer's ordering behavior with constant demand, it is shown by Haley and Higgins [1], Chung [13], Jaber and Osman [17] that the retailer's economic ordering quantity increases marginally under permissible delay in payment. Under the assumption that the interest rate for credit surplus is different from that of credit deficit, Goyal [12] discusses the optimal ordering quantity and optimal payment time for the retailer. With an optimal control approach,

☆ This work was supported by the Natural Science Foundation of China (11171180, 71471101), the Scientific Research Innovation Team in Colleges and Universities of Shandong Province and Taishan Scholarship of Shandong Province.

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http://dx.doi.org/10.1016/j.apm.2015.04.036
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Aggarwal and Jaggi [19] consider the retailer's optimal ordering strategy of deteriorating items under permissible delay in payment. For price-sensitive demand, Abad and Jaggi [20] consider the retailer's optimal decision of the selling price and length of the credit period. For the case that trade credit is dependent on the ordering quantity, Chung [16] proposes an inventory model through a discounted cash flow approach, while Teng [21] considers the case that the retailer can receive a full trade credit from the supplier and offer a partial/full trade credit to consumers. Due to the effect of cash in the business activities, Moussawi-Haidar and Jaber [22] establish a cash and inventory management joint model which is further developed by Moussawi-Haidar, Dbouk, Jaber, Osman [23] by taking the supplier capital constraints into consideration. Other papers for ordering problem under permissible delay in payment include Chung [13], Bregman [24] and Jamal, Sarkar, and Wang [2]. For the case that the demand is indeterministic, Skouri, Konstantarasa, Papachristos, and Teng [25] consider a supply chain inventory model with deteriorating items and ramp type demand under permissible delay in payment. Glock, Ries, and Schwindl [26] establish an optimal ordering strategy for the case that the retailer has a stock-dependent demand and the supplier offers a progressive payment scheme to the retailer.

For the trade credit model setting, Chen and Kang [27] establish an integrated vendor–buyer model, which shows that the buyer's ordering quantity and the frequency of each vendor's production run are jointly determined. For the case with varying credit period and cash discount, Zhang and Tang [28] considers the setting of the inventory model. Following the lot-for-lot policy and a price-sensitive demand, Kim, Hwang and Shinn [9] establish a supplier's optimal credit period determining model, and Jaber and Osman [17] develop a two-level joint decision model with delay in payment in which the optimal credit period, account-settled time and ordering batches of players are jointly determined to minimize the supply chain cost. For the supplier-Stackelberg model, Zhou and Zhou [18] propose an unconditional trade credit policy and a conditional trade credit policy. The model is further extended by Sarker, Jamal and Wang [29], Chang, Ouyang and Teng [30], Chung and Liao [31], Chung, Goyal and Huang [32], Ouyang, Teng and Goyal [33] to cover more practical scenarios such as that with shortage and order-size-dependent trade credit.

It should be noted that all the discussions above for trade credit policy are based on the assumption that the supplier is in a good financial condition. However, this is not the case as the circulation capital for each firm is frequently constrained in commercial activities, see Buzacott and Zhang [34], Kouvelis and Zhao [35]. Actually, many firm's endurance capacity in debet is limited and larger balance due may lead large straits. Certainly, one remedy for this is to let retailer jointly bear the financial pressure in the trade credit model. Based on this, in this paper, we introduce a conditional discount strategy into the setting to stimulate the retailer in a good financial condition to make a partial payment when ordering. Surely, this can balance the supplier's profit from the delay in payment strategy and the financial pressure caused by the trade credit policy. The running pattern of the model is as follows: as the leader of the game, the supplier first set the related parameters such as threshold for trade credit policy (decision variable), the proportion of payment for the order and the discount factor for partial payment, then as a follower, the retailer makes his decision accordingly, if retailer's ordering quantity is less than the given threshold, then the retailer should make a full payment for the order with full purchasing price, otherwise, the retailer can either make a partial payment in proportion of payment and enjoy the price discount, or make a full delay in payment with full purchasing price. Certainly, two parties constitute a Stackelberg game with the supplier being a leader in the game. In the model, the retailer can not only make a larger order but also make a partial payment for the order when he is in a good financial condition. Hence, the supplier's financial pressure is relieved and the ordering processing cost can be marginally reduced from the perspective of the supplier. Meanwhile, the retailer's benefit in the traditional trade credit model is not reduced. Hence a win–win outcome can be realized in the model. By analyzing two parties' optimal decisions in the game, we provide the supplier with a threshold for setting the model. The validity of the model is illustrated via a set of numerical experiments and its sensitivity analysis is also provided in this paper.

The remainder of the paper is organized as follows. Section 2 presents notations and assumptions used in the paper. Section 3 considers the setting of the conditional trade credit model with capital constraints from the perspective of the supplier by analyzing the two parties' decisions in the game model. The sensitivity analysis of the model is also provided in this section. The Pareto optimality of the Stackelberg model is discussed in Section 4. The conclusion and some remarks are given in the last section.

2. Assumptions and notations

We first give the notations and then give the assumptions used in the subsequent analysis.

D annual market demand of the item;
p unit selling price of the retailer;
c unit purchasing cost of the retailer, $c < p$;
A_r fixed ordering cost of the retailer for each order;
τ discount coefficient of the purchasing price offered by the supplier when the retailer makes a partial payment for an order, $\tau \in (0, 1]$.
h_r inventory holding cost per unit item per year of the retailer;
s_r opportunity cost of inventory capital per item per year of the retailer, which is measured by $I_r c$ where I_r is the interest charges per $ investment in inventory per year;