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The influence of financial conditions on optimal ordering and payment policies under progressive interest schemes ☆

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ABSTRACT

In many business-to-business transactions, the buyer is not required to pay immediately after the receipt of an order, but is instead allowed to postpone the payment to its suppliers for a certain period. In such a situation, the buyer can either settle the account at the end of the credit period or authorize the payment later, usually at the expense of interest that is charged by the supplier on the outstanding balance. Some payment terms, which are often referred to as trade credit contracts, contain progressive interest charges. In such cases, the supplier offers a sequence of credit periods, where the interest rate that is charged on the outstanding balance usually increases from period to period. If a buyer faces a progressive trade credit scheme, various options for settling the unpaid balance exist, where the financial impact of each option depends on the current credit interest structure and the alternative investment conditions. This paper studies the influence of different financial conditions in terms of alternative investment opportunities and credit interest structure on the optimal ordering and payment policies of a buyer on the condition that the supplier provides a progressive interest scheme. For this purpose, mathematical models are developed and analyzed.

1. Introduction

The focus of supply chain management has for many years been on the coordination of business functions such as purchasing, production and distribution within and across companies. Although it was stated early by many researchers that the management of supply chains should also include the integration of information and financial flows (cf. [22]), the management of financial issues in supply chains has only recently made its way onto research agendas (see, e.g., [26]). One financial instrument that has received considerable attention in recent years are trade credits (see [34] for a recent review of the literature). Trade credits are short-term debt financing instruments that enable buyers of intermediate goods or services to delay the payment to their suppliers for a predefined credit period, either free of cost or in exchange for a contracted interest rate.

The major advantage of delayed payments is that suppliers provide capital access and thus enable their customers to increase order sizes without approaching a liquidity bottleneck. In addition, they help to improve the competitive position of the suppliers, who can use payment delays instead of price discounts to promote sales and develop their product market position (cf. [41]). Other enablers facilitating the supply of trade credits are differences in the price elasticity between suppliers and buyers, collateral values of goods sold, credit intermediation between buyers and banks as well as the protection of non-salvageable investments in buyers (cf. [34]). Consequently, in many industries, trade credits have become one of the most important sources of short-term funding. A recent survey of the European Central Bank [12] showed that access to finance is one of the most pressing problems especially of small- and medium-sized companies in Europe. Trade credits are thus a promising option to get access to short-term finance for companies suffering under a credit crunch. Besides diminishing credit rationing, trade credits may also lead to a reduction of cost by pooling transactions, and they allow more financial flexibility than bank loans in the case of financial distress [14].

Trade credit terms may vary significantly from industry to industry. The simplest way to offer a trade credit is to define a fixed time period in which the buyer is allowed to delay the payment to its supplier. If the buyer fails to settle the account

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(completely) during this time span, then interest is charged on the outstanding balance. This type of trade credit was first analyzed in the context of an economic order quantity (EOQ) model by Goyal [15], who showed that the order quantity increases if predefined payment delays are permitted, as compared to the classical EOQ model. Subsequently, Dave [11] introduced a model that considered different purchasing and selling prices, and Chung [7] presented a simplified solution procedure for this model. Teng [45] further extended the model of Goyal [15] and demonstrated that in certain cases, it is beneficial for the buyer to reduce its order quantity if trade credits are offered, and to benefit from the permissible delay in payments by ordering more frequently. Huang [19] considered the case of a supplier that specifies a threshold order quantity, where the full trade credit is only granted if the buyer's order quantity exceeds this threshold. If the order quantity is below the predetermined quantity, then only a partial trade credit is offered. Similar works are the ones of Chung et al. [9] and Yang et al. [49], which assumed that if the order quantity is smaller than a predetermined quantity, the supplier does not offer a trade credit at all. Taleizadeh et al. [44] considered a scenario where a fraction of the purchasing cost has to be paid immediately after the order has been received into inventory, and where only the remaining fraction of the purchasing cost is subject to trade credits. A related scenario is the one where the supplier offers the trade credit on a one-time-only basis. Papers that fall into this stream of research assumed that the trade credit is available only for a single order at a pre-specified point in time, which is in contrast to the works discussed above that assumed that the trade credit is available in each order cycle. In case a one-time-only trade credit is offered, the buyer has an incentive to place a special order quantity once to benefit from the trade credit, and to revert to its original order policy after the trade credit option has expired. Works that belong to this stream of research are the ones of Goyal and Chang [17] and Chung and Lin [10], among others.

Other authors considered the case where the supplier offers more than a single credit period to the buyer. The general idea of a so-called progressive payment scheme is that no interest is charged in the first credit period, and that the interest rate then increases from credit period to credit period. Goyal et al. [16] were among the first to consider a progressive payment scheme. The authors studied the case of three different credit periods and analyzed their impact on an EOQ model. This paper was revisited by Chung [8], who improved the optimization procedure suggested by Goyal et al. [16]. The work of Goyal et al. [16] has frequently been extended in the past. Some authors, for example, assumed that demand is stock-dependent, which leads to higher customer demand early in the cycle and to lower customer demand at the end of the replenishment cycle (see, e.g., [39,40]). If such an inventory system is appropriately managed, then higher earnings at the beginning of a cycle enable the buyer to repay the supplier earlier, which leads to a higher profit for the buyer. If demand is stock-dependent, then the profit of the buyer can be increased if inventory is not fully depleted at the end of a cycle, which stimulates additional customer demand (see [47]). Other popular extensions of the work of Goyal et al. [16] include product deterioration (e.g., [38,47,35]), the production of defective items (e.g., [30]), the time value of money (e.g., [37,38]), or limited storage space (e.g., [35,47]).

A closer look at the literature reveals that research has frequently relaxed limiting assumptions of earlier works on trade credits to develop more realistic planning models that cover a wide range of practical scenarios. The seminal work of Goyal [15], for example, assumed that the product is sold to the end customer at the unit purchase price. This assumption was relaxed by Dave [11], Huang [18] and Teng et al. [48], for example, who assumed that the selling price is necessarily higher than the purchase price paid by the buyer. When analyzing the literature, we found that prior research consistently made the assumption that the interest rate charged by the supplier exceeds the credit interest rate of the buyer in all credit periods. The only exception is the work of Cheng et al. [6], which, however, did not consider a progressive payment scheme and assumed that the buyer settles its open account at the end of the replenishment cycle at the latest, as the supplier is not willing to make a new delivery before receiving the entire purchase price of the previous shipment.

It is clear that in practice, the interest rate charged by the supplier does not always exceed the credit interest rate of the buyer. On the contrary, the credit interest rate of the buyer, which could represent the interest rate the buyer could realize by depositing money in an interest bearing account or by investing it elsewhere, or the interest rate the buyer is charged from its bank [41], could exceed the interest charged by the supplier. Several empirical studies revealed that this is especially the case in duopoly industries with a small number of powerful customers (see, e.g., [25,21]). In such a case, it would not be rational from the buyer's point of view to settle the unpaid balance as soon as interest is charged on the outstanding balance, as was assumed in the literature so far. Instead, it would be better to keep the sales revenue invested and to settle the unpaid balance not before the interest charged by the supplier exceeds the incomes from the investment, or just before the next order is issued. Considering such arbitrage gains within the payment policy induces substantial savings and is suited to explain the differences in the working capital structure as can be observed, for example, in the retail sector (cf. Section 2). Another shortcoming we identified is that prior research on inventory models with progressive interest schemes usually assumed that the buyer has the option to settle the outstanding balance only at the end of the credit periods. It is, however, clear that the buyer may benefit from continuously settling the outstanding balance within the credit periods if the interest charged by the supplier exceeds the credit interest rate of the buyer. Furthermore, we found that compound interest the retailer may realize during the credit periods was neglected in prior trade credit inventory models. Clearly, especially in situations where the credit periods are long and interest rates are high, interest on interest earnings may represent an additional source of profit that should not be neglected. Finally, although inventory may be financed through bank loans instead of trade credits, which affects the respective interest rate, the substitutional relationship between trade credits and bank loans has not been considered so far.

In light of the research gaps identified above, the purpose of this paper is to generalize the trade credit inventory model with progressive interest scheme by considering a) the case where the credit interest rate of the buyer may (but not necessarily has to) exceed the interest rate charged by the supplier, b) where the buyer has the option to settle the outstanding balance continuously within the credit periods, c) where compound interest accrues at the retailer, and d) bank loans are available as a substitute for the trade credit. In addition, some inaccuracies in earlier formulations of the effective interest cost are corrected. The remainder of the paper is structured as follows: The next section illustrates the role of trade credits and working capital management in the retail sector. Section 3 then outlines assumptions and notations used throughout the paper and develops formal models for determining the optimal order quantity and payment scheme for different interest and payment conditions. Sections 4 and 5 present theoretical findings on the models developed and illustrate their behavior with the help of a benchmark case and an extensive simulation study. Section 6 finally concludes the article.