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Two-period supply chain with flexible trade credit contract

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ABSTRACT

This paper studies a two-period supply chain that consists of a retailer and a supplier. A newsvendor-like retailer is capital constrained and orders products using a supplier's trade credits to satisfy uncertain market demand. Most existing studies show that the retailer always postpones payment until the due date. To recall the loans earlier, we present a case in which the supplier, as a Stackelberg leader, offers an incentive of a discounted wholesale price in the second order to entice the retailer to choose flexible early payment. The proposed incentive is related to the retailer's early payment time in the first period. In the presence of bankruptcy risks for both the retailer and supplier, we propose a continuous newsvendor model of a two-period supply chain to analyze the decisions involved in the flexible trade credit contract. The analytic forms confirm that such an incentive can improve the decentralized supply chain efficiency and decreases the supplier's trade credit risk. The retailer always prefers early payment to payment around the due date to increase revenues. Furthermore, the action of paying early might help the retailer adjust cash flow between the two periods. We also find that a revenue sharing contract significantly affects the retailer's payment behavior and supplier's wholesale price. The numerical simulations support our results.

1. Introduction

Trade credit is a short-term business loan that allows a capital-constrained buyer to delay paying a purchase cost. It is one of the most popular financing vehicles in today's business. Trade credit accounted for roughly one-fifth of the total assets of a typical firm and approximately half of the short-term debt in two different samples of medium-sized UK firms and small-sized US firms (Cuñat, 2007). In the early 1990 s the percentage of trade credit was a significant part (17.8%) of total assets for a majority of business-to-business firms in the US (Rajan, & Zingales, 1995). Trade credit becomes an important source of working capital in emerging economies, such as China, where numerous firms, especially startup and growing firms, obtain limited support from the banking system (Ge, & Qiu, 2007). By offering trade credits, the seller shifts high-cost, unsold inventory to the buyer, who can hold the needed goods or services without immediately paying the full purchase cost. However, under the condition of a trade credit contract, when to pay the full loans becomes a crucial business decision. To reduce the liquidity risk and default risk, the seller prefers for trade credits to be paid quickly. Therefore, the supplier offers some incentive policies, such as a cash discount, to encourage the buyer to pay trade credits earlier.

Over the past decade, trade credit as a crucial issue in supply chain management has been well researched. Existing literature mainly focuses on two basic types of trade credit contracts: (1) a one-part contract and (2) a two-part contract. Goyal, (1985) first analyzed the retailer's economic order quantity (EOQ) under a one-part contract by setting a permissible delay in payment. His initial work was further explored in studies considering deteriorate products (Mahata, 2012; Sarkar, Saren, & Cárdenas-Barrón, 2015; Tiwari, Cárdenas-Barrón, Khanna, & Jaggi, 2016; Wang, Teng, & Lou, 2014; Wu, Al-khateeb, Teng, & Cárdenas-Barrón, 2016), allowable shortage (Ghoreishi, Weber, & Mirzazadeh, 2015; Taleizadeh, Pentico, Jabalameli, & Aryanezhad, 2013), two-level trade credit (Chung, Cárdenas-Barrón, & Ting, 2014; Shah, & Cárdenas-Barrón, 2015; Wu, Ouyang, Cárdenas-Barrón, & Goyal, 2014) and order quantity-dependent trade credit (Chen, Cárdenas-Barrón, & Teng, 2014; Chung, 2011; Ouyang, Yang, Chan, & Cárdenas-Barrón, 2013). This strand of literature assumes that the supplier predetermines a fixed permissible delay period without charging interest. The retailer is able to accumulate sales income and earn interest from the revenue collected. Hence, the retailer will always postpone payment until the due date. This, however, is obviously inconsistent

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with real businesses, which apply various early payments. For example, a large number of companies, such as Wal-Mart, Carrefour and Taobao, provide the incentives of discounted prices or coupons to stimulate buyers to pay as quickly as possible. Given certain financing limitations, Ng, Smith, and Smith (1999) constructed a two-part trade credit of $(\beta/M_1, n/M_2)$ to model a real deal of "2/10 net 30". In their study, a capital-constrained retailer is offered a cash discount of β percentage within paying off the trade credit in a given short period M_1; otherwise, the retailer enjoys only a delayed payment within a long permissible period M_2. Thanks to a cash discount, the retailer is likely to pay off the loans earlier than the time M_1 if revenue is sufficient. In practice, however, the retailer chooses to delay payment up to time M_1 to earn additional interest.

Following Ho, Ouyang, and Su (2008), Ng et al. (1999) discussed the integrated inventory model with two-part trade credit and presented an algorithm to solve it. Based on the above work, Chung and Liao (2011) further obtain the optimal closed-form formulation for the optimal number of shipments and developed effective algorithms. Zhong and Zhou (2012) discussed optimal ordering strategies and trade credit policy under two basic types of trade credit contracts. They show that it is more superior in reducing operational cost for the supplier to offer a two-part contract than to offer a one-part contract. Zhou, Zhong, and Wahab (2013) explore a two-part contract of $(\beta/M_1, n/M_2)$ to $(\lambda/M_1, n/M_2)$, in which the retailer receives a cash discount of β percentage for any λ fraction of the purchase cost within period M_1. Prior literature on a two-part contract implicitly assumes that the retailer has only two extreme payment choices, paying at either time M_1 or time M_2. By delaying payment up to the last day, the retailer is able to maximize the time value of money. This is similar to the choice in a one-part contract. This assumption, however, can be easily violated in the real marketplace. First, it is difficult for the supplier to determine an appropriate M_1 in a two-part contract. Besides the retailer's default risk, the supplier considers the opportunity cost, market risk and liquidity risk (Chang, & Rhee, 2011; Nooraie, & Parast, 2015; Nooraie, & Parast, 2016). Second, the retailer is willing to keep more cash for a potential investment opportunity.

This paper extends the prior literature on trade credit contracts. We allow the retailer to flexibly choose when to pay the loans within a permissible delay period M, i.e., we do not limit M_1. Equivalently, we explore typical two-part contracts of $(\beta/M_1, n/M_2)$ and $(\lambda/M_1, n/M_2)$ to a general contract $(\lambda/T', M)$. In this contract framework, the retailer flexibly chooses early payment T' before the due date. We present an incentive of a discounted wholesale price in the second order that is related to the retailer's early payment time. Under this more realistic framework, the retailer has flexible payment choices beyond a two-part contract. We also propose a two-period continuous newsvendor model for uncertain market demand. By incorporating the bankruptcy risks, we derive the critical demand and optimal order quantity analytically. We show that the retailer's flexible early payment improves the efficiency of a supply chain and lowers the supplier's trade credit risks. The supplier, therefore, employs this incentive to entice the retailer to pay early. The retailer can utilize this incentive to adjust his own cash flow between the two orders. We examine the influence of the revenue sharing rates on the optimal early payment time and wholesale price from a coordination perspective (Cachon, & Lariviere, 2005; Chen, 2015; Güler, & Keski˙n, 2013).

The rest of this paper is organized as follows. Section 2 presents an incentive of a discounted wholesale price in the second order, given the retailer's flexible early payment option. Section 3 proposes a two-period continuous newsvendor model to analyze all decisions involved in the flexible trade credit contract. The numerical simulations are illustrated to clarify our findings. Section 4 discusses the influence of the revenue sharing rates from supply chain coordination perspective. In Section 5, we discuss the managerial implications of the results and limitations of study. Section 6 concludes.

2. Model description, notation and assumptions

2.1. Model description

We analyze a two-period supply chain with a supplier and a capital-constrained retailer. The supplier, as a seller, sets the wholesale price and grants trade credits to the retailer. The retailer, as a buyer, makes an order decision at the beginning of the sales period according to the given wholesale price and market demand. The retailer sells products at a fixed price. The retailer can accumulate revenue and earn interest.

If the retailer does not repay his loans early, he can save the accumulated revenue in a bank and earn risk-free interest. Of course, the retailer also likely chooses to invest a certain project or asset to earn risk income. Here, we consider a simple case, i.e., the retailer earns risk-free interest from a bank. Our assumption is consistent with Chen et al. (2014); Chung et al. (2014); Shah and Cárdenas-Barrón, (2015). The retailer must pay all loans at the end of the permissible delay period; otherwise, the retailer goes bankrupt. The retailer is able to flexibly choose when to pay the loans (including interest charged by the supplier). After the retailer pays the full loans, he can reorder at the beginning of the second sales period. The permissible delay period M here coincides with the sales period T. In fact, (1) $T < M$ is not suitable to the business practice because the supplier commonly requires the retailer to pay the full loans after sales period T. (2) $T > M$ would lead to difficultly in setting M for the supplier. When facing uncertain market demand, the supplier is unclear of when the retailer will be able to pay the full loans before T. Therefore, we consider the case of $T = M$. The same assumption can be found in Chang and Rhee, (2011); Chen, (2015).

The trading details of a two-period supply chain are as follows:

(1) In the first sales period of $[0, T]$: The supplier sets a wholesale price W_1 per unit product with a fixed cost c. The retailer decides the order quantity Q_1 according to W_1 and the market demand level q_1. The fixed selling price is P per unit product. The supplier offers trade credits of W_1Q_1 to the retailer. The trade credit period is predetermined as T by the supplier. The retailer must pay the full loans by the due date; otherwise, the retailer goes bankrupt, and the supplier takes all the sales income. The retailer can flexibly choose early payment at any time $T'(T' < T)$. To recall all the loans, the supplier offers an incentive of a discounted wholesale price that is related to T'.

(2) In the second sales period of $[T, 2T]$: The retailer can reorders when he pays the full loans. If all the loans are paid at time $T'(T' < T)$, the retailer can enjoy a discounted wholesale price of $W_2(W_1, T')$ for order quantity Q_2 at the beginning of $[T, 2T]$. The supplier still offers trade credits of W_2Q_2 to the retailer. The retailer goes bankrupt if the full loans cannot be paid at the end of the second period. The cost c and selling price P per unit product remain fixed during both periods. The retailer sells same products in both periods, so there are the identical c and P. The same assumptions can be found in Bassok and Anupindi, (1997); Khouja, (2016). Fig. 1 illustrates the sequence of the transactions.

2.2. Notation and assumptions

c	Unit procurement cost in dollars.
P	Unit selling price in dollars.
T	Sales period.