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Bi-level credit period coordination for periodic review inventory system with price-credit dependent demand under time value of money



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ABSTRACT

A bi-level credit period coordination scheme is proposed for a supplier-retailer supply chain with a periodic review replenishment policy and price-credit dependent demand. The credit period offered by the retailer to its customers is a promotional effort to induce customer demand and gain market share. We model the problem under decentralized, centralized, and coordinated structures. Through the incentive scheme, the supplier seeks to increase the retailer's credit period by offering the retailer a credit period. Our results suggest that coordinating the inventory, pricing, and credit financing can improve the overall chain and individual member profitability.

1. Introduction

In an uber-competitive retail market, supply chain managers constantly seek to globally optimize the entire chain's profit, which can sometimes result in conflicts between the objectives of the individual chain members. In a typical supply chain, each partner will decide based on welfare maximization, which can lead to inefficient, decentralized decisions (Katok and Wu, 2009). As such, it is useful to consider and apply the notion of supply chain coordination to better align individual player incentives. According to Giannoccaro and Pontrandolfo (2004), coordination schemes incentivize the supply chain actors to adopt decisions which are optimal from a holistic supply chain perspective and to benefit all in the chain (Weng, 1995). Chen et al. (2001) suggest that channel coordination can be achieved by managing the costs and rewards of all partners, aligning their interests and objectives from a holistic viewpoint while allowing for decentralized decision-making. Coordination schemes have been investigated theoretically (Cachon, 2003), and experimentally (Katok and Wu, 2009). In the coordination literature, schema such as quantity discounting, revenue sharing, profit sharing, product buy-backs, two-part tariff, rebates, and collaborative models are common.

Among such contracts, the permissible delay in payment is most common. According to Kouvelis and Zhao (2012), a delay in payments is broadly applied as a trade credit whereby a supplier offers a specified credit period to the modern trade retailer. Trade credit, first mooted by Haley and Higgins (1973), is the most flexible short term financial instrument to help the modern trade retailer. These retailers, through their pricing policies, usually allow their customers to defer the payment of the goods purchased. More than 80 percent of the B2B transactions in the UK are done on trade credit; similarly for the US (Seifert et al., 2013). In practice, product demand can depend on the length of the credit period offered by the retailer. According to Jaggi et al. (2008), the credit

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period offered by a modern trade retailer to its customers has a positive effect on product demand, albeit this incurs more cost to the retailer and has a greater likelihood of default risk. However, doing so is anticipated to increase the market share of the upstream members. Thus, the credit financing decision requires coordination in the supply chain context.

In most commercial transactions, the practice is for the supplier to offer a delay in payment to the modern trade retailer and the retailer would pass on this delay in payment onto downstream customers preferably in full (Huang, 2007). Such a business structure is termed as the bi-level trade credit financing. For instance, TATA group, which is an Indian multinational conglomerate holding company, not only offers trade credit to its dealership but also takes advantage of the trade credit received from its suppliers (Mahata, 2012). Likewise, Toyota's business practice is to ensure that it receives a longer credit period from its supplier than what it offers to its dealerships (Huang, 2006; Tsao, 2017a).

Under bi-level trade credit financing, there is a need to consider the impact of the sale price in addition to the credit period offered by the modern trade retailer to the downstream consumers (Thangam and Uthayakumar, 2009). This is particularly crucial for fast-moving consumer goods (see Tavana, 2012) as many a time a large amount of stock would need to be removed to make way for newer products coming in, which then compels price markdowns for the older products. In reality, the retailer's demand needs to account for both the selling price and the credit period because the marginal effect of the credit period on sales is proportional to the unrealized potential of the market demand. The strength of the association between the selling price and credit period becomes more critical when it is a norm for stock clearance such as in the supermarkets. These curated examples highlight the practical value of incorporating a price and credit period dependent demand into bi-level trade credit models, hence providing the motivation for our study.

When consumer demand is sensitive to sale price, the wholesale price can alter this demand (Abad and Jaggi, 2003). Thus, the pricing decision as well as credit financing impact demand and the inventory system (Panda et al., 2015). Finding the optimal pricing approach will be mutually beneficial to the customers and chain members as the customers can enjoy lower prices and members reap more demand. At the same time, with price dependent demand, the decisions made downstream affect the profitability of the upstream members. Therefore, coordination is needed to enhance supply chain profitability. The coordination of replenishment decisions are mostly analyzed on the continuous review or Economic Order Quantity (EOQ) inventory systems. To the best of our knowledge, only Nematollahi et al. (2017b) have investigated the coordination of periodic review replenishment decisions. This paper extends the supply chain coordination literature for a periodic review policy, by incorporating price and credit finance decisions.

Credit terms can be examined through either opportunity cost or the time value of money approach. The later performs better than opportunity cost but it is less popular due to the complexity in modeling and analysis (Taleizadeh and Nematollahi, 2014). Schwartz (1974) showed that trade credit lowers purchasing cost due to the time value of money, which in turn allows the buyers of the goods to increase their order volume and frequency. The discounted cash flow (DCF) approach, popularized in finance, can be applied to evaluate the impact of the credit periods based on the time value of money. In the supply chain coordination literature, DCF analysis is mostly applied to find the interest earned and charged within a settlement period. To truly reflect the cost of capital and the opportunity cost of the trade credit, DCF analysis should be applied on the revenue which exceeds the interest earned and charged (Wu et al., 2016). In the current study, the impact of the downstream and upstream credit periods on the stakeholders' revenue are found through DCF.

We propose an upstream credit period as an incentive to coordinate a downstream credit period as well as the retail price and periodic review inventory decisions for a two-echelon supply chain. Through the incentive mechanism, a bi-level credit period is investigated whereby the upstream supplier seeks to stipulate the downstream retailer's credit period by offering the retailer a specified payment delay. In the investigated problem, the retailer manages inventory using a periodic review inventory system (R, T), with both the review period (T) and order-up-to-level (R) treated as decision variables. In addition, the retailer faces a price-credit dependent demand, and decides on the retail price and credit period. The credit terms offered by the modern trade retailer to the downstream customers is considered as a promotion effort to secure end-demand. Product shortage is allowed at the retailer's site.

We model the supply chain under three decision-making structures: (1) decentralized, (2) centralized, and (3) coordinated. Under a decentralized structure, the retailer offers a credit period to customers and determines the inventory, pricing, and credit financing decisions. The retailer's decisions may affect supply chain profitability and the supplier as well. Clearly, centralized decision making improves supply chain profitability. Should this centralized decision making incur losses for the retailer, the retailer will refuse to shift his status quo. Hence, using a credit option contract as an incentive mechanism, the inventory, pricing, and credit financing decisions are coordinated simultaneously. Through the incentive scheme, the supplier will allow the retailer a credit period to guarantee the profitability of all members. In so doing, we achieve channel coordination and distribute the profits of supplier and retailer equitably. Thus, our problem is the coordination of a bi-level credit period for a periodic review inventory model under a price-credit dependent demand using time value of money.

The rest of this paper is organized as follows. The related literature is reviewed in Section 2. Section 3 defines the problem along with the notations and assumptions. In Section 4, the mathematical formulation is developed under three decision-making structures, i.e. decentralized, centralized, and coordinated models, and the solution algorithms are proposed. Section 5 provides the numerical examples and sensitivity analyses for the performance of the proposed model. Section 6 concludes the paper and discusses future research directions.

2. Literature review

In what follows, we review the existing literature from two aspects: (1) bi-level credit financing, and (2) supply chain coordination of pricing and inventory decisions.

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