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Trade credit financing in the vendor–buyer inventory system with ordering cost reduction, transportation cost and backorder price discount when the received quantity is uncertain

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Abstract

Previous ordering cost reduction vendor–buyer inventory models with backorder price discount usually assumed that the buyer must pay to the vendor for the ordered items as soon as the items are received, the received quantity is same as the ordered quantity and the transportation cost is independent of the shipment lot-size. In practice, however, the vendor is willing to offer the buyer a certain credit period without interest to promote market competition as well as the buyer's quantity received may not match with the ordered quantity due to unavailability of the raw material, worker's strike, human errors in counting, transcribing, etc. Furthermore, the discounts are offered for the transportation cost of large ordered quantities. This paper derives a single-vendor single-buyer supply chain model for the ordering cost reduction inventory system with backorder price discount, taking into consideration the effect of transportation cost discount and the condition of permissible delay in payments include the case where the buyer's received quantity does not necessarily match the quantity requisitioned. We take the transportation cost as a function of the shipment lot-size and it is taken to be in an all-unit-discount cost format. Thus we incorporate transportation cost explicitly into the model and develop optimal solution procedures for solving the proposed inventory problem. Numerical example and sensitivity analyses are given to demonstrate the applications and performance of the proposed methodology.

Introduction

During the last few years, the notion of integrated vendor–buyer inventory management has attracted considerable attention, accompanying the growth of Supply Chain Management (SCM). Integrated supply chain management has been gradually recognized as a core competitive strategy, since enterprises continuously seek to provide products and services to customers faster, cheaper, and better than their competitors. In the supply chain, buyers are not only troubled with how much of each ordering quantities and when they require to purchase and carry in their inventory to effectively serve their customers, they are also apprehensive with their interactions with the manufacturing companies at the upstream source of the products to minimize their total costs in supply chain management without sacrificing their customer satisfaction. Coordination between two different business entities is an important mean to increase the competitive advantage because coordinative strategy lowers supply chain cost and increase their revenue. In the retailing industry, WalMart and Proctor and Gamble received substantial collaboration benefits by implementing collaborative planning, forecasting and replenishment [1]. Thus cooperation and integration is in hot board of supply chain management. The joint optimization concept for buyer and vendor was initiated by Goyal [2]. Subsequently, numerous scholars (for instance, see [3], [4], [5], [6], [7], [8], [9], [10], [11]) developed integrated inventory models under various assumptions. These integrated vendor–buyer inventory systems treat the ordering cost and/or lead time as constants.

In some practical situations, lead time and ordering cost can be controlled and reduced in various ways. The lead time can be reduced by an additional crashing cost. The crashing cost could be expenditures on equipment improvement, information technology, order expedite, or special shipping and handling [12]. Ordering cost reduction can be attained through worker training, procedural changes, and specialized equipment acquisition. Through the Japanese experience of using Just In Time (JIT) production, the advantages associated with efforts to reduce the order cost can be clearly perceived. It has been a trend by shortening the lead time and reducing ordering cost; we can lower the safety stock, reduce the stockout loss, and improve the service level to the customer so as to increase the competitive edge in business. Thus controllable lead time and ordering cost reduction are keys to business success and have attracted extensive research attention. Porteus [13] first developed a framework of setup cost reduction on the classical Economic Order Quantity (EOQ) model where he introduced the investment cost function for controlling setup cost. Then, Ouyang et al. [14] investigated the influence of ordering cost reduction on modified continuous review inventory systems involving variable lead time with partial backorders. Annadurai and Uthayakumar [15] addressed ordering cost reduction in probabilistic inventory model with controllable lead time and a service level. Woo et al. [16] developed an integrated inventory model for a single vendor and multiple buyers with ordering cost reduction. Zhang [17] extended Woo et al.'s [16] model by relaxing the assumption that the cycle times for all buyers and the vendor are the same. Later, some researchers (for instance, see [18], [19], [20]) extended the study of integrated inventory model with controllable lead time and ordering/or setup cost reduction under various assumptions.

On the other hand, in the real market, as unsatisfied demands occur, we can often observe that some customers may prefer their demands to be backordered, and some may refuse the backorder case. When a shortage occurs, many factors may affect the customers' willingness of accepting backorders. Moreover, there is a potential factor that may motivate the customers' desire for backorders. The factor is an offering of a backorder price discount from the buyer (see [21], [22], [23], [24]). In general, provided that a supplier could offer a backorder price discount on the stockout item by negotiation to secure more backorders, it may make the customers more willing to wait for the desired items. In other words, the bigger the backorder price discount, the bigger the advantage to the customers, and hence, a larger number of backorder rate may result. This phenomenon reveals that, as unsatisfied demands occur during the stockout period, how to find an optimal backorder rate through controlling a backorder price discount from a buyer to minimize the relevant inventory total cost is a decision-making problem worth discussing.

In recent years, supply chain management in the context of backorder price discount and ordering cost reduction has drawn a lot of attention from researchers (see Lee et al. [25] and Huang [26]). So far, the literature on this type of system is mostly limited to single echelons. Only one paper available in literature on multi-echelon systems with backorder price discount and ordering cost reduction. Namely, Lin [27] addressed an integrated vendor–buyer inventory model with backorder price discount and effective investment to reduce ordering cost. He base his analyses on simplified assumptions such as the buyer must pay to the vendor for the ordered items as soon as the items are received, the buyer receives the same order which he has replenished and the transportation cost is independent of the shipment lot-size. However, today's research is interested in focusing on supply chain models under permissible delay in payment (trade credit), uncertain received quantity and transportation cost discount which have real life applications.

In today's highly competitive business environment, entrepreneurs are increasingly using trade credit policy to attract customers. Therefore, trade credit plays an important role in modern business operation. Vendors offer trade credit period to buyers to encourage sales, promote market share, and reduce on-hand stock levels. During the period, the buyer does not charge any interest and can earn interest by depositing the generated sales revenue into an interest bearing account meanwhile vendors lose the interest earned during the same time. However, if the payment is not paid in full by the end of the permissible delay period, then vendors charge buyers an interest on the outstanding amount. The permissible delay in payment produces two benefits to the vendor: (i) it attracts new buyers who consider it to be a type of price reduction, and (ii) it may be applied as an alternative to price discount because it does not provoke competitors to reduce their prices and thus introduce lasting price reductions [28]. On the other hand, the policy of granting credit terms adds not only an additional cost but also an additional dimension of default risk to the vendor. Several articles discussing this topic have appeared in the literatures that investigate inventory problems under varying conditions. For instance, Goyal [29] first developed the EOQ inventory model under the condition of trade credit. Aggarwal and Jaggi [30] extended Goyal's [29] model to deteriorating items. Jamal et al. [31] further generalized Goyal's [29] model to allow for shortages. Wu [32] addressed a continuous review (Q, r) inventory policy under permissible delay in payments. Chang [33] explored the (Q, r) inventory policy and the investment strategy for ordering cost reduction under permissible delay in payments. Later, Jaber and Osman [34] developed a two-level supply chain system in which the retailer's trade credit offered by the supplier is considered as a decision variable in order to coordinate the order quantity between the two levels. Luo [35] treated a single-vendor single-buyer supply chain for a single product, and a model to study and analyze the benefit of coordinating supply chain inventories through the use of credit period is proposed. Sarkar et al. [36] addressed an integrated inventory model for defective products with variable lead time and permissible delay in payments. Huang [37] investigated an integrated inventory model under conditions of order processing cost reduction and permissible delay in payments. Recently, Uthayakumar and Priyan [20] developed two-echelon continuous review inventory model with permissible delay in payments, controllable setup cost and lead time under service level constraint. In addition, reviews of literature on inventory systems with trade credit are available in Seifert et al. [38]

In practice, the quantity received may not match with the quantity ordered due to unavailability of the raw material, rejection during inspection, worker's strike, electricity failure, human errors in counting, transcribing, etc. an example would be one individual recording a seven on an order form, with a second person interpreting it as a 9 (for more see Silver [39]). Supply chain risk uncertainty can create severe repercussions, thus it is not surprising that research interest in supply chain uncertainty has been growing. Whereas extant inquiry is instructive, there is a lack of investigations that core on supply chain investment decisions when facing high levels of risk uncertainty. Given the prospective dollar value involved in these decisions, an understanding of how these supply chain decisions are made is of significant hypothetical and practical importance. To the extent that uncertainty surrounds a decision, managers prefer to postpone major investments while maintaining the potential to exercise the option by moving more boldly at some future point. In recent years, researchers have used real options to analyze firms' investments in areas such as research and development, knowledge, and technology. Silver [39] established an EOQ model when quantity received in the buyer's inventory is uncertain and is a random variable with a specified mean and variance. Kalro and Gohil [40] extended Silver's [39] model by allowing shortages. Noori and Keller [41] gave a stochastic model when the quantity received is uncertain. Wu [42] developed a continuous review inventory model with variable lead time and the received quantity is uncertain. Unlike above models, an integrated strategy is discussed by Shah and Gor [43] for both vendor and buyer when the input is random. They numerically showed that the cooperative approach is beneficial to reduce the cost when compared with an independent decision by both the parties.

In a practical logistic system, when products are delivered from the vendor to the buyer, transportation costs are incurred, and we can observe that the transportation cost is a function of the shipment lot size. Hence, with the increased emphasis on supply chain management, the need to develop models with appropriate representation of transportation cost considerations is more enhanced. Lee [44] is one of the earliest studies that explicitly incorporate the discounted freight rate into EOQ model. He assumed that shipment transportation cost is fixed and increases in a step function format depending on the order size. Ganeshan [45] presented a (s, Q) inventory policy for a network with multiple suppliers by replenishing a central depot, which in turn distributes to a large number of retailers. He considered that the transportation cost is a function of the shipment lot size. Later, some researchers (for instance [46], [47], [48], [49], [50]) developed transportation inventory model with different transportation cost functions. In 2007, Ertogral et al. [51] developed two new integrated vendor–buyer models that incorporate transportation cost explicitly. They assumed that the transportation cost is a function of the shipment lot size and all-unit-discount transportation cost structures with and without over declaration have been considered.

Recently, three topics that have separately received considerable attention in the inventory control literature are trade credit period, uncertain received quantity and transportation cost discount. Here we develop a model that combines these three extensions of the backorder price discount and ordering cost reduction vendor–buyer inventory model developed by Lin [27]. The remainder of this paper is organized as follows. The next section illustrates the motivations of the proposed research. Section 3 describes the notations and assumptions used throughout this study. In Section 4, we mathematically formulate the proposed model without transportation cost as well as the solution procedure is design and numerical example is given. The transportation cost is included into the model as well as the solution procedure is given and numerical example is also provided in Section 5. Finally, we give conclusions of the paper in Section 6.

Section snippets

Motivation of the research

In competitive commercial market of present circumstances, many vendors and buyers would like to make long-term co-operative relationship as integrated supply chain model to get tensionless steady sources of supply and demand to minimize costs and improve overall quality. Therefore, in recent years, both parties make a collaborative effort between the organizations for success. Today, the vendors offer its buyers a delay period known as the trade credit period to settle his account within the...

Notations and assumptions

To develop the proposed model, we adopt the following notations and assumptions which are similar to those used in Lin [27]....

Formulation of vendor–buyer inventory system without transportation cost

The transportation cost per unit from the vendor to the buyer is independent of the ordering quantity. Hence, in this section, for the simplification, the total transportation cost per unit time is ignored. The joint expected annual total cost $JEAC(Q, A, \pi_x, L, n)$ = The buyer's expected annual total cost $EAC_b(Q, A, \pi_x, L)$ + The vendor's expected annual total cost $\mathrm{EAC}_v(Q, n)$....

Formulation of vendor–buyer inventory system with transportation cost

Today's highly competitive business environment, transportation cost is a major part of the total operational cost. To appropriately incorporate transportation cost into the total annual cost function, it must first be possible to identify transportation cost functions that emulate reality. In most joint vendor - buyer models, the transportation cost is only considered implicitly as a part of fixed setup or ordering cost and thus is assumed to be independent of the size of the shipment. In this ...

Conclusion

In this paper, we have complemented the shortcomings in [27], and relaxed the improbable assumptions that the buyer receives the same order which he has replenished, the buyer must pay to the vendor for the ordered items as soon as the items are received and the transportation cost is independent of the ordered quantity. We developed two new integrated vendor–buyer models that incorporate transportation cost explicitly. All-unit-discount transportation cost structures have been considered....

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>
> …Bazan et al. [19] took into account a vendor-buyer SC that operated under a VMI-CS agreement by considering imperfect products. Priyan and Uthayakumar [20] improved the model proposed by Lin [21] by relaxing the implausible assumptions. They developed two new integrated vendor-buyer models that incorporated the transportation cost.…

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> …Wu [19] developed a continuous review inventory model involving the received quantity is uncertain with variable lead time. Priyan and Uthayakumar [20] addressed the vendor–buyer inventory system with the consideration of received quantity is uncertain and variable ordering cost involving transportation cost and backorder price discount in the trade credit environment. In real life business via share marketing, trade credit finance can improve sales in health care industries.…

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