Computers & Industrial Engineering 113 (2017) 630–645

Contents lists available at ScienceDirect

Computers & Industrial Engineering

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

Coordination and benefit sharing in a three-echelon distribution channel with deteriorating product

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ARTICLE INFO

Keywords:
Channel coordination
Deterioration
Quantity discount
Compensation on disposal cost
Bargaining

ABSTRACT

This paper proposes two hybrid contract-bargaining processes- backward and forward, aiming at channel coordination and benefit sharing in a manufacturer-multiple distributers-multiple retailers supply chain that deals with a deteriorating product. The hybrid contract consists of quantity discount that the manufacturer provides to distributers and compensation on deterioration cost, which distributers provide to retailers. Although both processes coordinate the channel and distribute benefits, distributers prefer backward contract-bargaining but retailers and manufacturer prefer the other. Moreover, without receiving quantity discounts, distributers can coordinate the channel by providing compensations on deterioration costs, which may be larger than deterioration costs. A numerical example explains the model.

1. Introduction

In a decentralized supply chain that consists of one manufacturer, multiple distributers and multiple retailers under each distributer, the decisions are suboptimal (Aljazzar, Jaber, & Moussawi-Haidar, 2016, 2017; Cárdenas-Barrón & Sana, 2015) because each channel member seeks to minimize its own cost. Ideally the success of individual channel member depends on overall channel success. So, the coordination among channel members is needed for improving channel wide performance. To cut out channel conflict, coordination contracts are used to align all the channel members' decisions with the channel best decision. The coordination contracts differ by contractual classes among the channel members. Interestingly there is no universal coordination contract that effectively resolves channel conflict because performance of a coordination contract depends heavily on the supply chain characteristics (Bazan, Jaber, & Zanoni, 2015; Zhang & Liu, 2013). Several coordination contracts e.g. quantity discount (Panda, Modak, Basu, & Goyal, 2015), buy back (Chen & Bell, 2011), two part tariff (Modak, Panda, & Sana, 2016), quantity flexibility (Chung, Talluri, & Narasimhan, 2014), revenue sharing (Modak, Panda, Mishra, & Sana, 2016), sales rebate (Lan, Zhao, & Tang, 2015) are used to resolve channel conflict.

Majority of these contracts addresses two-echelon supply chain coordination rather than discussing double marginalization in three-echelon supply chain. Munson and Rosenblatt (2001) developed a three-level supply chain that consists of one member at each level. They have assumed that the manufacturer obtains quantity discount from its supplier without worsening its financial performance. Jaber, Osman, and Guiffrida (2006) extended Munson and Rosenblatt (2001) model by assuming profit function, discount dependent demand and profit sharing. Jaber, Bonney, and Guiffrida (2010) studied a three-stage supply chain with learning based continuous improvement. Huang, Huang, and Newman (2011) developed analytical and computational methods to coordinate enterprize decisions in a multi-level supply chain composed of multiple suppliers, a single manufacturer and multiple retailers. Panda, Modak, and Basu (2014) developed a three-tire supply chain model for deteriorating product. They assumed that the manufacturer and the distributer form a coalition that provides compensation on disposal cost to the retailer for the coordinated order quantity. In this direction works of Drechsel (2010) and Tavakoli and Mirzaee (2014) are worth mentioning. All these models cited above assume one player at each level in three-stage supply chains.

Models dealt with more than one member in different stages are very few because of its complex nature. Khouja (2003a) developed a three-echelon supply chain, where at each stage there are multiple members and each member can supply to two or more buyers. Ben-Daya and Al-Nassar (2008) generalized Khouja (2003a) to the case, where shipment between stages can be made before a whole lot is completed. In another paper Khouja (2003b) proposed synchronization of decisions that starts from supply of raw materials and ends at

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http://dx.doi.org/10.1016/j.cie.2017.09.033
Received 11 January 2017; Received in revised form 25 July 2017; Accepted 19 September 2017
Available online 23 September 2017

customers. Cárdenas-Barrón (2007) extended the model of Khouja (2003b) by considering n-stages. Jaber and Goyal (2008) investigated the synchronization of order quantities in a three-echelon supply chain. In the first, second and third level of the chain there are multiple buyers, one manufacturer and multiple retailers respectively. They showed that, when the players agree to coordinate, it is possible to have some of the players benefiting more than others. They have not proposed any coordination contract that resolves channel conflict. Jonrinaldi and Zhang (2013) developed a supply chain that consists of multiple players in different echelons. They assumed finite production capacity of the suppliers and determined the optimal decisions over a finite time horizon considering reverse logistics.

Bargaining theory had been widely applied to resolve conflict of interests in a supply chain for its appealing characteristics. Bargaining refer to situations where two or more players trying to reach on favorable agreement regarding distribution of monetary amount. There are two streams of bargaining approaches, e.g. axiomatic, where outcome is based on a set of axioms and strategic, where based on offers and counter offers an outcome can be realized. Nagarajan and Sosic (2008) mentioned that generally to negotiate finding compromise solution bargaining theory has been used. For example, Sucky (2004) analyzed a bargaining model with asymmetric information about the buyer's cost structure in a supply chain. Kohli and Park (1989) considered a bargaining problem in which the buyer and the seller negotiate over the order quantity and the average unit price. In this model they discussed the effects of risk sensitivity and bargaining power on quantity discounts. Kalai and Smorodinsky (1975) showed unique solution exist in a two person bargaining problem, which is different from the solution suggested by Nash. Sucky (2005) presented several bargaining models depending on alternative production policies of the supplier. Ertogral and Wu (2001) examined a bargaining theoretic approach to supply chain coordination. They showed that in subgame perfect equilibrium the first best case is optimal for the buyer and the supplier. To achieve better coordination Hou, Zeng, and Zhao (2009) used revenue sharing contract in a two-echelon supply chain and have used bargaining to divide the surplus between the parties. Gurnani and Shi (2006) used generalized Nash bargaining game to study a business to business supply chain. They indicated that bargaining in practice is not merely a relationship in which upstream channel member makes take-it or leave-it offers to downstream channel member. Rather the relationship involves bargaining over the term of trade such as quantity discount, compensation on deteriorated products, etc. Although economic literature has rich content on bargaining among multiple players, to the best of the authors knowledge none has used bargaining theoretic framework to find the win-win cost ranges for the channel members and to divide the channel cost saving in a multi-echelon supply chain.

The purpose of the paper is to address aforementioned issues in a conventional distribution channel that consists of a manufacturer, multiple distributers and multiple retailers corresponding to each distributer. The manufacturer produces a deteriorating product and sells it to the customers through the distribution channel. The research proposes a hybrid contract-quantity discount-compensation on deterioration cost combining with Nash bargaining and examines its efficiency in resolving both horizontal and vertical conflict and in dividing benefit.

Present study differs from the prior works in the following aspects. Firstly, instead of considering channel structure of Jaber and Goyal (2008), this paper assumes that the third level of the channel consists of a manufacturer, the second level consists of multiple distributers and in the first level corresponding to each distributer there are multiple retailers. Secondly, the paper analyzes echelon wise coordination issues and examines the cost benefit that the channel can accrue from this. It is found that retailers' costs increase but other channel members costs decrease due to horizontal coordination among the channel members. Thirdly, present paper applies a hybrid contract to eliminate channel conflict. The hybrid contract consists of quantity discount that the manufacturer provides to each distributer and percentage compensation on deterioration cost, which each distributer provides to each of it's retailers. The win-win ranges for all the channel members for coordinated decision are identified in closed forms. The distributers act as the intermediators and play central roles. When coordination contract is applied to resolve channel conflict and the channel members bargain to divide the benefit, the distributers' costs depend on the sequence of approaches towards sharing the costs. As a consequence, the paper incorporates two procedures, namely backward contract-bargaining process and forward contract-bargaining process. In the former process, each retailer of a particular distributer assumes the distributer does not get anything from the manufacturer. Based on it, first win-win ranges for the retailer and the distributer for compensation on deterioration cost are identified. Within this range they bargain on compensation for benefit split. A particular distributer has multiple retailers and the distributer has different reservations for different retailers. Corresponding to each retailer, the distributer settles benefit share. In the second stage, based on the decentralized cost minus accumulated benefit shares from the retailers, first the distributer and the manufacturer identifies the win-win ranges for quantity discount. Finally, they bargain on quantity discount for a particular benefit share. Since, the manufacturer also has different reservations for different distributers, it identifies win-win range and benefit share for each distributer independently. Thus, in the backward contract-bargaining process the coordination contracts and bargaining are interdependent. The process is also nested because of the sequence of events as, percentage compensation on deterioration cost for win-win range → bargaining on compensation for benefit share → quantity discount for win-win range → bargaining on quantity discount for benefit share. In the forward contract-bargaining process, same events in reverse sequence are performed. Based on decentralized cost minus benefit share from the manufacturer, a distributer and each of its retailers determine their win-win ranges for compensation fractions. Finally, they bargain for particular benefit splits. The bargaining game that is used here is based on Nash bargaining product. Moreover, as the inventory decision depends on quantity discount and percent compensation on deterioration cost, these two become key parameters for the best outcome in such a supply chain. Fourthly, a comparison of these two processes is presented and it reveals that choice of the process is different for different channel members. In particular, distributers prefer the backward process, whereas other channel members prefer the forward. Fifthly, unlike the earlier papers, here it is found that the distributers are powerful enough to coordinate the channel. As without receiving any discount from the manufacturer, the distributers can provide compensation to the retailers and coordinate the channel.

The rest of the paper is organized as follows. In Section 2 the model is developed and some basic analysis is performed. Section 3 justifies the model and its findings through a numerical example. Finally Section 4 represents some concluding remarks and future research directions.

2. Model description and basic analysis

The parameters, decision variables and cost functions for developing the model are listed in Appendix A. Consider a three-echelon distribution channel consisting of a manufacturer, multiple distributers and multiple retailers of each distributer. Fig. 1 represents a descriptive diagram of the supply chain. This type of distribution channel is generally found in bakery, fruit, grocery industries.

The manufacturer produces a deteriorating product and supply it to n distributers. The jth distributer ($j = 1,2,...,n$) transfers the product to its n_{ij} ($i = 1,2,...,n_j; j = 1,2,...n$) number of retailers and the retailers sell the product to customers and fulfill the channel demand. Thus, there is $\sum_{j=1}^{n}\sum_{i=1}^{n_j} n_{ij}$ number of retailers in the system. Assume that each of n_{ij} ($i = 1,2,...,n_j; j = 1,2,...n$) retailers faces deterministic demand D_{ij}^{r} ($i = 1,2,...,n_j; j = 1,2,...n$) per unit time. A particular retailer can place an order to a particular distributer, who is associated with it, i.e., for each retailer there is only one available distributer. The product deteriorates