A study on coordination of capacity allocation for different types of contractual retailers

Yeu-Shiang Huang *, Jun-Ming Chen, Zu-Liang Lin

Department of Industrial and Information Management, National Cheng Kung University, Taiwan, ROC

ARTICLE INFO

ABSTRACT

Because the demand is uncertain and it is impossible to expand capacity immediately, suppliers in supply chains are faced with insufficient capacity. As a result, they are unable to satisfy fully the demand from many retailers. Sometimes the use of additional shifts or outsourcing may resolve the problem, but many times, suppliers have to seek ways to appropriately allocate their limited capacity to the retailers. A non-cooperative coordinative mechanism is often required which has to be acceptable and beneficial for all members of the supply chain. This study considers a supply chain with a single supplier and multiple retailers in which the retailers are categorized into two types: ordinary and privileged, according to the steadiness of their partnership with the supplier. The primary concern is to coordinate the capacity allocation within the supply chain with the uses of quantity discount and strategic price-quantity auction with consideration of maintaining fairness and a long-term steady partnership. Our analytical results show that both parties benefit from these coordination mechanisms since the supplier's profit increases because the retailers are incentivized to place orders with higher quantities, lowering the cost of idle capacity and increasing revenues. In the meantime, retailers are able to trim down their ordering costs and fairly compete for limited capacity, which reduces the transaction risks and shortage costs for uncertain demands, and thus increases their profits.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Effective supply chain management can enhance the performance of the entire supply chain and provide more benefits for its members. However, companies nowadays face a globally competitive market in which product life cycles shrink, product variability boosts, and post-sale customer services are desperately desired, so the cost and complexity of supply chain management dramatically increase. In particular, in the presence of conflicting objectives among members of a supply chain, the performance of the entire supply chain would also be seriously harmed. Therefore, in considering the complexity of supply chain, it is of special importance to have an appropriate coordination mechanism to ensure members of a supply chain can maintain long-term partnership and profitability. Coordination in supply chains can effectively reduce risk and uncertainty, usually achieved by upholding a steady supply for each retailer. A vast amount of literature has discussed different methods of profit sharing with non-cooperative coordination via quantity, lead time, an quality discount policies [2,3,9,16,18,20,21,24,26,31]. In addition, research on auction mechanism for coordination is also widely studied in the literature [10,14,15,22,27–29,32,34]. Other coordination methods can also be found in the literature, such as market-base coordination [17] and dual sourcing coordination in the presence of insufficient capacity [30]. In summary, coordination can be successful with appropriate motivators, e.g. fair profit sharing programs, by using effective information to satisfy all members of a supply chain. Therefore, in this study, a non-cooperative coordinative mechanism is considered to deal with the capacity allocation problem for a supply chain with a single supplier and multiple retailers.

It is common that short supply due to insufficient capacity may occur in supply chains, since the extension of capacity is often expensive and time consuming for companies. In such a case, it is critical to determine an appropriate way to allocate the insufficient capacity to multiple retailers. Research on capacity allocation has been studied in straightforward ways in dealing with the problem of allocating insufficient capacity [4–6,11,19,30]. The typical use of uniform allocation is unfair for retailers with larger or small demands, since the amount of short supply is born equally by all the retailers. Another popular approach uses order quantities as the criteria for allocating the insufficient capacity which gives larger capacities to retailers with greater demands. It is possible that some retailers may exaggerate their order quantities to gain more capacity which thus aggravates the bullwhip effect [23].Therefore, with a more comprehensive perspective, this study contributes to the literature with a non-cooperative quantity discount and strategic price-quantity auction coordination mechanism in which the capacity allocation problem under conditions of insufficient and

* Corresponding author at: Department of Industrial and Information Management, National Cheng Kung University, 1 University Rd., Tainan 701, Taiwan, ROC. Tel.: +886 6 2757575x53723; fax: +886 6 2362162.
E-mail address: yshuang@mail.ncku.edu.tw (Y.-S. Huang).

excess capacities can be fairly dealt with for both ordinary and privileged retailers. As a result, the retailers' shortage costs can be reduced and both parties of the supply chain can benefit.

However, non-cooperative coordination may have to be facilitated by contractual agreements to provide members with guidelines for enhancing profits for themselves as well as the entire supply chain. Contractual agreements are usually contingent and customized according to real needs in practice. Some contracts focus on the order quantity that both parties can agree upon: for example, [1,8] considered a minimum quantity commitment contract and a total order quantity commitment contract, respectively. Some contracts focus on the order delivery schedule for the consideration of just-in-time production: for example, [12,25] deliberated a just-in-time contract and a fixed delivery contract, respectively. Other types of contracts were also proposed with different concerns: [13] proposed a forecast-commitment contract, [7] proposed a revenue-sharing contract, [35] considered a two-stage assembly system contract, and [33] proposed an option-based coordination contract. All the proposed existing contracts may have their suitable implementing conditions with corresponding types of supply chain. Therefore, In this study, two types of retailers are considered, such as ordinary and privileged retailers, according to the steadiness of their partnership with the supplier, and the contractual agreements with respect to each retailer would be facilitated to fairly allocate the excess or insufficient capacity, and a coordination mechanism is proposed with the considerations of quantity discount and strategic price-quantity auction.

Based on the aforementioned discussion, a capacity allocation non-cooperative coordination mechanism is proposed for supply chains with a single supplier and multiple retailers with which a long-time steady partnership can be maintained among the members and the profit of the entire supply chain can be enhanced. This paper is organized as follows: Section 2 states the research problem of coordination in supply chain management; Section 3 depicts the development of the proposed approach; Section 4 demonstrates the effectiveness of the proposed approach by performing analytical investigation, with sensitivity analyses also carried out to probe into the important factors which may influence the results; and finally, Section 5 draws the concluding remarks.

2. Capacity allocation in supply chains

Suppose that, in a two-echelon supply chain with one supplier and N retailers, the capacity allocation problem is essential for the members, and each individual retailer i faces a different demand d_i with probability density function (pdf) $f_i(.)$ and cumulative density function (cdf) $F_i(.)$. The N retailers are classified into two segments: ordinary and privileged retailers, based on the business relationships and the degrees of information sharing with the supplier. Privileged retailers have had long-term steady partnership and built mutual trusts with the supplier, while ordinary retailers are new or short-term business partners to the supplier. Contractual agreements should be made between the supplier and the retailers to set up criteria for proper capacity allocation, and which have to be based on the considerations of the supplier's production cost C_P, fixed cost C_F, and cost of idle capacity C_I, as well as the retailers' purchasing costs, inventory handling costs, and shortage costs. In addition, both market status and partnership conditions should also be taken in to account in establishing the contractual agreements. Suppose that upon negotiating with the retailers, a lower limit of order quantity l_i for each retailer i (ordinary or privileged) is settled by mutual agreement with which if retailer i orders $Q_i \geq l_i$, the purchasing cost for unit capacity is P_u, but if an ordinary retailer i orders $Q_i < l_i$, some penalty costs have to be born and the purchasing cost for unit capacity becomes P_P, where $P_P > P_u$. Note that the privileged retailers will always order at least l_i since it is a customary practice of the long-term steady partnership. According to the contractual agreements, in case of insufficient capacity, the supplier would first allocate only the lower limit

quantity l_i to the ordinary retailers if they order more than l_i, and in addition, since a good relationship exists between the privileged retailers and the supplier, the supplier must fulfill each privileged retailer's order no matter how great the order size is. Table 1 summarizes the contractual agreements.

With regard to a lack of coordination in the supply chain, both parties will focus merely on their own interests and aim to maximize their own profits. In cases of insufficient capacity, in attempting to ingratiate the ordinary retailers with more demands, the supplier will tend to allocate enough capacity to the ordinary retailers with bigger orders first to avoid losing such favorable retailers when the market demands become less. Note that the profits gained by such an allocation policy would be greater than by a proportionally rationing one, since more administration cost can be saved due to the less number of orders. In contrast, in cases of excess capacity, in which no quantity discount for coordination exists to attract the retailers to order more, the supplier would have idle capacity left after fulfilling the orders of both ordinary and privileged retailers, which results in large opportunity loss. Both cases would not be able to maintain long-term cooperative partnerships for the supply chain.

However, in order to effectively use the available capacity and trim down the loss from idle capacity, the supplier would often offer various quantity discount programs to coordinate with the retailers for selling more products. On the other hand, when the overall demand exceeds the supplier's capacity, upon satisfying the base demands of the retailers according to the contracts, based on the perception of fairness and openness, a price-quantity auction would be undertaken to let retailers compete for the insufficient capacity among the ordinary retailers. Therefore, the proposed coordination mechanism is formulated by the uses of both quantity discount and price-quantity auction for the cases of excess and insufficient capacities.

In cases of excess capacity, for every one more product which retailer i orders will have a discount rate α, resulting in a new lower price for the extra units $(1-\alpha)P_u$. On the other hand, in case of insufficient capacity, retailer i who is privileged will obtain capacity which can fulfill his order quantity Q_i, but retailer i who is ordinary will have to bid $P_i^{(j)}$ per unit for $B_i^{(j)}$ amount of capacity in the jth round of auction (will be discussed later).

The assumptions made in this study are stated as follows:

(1) Since the focal interest of the study is the capacity allocation problem between the supplier and the retailers, it is assumed that there is no competition and conspiracy consideration in the supply market.

(2) With regard to the case with coordination, the supplier will produce after coordination is accomplished, and the amount provided matches the order quantities exactly. Therefore, inventory holding cost is not considered for the supplier.

(3) The supplier only provides a single product to the retailers. The demands of the retailers will not be very different, i.e., there is no dominant retailer in the supply chain, and each individual retailer will not place an order which exceeds the capacity of the supplier.

(4) The supplier's capacity, in any event, is able to satisfy all the privileged retailers' order quantities plus the ordinary retailers' contractual lower limit order quantities.

Table 1
Contractual agreements between the supplier and the retailers.

Lower limit of order quantity		Purchasing price		Capacity to be allocated	
		$Q_i < l_i$	$Q_i \geq l_i$	$Q_i < l_i$	$Q_i \geq l_i$
Privileged retailers	l_i	NA	P_u	NA	Q_i
Ordinary retailers	l_i	P_p	P_u	Q_i	l_i (insufficient capacity) Q_i (excess capacity)