Omega 49 (2014) 42–52

Contents lists available at ScienceDirect

Omega

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

Potentially self-defeating: Group buying in a two-tier supply chain ☆

Yuan Zhou *, Jinxing Xie

Department of Mathematical Science, Tsinghua University, Beijing, China

ARTICLE INFO

Article history:
Received 12 December 2011
Accepted 19 May 2014
Available online 29 May 2014

Keywords:
Group buying
Quantity discount
Economies of scale
Price-dependent demand
Supply chain management
Game theory

ABSTRACT

Retailers have an incentive to cooperate in the form of group buying (GB) when a supplier provides quantity discounts, because wholesale price under GB depends on total purchasing quantity rather than individual purchasing (IP) quantity. Most previous studies on GB focus on the benefits that buyers get but ignore the supplier's response to GB. In this paper, we take the supplier's response into consideration, and present a game model with a single supplier and two symmetric competing retailers in two systems: the retailers purchase individually, and the retailers group buy. Under a general quantity discount schedule, each system has a unique sub-game perfect equilibrium. The comparison between IP and GB suggests that GB may sabotage the benefits of all members in the supply chain (i.e., the supplier, the retailers, and the consumer). Retailers may hold contradictory attitudes toward GB before and after the publishing of the discount schedule. These insights are shown to be robust for the case when more than two retailers are involved, as well as the case when the supplier enjoys economies of scale based on the order volume. We suggest that a mixed discount schedule may help prevent the potential damage of GB. In addition, with significant economies of scale, the supplier and retailers may be better off under GB. Then GB can be a favorable purchasing strategy.

1. Introduction

Retailers have an incentive to cooperate in the form of group buying (GB) when a supplier provides quantity discounts, because wholesale price under GB depends on total purchasing quantity rather than individual purchasing (IP) quantity. GB is commonly observed and widely used in buyer groups, group purchasing organizations, and purchasing consortia. In many European countries, buyer groups account for a significant proportion of sales in food retail distribution [1]. GB is also commonly used by healthcare institutions, schools, and government organizations as well as by small- to medium-sized businesses in other retail industries (e.g., [2–6]).

However, there are many controversies related to the influence of GB on both the buyer and seller sides. On the one hand, for the retailers' benefit, a fundamental issue is that GB may not help to reduce the purchasing cost [7]. For instance, in the United States, group purchasing organizations for healthcare products do not guarantee that hospitals will save money; their “prices were not always lower but often higher than prices paid by hospitals negotiating with vendors directly” [8].

On the other hand, for the suppliers' benefit, they are under great pressure due to buyer groups' focus on short-term benefits. For example, many European suppliers concern about their profits when buyer groups are aggregating orders across countries for Europe-wide discounts [1]. Many empirical studies suggest that the existence of buyer groups leads to a reduction in the suppliers' profit (e.g., [9], [10]). Given these undesirable impacts, GB has potential drawbacks to supply chains.

Previous studies on GB often focus on the benefits received by buyers [11] and do not consider the supplier's response to GB. In this paper, we think over the supplier's response and examine how GB affects all members in the supply chain (i.e., the supplier, the retailers, and the consumer). We establish a two-tier supply chain consisting of a single supplier, who dictates a general quantity discount schedule, and two retailers, who compete in the final market. We derive the equilibrium outcomes for IP and GB respectively. Under IP, the retailers purchase individually; and under GB, the retailers group buy.

Based on the comparison between IP and GB, we have the following findings. (1) Without the effect of economies of scale, the supplier is worse off under GB even if he adjusts the discount level to address the aggregation of retailers. (2) For a type of general discount schedules, retailers are likely to suffer losses under GB when they cooperate in a weakly competitive market. GB may become a self-defeating strategy for retailers. (3) The demand quantity is lower under GB for a type of general discount

☆ This manuscript was processed by Associate Editor Ryan.

* Corresponding author. Tel.: +86 10 62787812; fax: +86 19 62773400.
E-mail addresses: yzhou10@mails.tsinghua.edu.cn (Y. Zhou), jxie@math.tsinghua.edu.cn (J. Xie).

http://dx.doi.org/10.1016/j.omega.2014.05.003
0305-0483/

schedules, and thus according to the aggregate consumer utility function, the welfare of consumers is reduced. These insights are shown to be robust for the case with more than two retailers. (4) We suggest that a mixed discount schedule can prevent retailers from choosing to group buy in a weakly competitive market. (5) When the supplier enjoys economies of scale based on the order volume, the supplier probably benefits from GB, while retailers may still be self-defeating. Furthermore, with significant economies of scale (measured by a scale parameter), GB can be a favorable purchase strategy, since the supplier and retailers are better off. The results of this paper are helpful for the managers to understand the potential benefits and drawbacks of GB.

The following is a brief literature review. A large body of theoretical and empirical literature on GB demonstrates that GB can reduce acquisition costs or enhance buying power (e.g., [12–17]), but most of these studies do not take the competition among buyers (retailers) into account. Some studies show that GB may influence sellers' (suppliers') rivalry or upstream technology choices (e.g., [7,11,13,18–21]). However, these studies usually ignore the primary motive of retailers to form buyer groups, and that is the quantity discount provided by suppliers [1]. In this paper, we regard the supplier as a Stackelberg leader who provides the quantity discount to competing retailers who are able to purchase in group. Keskinocak and Savaşaneril [22] assume the supplier employs an approximately linear quantity discount schedule, and adopt a theoretical approach to deal with group buying among competing buyers. The difference between their model and ours is that we assume the supplier provides a general quantity discount schedule. In addition, our model incorporates economies of scale in the supplier's cost and examines his profit, whereas Keskinocak and Savaşaneril [22] consider the supplier's revenue without considering his cost.

In recent years, web-based GB has attracted much theoretical and experimental attention (e.g., [6,23–30]). Anand and Aron [6] develop a theoretical model to show that web-based GB can be a price discovery mechanism in an uncertain market. Chen et al. [25] and their follow-up studies ([26,27]) analyze the performance of a web-based GB auction model. Chen et al. [28] consider the inventory rationing problem for the seller based on the web-based GB. Vaghefi et al. [29] analyze the waiting time for the web-based GB auction and Luo et al. [30] study the deal popularity of the web-based GB. These studies see models similar to auctions and are based on consumer behavior, which differs from our assumptions. We hold that retailers have no purchasing uncertainty and investigate how GB influences the supply chain.

Our paper is most related to that of Chen and Roma [31]. They consider the competing retailers' choice of group buying under given quantity discount schedules. They find that under GB symmetric competing retailers (i.e., with the same market base and operational cost) always have higher profits, and the supplier also has a chance to be good. In Chen and Roma [31], the supplier offers a quantity discount schedule and keeps the same price for both individual and group purchases. We extend their model and assume the supplier acts as a Stackelberg leader and adjusts the discount level according to retailers' individual or group purchases. Due to the assumption of a different game setting, we draw different conclusions from Chen and Roma's results concerning the effects of GB on the profits of the retailers and the supplier; we suggest that under GB retailers may not always get higher profits and the supplier will always be worse off if there is no economies of scale.

Our study is also bound up with quantity discount. The literature on quantity discount mostly consists of three aspects [31]: price discrimination (e.g., [32–35]), channel coordination (e.g., [36–40]), and operating efficiency (e.g., [41–44]). Some studies focus on the designing of the quantity discount schedule to extract all or some of consumer surplus [22] (e.g., [32–35]). Some other studies discuss how quantity discounts address channel coordination under different market conditions (e.g., [36–40]) and how to improve the conflict between suppliers and retailers (e.g., [41–44]). Apart from these aspects, some studies incorporate quantity discounts to analyze the pricing or allocation problem in the supply chain (e.g. [45,46]). For more information about the literature on quantity discount, the readers can refer to Dolan [47], Weng [48], and Kanda and Deshmukh [49], where excellent reviews are provided. Similar to Chen and Roma [31], our work is also attached to channel coordination, but we further setup a dynamic game, and examine how GB, which is based on quantity discount, affects all members in the supply chain.

The rest of the paper is organized as follows. Section 2 describes the game model and derives the equilibrium outcomes. Section 3 presents comparisons and discussions. Section 4 provides three extensions: we first of all suggest a mixed discount schedule to prevent retailers from purchasing in group; we then extend the model to a case with more than two retailers; finally considering the benefits of the supplier, we introduce the economies of scale in the model of the supplier's cost, and examine the robustness of the results. Section 5 concludes the paper.

2. Model and analysis

2.1. Model

We consider a two-tier supply chain consisting of a single supplier and two retailers. The supplier sells a single product and provides a quantity discount schedule, as in the power function derived by Schotanus et al. [50]. Specifically, the unit wholesale price $w(q)$ is

$$w(q) = a + \frac{d}{q^e}, \quad de > 0, \tag{1}$$

where q is the purchase quantity, $a \geq 0$ is the base wholesale price, d scales the function, and e is the steepness. Schotanus et al. [50] show that this general discount schedule fits very well with 66 discount schedules found in practice, with e varying from -1.00 to 1.60. In general, the steepness e captures the variation tendency of the wholesale price over the purchase quantity. In particular, with positive steepness (e.g., $e = 1$, two part tariff with $w(q) = a + d/q$), the wholesale price flattens out gradually after a steep fall, while with negative steepness (e.g., $e = -1$, linear quantity discount with $w(q) = a + dq$), the wholesale price decreases persistently with the purchase quantity. In this paper, we assume the steepness e is exogenous.

For tractability, we assume the steepness $e \in [-1, 1]$. Thus, the wholesale price $w(q)$ is convex, and the total cost $w(q)q$ is concave in q. We assume $e \neq 0$ because $e = 0$ is the trivial case of no discount. In addition, under two part tariff (i.e., $e = 1$), the supplier can set the scaling parameter d where retailers have 0 profits, which is a simple case. Thus, we assume $e \neq 1$. Then, the steepness e characterizes the quantity discount schedule into two categories: positive steepness ($0 < e < 1$) and negative steepness ($-1 \leq e < 0$).

In the quantity discount schedule, $de > 0$ is required to ensure that the wholesale price decreases with purchase quantity q ([31,50]). Then, for positive steepness ($0 < e < 1$), the scaling parameter $d > 0$, and the base wholesale price a represents the theoretical minimum wholesale price (i.e., $q = \infty$). For negative steepness ($-1 \leq e < 0$), the scaling parameter $d < 0$, and a represents a theoretical maximum wholesale price (i.e., $q = 0$). The absolute value of the scaling parameter $|d|$, referred to as the discount level, reflects how quickly the wholesale price decreases with the purchase quantity. The higher the $|d|$, the more effective the demand aggregation by retailers [31]. In practice, suppliers