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Analysis of pricing strategies for community-based group buying: The impact of competition and waiting cost

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Abstract Group buying is one of the major pricing mechanisms in which retailers can offer low group rates due to a saving on transaction costs and its target consumers are those with lower sensitivity on waiting time. Under group buying, group size significantly affects the waiting cost to which consumers have different tolerances. In this paper, we develop a two-stage pricing game to evaluate the impact of the waiting cost, competition, and group-facilitating technology on the profitability and efficiency of community-based group buying. Our results point out that when a monopolistic retailer operates a mixed channel, the retailer will charge a relatively high group rates in the group-buying channel to force most consumers to choose individual buying unless the transaction cost in the individual-buying channel is sufficiently high. If two competing retailers adopt different pure channels, investment in group-facilitating technology may weaken the profit of the retailer adopting community-based group buying when the actual selling-cost saving resulted from community-based group buying is not significant.

Keywords Group buying · Channel competition · Waiting cost · IT investment

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1 Introduction

To date, many retailers offer a variety of online purchasing to meet differing consumer requirements and create more revenues from potential markets. Retailers can now sell their goods over the Internet at specific prices that change frequently depending on demand and the competition from other Web sites (Kannan and Kopalle 2001). Group buying is one of the major pricing mechanisms associated with bundling, and the incentive for retailers to offer low group rates in group-buying channels comes from a saving on the transaction cost that may be variable to the group size. For example, some U.S. ski resorts sell group tickets at a discount group rate that are considerably cheaper than individual tickets.

From the viewpoint of consumers, they can aggregate their purchasing power and obtain a special discount from retailers. While consumers have the advantage of getting goods at a lower group rate via group buying, they also face the disutilities for a group to be formed. For example, a consumer may change mind and withdraw his registration before the group is formed or break the agreement to buy the good when the group purchasing order is confirmed. Another natural inconvenience is that the consumers have to postpone getting the goods. Thus, the target consumers of group buying are those with lower sensitivity on group formation cost, which is composed of uncertainty risk and waiting cost. Because formation cost increases with the number of consumers who join the purchasing group, most consumers would prefer purchasing from other offline and online discount retailers unless the group rate is attractive enough for them. In the paper, we assume uncertainty risk can be transferred to time cost (i.e. the transaction will be completed but in delay) and use waiting time as the main formation cost. Therefore, the consumers with lower sensitivity on waiting time would purchase their goods via group buying due to low group rates, and the others with no patience would prefer individual buying.

A group-buying service can be operated by a third party, such as TeamBuy (http://www.teambuy.ca), offering various goods on its website for a certain time period and very large discounts on retailers by guaranteeing them a minimum amount of consumers. For each kind of goods sold by TeamBuy, everyone gets it only if a minimum number of consumers sign up for it by entering their purchasing information before the end of sales time. However, many of such services failed because reaching consumers has turned out to be a tough job. For example, Mercata.com and LetsBuyIt.com, two of the biggest earlier generation websites, filed for bankruptcy protection in 2001 (Tang 2008). A third, Mobshop.com, ceased its B2C operations, and fully repositioned itself as an e-commerce software licensing firm. Mark Melville, MobShop's Senior Director of Corporate Development, indicated that fierce competition on the Internet and high consumer acquisition cost are two primary factors for ceasing MobShop's group-buying services (Kauffman and Wang 2002).

Although several group-buying services provided by a third party failed, a new type of group-buying services relying on online communities has emerged. An online community is a type of social networks where people can aggregate together to share thoughts, find solutions, and pursue innovation (Brown and Duguid 2001). Like most of the group-buying services provided by a third party, community-based group buying also runs on websites. However, the goal of the platform operated by a third party is to implement group buying, but the goal of an online community is to share ideas, achieve consensus, and exchange information frequently. As a result, consumers can be easily aggregated into online communities. Accordingly, consumers under a community-based group-buying service can form a group in a shorter time than those under a group-buying service operated by a third party. That is, community-based group buying takes the advantage of online communities so that retailers can easily reach their target consumers. For example, CleanMPG.com offers "For-Sale/Wanted" in its menu, and each participant can initiate a new group-buying activity or join one of the current purchasing groups. Other communities, such as MP3Car, BikeForums, and TundraSolutions, also offer analogical functions in their boards. In CleanMPG.com, participants can click on the "Buy Now" button to pre-pay, and orders will be shipped when the minimum number of consumers has been reached. For convenience, in the present study we refer to community-based group buying as group-buying and focus on this service.

In the bricks-and-mortar world, individual buying, where retailers display the rates they ask for the good and consumers face a take-it-or-leave-it decision, has been the dominant pricing strategy (Kauffman and Wang 2002). What is the difference between individual buying and group buying? Under group buying, because information technology plays an important role to drive the network externality and enable lower operation cots, consumers become more active in the price discovery processes and lead the purchasing group to reach a satisfactory price by negotiating with retailers (Liang and Doong 1998; Muthoo 1999; Kauffman and Wang 2002). The dramatic development of information technology provides a convenient approach for group buying, compared with the difficulty of forming a large purchasing group in earlier generation sites. Consequently, based on the spirit of Web 2.0, the retailers who want to provide group-buying services can expedite the formation of a purchasing group by building or joining an online community.

1.1 Problems and motivation

Group-buying models have two varieties: one is with a fixed time period to completion of an auction, and the other is with a fixed rate that is achieved only when enough consumers participate (Kauffman and Wang 2002). Here, we focus on the latter and consider the scenario where retailers can sell the identical goods to consumers with heterogeneous disutilities and develop a variety of pricing schemes, including an individual buying, a group buying, and a mixed strategy; subsequently, we discuss and compare them under monopolistic and duopolistic market structures. Since the nature of group buying lowers consumer acquisition and inventory costs, the retailers operating group buying can utilize rate difference as an incentive to gain more sales. Although group buying incurs additional cost during group formation, the retailers can reduce this by strategic investment in group-facilitating technology. So far, there has been relatively little group-buying research dealing with the decision of IT investment. Therefore, we address the following research questions: What is optimal pricing strategy in group-buying services? What are the differences in pricing strategy in a monopolistic setting and in a duopolistic one? What is the optimal investment in group-facilitating technology, and how much should the retailers operating group buying invest? How do the characteristics of selling-cost savings affect a retailer's desire to invest in group-facilitating technology? Under which conditions will a market be efficient, and would a retailer's investment be more or less than that based on the viewpoint of social welfare (market efficiency) ?

1.2 Contributions and findings

Like Anand and Aron (2003) and Chen et al. (2007), we compare individual buying with group buying in our study. Anand and Aron (2003) find that the gains from using group buying increase as the demand heterogeneity increases. In addition, under production postponement, the profits for a monopolist from group buying dominate those under individual buying. Chen et al. (2007) indicate that group buying outperforms individual buying when economies of scale are considered or the retailer is risk-seeking.

Despite focusing on the same research objective, our findings are based on a different methodology and motivated by several distinct features of group buying. First, we consider the consumer disutility caused by group formation cost and analyze social welfare (market efficiency) under different market structures. Second, we study the impact of competition and investigate retailer reactions to each of several possible events, such as the change of transaction costs and waiting cost. Finally, we examine the relation between the degree of reduction in transaction costs and the level of investment in group-facilitating technology.

We find that using the group-buying channel in a monopolistic market would result in overinvestment in group-facilitating technology when the value of goods is sufficiently high, whereas the same setting would result in underinvestment when the value of goods is sufficiently low. In addition, we find that when one retailer operates an individual-buying channel and the other operates a group-buying channel, whether the retailer operating a group-buying channel prefers to invest more in group-facilitating technology depends on the actual selling-cost savings in group buying, compared with individual buying. Moreover, from the viewpoint of social welfare, retailers may achieve socially optimal results (i.e., a socially optimal market) when the difference in transaction costs between group buying and individual buying is about half of the maximal waiting cost.

The remainder of this paper is organized as follows. In the next section, we review prior research to highlight aspects significant to our study. In Section 3, an analytical model that stems from the consumer viewpoint is introduced. Then, the social efficiency of exploiting group buying and the optimal investment in group-facilitating technology are analyzed in Sections 4 and 5, respectively. Finally, we discuss the managerial insights of our research and provide possible future directions in Section 6.

2 Literature review

As a result of the low transportation costs required to visit a virtual store (Moe and Fader 2004) and the flexibility of the Internet for performing good searches and price comparisons, a vital concern for retailers is to understand the barriers and incentives of online purchasing and construct websites that can turn visitors into paying consumers (Venkatesh and Agarwal 2006). Bundling and group buying are two similar pricing mechanisms, but they are different in several operation features. Bundling means that two or more goods are fastened or wrapped together to be sold as one unit. That is, a consumer can buy multiple goods with a certain price, which is, in general, lower than the total price for purchasing separately. Unlike bundling, group buying means that each consumer buys one unit of goods, but they form a purchasing group to buy the goods. From the perspective of retailers, they just sell multiple units once a time under bundling and group buying; however, from the perspective of consumers, they receive one unit of goods under group buying but multiple units of goods under bundling. Although consumers have more flexibility under group buying, they incur inconvenience cost due to waiting time. Subsequently, we compare the findings and problems in the bundling literature with ours as follows.

2.1 Bundling

Much of the academic literature focusing on the conditions under which bundling is optimal for a retailer enjoying a monopoly in bundling strategy is rooted in seminal work developed by Adams and Yellen (1976). In their seminal work, the monopolistic retailer sells two different goods, and each consumer desires at most one unit of each good. By employing their work, Schmalensee (1984) studies the optimality of bundling for the special case of a joint normal distribution of reservation values. McAfee et al. (1989) enhance the seminal work by considering the case in which the monopolist can and cannot monitor the purchases of consumers.

Most of these bundling articles assume that a consumer's reservation price for the bundle equals the sum of his/her separate reservation prices for the individual goods. Thus, Venkatesh and Kamakura (2003) examine contingent valuations by considering that a consumer's reservation price for the bundle is higher or lower than the sum of his/her separate reservation prices for the individual goods. In the bundling strategy examined by Geng et al. (2005), consumers' average value for information goods declines with the number consumed. Basu and Vitharana (2009) consider the distribution of reservation prices of goods over the consumer population and posit that consumer knowledge of goods affects this distribution.

Recent literature (Carbajo et al. 1990; Matutes and Regibeau 1992; Chen 1997; Ghosh and Balachander 2007) has studied the bundling strategies of oligopolistic retailers. Most of them identify conditions under which one or both of the duopolistic retailers may or may not resort to bundling. However, there are several differences between our approach and existing literature. First, if a retailer is in a monopolistic market, bundling literature considers either that each consumer can buy multiple units of goods or that the retailer can sell multiple types of goods. On the contrary, in the present study, each consumer in the group-buying service can buy at most one unit of goods, and each good sold by the monopolistic retailer is identical. Therefore, although bundling literature considers that consumer's reservation price can be affected by the number of goods, consumer's knowledge, and other factors, consumers in the group-buying service are major affected by waiting cost. Second, if retailers are in a duopolistic market, most bundling literature commonly considers that different retailers can sell various goods, which may lead to the consideration of compatibility. However, we consider that the two retailers sell the identical goods; therefore, the present study focuses on the impact of waiting cost and group-facilitating technology on the profitability and efficiency of group buying.

2.2 Group buying

Group buying is different from traditional bundling because the group of consumers plays the most important role in group buying and all consumers have to wait until the group size cumulatively attains a certain level. In addition, a consumer is allowed to buy one unit of goods in group buying, but a consumer buys a bundle of goods at a single price in traditional bundling. The work of Kauffman and Wang (2001), the pioneer studying in group-buying mechanisms, empirically analyzes patterns of bidder behavior that were collected from MobShop.com. They propose two of key observations on group buying that emerged from their empirical analysis. First, the number of existing orders stimulates new bidders' willingness to place their orders, forming a network externality (Katz and Shapiro 1985; Shapiro and Varian 1998). Therefore, consumers who bid early induce other consumers to bid (Anand and Aron 2003) and retailers can raise demand and enhance their revenues by utilizing discounts.

Second, when the chance of price reduction is forthcoming and wait-and-see consumers believe that their purchase action can facilitate the realization of a quantity discount, the motivation to place the order become stronger. In addition, from the viewpoint of economics, Anand and Aron (2003) analyze a monopolist's optimal group-buying schedule in comparison with an individual-buying approach. Their analysis confirms that when production costs are sunk, group buying cannot outperform individual buying when demand uncertainty has vanished. However, when production can be dynamically adjusted to meet revealed demand, the profit from group buying will dominate that of individual buying for a monopolist under production postponement.

The operational principle of group buying is based on quantity discounts, which can be classified into two categories: (i) incremental quantity discounts and (ii) all-unit quantity discounts (Johnson and Douglas 1974; Dolan 1987). In fact, based on the assumption that retailers have complete knowledge of consumer information, the optimal all-unit quantity discount policy is equivalent to the optimal incremental quantity discount policy (Weng 1995). The function of quantity discounts is to implement price discrimination and improve transaction efficiency (Kohli and Park 1989). Because their operation costs will be reduced with larger orders, many retailers frequently use quantity discounts as incentive schemes in their pricing policies (Monahan 1984; Dada and Srikanth 1987; Corbett and Groote 2000).

Heretofore, there are many studies examining group buying but few studies focusing on the same research objective as the one in this study (Anand and Aron 2003; Chen et al. 2007; Chen et al. 2010). Compared with the extant study regarding bundling and group buying, our research has the following different features. First, we consider that consumers have heterogeneous disutilities resulted from the inconvenience cost for a group to be formed and their preferences are decreasingly differentiated according to individual patience. Second, we evaluate the impact of waiting cost, competition and group-facilitating technology on the profitability and efficiency of community-based group buying.

3 The model

Here, we use a variation of the Hotelling-type linear city model (Hotelling 1929) to formulate a two-stage pricing game in which retailers announce rates in stage one and consumers choose their preferable purchasing channels in stage two. A large number of surveys about this can be found in the study by Greenhut et al. (1987). In our scenario, we first consider a monopolistic market and then extend our model to a duopolistic setting. The total number of consumers in a market is denoted as η_0 and each consumer buys at most one unit of goods. Following prior study (Chun and Kim 2005; Fan et al. 2007–2008; Fan et al. 2009), we assume that consumers have homogenous valuation of V for the good. While the setting is mainly for analytical convenience, it can be applied to some commodities on which the heterogeneity of individual valuation is not significant.

There are two ways for retailers to sell their goods: one is to sell single units by individual buying, whereas the other is to sell a large bundle of units by group buying. That is, each consumer can choose to buy the good directly with an individual rate (i.e., from an individual-buying channel) or join a purchasing group to buy the good at a group rate (i.e., from a group-buying channel). Therefore, we may denote the total number of consumers who buy the goods from an individual-buying channel and from a group-buying channel as η_I and η_G (i.e., $\eta_I+\eta_G=\eta_0$), respectively. Furthermore, consumers who choose to participate in the purchasing group need to wait until the group reaches the targeted size.

We let p_I denote the individual rate in an individual-buying channel, and p_G the group rate in a group-buying channel with bundle size η_G (see Table 1 for a complete list of notations). Similarly, we denote the transaction cost per unit as c_I for individual-buying goods, and c_G for group-buying goods.[1] Therefore, the profits gained from the individual-buying channel and group-buying channel can be written as $(p_I - c_I)\cdot\eta_I$ and $(p_G - c_G)\cdot\eta_G$, respectively. In addition, there exists a waiting cost for the consumers who participate in the formation of a purchasing group. We assume that individual waiting cost in the purchasing group with size η_G is $\delta_i\beta\eta_G$, where β is the level of time value and δ_i is consumer's sensitivity to the waiting time

Here, we let consumer disutility be uniformly distributed within a unit interval. Consequently, a consumer i with higher δ_i has a higher level of impatience. In order to compensate each consumer for transaction loss due to the inconvenience, the retailer operating a group-buying channel must reduce its rate as an incentive to persuade consumers to buy the good from his/her channel. Therefore, if the value of goods, denoted as V, is higher than each consumer's payment, everyone buys the good in equilibrium. Consequently, the utility of a typical consumer i is given by

$$U_i = \begin{cases} V - p_I, & \textit{if customer i chooses individual buying} \\ V - \beta\eta_G\delta_i - p_G, & \textit{if customer i chooses group buying} \end{cases} \tag{3.1}$$

[1] Indeed, the transaction cost for group-buying goods should be a function of the amount of consumers in the group-buying channel. However, because of the degree of complexity resulted from the consideration, we adopt a fixed transaction cost for group-buying goods to derive analytical solutions.

3.1 Demand functions

In this section, we consider three types of channel configurations as follows. First, if only an individual-buying channel is provided, then all consumers buy the good (i.e., $\eta_I=\eta_0$, for all $p_I < V$). Second, if only a group-buying channel is provided, then the consumers with $\delta_i \le \sqrt{(V-p_G)/(\beta\eta_0)}$ will buy the good.[2] Hence, the demand function of the group-buying channel is given by $\eta_G = \sqrt{(V-p_G)\eta_0/\beta}$. Finally, if both channels coexist in a market, the market-segmentation condition is given by $V - p_I = V - p_G - \beta\cdot\eta_G\cdot\widehat{\delta}$, where the consumer with impatience index $\widehat{\delta}$ is indifferent between the channels. Consequently, the consumers with $\delta_i < \widehat{\delta}$ will select the group-buying channel and the others will choose the individual-buying channel. The market shares of these two channels are $\eta_I = (1-\widehat{\delta})\eta_0$ and $\eta_G = \widehat{\delta}\eta_0$, where $\widehat{\delta}$ is given by $\sqrt{(p_I-p_G)/(\beta\eta_0)}$. As a result, the demand functions of the individual-buying channel and group-buying one are given by

$$\eta_I = \eta_0 - \sqrt{(p_I-p_G)\eta_0/\beta},\ \eta_G = \sqrt{(p_I-p_G)\eta_0/\beta} \tag{3.2}$$

3.2 Monopolistic market

For a monopolistic market, we consider three types of channels that a monopolistic retailer could offer: an individual-buying channel, a group-buying channel, and a mixed channel (i.e., both channels are offered simultaneously). If the monopolistic retailer provides an individual-buying channel, it will set the individual rate for a good to be $p_I = V$. All surplus of the consumers is extracted and all consumers buy the goods (i.e., $\eta_I = \eta_0$). Therefore, the retailer's profit is $\pi_m^I = (V-c_I)\eta_0$. If only a group-buying channel is offered, the retailer's profit-maximization problem is given by

$$\max_{p_G} \pi_m^G = (p_G - c_G)\eta_G = (p_G - c_G)\sqrt{(V-p_G)\eta_0/\beta} \tag{3.3}$$

Solving $\partial\pi_m^G/\partial p_G = 0$ yields the optimal group rate, which is given by $p_G^* = (2V + c_G)/3$. In addition, the optimal group rate p_G^* would be $V-\beta\eta_0$ when

[2] Solving the following mathematical program yields the upper bound where consumers would buy the good when his/her disutility cost δ_i is less than it:

$$\begin{aligned} &Max\ \ \delta_i \\ &s.t. \\ &V - \beta\eta_G\delta_i - p_G \ge 0 \\ &where\ 0 \le \delta_i \le 1,\ and\ \eta_G = \eta_0\delta_i \end{aligned}$$

Table 1 Definition of notation

Notation	Description
$p_I(p_G)$	The individual rate (group rate)
$c_I(c_G)$	The unit cost of a good sold through an individual-buying (group-buying) channel
η_0	The total number of consumers in a market
$\eta_I(\eta_G)$	The number of consumers in an individual-buying (a group-buying) channel
β	The level of time value
δ_i	The consumer i's sensitivity to the waiting time
V	The value each consumer receives if he/she does buy a good
$\pi_m^I(\pi_m^G, \pi_m^{I+G})$	The profit of a monopolistic retailer providing an individual-buying channel (a group-buying channel, a mixed channel)
$\pi_c^I(\pi_c^G)$	The profit of a retailer providing an individual-buying channel (a group-buying channel) in a duopolistic market
$W_m^I(W_m^G)$	The social welfare of a monopolistic retailer providing an individual-buying (a group-buying) channel
$W_m^{I+G}(W_c^{I+G})$	The social welfare of a monopolistic (duopolistic) retailer providing g a mixed channel
$W_w^I(W_w^G, W_w^{I+G})$	The social welfare of a socially optimal market providing an individual-buying channel (a group-buying channel, a mixed channel)

$V - c_G \geq 3\beta\eta_0$. That is, when the value of goods is sufficiently high, a monopolistic retailer operating the group-buying channel can set the optimal group rate directly according to market size and waiting cost, not the consumer demand function. Therefore, the profit and demand of the group-buying channel is given by

$$[\eta_G, \pi_m^G] = \begin{cases} \left[\sqrt{(V - c_G)\eta_0/(3\beta)}, 2\sqrt{\eta_0/\beta}((V - c_G)/3)^{1.5}\right], & \textit{if } V - c_G < 3\beta\eta_0 \\ [\eta_0, (V - \beta\eta_0 - c_G)\eta_0] & \textit{if } V - c_G \geq 3\beta\eta_0 \end{cases} \tag{3.4}$$

Finally, if a mixed channel is provided by the monopolistic retailer, his/her profit-maximizing problem is given by

$$\max_{p_I, p_G} \ \pi_m^{I+G} = \pi_m^I + \pi_m^G = (p_I - c_I) \cdot \left(\eta_0 - \sqrt{(p_I - p_G)\eta_0/\beta}\right) + (p_G - c_G) \cdot \sqrt{(p_I - p_G)\eta_0/\beta} \tag{3.5}$$

Then, plugging the optimal rates, $p_I^* = V$ and $p_G^* = V - (c_I - c_G)/3$, into the demand functions (3.2) and profit function (3.5) yields

$$\eta_G = \sqrt{(c_I - c_G)\eta_0/(3\beta)}, \eta_I = \eta_0 - \eta_G \tag{3.6}$$

$$\pi_m^{I+G} = (V - c_I)\eta_0 + 2\sqrt{\eta_0/\beta}((c_I - c_G)/3)^{1.5} \tag{3.7}$$

From the viewpoint of a monopolistic retailer, if $c_G > c_I$ holds, then the profits for the monopolistic retailer from individual buying dominate those under group buying due to waiting cost.

Proposition 1 (*Monopolistic market*)

(1) If $c_G < c_I < 3\beta\eta_0 + c_G$ holds, then the monopolistic retailer always generates more profit from the mixed channel than the other pure channels, and the extra profit is convexly increasing with the degree of reduction in transaction cost. Moreover, the mixed channel degenerates to an individual-buying channel when $c_I = c_G$ and degenerates to a group-buying channel when $c_I = 3\beta\eta_0 + c_G$.

(2) In the mixed channel, the individual rate will be set as high as possible, whereas the group rate decreases with the level of its selling-cost saving under group buying. Formally, $p_I^* = V$ and $p_G^* = V - (c_I - c_G)/3$.

The monopolistic retailer's optimal strategy is shown in Fig. 1. We find that when the transaction costs of both channels are the same, the monopolistic retailer cannot gain more profit by group buying due to its absolute inferiority. Similarly, when the degree of reduction in transaction cost is sufficiently high, the monopolistic retailer would close its individual-buying channel because the saving of transaction cost in the group-buying channel dominates the additional benefit derived from offering an individual-buying channel. Moreover, we find that in the monopolistic market, the optimal bundle size of goods sold in a pure group-buying channel is larger (smaller) than that in a mixed channel. Also, because of the characteristics of a monopoly, the profit gained from the group-buying channel can be enhanced by reducing consumer's waiting time.

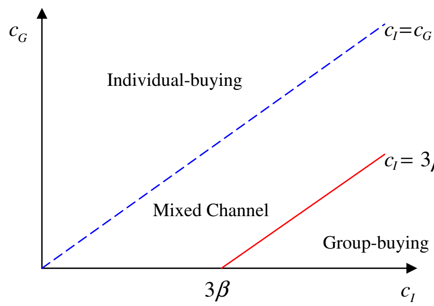

Fig. 1 The monopolistic retailer's optimal strategy

3.3 Duopolistic market

Subsequently, we extend the pricing model to a duopolistic market where there are two competitive retailers. To date, Walmart (RIS News 2009), earning nearly five times more than the second largest retailer in U.S., still operates its individual-buying channel and there is no conspicuous evidence to show that it would involve group buying in its pricing strategy. Meanwhile, Groupon.com (McCarthy 2009), a pure group-buying site competing against Wal-Mart for consumer goods and electronics, had reached profitability in June 2009, just 6 months after launching its service, and plans to do $100 million in gross merchandise sales in 2010. Therefore, the practical evidence enables us to emphasize the most important scenario in which one retailer operates an individual-buying channel and the other operates a group-buying channel. The other possible scenarios in the duopolistic setting and a sequential setup can be found in the Appendix.

If one retailer operates an individual-buying channel and the other operates a group-buying channel, the equilibrium rates, demands, and profits are given as follows:

$$p_I^* = c_G + (3\beta\eta_0/25)(1 + \sqrt{1 + 5(c_I - c_G)/(\eta_0\beta)})^2 \tag{3.8}$$

$$p_G^* = c_G + (2\beta\eta_0/25)(1 + \sqrt{1 + 5(c_I - c_G)/(\eta_0\beta)})^2 \tag{3.9}$$

$$\eta_I = 4\eta_0/5 - (\eta_0/5)\sqrt{1 + 5(c_I - c_G)/\eta_0\beta} \tag{3.10}$$

$$\eta_G = \eta_0/5 + (\eta_0/5)\sqrt{1 + 5(c_I - c_G)/(\eta_0\beta)} \tag{3.11}$$

$$\pi_c^I = (p_I^* - c_I)(\eta_0/5)(4 - \sqrt{1 + 5(c_I - c_G)/(\eta_0\beta)}) \tag{3.12}$$

$$\pi_c^G = (2\beta\eta_0^2/125)(1 + \sqrt{1 + 5(c_I - c_G)/\eta_0\beta})^3 \tag{3.13}$$

These results show that the incentive (i.e., $p_I^* - p_G^*$) increases with consumer's waiting cost, market size, and the level of selling-cost savings. If the saving of transaction cost in the group-buying channel is very small ($c_I \approx c_G$), then the above results become $p_I^* \approx c_G + \frac{12}{25}\beta\eta_0, \eta_I^* \approx \frac{3}{5}\eta_0, \pi_c^I \approx \frac{36}{125}\beta\eta_0^2, p_G^* \approx c_G + \frac{8}{25}\beta\eta_0, \eta_G^* \approx \frac{2}{5}\eta_0$ and $\pi_c^G \approx \frac{16}{125}\beta\eta_0^2$.

Proposition 2 (*Duopolistic market*)

(1) If one retailer operates an individual-buying channel and the other operates a group-buying channel,[3] the individual rate increases with the level of β.
(2) The profit of individual buying increases with the level of β. In addition, the profit of group buying increases with the level of β when $\beta > \underline{\beta}$ but decreases with the level of β when $\beta < \underline{\beta}$, where $\underline{\beta} = 0.625(c_I - c_G)/\eta_0$.

If one retailer operates an individual-buying channel and the other operates a group-buying channel, we have an interesting finding as follows. When the saving of transaction cost in the group-buying channel is sufficiently small, both retailers' profits increase with β. Intuitively, the profit of the retailer operating the individual-buying channel increases with the level of β; however, it is counterintuitive that the profit of the retailer operating the group-buying channel also increases with the level of β. The counterintuitive result only arises when the level of β is so small that both retailers fall into the trap of Bertrand competition.

The reason for the counterintuitive result is as follows. Indeed, by investing in virtual communities, the retailer operating the group-buying channel can boost market share by reducing waiting cost. In the case, the retailer operating the individual-buying channel would decrease its individual rate to attract consumers. Notice that the group rate is always less than the individual rate. Consequently, when the difference in the transaction costs between the group-buying and individual-buying services is very small, the profit of the retailer operating the group-buying channel would be significantly affected by the low individual rate.

In fact, examining $\partial\pi_c^G/\partial\beta$, we know that the profit of the retailer operating the group-buying channel increases with the level of β when $\beta > \underline{\beta}$ and decreases with the level of β when $\beta < \underline{\beta}$. In other words, when the saving of transaction cost in the group-buying channel is significant, the retailer operating the group-buying channel faces an important decision: Should it augment investment in virtual communities to reduce consumer's waiting cost? This question is analyzed in Section 5.

[3] Because of the effect of Bertrand competition, if both retailers operate the same type of channels, the profit in a group-buying channel is larger than that in a mixed channel, whereas the profit in a mixed channel is larger than that in an individual-buying channel.

4 Analysis of market efficiency

In this section, we analyze the social welfare (market efficiency) of various channels in monopolistic and duopolistic markets and compare them with socially optimal results. Here, we consider three cases: (i) a monopolistic retailer operating a mixed channel, (ii) one retailer operating an individual-buying channel and the other operating a group-buying channel, and (iii) a socially optimal market operating a mixed channel. The social welfare of a market is defined as a summation involving retailers' profits and consumers' surplus, which is given by

$$W = \pi_I + \pi_G + \sum_i^n U_i \tag{4.1}$$

where the variable n represents the number of consumers purchasing the goods. Since all related analytic results were derived from Section 3, we can list the social welfare levels with respect to corresponding cases as follows:

(1) A monopolistic retailer operating a mixed channel:

$$\begin{aligned} W_m^{I+G} &= \pi_I + \pi_G + \sum_i^n U_i \\ &= (V - c_I)\eta_0 + 2.5\sqrt{\eta_0/\beta}((c_I - c_G)/3)^{1.5} \end{aligned} \tag{4.2}$$

(2) One retailer operating an individual-buying channel and the other operating a group-buying channel:

$$W_c^{I+G} = (V - c_I)\eta_0 - \beta\eta_G^3/2\eta_0 + (c_I - c_G)\eta_G \tag{4.3}$$

Thus, we make Proposition 3 to highlight our findings from the above results.

Proposition 3 (*Efficiency of a Mixed Channel in a Monopolistic Market*)

The social welfare (market efficiency) of a mixed channel in a monopolistic market would decrease (increase) with the transaction cost of the individual-buying channel when $c_I < c_G + 1.92\beta\eta_0 (c_I > c_G + 1.92\beta\eta_0)$ holds.

Surprisingly, we find that the social welfare of the mixed channel in a monopolistic market may increase with the transaction cost of its individual-buying channel when $c_I > c_G + 1.92\beta\eta_0$, as shown in Fig. 2. The reason for this counterintuitive result is demonstrated as follows. First, the monopolistic retailer's best strategy is to keep the highest individual rate (i.e., $p_I = V$) and set the group rate according to the difference of transaction costs. Therefore, even if some consumers with lower sensitivity on waiting time could have higher utilities from the group-buying channel, the monopolistic retailer would charge a sufficiently high group rate so as to prevent these consumers from purchasing group-buying goods. Obviously, the social welfare can be enhanced by lowering the group rate. Therefore, when the transaction cost of the individual-buying channel is higher than a specific threshold, the retailer has to significantly decrease the group rate to attract more consumers to buy group-buying goods. In the case, more consumers with lower sensitivity on waiting time could buy low price goods from the group-buying channel. Therefore, the social welfare would increase with the transaction cost of the individual-buying channel because consumers' increased utilities would be higher than retailer's loss.

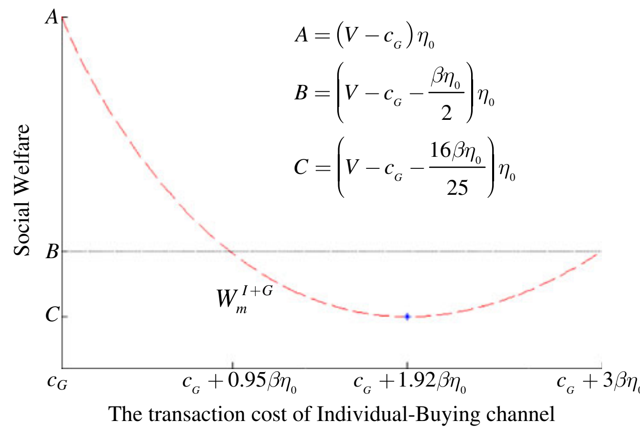

Fig. 2 Social welfare (individual buying plus group buying, c_G is fixed)

A socially optimal market is an ideal market whose social welfare is maximal. Thus, the social welfare of a socially optimal market operating a mixed channel can be derived as follows.

$$\begin{aligned} \underset{\eta_I,\eta_G}{Max}\; W_w^{I+G} &= \pi_I + \pi_G + \sum_i^n U_i \\ &= (p_I - c_I)\eta_I + (V - p_I)\eta_I + (p_G - c_G)\eta_G \\ &\quad + (V - p_G)\eta_G - (\beta\eta_G E[\delta])\eta_G \\ &= V - (\beta\eta_G E[\delta])\eta_G - \eta_I c_I - \eta_G c_G \end{aligned} \tag{4.4}$$

where $\delta \in [0, \eta_G/\eta_0]$ is a uniform random variable.

Solving the above program yields the corresponding demands which are given by

$$\eta_G = \sqrt{2(c_I - c_G)\eta_0/(3\beta)}\ , \text{ and } \eta_I = \eta_0 - \eta_G \tag{4.5}$$

As a result, by plugging these demands into the social welfare Eq. (4.4) yields W_w^{I+G}, which is given by

$$W_w^{I+G} = (V - c_I)\eta_0 + \sqrt{\eta_0/\beta}(2(c_I - c_G)/3)^{1.5} \tag{4.6}$$

Proposition 4 (*Socially optimal Market*)

(1) In a socially optimal market, the social welfare (market efficiency) of a mixed channel is higher than that of the other pure channels when $c_G < c_I < 1.5\beta\eta_0 + c_G$.

(2) When one retailer operates an individual-buying channel and the other operates a group-buying channel and the difference in transaction costs between group buying and individual buying is about half of the maximal waiting cost, then the social welfare (market efficiency) in this case is the same as that in a socially optimal market operating a mixed channel. Formally, ${W_c}^{I+G} = W_w^{I+G}$ when $c_I - c_G \approx 0.49\beta\eta_0$.

When one retailer operates an individual-buying channel and the other operates a group-buying channel, as shown in Fig. 3, the retailer operating a group-buying channel would oversupply the goods until the difference of transaction costs goes beyond half of the maximal waiting cost. On the contrary, the monopolistic retailer operating a mixed channel would undersupply the goods sold in the group-buying channel until he/she terminates the individual-buying channel.

5 Investment of information technology

A monopolistic group-buying retailer can enhance its profitability by investing in virtual communities so as to reduce waiting cost. Therefore, the retailer should make a proper investment in its IT department or determine an ideal budget for outsourcing related work. In this section, we address the following research questions: What is the optimal investment? Is the investment in a monopolistic setting or a duopolistic one higher (or lower) than that in a socially optimal market? In order to answer these questions, below, we present our formulation and assumptions of the model with respect to the IT investment decision. First, before the rates of the goods are chosen, the retailer operating a group-buying channel needs to decide how much to invest in group-facilitating technology. The development cost is defined as $c_d(\omega)$, where ω represents the level of investment in group-facilitating technology. Moreover, we associate the level of investment with waiting cost by defining $\beta = \psi(\omega)$, where its first order condition should be less than zero to indicate that the waiting cost can be reduced by investment in group-facilitating technology.

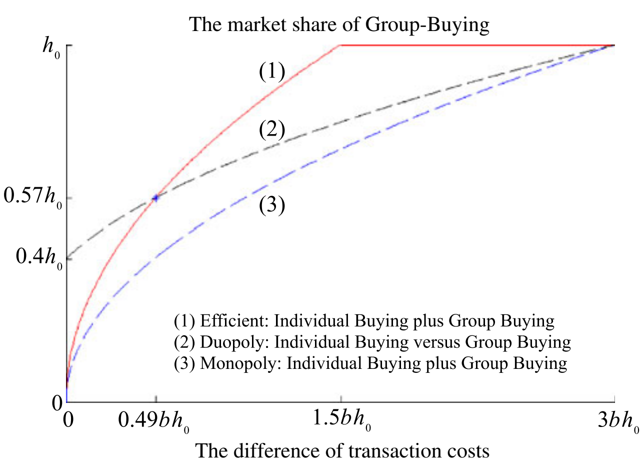

Fig. 3 Market shares of group-buying under different market structures

For the sake of simplicity, we directly associate the waiting cost with the IT development cost. That is, we denote $T(\beta) = c_d(\psi^{-1}(\beta))$ as the IT development cost, where $\partial T/\partial\beta < 0, \partial^2 T/\partial\beta^2 > 0$, and $T(0) = \infty$. Because initiating a group-buying channel requires a substantial spending (e.g., for a web server), we assume $\overline{\beta}$ as the waiting cost resulted from the spending (i.e., the minimal development cost). In other words, the retailer can choose the simplest investment in group-facilitating technology, which incurs $\overline{\beta}$, or invest more in IT equity, which results in a smaller β, where $\beta < \overline{\beta}$. Moreover, $\partial^2 T/\partial\beta^2 > 0$ and $T(0) = \infty$ represents the difficulty of lowering consumer's waiting cost, which results from what psychological factors, such as trust, cannot be enhanced easily by using group-facilitating technology.

Consequently, each retailer's profit can be rewritten as $Max\ \widehat{\pi} = \pi(\beta) - T(\beta)$, whereas the social welfare (market efficiency) in a socially optimal market can be rewritten as $Max\ \widehat{W} = W(\beta) - T(\beta)$. All $\pi(\beta)$ and $W(\beta)$, depending on different market types and channel classes, can be found in Sections 3 and 4.

Corollary 1 *When the value of goods is sufficiently high (low), regarding a pure group-buying channel, the investment in group-facilitating technology in a monopolistic market is higher (lower) than that in a socially optimal market.*

Corollary 1 shows that the group-buying channel in a monopolistic setting would result in overinvestment when the value of goods is sufficiently high, whereas the same setting would result in underinvestment when the value of goods is sufficiently low. Similarly, considering a mixed channel by the same analysis technique, we also find that the investment in group-facilitating technology in a monopolistic market is lower than that in a socially optimal market. Moreover, regarding a duopolistic setting, from Proposition 2 we determined that the profit of a retailer operating a group-buying channel is a convex function with the parameter β. Thus, considering the aspect of IT development cost, we give the following corollary.

Corollary 2 *In a duopolistic setting, if one retailer operates an individual-buying channel and the other operates a group-buying channel, the retailer operating a group-buying channel may choose the simplest investment* *in group-facilitating technology when the marginal development cost is sufficiently high; otherwise, the retailer prefers to invest T(β*), where β* < $\underline{\beta}$.*

Corollary 2 shows that reducing waiting cost would lead to price competition at the very start of the contest. Therefore, when the marginal IT development cost is sufficiently high, in order to save cost and prevent rival retailers from cutting price, the retailer operating a group-buying channel would plan to invest the minimum amount $T(\overline{\beta})$. However, ignoring the impact of the IT development cost, the profit of the retailer operating group buying would increase by reducing consumer's waiting cost β when $\beta < \underline{\beta}$. Therefore, the retailer operating a group buying channel may consider investing more in group-facilitating technology when the amount of $c_I - c_G$ is significant. That is, in a duopolistic setting, whether the retailer prefers to invent more in group-facilitating technology depends on the actual selling-cost savings from operating group buying.

6 Conclusion

In this paper, we have developed an economic model to evaluate the impact of group-buying channels on the profitability and efficiency of electronic commerce. In our model, we highlight the importance of information technology because it expedites the formation of a group and reduces waiting cost. Interestingly, the pricing strategy of the mixed channel in a monopolistic market and in a socially optimal market is independent of the factor of information technology. However, in a duopolistic market, if one retailer operates an individual-buying channel and the other operates a group-buying channel, our results show that the retailer operating a group-buying channel prefers the simplest investment in group-facilitating technology unless the actual selling-cost saving resulted from operating a group-buying service is significant, which is contrary to the result in a monopolistic market. Indeed, advancement of information technology creates additional commercial chances; nevertheless, businesses conducting electronic commerce also face the challenges of traditional competition. Therefore, they should differentiate their goods from these of competitors by concentrating on various attributes other than price.

In a monopolistic market, we find that group buying is mainly used to reduce transaction (operation) costs; however, in a competitive market, the function of group buying is not significant when multiple retailers operate the same channels. In addition, due to the effect of competition, we suggest that retailers operating group-buying services may register on third party websites and maintain a relatively high price because they can monitor their competitors easily. To date, many websites in China, known as "tuangou", offer this service. For example, Teambuy.com.cn offers a common online space in which many retailers implement group buying.

In our model, we assume that the valuation of goods is homogeneous for all consumers. Therefore, investigating the corresponding pricing strategies regarding heterogeneous valuation is a potential future extension. In addition, it is worthy to further study how IT investment changes the demand structure of the market, which would subsequently change the strategies under different market structures. Beyond the investigation of single bundle size in a group-buying channel, an interesting topic for future research is to study the provision of multiple bundle size, where a retailer can provide several bundle sizes for various purchasing groups. Moreover, the transaction cost of group buying is assumed to be an exogenous parameter in this paper; in other words, we simplify the relation between transaction cost and group size. Obviously, the total order processing cost will depend on batch sizes (number of batches). That is, the production side may also save on setup costs. Thus, it is important to identify the sources of transaction cost savings. Also, the model can benefit from a more consistence characterization of consumer arrival. That is, we can further consider a continuous arrival process, in which case consumers who arrive late will wait less.

Finally, in the present study, in either a monopolistic or duopolistic market, if each consumer can decide to buy his/her good through group buying or individual buying, the group size decreases with the value of time and increases with the selling-cost saving. However, if the monopolistic retailer only offers group buying, the group size will decrease with the value of time but increase with the value of goods. In order to more accurately examine the optimal group size, these findings regarding the group size can be further examined by exploring the case in which the transaction cost of group buying decreases with the group size and consumers are heterogeneous in valuation of goods.

Appendix

Appendix 1 (The other possible scenarios in the duopolistic setting)

For the convenience of discussion, the total 9 scenarios are shown in the following table. Due to symmetry, the number of the scenarios in the duopolistic setting can be reduced to 6: (i) (Individual-buying vs. Individual-buying), (ii) (Group-buying vs. Group-buying), (iii) (Mixed vs. Mixed), (iv) (Individual-buying vs. Mixed), (v) (Individual-buying vs. Group-buying), and (vi) (Group-buying vs. Mixed). Subsequently, we will show that there are only two possible types of Nash equilibria: (v) (Individual-buying vs. Group-buying) or (vi) (Group-buying vs. Mixed). Each of the other scenarios ((i)–(iv)) is never a Nash equilibrium because one of the retailers would receive a higher profit by choosing other types of channels.

		Retailer 2		
		Individual-Buying Channel	Group-Buying Channel	Mixed Channel
Retailer 1	Individual-Buying Channel	$\pi_1^{I,I}, \pi_2^{I,I}$	$\pi_1^{I,G}, \pi_2^{I,G}$	$\pi_1^{I,I+G}, \pi_2^{I,I+G}$
	Group-Buying Channel	$\pi_1^{G,I}, \pi_2^{G,I}$	$\pi_1^{G,G}, \pi_2^{G,G}$	$\pi_1^{G,I+G}, \pi_2^{G,I+G}$
	Mixed Channel	$\pi_1^{I+G,I}, \pi_2^{I+G,I}$	$\pi_1^{I+G,G}, \pi_2^{I+G,G}$	$\pi_1^{I+G,I+G}, \pi_2^{I+G,I+G}$

(i) Individual-buying vs. Individual-buying: Because of the effect of Bertrand competition, we have $p_1^{I,I} = p_2^{I,I} = c_I$. That is, both retailers can receive $\pi_1^{I,I} = \pi_2^{I,I} = 0$. Thus, this scenario cannot be an equilibrium because either retailer has incentive to deviate by choosing other channels.

(ii) Group-buying vs. Group-buying: This scenario cannot be an equilibrium because either retailer has incentive to choose mixed channels to receive additional profit from an individual-buying channel. Notice that in this scenario, including an additional new individual-buying channel will not affect the original revenue derived from the group-buying channel because the individual-buying channel mainly serves the consumers who never purchase group-buying goods due to very small patience in waiting.

(iii) Mixed vs. Mixed: In this scenario, the equilibrium individual rates are $p_1^{I+G,I+G} = p_2^{I+G,I+G} = c_I$ due to Bertrand competition. In addition, the low individual rates (cost equivalent) in individual-buying channels will push the group rates for group-buying goods lower and result in lower revenue derived from group-buying channels. Therefore, this scenario cannot be an equilibrium because either retailer can be better off by choosing a pure group-buying channel.

(iv) Individual-buying vs. Mixed: In this scenario, the equilibrium individual rates are $p_1^{I,I+G} = p_2^{I,I+G} = c_I$ due to Bertrand competition so that the retailer adopting an individual-buying channel will earn a zero profit. Thus, this scenario cannot be an equilibrium because the individual-buying retailer will be better off if it switches to adopt a group-buying channel.

Therefore, we can only compare (v) (Individual-buying vs. Group-buying) with (vi) (Group-buying vs. Mixed). Obviously, in order to avoid Bertrand competition, when one retailer chooses an individual-buying channel, the other retailer always chooses a group-buying channel to respond. On the other hand, when one retailer chooses a group-buying channel, the other retailer won't choose a group-buying channel to respond because it can gain a higher profit by choosing a mixed channel to receive additional profit from an individual-buying channel. Thus, we have the following conditions. First, (Individual-buying vs. Group-buying) will be a Nash equilibrium if the condition $\pi_2^{G,I} > \pi_2^{G,I+G}$ holds. Second, (Group-buying vs. Mixed) will be a Nash equilibrium if the condition $\pi_2^{G,I} < \pi_2^{G,I+G}$ holds. Because of the complexity, the closed forms of the profits for the retailers in (vi) (Group-buying vs. Mixed) are unobtainable. However, our extensive numeric simulation exhibits that the equilibrium (Individual-buying vs. Group-buying) exist when the level of time value (waiting cost) β is sufficiently large and the difference in transaction costs between individual buying and group buying is sufficiently small. The intuition can be explained as while adopting mixed channels can gain an additional profit derived from a group-buying channel, the extra profit, however, sometimes cannot fully compensate the loss of individual buying resulted from decreasing the demand of individual buying.

Appendix 2 (Sequential Competition)

In fact, we may utilize a sequential game in which the retailer operating an individual-buying channel moves first and then the retailer operating a group-buying channel moves next. The equilibrium rates, demands, and profits in the sequential game are given as follows:

$$\begin{aligned}
p_I^* &= c_G + (\beta\eta_0/3)\left(1 + \sqrt{1 + (c_I - c_G)/(\eta_0\beta)}\right)^2,\\
p_G^* &= c_G + (2\beta\eta_0/9)\left(1 + \sqrt{1 + (c_I - c_G)/\eta_0\beta}\right)^2,\\
\eta_I &= 2\eta_0/3 - (\eta_0/3)\sqrt{1 + (c_I - c_G)/(\eta_0\beta)},\\
\eta_G &= \eta_0/3 + (\eta_0/3)\sqrt{1 + (c_I - c_G)/(\eta_0\beta)},\\
\pi_c^I &= \left(c_G + (\beta\eta_0/3)\left(1 + \sqrt{1 + (c_I - c_G)/(\eta_0\beta)}\right)^2 - c_I\right)\\
&\quad \cdot\left(2\eta_0/3 - (\eta_0/3)\sqrt{1 + (c_I - c_G)/(\eta_0\beta)}\right),\\
\pi_c^G &= (2\beta\eta_0^2/27)\left(1 + \sqrt{1 + (c_I - c_G)/(\eta_0\beta)}\right)^3.
\end{aligned}$$

It is straightforward to verify that the findings (i.e., the signs of $\partial p_I^*/\partial\beta, \partial p_G^*/\partial\beta, \partial\pi_c^I/\partial\beta$ and $\partial\pi_c^G/\partial\beta$) shown in Proposition 2 are the same as those derived from the sequential game other than $\underline{\beta} = 0.125(c_I - c_G)/\eta_0$. Thus, comparing with simultaneous competition, the retailer operating the group-buying channel in the sequential setup would have more incentive to expedite the formation of a group.

Appendix 3 (Mathematical Proof)

Proposition 1 *Consider the following optimization problem:*

$$\max_{p_I, p_G} \ \pi_m^{I+G} = (p_I - c_I)\cdot\left(\eta_0 - \sqrt{(p_I - p_G)\eta_0/\beta}\right) + (p_G - c_G)\cdot\sqrt{(p_I - p_G)\eta_0/\beta}\,.$$

By checking first-order conditions, we find that $\partial\pi_m^{I+G}/\partial p_I = 0$ and $\partial\pi_m^{I+G}/\partial p_G = 0$ can't hold simultaneously. Therefore, by considering boundary conditions, $p_I^* = V$, solving $\max_{p_G} \ \pi_m^{I+G} = (V - c_I)\cdot\left(\eta_0 - \sqrt{(V - p_G)\eta_0/\beta}\right) + (p_G - c_G)\cdot\sqrt{(V - p_G)\eta_0/\beta}$ can yield $p_G^* = V - (c_I - c_G)/3$.

Proposition 2 *Solving* $\partial\pi_c^G/\partial p_G = 0$ *yields* $(2p_I^* + c_G)/3 = p_G^*$; *then, we may plug* $p_G^* = (2p_I^* + c_G)/3$ *into* $\partial\pi_c^I/\partial p_I = 0$, *which leads to* $2\beta\left(\eta_0\sqrt{\frac{(p_I^* - c_G)\eta_0}{3\beta}} - \frac{(p_I^* - c_G)\eta_0}{3\beta}\right) - (p_I^* - c_I)\eta_0 = 0$. *From this equation, we find the closed form of* p_I^* *and* p_G^* *given by*

$$p_I^* = c_G + \frac{3\beta}{25}\eta_0\left(1 + \sqrt{1 + \frac{5(c_I - c_G)}{\eta_0\beta}}\right)^2 \text{ and}$$

$$p_G^* = c_G + \frac{2\beta}{25}\eta_0\left(1 + \sqrt{1 + \frac{5(c_I - c_G)}{\eta_0\beta}}\right)^2.$$

The market shares of both channels are given by

$$\eta_G^* = \frac{\eta_0}{5} + \frac{\eta_0}{5}\sqrt{1 + \frac{5(c_I - c_G)}{\eta_0\beta}} \text{ and}$$

$$\eta_I^* = \frac{4\eta_0}{5} - \frac{\eta_0}{5}\sqrt{1 + \frac{5(c_I - c_G)}{\eta_0\beta}}.$$

By first order condition, we know that the sign of $\partial\pi_c^G/\partial\beta$ is the same as that of $2\left(1 + \sqrt{1 + \lambda\beta^{-1}}\right) - 3\frac{\lambda\beta^{-1}}{\sqrt{1 + \lambda\beta^{-1}}}$, where $\lambda\beta^{-1} = \frac{5(c_I - c_G)}{\eta_0\beta}$. Therefore, we know that $\frac{\partial\pi_c^G}{\partial\beta} = \begin{cases} > 0 & ,\beta > \underline{\beta} \\ \le 0 & ,\beta \le \underline{\beta} \end{cases}$, where $\underline{\beta} = \frac{0.625(c_I - c_G)}{\eta_0}$.

Proposition 3 *All computations are straightforward. Furthermore, we find that* $\partial W_m^{I+G}/\partial c_I = 0$ *and* $\partial^2 W_m^{I+G}/\partial c_I^2 > 0$ *when* $c_I = c_G + 1.92\beta\eta_0$.

Proposition 4 *All computations are straightforward. Furthermore, solving* ${W_c}^{I+G} = W_w^{I+G}$ *yields the part (a) of Proposition 4, whereas the other can be derived by letting* $\eta_G = \eta_0$ *and* η_G=0 *in the socially optimal market operating a mixed channel.*

Corollary 1 *We list all related computations as follows:*

(1) Monopolistic setting with pure Group-buying channel

$$V > 3\beta\eta_0 + c_G : \widehat{\pi}_m^G = (V - \beta\eta_0 - c_G)\eta_0 - T \tag{1.a}$$

$$V \le 3\beta\eta_0 + c_G : \widehat{\pi}_m^G = 2\sqrt{\frac{\eta_0}{\beta}}\left(\frac{V - c_G}{3}\right)^{1.5} - T \tag{1.b}$$

(2) socially optimal market with pure Group-buying channel

$$V > 3\beta\eta_0 + c_G : \widehat{W}_w^G = (V - c_G - \frac{\beta\eta_0}{2})\eta_0 - T \tag{2.a}$$

$$V \le 3\beta\eta_0 + c_G : \widehat{W}_w^G = \sqrt{\frac{\eta_0}{\beta}}\left(\frac{2}{3}(V - c_G)\right)^{1.5} - T \tag{2.b}$$

By first order condition, when $V > 3\beta\eta_0 + c_G$ holds, we find that $\left.\frac{\partial\widehat{\pi}_m^G}{\partial\beta}\right|_{\beta_1^*} = 0$ if and only if $-\eta_0^2 = \left.\frac{\partial T}{\partial\beta}\right|_{\beta=\beta_1^*}$ and $\left.\frac{\partial\widehat{W}_w^G}{\partial\beta}\right|_{\beta_2^*} = 0$ if and only if $-\frac{\eta_0^2}{2} = \left.\frac{\partial T}{\partial\beta}\right|_{\beta=\beta_2^*}$. Therefore, we derive the relation $\left.\frac{\partial T}{\partial\beta}\right|_{\beta=\beta_1^*} = -\eta_0^2 \le -\frac{\eta_0^2}{2} = \left.\frac{\partial T}{\partial\beta}\right|_{\beta=\beta_2^*} < 0$, which conclude the first part of Corollary 1 by the assumptions $\partial T/\partial\beta < 0$ and $\partial^2 T/\partial\beta^2 > 0$. Similarly, the remaining part of Corollary 1 can be examined by the same technique.

Corollary 2 *Because of* $\partial T/\partial\beta < 0$, *and* $\partial^2 T/\partial\beta^2 > 0$, *by first order conditions, we can find that* $\underline{\beta} = 0.625(c_I - c_G)/\eta_0$.

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