Marketing Games in Social Commerce

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Abstract. This study first provides a stylized model that captures the essential features of the SC(Social Commerce) business. The model focuses on the relationship between key decision issues such as marketing inputs and revenue stream. As more SCs join the industry, they are inevitably faced with fierce competition, which may lead to sharp increase in the total marketing and advertising expenditure. This type of competition may lead the industry away from its optimal development path, and at worst, toward a disruption of the entire industry. Such being the case, another goal of this study is to examine the possibility that the tragedy of commons may occur in the industry. Our basic analysis presents Nash equilibria with both homogeneous and heterogeneous players. Under a symmetric situation with homogeneous SCs, our analysis specifies the conditions that the tragedy of commons can occur. Further discussions provide strategic implications and policy directions to overcome the shortcomings intrinsic to the current business model, and help the industry to sustainably develop itself toward the next level.

Keywords: Social commerce, SNS, Marketing competition, Game model, Tragedy of commons, Regulation.

1 Introduction

SC(Social Commerce or social shopping) providers started their business by combining group buying with selling discounts from their partners over the Internet. SC providers split the revenue with their business partners at a predefined commission rate. After Groupon first initiated this business model in 2009, this type of services has been called 'group buying' since the service proposals become effective only when more than a certain number of customers buy the coupons. The SC services are also called 'daily deal' or 'flash deal,' which emphasizes the aspect of the service offerings that are usually valid for a short period of time.

SC, barely three years old as a new industry, has been witnessing rapid growth, and more customers, business partners and investors have joined the industry. More than 500 SC providers (hereafter, simply referred to as SCs) are running their business worldwide([15]).[1] In Korea, one of the hottest regions of the SC industry, the

[1] The statistics vary to some extent since the ways to define the SC industry are different across countries. Another statistics argue that the number of SCs in the middle of 2011 amounts to 320 in the U.S., more than 3,000 in China, more than 300 in Japan, and 230 in Korea, respectively (Kim, 2011; Lee, 2011; ROA Holdings, 2011).

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transaction scale over one quarter amounts to more than 200 million dollars. The sales revenue of SCs has increased from 45 million dollars in 2010 to almost 500 million dollars in 2011. These figures mean that the industry has grown 10 times in terms of sales revenue and 20 times in terms of transaction scale over a year. As of the end of 2011, more than a third of the population in Korea subscribed to and experienced the service([9]). One observes similar figures about the industry in the East Asian region, where the SC business is most popular other than the U.S. Over the past years, for example, the sales revenue has increased from 780 billion dollars to more than 1 trillion dollars in the U.S., from 1,200 million dollars to 3,550 million dollars in China, from 8,400 million dollars to 11 billion dollars in Japan([5]).

The emergence of SC reflects the collective bargaining power of end-users as the Internet has shifted the bargaining power from sellers to customers. One of the distinct examples of this change is what SNS(Social Network Service) brought to the distribution channels and marketing efforts. Thanks to this new opportunity, customers, particularly in younger generations who are now initiating and shaping the consumer trends, have been exposed to more deals, discount chances, and new information around their local areas. Accordingly, they have been easily allured to the service proposals from SCs and gave a boost to the industry in its early stage.

However, many criticisms about the SC businesses are emerging now: for example, [12], [14], [15], [18], [19] etc. These startups have drawn skepticism for unusual accounting practices, rising marketing costs and quality assurance. This could make it more difficult for SCs to lure investors. Actually, Groupon experienced an unstable fluctuation of stock price after its IPO, and LivingSocial withdrew its actions towards IPO. However, the most urgent, critical view on the SC industry points out that the industry's growth rates are unsustainable. One also argues that the business model of SC has some flaws and cannot be justified by the current overheated market. The resulting instability may suddenly leave customers, partners and investors disenchanted. According to Korea Consumer Protection Board, the number of accusation cases about service failures and customer damages reaches 500 in 2011([9]). Furthermore, many SCs seem to suffer from huge marketing expenses and low ARPU(Average Revenue Per User). This result has been predicted since their business practices reinvested a big portion of revenue on advertising and promotion, and maintained a wide range of service offerings, of which the assortment and operations costs are too high to justify. Actually, in most countries, ARPU has been tied up at a very low level: for example, [9], [11], [16].

The prosperity and adversity of the SC industry carries meaningful implications to other e-commerce industries. The business model of SC may seem to be IT-intensive at a glance, but it heavily relies upon laborious works. In fact, the human resource and manpower is the main source of competition in this industry. The SC business model needs to investigate various commercial districts, negotiate and contract with the partners, and advertise and promote the service offerings to anonymous consumers. All of these activities require human interventions. This explains why the average sale amount per employee is far lower than ones in other e-commerce sectors such as SNS, search engines, and business portals([5], [11]). Thus, the low entry barrier in the SC industry is very likely to propel the industry to a chicken game in marketing. The worst outcome of persistence of the current situation is that the business model could end up with another bubble and the entire industry could collapse. SCs, entering a new phase, should revise the value proposition that they are willing to deliver to the market and develop a niche differentiated from online shopping mall or open markets.

This study aims at providing a stylized model that captures the essential features of the SC business model. We will analyze the model to see whether SC is sustainable or not and find some conditions for stable evolution of the industry. Our approach first focuses on the relationship between marketing efforts and revenue stream. As more SCs join the industry, fierce competition is inevitable, resulting in sharp increase of the marketing and advertising expenditure. This type of competition may lead the industry away from its optimal development path, and at worst, toward a disruption of the entire industry. Such being the case, the contribution of this study can be seen as examining the possibility that 'the tragedy of commons' occurs in the industry and devising a means of avoiding the tragedy.

The organization of our paper is as follows. In Section 2, we present our model that is stylized to demonstrate the essential features of SC business process and competitive landscape. We analyze the model in the next section and investigate the possibility that the tragedy of commons occurs in the industry due to an excessive competition in market share. Implications of our findings through modeling and analysis are followed in the next section. Section 4 also discusses the future development of the SC business model to overcome its limitations. The last section concludes the paper and suggests future works.

2 Model

SC offers a value proposition to potential customers by allowing them to buy in groups and receive quantity discounts. Merchants or suppliers (as business partners with SCs) also gain benefits from selling a significant amount of volume (rather than selling one by one and customer to customer) through a single SC channel. Furthermore, suppliers use SCs as a marketing channel to access potential customers and increase sales. Thus, the key to the SC business model lies in a deep discount or pooling willingness-to-buy from customers and turning that potential to an effective real demand. Our study focuses on the latter part of the business model: i.e., pooling the potential demand and turning it to real one. For example, Groupon tries to attract the minimum required number of users to unlock the corresponding offer.

However, potential investors are not quite sure about whether the business model is sustainable. Those who considered investing in SC startups seem less interested now([12], [15], [19] etc.). The weakest link of the business model comes from its simplicity. It is simple enough to be copied without heavy initial installation costs; as a matter of fact, it is too simple to prevent potential competitors from entering the industry. Accordingly, the competition is increasingly intensifying.

Some investigations show that SCs are forced to spend more money to acquire customers due to intensifying competition. In 2010, Groupon spent $4.95 per subscriber added, but in 2011, it spent $5.30 for each additional subscriber([12]). This increase will be worrisome to potential investors since it could be a signal that the business is getting more costly for a SC to acquire and retain customers in order to keep the revenue stream. The business model reveals the nature that a success constrains its growth.

This self-destructive aspect can be best disclosed when there is less volume of available inventory or service capacity (ironically, thanks to a success of its SC business) for many deal-prone customers. In that situation, which is quite plausible, the willingness of partner suppliers to offer a deep discount will go down, and price-sensitive shoppers switch to another SC which offers a better deal. In the long run, competition among SCs will drive down the discount rate and/or the minimum required threshold.

Considering the arguments above, here, we formulate the SC business model that incorporates both the bright side and inherent weakness, and delve into the possibility of self-destruction. We focus on key decision issues of SCs such as marketing efforts and service configurations offered to customers. Due to fierce competition among SCs, however, the commission rate is highly likely to be standardized and common to all the SCs. For example, the commission rate in Korea has been almost fixed at 20% over one year ([9]). With a fixed commission rate, our model allows a SC to leverage its minimum required number (refer to the definition of threshold below) as a competition tool depending on its competitive capability. We further assume that the discount rates in service configuration are already reflected in this threshold level. In sum, for the purpose of our study, it suffices to focus on the marketing expenses and the threshold level.

Let's suppose that there is a set composed of N SCs, where k is employed as the index for an individual (sometimes representative) SC. N may also denote the set of SCs if it is clearly distinguishable in the context: i.e., $N = \{1, \ldots, n\}$. We define some notations for the model elements as follows:

- e_k: marketing efforts of SC k,
- t_k: customer favor threshold (hereafter, simply referred to as 'threshold') set by SC k (i.e., a reference point representing a service configuration including a discount package and a minimum number of customers in order for the service offering to be effective),
- δ_k: SC k's tolerance capability to maintain positive cash flows in choosing the threshold level (i.e., the maximum level of threshold that SC k endures),
- E: total marketing efforts currently under way in the industry (i.e., $E = \sum_{k \in N} e_k$).

Then, the stylized business model of SCs is abstracted as follows. First, a SC issues coupons that can be used to purchase products or services from a partner supplier at a constant discount rate. However, those coupons are effective only when the amount of coupons sold exceeds a minimum required number of users, or a threshold (t_k) set by the corresponding SC k. The revenue of the SC k will be proportional to the effective demand that the SC faces. Usually, the revenue function of SC k can be represented by $r_k(t_k, e_k, E)$.

$$, \text{where } \frac{\partial r_k}{\partial e_k} > 0, \ \frac{\partial r_k}{\partial E_{-k}} < 0, \text{ and } \frac{\partial^2 r_k}{\partial t_k^2} < 0. \tag{1}$$

For example, we may employ $r_k(t_k, e_k, E) = (e_k / E) \cdot t_k \cdot (\delta_k - t_k)$, where δ_k is the maximum level of threshold that SC k endures, and simply called the capability of SC k; that is, SC k loses money if it sets t_k beyond δ_k.

Now, we need to explain more about the conditions in (1). First, the sales revenue (the amount of deals concluded) of k will be proportional to the relative marketing expenses. This feature reflects the current situation with a very low entry barrier and brand-recognition directly related to market share. Thus, we get the first inequality in (1). However, the marketing efforts of other players put a negative effect on the corresponding revenue r_k, which the second inequality in (1) suggests.

Before explaining the third inequality, note that the threshold has an effect both for and against the sales amount of SC k. The bigger t_k, the larger profit margin SC k will expect. On the other hand, the probability of 'service failure' increases as t_k rises. What we mean by 'service failure' is the service that was offered but failed to be delivered due to the effective demand falling short of the threshold. In its turn, the SC should compensate for the failure according to the predefined SLA(Service Level Agreement), which results in a loss on the revenue stream. According to a survey conducted by the Korea Chamber of Commerce and Industry, more than 50% of complaints from SC customers come from service failures such as shortage in quantity and quality degradation due to excessive sales of coupons([8]). SCs are responsible for the service failures, and they should compensate the corresponding customers for breach of service agreement, which ultimately reduces the actual revenue. Thus, the increase of the threshold t_k will enhance the revenue at first, but it will also increase the possibility of service failure, thereby reducing the real revenue in the end. We model this effect of t_k on the revenue in a concave shape, thereby requiring the third inequality in (1).

Finally, we need to net out the costs of individual efforts of SC k, which is assumed to be proportional to the amount of effort e_k: that is, $c_k \cdot e_k$. Note that c_k involves both pecuniary and non-pecuniary unit cost incurred in the course of operations pertaining to marketing. Thus, it can be thought of as all the *ex ante* burden when SC k implement one unit of marketing action. And c_k should not be confused with marketing expenses e_k, which represents *ex post* values paid for marketing-related activities. There will be no costs associated with the decision of t_k since the decision is a matter of deliberation and does not incur pecuniary costs. In sum, our final payoff (profit) of SC k is formulated as follows:

$$\pi_k = r_k - c_k \cdot e_k = t_k \cdot \frac{e_k}{E} \cdot (\delta_k - t_k) - c_k \cdot e_k \quad (t_k \le \delta_k). \tag{2}$$

And the total industry profit is naturally defined as $\sum_{k \in N} \pi_k$.

3 Analysis

Our analysis first presents Nash equilibria of the model. Assuming that heterogeneous SCs may employ different strategies, the following **Proposition** shows that there are infinitely many solutions, in particular, for a best response of individual marketing effort e_k.

Proposition 1. Let k denote an arbitrary SC among N SCs: i.e., $k \in \{1, \ldots, N\}$. We also define constants $\zeta_{ij} \equiv \frac{\delta_i^2}{\delta_j^2} \cdot \frac{c_j}{c_i}$ for all i<j and $\varepsilon_j \equiv \frac{e_j}{E}$ for all j in N.[2] The latter represents the relative strength of marketing effort from SC j. Given that (N−1) SCs (except k) have decided their optimal (best-response) threshold t_j^* and marketing effort e_j^* (j = 1, …, k−1, k+1, …, N), SC k's optimal t_k^* and ε_k^* (both positive) are determined as follows:

$t_k^* = \frac{\delta_k}{2}$ and

ε_k^* as a solution to the following linear equation system, $1 - \zeta_{ij} = -\zeta_{ij} \cdot \varepsilon_i^* + \varepsilon_j^*$, $\forall\, i < j$ in N.

Then, e_k^* is determined by $P \cdot \varepsilon_k^*$ with a suitable proportional constant P.

Proof: First, one can easily show that t_k^* satisfies the FONC(First Order Necessary Condition). The linear equation system for ε_k's (k = 1, …, N) comes from a set of FONCs for e_k^*'s. It is possible to derive a closed form solution for ε_k^* by utilizing the matrix structure of the linear system and employing Cramer's rule. However, the detailed procedure is omitted here; instead, an example is demonstrated below. Once ε_k^*'s are identified, we can construct e_k^* by simply multiplying a constant P to the corresponding ε_k^*. Although the system of simultaneous equations for e_k's has infinitely many solutions, thanks to the linearity of the equation system for ε_k's, e_k^* is unique up to scalar multiplication.

To check out the SOSC(Second Order Sufficient Condition), we construct the Hessian matrix H as follows. One can easily show that H is negative definite at the points satisfying the FONCs if both t_k^* and e_k^* are positive as assumed in the **Proposition** above.

$$H = \begin{bmatrix} -\frac{2E \cdot E_{-k} \cdot t_k \cdot (\delta_k - t_k)}{E^4} & \frac{E_{-k} \cdot (\delta_k - 2t_k)}{E^2} \\ \frac{\delta_k - 2t_k}{E} & -\frac{2e_k}{E} \end{bmatrix}, \text{ where } E_{-k} = \textstyle\sum_{i \neq k} e_i . \quad \text{Q.E.D.}$$

According to **Proposition 1**, the optimal threshold is proportional to the capability that the corresponding SC can exert in the market. The (relative) marketing effort of

[2] As stated before, the notation 'N' stands for either the number of SCs or a set of SCs. This usage will not cause any confusion since it is clear from the context what it means.

SC k, ε_k^* (thereby, e_k^* too) increases as ζ_{kj} ($j \neq k$) increases, but decreases as ζ_{jk} ($j \neq k$) increases. Thus, more marketing efforts of SC k are expected if the relative capability (i.e., $\frac{\delta_k}{\delta_j}$, $j \neq k$) is enhanced and/or the relative marketing cost (i.e., $\frac{c_k}{c_j}$, $j \neq k$) decreases. However, the former will have a stronger effect on e_k^* than the latter since ζ_{ij} is proportional to square of the relative capability. Subsequently, the critical competitive edge can be gained from enhancing the capability that a SC can maintain a positive cash flow against low margins.

If all the SCs have the same capability and cost structure, a symmetric Nash equilibrium can be found in the following **Proposition**. This sort of symmetric cases with homogeneous SCs may fit two stages of the industry life-cycle. The first is the infant or very early stage of the industry, where a small number of similar size companies constitute the industry. Another one is the mature stage of the life-cycle, where many small- and medium-sized SCs (in particular, with low δ_k) are forced out of the market and a small number of big SCs with similar properties survive.

Proposition 2. In a symmetric case, where $c_k = c$ and $\delta_k = \delta$ for all k = 1, …, N, a symmetric Nash equilibrium is determined as follows:

$$t_k^* = t^* = \frac{\delta}{2} \quad \text{and} \quad e_k^* = e^* = \frac{N-1}{N^2} \cdot \frac{\delta^2}{4c} \quad \text{for all } k = 1, \ldots, N.$$

Proof: As for t_k^*, the same reasoning as in **Proposition 1** is applied. Thanks to the symmetric strategy assumption, we can construct the system of linear equations for e_k's directly from the set of FONCs, $c \cdot (E^*)^2 = (\delta^2/4) \cdot E_{-k}^*$, for all k. The last equation reduces into $c \cdot N^2 \cdot e^* = \delta^2 \cdot (N-1)/4$ since $E^* = N \cdot e^*$ and $E_{-k}^* = (N-1) \cdot e^*$. Thus, we get t_k^* and e_k^* as above, from which we see that SOSCs are trivially satisfied. Q.E.D.

First note that in the case of symmetric strategy, the optimal level of the customer favor threshold t^* does not depend on the number of SCs in the industry. On the other hand, it is interesting to look into the combined effort or total expenditure from all SCs (i.e., $E^* = N \cdot e^* = \frac{N-1}{N} \cdot \frac{\delta^2}{4c}$), which depends on the number of SCs. The combined effort increases with N (i.e., $\frac{dE^*}{dN} > 0$), but the rate of growth is diminishing with N (i.e., $\frac{d^2E^*}{dN^2} < 0$). Furthermore, E^* converges to a number as N goes to infinity: i.e., $lim_{N \to \infty} E^* = \frac{\delta^2}{4c} \equiv \hat{E}$. In sum, E^* is a concave function of N, which converges to $\hat{E}$.

Although each SC may exert less marketing effort as there are more SCs (see e^* in **Proposition 2**), the addition of new SC swamps this effect, thereby, increasing the total marketing efforts (E^*) into the market. If we assume that the revenue function reflects the market demand, there will be a strong possibility of overexploitation of customers; that is, collectively, SCs will exert marketing efforts far beyond the point that boosts the potential market demand at its maximum level. This resembles the typical situation of 'the tragedy of commons,' where this sort of negative externality is at the heart of the problem ([3], [6], [7]). When a SC advertises, it doesn't take into account the negative effect that its action might have on the revenue streams of other SCs.

To examine this possibility more precisely, let's first define the industry performance measure W(-) as a function of the total marketing expenses E and the average customer favor threshold $\bar{t}$ as follows:

$$W(\mathrm{E}, \bar{\mathrm{t}}) = \mathrm{CB}(\mathrm{E}, \bar{\mathrm{t}})\cdot\mathrm{PB}(\mathrm{E}, \bar{\mathrm{t}}). \tag{3}$$

where CB and PB stand for 'Customer Benefits' and 'Producer Benefits,' respectively. Under symmetric strategies (i.e., $\bar{\delta} = \delta$ and $\bar{\mathrm{t}} = \mathrm{t}$), the latter is simply the sum of all the profits from SCs: that is, $\mathrm{PB}(\mathrm{E}, \mathrm{t}) \equiv \sum_{k\in N} \pi_k = \mathrm{t}\cdot(\delta - \mathrm{t}) - \mathrm{c}\cdot\mathrm{E}$.

CB is supposed to have a linear and additive relationship with E and $\bar{\mathrm{t}}$: that is, $\mathrm{CB}(\mathrm{E}, \bar{\mathrm{t}}) = \alpha\cdot\mathrm{E} - \beta\cdot\bar{t}$, where α and β are all positive coefficients. This notion of CB is natural since the scale of demand for SC services is more likely to increase with greater total marketing efforts. In addition, the degree of customer benefits (for instance, higher reliability and assurance of services) enhances as the average threshold level reduces.

However, CB and PB are not generally commensurable, and they cannot be combined in a simple (weighted) sum. Literature on cost-benefit analysis and multi-criteria decision making suggests to employ a multiplicative form (instead of a summation) when combining two terms incommensurable with each other. One may incorporate additional weights to adjust the balance between CB and PB. However, we did not apply such weights in (3) since our purpose of study is not to quantify or estimate the exact amount of the industry performance, but to examine qualitative behaviors of the system. As a result, our industry performance measure has been proposed as the product of CB and PB, and the expression for W(-) in (3) has been arranged into the following specific form:

$$W(\mathrm{E}, \mathrm{t}) = \{\mathrm{t}\cdot(\delta - \mathrm{t}) - \mathrm{c}\cdot\mathrm{E}\}\cdot(\alpha\cdot\mathrm{E} - \beta\cdot\mathrm{t}). \tag{4}$$

With the industry performance measure in (4), the following **Proposition** explains how socially optimal E_0 and t_0 are determined.

Proposition 3. Let's assume the symmetric situation as in Proposition 2, and suppose that the following condition holds: $\frac{\delta}{c} > \frac{\beta}{\alpha} \cdot \left(1+\sqrt{3}\right)$. Then, the total marketing efforts E_0 and the average threshold t_0 maximize the industry performance defined in (4).

$$t_0 = \frac{\delta}{2} \quad \text{and } E_0 = \frac{\delta \cdot (\alpha \cdot \delta + 2c \cdot \beta)}{8c \cdot a}.$$

Proof: First, it's easy to show that FONCs are satisfied with t_0 and E_0 if $\alpha \cdot \delta > c \cdot \beta$ (in particular, for t_0), which is also satisfied by the condition above. To check out SOSC, we construct the Hessian matrix below:

$$\text{H} = \begin{bmatrix} -2c \cdot \alpha & c \cdot \beta + \alpha \cdot (\delta - 2t) \\ c \cdot \beta + \alpha \cdot (\delta - 2t) & \beta \cdot (4t - \delta) - 2\alpha \cdot E \end{bmatrix}.$$

This Hessian is indeed negative definite at t_0 and E_0 when $(\alpha \cdot \delta - c \cdot \beta)^2 > 3(c \cdot \beta)^2$, which is equivalent to $\left(\frac{\delta}{c} - \frac{\beta}{\alpha}\right)^2 > 3 \cdot \left(\frac{\beta}{\alpha}\right)^2$, or $\left(\frac{\delta}{c}\right)^2 - 2\frac{\beta}{\alpha} \cdot \frac{\delta}{c} - 2\left(\frac{\beta}{\alpha}\right)^2 > 0$. Since $\frac{\delta}{c}$ is positive, this inequality is satisfied if the condition in the **Proposition** holds. Q.E.D.

Note that $t_0 = t^*$; that is, at least for the threshold, the socially optimal level and the optimal level of an individual choice coincide. Therefore, we may predict that SCs will manage their threshold levels at the socially optimal level.

However, this desirable feature may not be sustained when we consider the total marketing efforts. Furthermore, a ramification of the tragedy of commons shows a 'phase transition' nature, where the relationship between $\frac{\delta}{c}$ and $\frac{\beta}{\alpha}$ specifies the sharp boundary of the phase transition. We've already seen that a relationship between these two terms presents the conditions in **Proposition 3**. These conditions hold when $\frac{\delta}{c}$ is far larger than $\frac{\beta}{\alpha}$. **Proposition 4** goes further and provides another relationship (in somehow different format) between these two terms. This relation is critical in triggering the situation of 'the tragedy of commons.'

Proposition 4. Let's assume the symmetric situation as in Proposition 2. Now, consider the following two cases that are mutually exclusive and complete.

Case (a) $\frac{\delta}{c} > 2\frac{\beta}{\alpha}$: Then, there is a positive critical value T such that the tragedy of commons occurs (i.e., $E^* > E_0$) if the number of SCs exceeds this critical point (i.e., $N \geq T$). T is larger than one and determined as follows:

$$T = \frac{2\alpha \cdot \delta}{\alpha \cdot \delta - 2c \cdot \beta},$$

Case (b) $\frac{\delta}{c} \leq 2\frac{\beta}{\alpha}$: Then, for any N, the total marketing efforts falls short of the socially optimal level (i.e., $E^* \leq E_0$).

Proof: $E^* > E_0$ if and only if $(\alpha\cdot\delta + 2c\cdot\beta)\cdot N < 2\alpha\cdot\delta\cdot N - 2\alpha\cdot\delta$, which is further arranged into $(2c\cdot\beta - \alpha\cdot\delta)\cdot N < -2\alpha\cdot\delta$. Then, we have two cases. The condition in Case (a) corresponds to the situation where the left-hand side is negative; while the condition in Case (b) guarantees that the left-hand side is non-negative. Thus, in Case (b), the inequality $E^* > E_0$ cannot hold unless N is negative, which is impossible. In Case (a), $E^* > E_0$ holds for $N > \frac{2\alpha\cdot\delta}{\alpha\cdot\delta - 2c\cdot\beta} \equiv T$. Furthermore, the denominator of T is always bigger than the numerator under the condition in Case (a), which guarantees $T > 1$. Q.E.D.

The results of the **Proposition** imply that one cannot expect that the SC industry will be sustained unless the condition in Case (b) comes true. It depends on the number of SCs whether the industry in Case (a) survives or not. That is, a limited number of SCs may thrive only if the size of the industry is maintained less than T. It's not difficult to construct an example where Case (b) together with the limited opportunity of $N < T$ in Case (a) of **Proposition 4** are rarely observed. Therefore, the tragedy of commons seems inevitable in most practical situations.

By rearranging T into $\frac{2\alpha}{\alpha - \frac{2c\cdot\beta}{\delta}}$, we know that T is larger than 2 and converges to 2 as δ becomes larger. Since $\frac{dT}{d\delta} < 0$ and $\frac{d^2T}{d\delta^2} > 0$, T is diminishing but slowly converges to 2 as δ goes infinity. However, T shows a different behavior when $q \equiv \frac{\beta}{\alpha}$ changes. Again, by rearranging terms in T, we get another expression of $T = \frac{2\delta}{\delta - 2c\cdot q}$, and $\frac{dT}{dq} > 0$ and $\frac{d^2T}{dq^2} > 0$ when $\delta > 2c$. Subsequently, T is close to 2 when α is far larger than β (i.e., $\frac{\beta}{\alpha} \approx 0$), and very rapidly increasing (to infinity) as $\frac{\beta}{\alpha}$ approaches to $\frac{\delta}{2c}$ (> 1). This behavior implicitly puts an upper bound on the relative size between α and β; that is, β cannot be larger than $\frac{\delta\cdot\alpha}{2c}$. As a result, T appears more sensitive to $\frac{\beta}{\alpha}$ than to δ.

Since $t_0 = t^*$ and they do not depend on the number of SCs under symmetric strategies, we can view the performance structure from a different angle by defining two parametric functions based on our model: that is, $H = H(\bar{t}) \equiv -\beta\cdot\bar{t}$ and $J = J(\bar{t}) \equiv \bar{t}\cdot(\bar{\delta} - \bar{t})$. Note that at a symmetric equilibrium, both H(-) and J(-) are constant functions: specifically, $\mathrm{H} = -\frac{\beta \cdot \bar{\delta}}{2}$ and $\mathrm{J} = \frac{\bar{\delta}^2}{4}$ for both social and individual optimal levels (t_0 and t^*). Accordingly, the performance measure (4) can be simply viewed as if it were a function of E only as below:

$$\hat{W} = (\alpha \cdot \mathrm{E} + \mathrm{H}) \cdot (\mathrm{J} - c \cdot \mathrm{E}) . \quad (5)$$

In fact, this expression of the system performance is similar to a well-known system performance measure in ecology([3], [7]). First, one can interpret H and J as a location parameter and an ecological capacity, respectively. The latter (J) is proportional to the average capability and the former (H), together with J, determines the generic performance without marketing efforts; that is, J·H (< 0) corresponds to the performance level when E = 0. From (5), we know that both solutions to $\hat{W} = 0$ (in terms of E) are positive, and $\hat{W}$ is maximized at $\hat{E} = \frac{\alpha \cdot J - c \cdot H}{2\alpha \cdot c}$.

There are two forces at work in (5). First, for a given potential market size (i.e., a fixed H and J), more marketing efforts by SCs mean more revenue streams: the first term (α·E + H) in (5). In fact, at the early stage of the industry, the marketing chicken game has contributed to the rapid growth of the entire market for SC services([4]). In Korea, the SC business has grown into a one billion dollar industry over the last two years, and many experts agree that the massive marketing activities have raised customers' awareness of the SC businesses. However, due to the fierce competition with a fixed installed base, more marketing efforts also result in a smaller population to target in the next period: the second term (J – c·E) in (5). The overall effect of these two forces comes up with the system performance measure in a multiplicative form as above.

Corollary 5 below provides more streamlined expressions of the conditions pertaining to the tragedy of commons when t_k's are identical and fixed at some t such as $t_0 (= t^*)$ for some policy reasons, and e_k is the only effective strategy of SC k (k = 1, … , N).

Corollary 5. Let's assume that t_k's are fixed at t and the performance measure is given as (5). With symmetric strategies as in Proposition 2, each SC sets its optimal marketing effort at $\frac{t \cdot (\delta - t)}{c} \cdot \frac{N-1}{N^2}$ (thereby, $\mathrm{E}^* = \frac{t \cdot (\delta - t)}{c} \cdot \frac{N-1}{N}$). And we have the following two cases.

Case (a) $c \cdot \beta < \alpha \cdot (\delta - t)$: Then, there is a positive critical value $\hat{T}$ such that the tragedy of commons occurs (i.e., $\mathrm{E}^* \geq \hat{E}$) if the number of SCs exceeds this critical point (i.e., $\mathrm{N} \geq \hat{T}$). $\hat{T}$ is larger than one and determined as follows:

$$\hat{T} \equiv \frac{2\alpha \cdot (\delta - t)}{\alpha \cdot (\delta - t) - c \cdot \beta},$$

Case (b) $c \cdot \beta \geq \alpha \cdot (\delta - t)$: Then, for any N, the total marketing efforts falls short of the socially optimal level (i.e., $\mathrm{E}^* < \hat{E}$).

Proof: The proof is straightforward and follows the procedures similar to **Proposition 3** and **Proposition 4**. We omit the proof. Q.E.D.

Note that $\hat{T} > 1$ in Case (a) of **Corollary 5**. Thus, we still have a chance to escape from the tragedy of commons even in Case (a) when N < $\hat{T}$. Unfortunately, however, a reasoning procedure similar to one derived from **Proposition 4** reveals that $\hat{T}$ is always larger than 2 but quite small in most normal situations.

4 Conclusion and Future Works

The SC startups have drawn criticism for unusual accounting practices, rising marketing costs and inadequate quality assurance, despite a rapid growth in their early stage. We tried to understand the current critical situation and figure out the causes of the pessimistic view toward the SC industry. For the purposes, our study developed stylized game models and analyzed them to find out some potential (but critical) problems inherent in the business model at the early stage of industrial life-cycle. In particular, we focused on the conditions under which the SC industry is sustainable. Our findings and analytical results provided strategic implications and policy directions to overcome the shortcomings intrinsic to the current business model. For example, a set of regulations on the marketing activities may help the industry to sustainably develop itself toward the next level. Along this line, our future works will pursue some empirical studies to identify the parameters in our model so that we can further enrich knowledge about the industry. For example, although gathering data will be intrinsically difficult due to the early stage of the industry, we need to develop an operational definition of the social welfare W to estimate the relevant parameters such as α and β in our model. Then, we will be able to quantify the conditions under which a (group of) first-mover(s) survives and estimate a proper size of the industry sustainable in the long run.

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