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Externality and Market Structure of Social Network Sites Industry

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Abstract. Social networking sites (SNS) like Facebook are changing our way of life not only on the virtual world, but also in real life markets and social interactions. With the ability to reach a large part of the population and to influence consumer behavior, many firms find the need to have a presence on these SNSs. The most prominent bellwether of SNSs is Facebook, which embraces an annual revenue of US$800 million and more than 600 million active users. The emergence of the SNS industry can potentially have a large influence on society. Although it has attracted much academic attention, especially on the social front, the business strategy aspects of SNSs have yet been theoretically analyzed. This paper aims to study the market structure of the SNS industry and discuss the appropriate advertising price strategies for SNS Companies. The market structure of the SNS industry is multi-sided; the service is provided by the SNS Companies and consists of three distinct user groups that provide each other with network externalities. The three distinct major players in the SNS market are the direct SNS users, application developers and advertisers. Analysis of the network externalities among these entities and the compromise adopted by the SNS Companies are presented in our study. There are two forms of revenue that the SNS Company can receive; advertising revenue from advertisers and revenue collected from application developers. Using economic theory, we set up the utility functions of each entity in this multi-sided market and examine how the SNS companies can maximize profits with these constraints. We compare the level of advertisement which resulted from a monopolist and a social welfare optimizer. One key result is that the price set by the SNS Company may result in over advertisement. This result is mainly due to our assumption that advertisement is purely an annoyance factor to consumers rather than a source of information to consumers such as that described in Shapiro (1980).

Keywords: SNS Industry, Externality, Multi-sided Market, Market Structure

1. Introduction

A Social Network Site (SNS) provides services through an online platform. SNSs mainly focus on constructing and maintain social networks or social relations among people, and also a variety of additional activities. Generally speaking, social network sites usually provide an individual-centered service which allows users to share ideas, activities, events and interests within their own individual network groups.

Humans being social creatures have a need to communicate and express their thoughts. Development of technology enables more and more sophisticated ways of communication. The invention of letters, telephones, and e-mails, could be generously rewarded as communication revolutions in human history. In the early 1990s, with the tremendous development of Internet, there was potential to develop new forms of computer-mediated social interactions between large amounts of friends. Early versions of these online communities include Usenet, ARPANET and LISTSERV. In the late 1990s, introduction of user profiles became a central feature of social networking sites, by allowing users to compile lists of "friends" and search for other users with similar interests. With this innovation, the SNSs industry experienced unconceivable growth. Currently, the largest SNS is Facebook, which is estimated to have more than 600 million active users.

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It is self-evident that the potential power of the emerging SNSs industries is beyond our imagination. SNSs influence nearly every aspect of our society, including communication, production, social ethics and even military. A prominent and recent instance of this influence is the 2011 Egyptian Revolution, where Facebook groups were one of the main tools used in the call for mass demonstrations.

Although considerable amount of research has been done on the aspects of Media and Information of SNSs industries, little contributions have been made on the economic side of the research of the emerging industry. The objective of our theoretical study is to find the market structure of the emerging SNSs industry. We are then interested in the relationship between each player in this market, namely the direct and indirect network externalities between each entity in this market. The SNSs industry could be generalized into four parties, namely the SNSs Companies, consumers, advertisers and third-party. This paper mainly focuses on the study of the internal externalities of each of four entities inside the market, as well as the advertisement price strategies of SNSs Companies under distinct scenarios. The last objective of our study is to find out the advertising strategies of the SNSs companies under monopoly and social optimal scenarios.

The supporting theories we referred to in this paper are mainly from the study of the bandwagon model for high tech industries by Rohlfs (2003), as well as the two sided market model introduced by Armstrong (2006). We review these and other related literature in the next section. This is followed by the model and discussions.

2. A Three-Sided Market Model

2.1. Definition and Assumptions

First, we define the notations used in the model. We use numerals to present each party (i) in the three-sided market, *1* represent consumers, *2* represent advertisers and *3* represents application developers. n_1 represents the number/quantity of party i. $a_{i,j}$ represents the externalities exerted by party j on one member of party i, given that $j \neq i$. When $j=i$, $a_{i,j}$ represents the direct network externalities each party exerts on its own individual member. u_i represents the utility of party i and p_i represents price paid by a member of party i. $a_{i,j}$ is generally assumed to be positive and its maximum is normalized to 1. Special cases for specific $a_{i,j}$ are; *1*. $a_{i,j} \in [-1.1]$, advertisers can exert a negative network externalities on consumers (Advertisement is purely an annoyance factor to consumers rather than a source of information to consumers such as that described in Shapiro (1980).); *2*. $a_{2,2} = a_{3,3} = a_{2,3} = a_{3,2} = 0$, network externalities are assumed to be non-existent between and within advertisers and app developers. The number of other advertisers or app developers does not have an effect on its own and each other's utility, this may not be true in real life.

We can use the matrix to represent the network externalities of the four sides in the model:

$$\begin{bmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{bmatrix}$$

We use the matrix multiplication to find the utility function of each side:

$$\begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix} = \begin{bmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ a_{3,1} & a_{3,2} & a_{3,3} \end{bmatrix} \cdot \begin{bmatrix} n_1 \\ n_2 \\ n_3 \end{bmatrix} - \begin{bmatrix} p_1 \\ p_2 \\ p_3 \end{bmatrix} = \begin{matrix} n_1 a_{1,1} + n_2 a_{1,2} + n_3 a_{1,3} - p_1 \\ n_1 a_{2,1} + n_2 a_{2,2} + n_3 a_{2,3} - p_2 \\ n_1 a_{3,1} + n_2 a_{3,2} + n_3 a_{3,3} - p_3 \end{matrix}$$

Assuming that n_i and u_i are positively related, we can write the demand function as a function of the utility of each party i where:

$$n_i = g_i(u_i); \quad g_i'(u_i) > 0$$

With this setup, we will first look at the profit maximizing monopolist case to find the profit maximizing levels of prices. Next, we examine the social optimum and compare between the two cases.

2.2. The Profit Maximizing Monopolist

2.2.1. Profit Maximizing Utility and Price Level

We assume that the SNS firm has significant market power and that consumers make a discrete choice between being part of the SNS or not. In the monopoly case, consumers will choose the price level to

maximize its' own profit. We make the simple assumption of marginal cost of being f_1, f_2 and f_3 for each respective party. The profit function for SNS firm can be written as:

$$\pi = n_1(p_1 - f_1) + n_2(p_2 - f_2) + n_3(p_3 - f_3)$$

To get the profit-maximizing point, we find the critical points of the three-dimensional function where:

$$\frac{\partial \pi}{\partial u_1} = \frac{\partial \pi}{\partial u_2} = \frac{\partial \pi}{\partial u_3} = 0$$

During the simplification of the model, we assume that there are no externalities between these two entities, namely we assume that $a_{2,2} = a_{3,3} = a_{2,3} = a_{3,2} = 0$. Therefore, the utility level of each entity is found to be the following:

$$u_1^m = 2a_{1,1}g_1(u_1^m) + (a_{1,2} + a_{2,1})g_2(u_2^m) + (a_{1,3} + a_{3,1})g_3(u_3^m) - \frac{g_1(u_1^m)}{g_1'(u_1^m)} - f_1$$

$$u_2^m = (a_{1,2} + a_{2,1})g_1(u_1^m) - \frac{g_2(u_2^m)}{g_2'(u_2^m)} - f_2$$

$$u_3^m = (a_{1,3} + a_{3,1})g_1(u_1^m) - \frac{g_3(u_3^m)}{g_3'(u_3^m)} - f_3$$

Then substitute the utility functions of the three sides into the price utility function to get the profit maximizing prices:

$$p_1^m = -a_{1,1}n_1 - a_{2,1}n_2 - a_{3,1}n_3 + \frac{g_1(u_1)}{g_1'(u_1)} + f_1$$

$$p_2^m = -a_{1,2}n_1 + \frac{g_2(u_2)}{g_2'(u_2)} + f_2$$

$$p_3^m = -a_{1,3}n_1 + \frac{g_3(u_3)}{g_3'(u_3)} + f_3$$

2.2.2. Profit Maximizing Quantity Level

According to our precondition on demand function, we have the relationship: $n_i = g_i(u_i)$; $g_i'(u_i) > 0$. In order to solve the profit maximizing utility function, we need to specify the demand function $g_i(u_i)$. One of the simplest specifications is $g_i(u_i) = u_i$, which satisfies the strictly increasing property. Under our assumption $n_i = g_i(u_i) = u_i$, the revised utility function (quantity function) is as below:

$$n_1^m = u_1^m = \frac{4f_1 + 2(a_{1,2} + a_{2,1})f_2 + 2(a_{1,3} + a_{3,1})f_3}{8(a_{1,1} - 1) + 2(a_{1,2} + a_{2,1})^2 + 2(a_{1,3} + a_{3,1})^2}$$

$$n_2^m = u_2^m = \frac{2(a_{1,2} + a_{2,1})f_1 - [4(a_{1,1} - 1) + (a_{1,3} + a_{3,1})^2]f_2 + (a_{1,2} + a_{2,1})(a_{1,3} + a_{3,1})f_3}{8(a_{1,1} - 1) + 2(a_{1,2} + a_{2,1})^2 + 2(a_{1,3} + a_{3,1})^2}$$

$$n_3^m = u_3^m = \frac{2(a_{1,3} + a_{3,1})f_1 + (a_{1,2} + a_{2,1})(a_{1,3} + a_{3,1})f_2 - [4(a_{1,1} - 1) + (a_{1,2} + a_{2,1})^2]f_3}{8(a_{1,1} - 1) + 2(a_{1,2} + a_{2,1})^2 + 2(a_{1,3} + a_{3,1})^2}$$

2.3. The Social Welfare Optimizer

2.3.1. Social Optimum Utility and Price Level

To optimize social welfare we sum up the net benefits of all the four parties in this three-sided market. The net benefit for the SNS firm is its profit as given in the monopoly case. We use r_i to denote the residual (net) utility of party i, for the remaining three parties. According to Armstrong (2006)'s study, r_i has got the property that $r_i' = g_i(u_i)$. The net social welfare function can thus be written as:

$$\omega = \pi + r_1 + r_2 + r_3$$

We can substitute the profit function of SNS Company π into the social welfare function, then take the first partial derivative of ω to find the utility level of each entity is found to be the following:

$$u_1^s = 2a_{1,1}g_1(u_1^s) + (a_{1,2} + a_{2,1})g_2(u_2^s) + (a_{1,3} + a_{3,1})g_3(u_3^s) - f_1$$

$$u_2^s = (a_{1,2} + a_{2,1})g_1(u_1^s) - f_2$$

$$u_3^s = (a_{1,3} + a_{3,1})g_1(u_1^s) - f_3$$

We substitute these into the price utility function to obtain the social optimal prices:

$$p_1^s = -a_{1,1}n_1 - a_{2,1}n_2 - a_{3,1}n_3 + f_1$$
$$p_2^s = -a_{1,2}n_1 + f_2$$
$$p_3^s = -a_{1,3}n_1 + f_3$$

2.3.2. Social Optimum Quantity Level

We still stick to our earlier assumption that: $n_i=g_i(u_i)$; $g_i'(u_i)>0$. By applying *Cramer's Law* we can derive the social optimal utility and quantity function. Under our assumption $n_i=g_i(u_i)= u_i$, the revised utility function (quantity function) is as below:

$$n_1^s = u_1^s = \frac{f_1 + (a_{1,2} + a_{2,1})f_2 + (a_{1,3} + a_{3,1})f_3}{(2a_{1,1} - 1) + (a_{1,2} + a_{2,1})^2 + (a_{1,3} + a_{3,1})^2}$$

$$n_2^s = u_2^s = \frac{(a_{1,2} + a_{2,1})f_1 - [(2a_{1,1} - 1) + (a_{1,3} + a_{3,1})^2]f_2 + (a_{1,2} + a_{2,1})(a_{1,3} + a_{3,1})f_3}{(2a_{1,1} - 1) + (a_{1,2} + a_{2,1})^2 + (a_{1,3} + a_{3,1})^2}$$

$$n_3^s = u_3^s = \frac{(a_{1,3} + a_{3,1})f_1 + (a_{1,2} + a_{2,1})(a_{1,3} + a_{3,1})f_2 - [(2a_{1,1} - 1) + (a_{1,2} + a_{2,1})^2]f_3}{(2a_{1,1} - 1) + (a_{1,2} + a_{2,1})^2 + (a_{1,3} + a_{3,1})^2}$$

3. Conclusion

3.1. Price and Quantity Comparisons of Each Group

For the consumer aspect of the SNSs market, when network externalities are low, there will be more consumers in the social optimum SNSs Market than in the monopolist. The price level charged by monopolist is higher than social optimum. However, when network externalities are higher, more consumers will join monopolist and the quantity of consumers in monopolist is comparatively higher than social optimum. Moreover, the price charged by monopolist decreases with the increase in quantity of consumers, which leads to a lower price level charged by monopolist than social optimum.

For the advertiser aspect of the SNSs market, when network externalities are low, there will be more advertisers in the social optimum than in the monopolist due to the larger consumer base. The price level charged on advertisers is higher in the social optimum case. However, when network externalities become higher, more advertisers will shift to the monopolist market, which drives the quantity of advertisers in monopolist higher than social optimum. Moreover, the price level charged on advertisers in monopolist exceeds the price level in social optimum with the increase of externalities.

For the application developer aspect of the SNSs market, when network externalities are low, there will be more app developers in the social optimum than in the monopolist due to a comparatively larger consumer base. The price level charged on app developers by social optimum is also relatively higher than the monopolist. However, with the increase of network externalities, more app developers will join the monopolist market, and at certain point, the quantity of app developers in monopolist exceeds the quantity in social optimum. Moreover, the price level chosen by monopolist increases with the quantity of consumers and exceeds the price level of social optimum at certain point.

3.2. Intuition and Limitations

Throughout the whole paper, quantity level and price level of each entity is discussed based on the network externalities. By doing numerical analysis based on the changes of network externalities, we draw the conclusion that the SNSs market tends to be competitive market which is social optimum when network externalities are comparatively lower. However, with the increase of network externalities, the monopoly market seems more efficient and preferable, which is also consistent with real life scenarios. Since users of SNSs market would obviously prefer a use a single SNS page than to login several different SNS pages. Monopolist, such a Facebook, is definitely more social efficient in connecting consumers at a higher level of network externalities.

However, there are still limitations in this model. In real life scenarios, consumers of SNS are more often of free entry instead of facing a price charging. Moreover, the quantity utility function could be revised in different specification instead of the general one. Lastly, a dynamic model of three-sided market will be more relevant with real life scenario.

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