Pricing Web 2.0 Related Services: Peer Production

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ABSTRACT
Peer production has played an important role in the economics of Web 2.0 related services. User participation and contribution become the main driving dynamics of this new economic paradigm, significantly different from traditional firm-based or market-based production. However, the quality of peer production based service is uncertain, and highly related to not only the level of individual contribution but also the network externality of these contributions. To address and resolve this issue, in this paper, we propose an analytical model based on the concepts of peer contribution and quality warranty to study the pricing strategy of the increasingly emerging Web 2.0 related services. Best quality strategy under monopolistic market is found in our research. And under duopolistic market, one of the providers may provide higher quality than he advertises is also an important finding. Several implications have been discussed to help clarify the progress of peer production, and hints for peer production service providers are also presented.

Categories and Subject Descriptors
K.6.0 [**Management of Computing and Information Systems**]: General – *economics*

General Terms
Management

Keywords
Web 2.0, Peer Production, Quality Warranty, Information Goods, Pricing Strategy, Competition

1. INTRODUCTION
Peer production was first introduced to describe a new model of economic production [4]. In this model, different from traditional firm-based and market-based model, the creativity and ideas of large numbers of people are cooperated through Internet to work on a project which is not initiated by traditional company but started from a simple idea. In a firm-based production model, a centralized decision process decides what products to be produced and who will produce them. Market-based model sets different prices for differentiated jobs to attract people who are interested in doing this. Compared to the above two models, all participants in peer production may be volunteers and even don't expect to receive any money or salary from his/her contribution. The impressive business event that Google's acquisition of YouTube indicates customer-contributed content is changing traditional business practice and letting customers organize their resources and share them with others is profitable. The peer production model suggests two more useful principles: group forming and creation tools [1].

Generally speaking, most of the peer productions are information goods. Traditional information goods, which are created by a dedicated provider, typically have high fixed costs and relatively low or even non-existent marginal costs. Information is costly to produce but cheap to reproduce [16]. In contrast to traditional information goods, the fixed cost of peer production is very low or even zero. Reduced creation cost may be the positive economic factor of considering peer production model, however, due to the decentralized and loosely self enforced contribution, the quality of service (QoS) based peer production becomes less stable and without warranty. Therefore, one of the essential components for supporting the realization of pricing strategy of peer production related service is to enforce the measurability and guarantee of the QoS. In this paper, we focus on the study of pricing strategy of peer production based service, based on the concept of service level agreement (SLA). There exist many popular realized peer production based services (includes P2P file sharing, knowledge sharing, and Web Services, etc). We propose a general framework for investigating the pricing and quality strategies of Web 2.0 related services under various market structure settings, but do not limit to specific business applications.

The remainder of the paper is organized as follows. In Section 2, we review the related literature. Section 3 we describe the basic model and discuss the monopolistic pricing. In addition, we extend the model to a duopolistic market. Finally, Section 4 provides concluding remarks and offers future research directions.

2. RELATED LITERATURE
2.1 Peer production and information goods
Ubiquitous networking and low-cost computing provide an environment where various information products that were traditionally distributed as physical goods, can now be delivered in digital format [6]. This change has obvious implications on the cost structure and strategies of companies that are in the business of providing information goods. Information goods are anything that can be digitized, such as a book, a movie, a record, or a

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telephone conversation [16]. Information goods are a type of commodity whose main market value derives from information contained. Peer production refers to any coordinated, internet-based effort whereby volunteers contribute project components, and there exist some process to combine them to produce a unified intellectual work [11]. It refers to production systems that depend on individual action that is self-selected and decentralized, rather than hierarchically assigned. Based on the definition of Varian [16] and Krowne [11], we can consider peer production as a kind of model for providing information goods, and anyone who provides related services is said to be an information service provider.

Benkler [4] identifies two advantages of peer production. First, peer production is better than either companies or markets at "identifying and assigning" the best people to do a job. The second advantage is one of increasing returns as more and more contributors seamlessly search through growing knowledge pools to find work that suits those [14]. Although peer production has many advantages, there are still some drawbacks. One of the most important questions is the quality issue.

2.2 Information goods pricing

Price has an important impact on access to information service for individuals. There are many researches focused on the pricing strategy of information goods. In an era of ubiquitous communications and nearly limitless, free information availability, the information service provider adds value by location, filtering, and communicating what is useful to the consumer [6]. The conclusion that information goods can be distributed and reproduced with zero or very low marginal costs was recognized by many researchers [15] [2]. One important feature of information goods is that they have relatively large fixed costs to produce, and small variable costs to reproduce. Different consumers may have totally different values for the same information good, thus cost-based pricing may be not so fit in this context. Jain and Kannan [9] summarized the pricing strategies of online servers and categorized them into four categories: connect-time-based, search-based, subscription-fee, and others (free, contracts, contribution). Because of the characteristics of peer production, pricing strategy based on contribution is suitable for our research. Gupta et al. [7] proposed a pricing scheme in which a user of Internet services can choose from a menu of options which include the price, quality level of service and expected time at which the service will be provided. Our research adopts quality level of service as the decision variable, and this paper primarily focuses on the pricing issue of peer production services and doesn't cover other factors.

3. THE MODEL

We consider a peer production related service market which includes the participatory platform (infrastructure) providers, whose objective is profit-maximizing, and the peer participants whose objective is to exploit the content, knowledge, or computing resource pooled in the networks. In order to utilize the pooled resource, a peer participating in a peer production system needs to contribute a certain portion of resource and pay a subscription fee to the platform provider. Peer to peer processes occur in distributed networks in which autonomous agents can freely determine their behavior and linkages [3]. All peer productions are open to all consumers provided they have the skills to contribute. Quality refers to resource availability; quantity refers to the admission number of the peer participants. In our model, we transform the problem of quality into the quantity of peer participants. This help to clarify the relationship of user participation and quality and simplify the model.

3.1 QoS and subscription functions

Denote contribution rate h_i as the resource (content, knowledge, computing service etc) availability of peer node i, where $0<h_i<1$. Since the provision of the resource from a node in a distributed system is stochastic, from the perspective of reliability theory, h_i can be interpreted as the probability that a given requested resource can be found at peer node i. Notice that the contribution rate among individuals is independent, therefore, it is possible that more than one peer provider provide the same resource in the same time. Assume the total potential number of users of the peer production system is η_0 and total number of subscribed users is η. The quality of the peer production system is estimated as

$$H = 1 - \left(1 - \prod_i^{\eta} h_i\right)$$

Quality index H measures the availability of any given requested resource in the peer production system. In order to simplify our model, we assume an *average* contribution rate $\overline{h}$ with all participants. Therefore, the quality of service approximately becomes

$$H = 1 - \left(1 - \overline{h}\right)^{\eta}$$

The quality of peer production is related to average users' contribution rate $\overline{h}$ and the subscription number of the users η. The peer participants of the peer production system are heterogeneous on the valuation of the quality of service H. We assume that consumers have an independent value v for service that is unknown to providers and uniformly distributed in interval $[0, V]$. Denote v_i as the valuation of customer i on the service provided in the peer production system. U_i is the utility function, and p is the price of the service. The utility function of user i can be formulated as

$$U_i = v_i H - p$$

For pricing new products, skimming and penetration are classical strategies. A firm skims the market by offering the product at high prices first and then decreasing the prices over time [10]. Thus, only the customers with utility $U_i \geq 0$ will subscribe in the peer production network. That is, the subscription demand of the systems is from those customers with higher value $v_i \geq \hat{v} = \dfrac{p}{H}$.

The number of the subscription is derived as

$$\eta = \left(1 - \frac{p}{VH}\right)\eta_0$$

3.2 Monopolistic pricing

For a peer production service provider to be succeeded, it must have low-cost integration on quality control and integrating the contributions into the finished product [4]. The objective of the monopolistic service provider is to choose the QoS warranty level H and an appropriate price p to maximize the profit. QoS warranty is business contract that describes the service level agreement (SLA) that a provider need follows. The detailed enforcement of the agreement is beyond the scope of the paper. We assume the penalty for violating the service quality warranty is huge such that the firm definitely commits the advertised QoS. Thus, the objective function the service provider can be written as

$$\underset{H,p}{Max}\ \pi_m = p\eta - K(\eta_k) \text{ s.t. } H \le 1-\left(1-\bar{h}\right)^{\eta} \text{ and } \eta \le \eta_k$$

, where $K(\eta_k)$ is the cost of infrastructure investment which affords to accommodate η_k number of users in the same time. Here, we assume the capacity investment is sufficient large to support all the activities of the subscribed customers.

3.2.1 Pricing strategy

Given the quality advertised H^* and solving the first order condition $\partial\pi/\partial p = 0$, we get optimal price $p^* = VH^*/2$. Under the optimal price p^*, the total demand becomes $\eta_0/2$, the total number of all potential customers of the system should satisfy condition,

$$\eta_0 \ge 2\hat{\eta}\text{, where } \hat{\eta} = \frac{\ln(1-H^*)}{\ln(1-\bar{h})}$$

PROPOSITION 1. *In a peer production environment with sufficient capacity, (i) the higher the contribution of individuals, the higher the quality, (ii) the larger the population of peer producers, the higher the quality, and (iii) the higher the quality, the higher the price.*

Intuitions from proposition 1 are straightforward. New users specialized in different activities needed by the peer production system make their own contributions and promote the quality, and higher quality attracts new users. Because the quality is determined by contribution rate, the increasing of participants will help to improve the quality. Raymond [13] gave an excellent explanation: "Given enough eyeballs, all bugs are shallow." Once the quality is higher, providers can price the peer production at higher level.

In order to achieve optimal price, the user population η_0 must exceeds the threshold $2\hat{\eta}$. The contribution rate can highly determine the population threshold. However, if the user population is lower than it, .i.e., $\eta_0 < 2\hat{\eta}$ the price becomes $p = VH^*(1-\hat{\eta}/\eta_0)$. When there is only one peer production platform provider, the price can be summarized as:

$$p^* = \begin{cases} VH^*/2 & \text{if } \eta_0 \ge 2\hat{\eta} \\ VH^*(1-\hat{\eta}/\eta_0) & \text{if } \hat{\eta} \le \eta_0 < 2\hat{\eta} \\ 0 & \text{if } \eta_0 < \hat{\eta} \end{cases} \quad (1)$$

Equation (1) indicates that when the user population is low, provider can only price at marginal cost (zero in this case). This is quite straightforward because low user population leads to low quality, users are willing to select this peer production only when it is free of charge. This usually happens when the peer production is initiated and introduced at early development stage. Under this circumstance, the provider has to try any possible means to raise user population. The provider also needs to review the peer production itself. For a peer production to be successful, it must be modular [4]. This enables production to be incremental and asynchronous, pooling the different people and resources at different times [5].

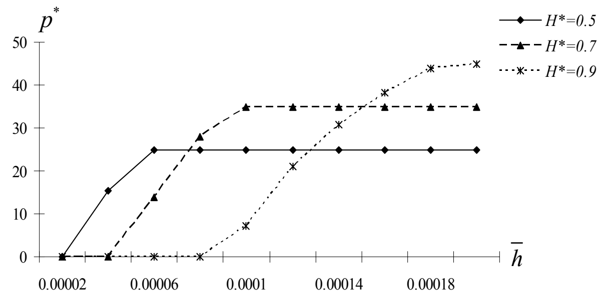

Figure 1. Monopolistic price as function of average contribution rate $\bar{h}$

The phenomenon of equation (1) can be clearly observed from Figure 1, in which optimal price is plotted against $\bar{h}$ where V=100, η_0 =25000. As we can see, the higher the advertised quality, the higher the price can be set. Given a quality warranty level, if the average contribution rate of a peer node is too small, the price equals to zero because the quality warranty is never satisfied. As average contribution exceeds critical contribution rate, quality warranty become committable and the service provider starts to charge the participants. At this stage, the subscription fee increases with the average contribution rate because more people are willing to use the service. When average contribution rate reaches another threshold, the price becomes flat because it is determined based on advertised quality but not actual quality. And the users enjoy better quality than he/she expects.

Figure 2 is plotted with parameters H^* =0.5, $\bar{h}$ =0.00002, V=100 and η_0 from 10000 to 100000. As the figure shows, when the user population is too small the price is set to 0 since the quality warranty won't be committed. Thus, a critical mass of population is required to reach for a commercial peer production system to emerge. As the user population grows higher than $\hat{\eta}$, more and more contributors join and the value is then promoted, some users are willing to pay higher as long as the system can ensure the quality warranty. As the user population grows, price arises until it reaches upper bound, $VH^*/2$.

The corresponding subscription population is:

$$\eta^* = \begin{cases} \eta_0/2 & \text{if } \eta_0 \ge 2\hat{\eta} \\ \hat{\eta} & \text{if } \hat{\eta} \le \eta_0 < 2\hat{\eta} \\ 0 & \text{if } \eta_0 < \hat{\eta} \end{cases} \quad (2)$$

If the user population is too small, then quality warranty will be enforced such that no users will subscribed to the system, even the price is set to be zero. Notice that without the quality guarantee, there won't be any users for a specific peer production, and price can be positive whenever there exist value from resource sharing.

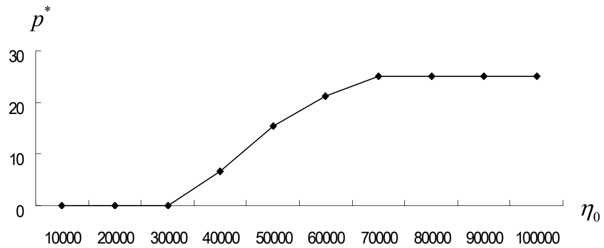

Figure 2. Monopolistic price as function of user population η_0

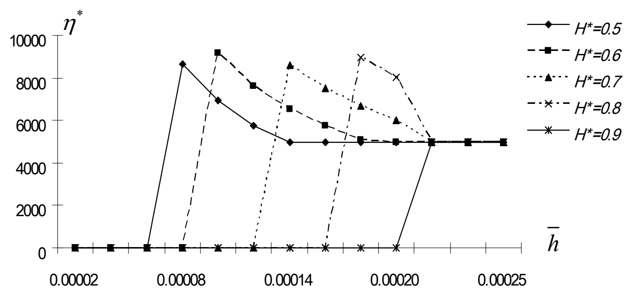

Figure 3. Monopolistic subscriptions as function of average contribution rate $\bar{h}$

Figure 3 illustrates the change of subscription population against $\bar{h}$, where V=100, η_0 =10000. When the individual contribution is too small, none will subscribe to the system. As the average contribution rate increases, the number of subscription increases until it reaches a "peak", then goes down. When contribution rate is sufficiently large, the number of the subscription become stable (equal half of the total population of the potential users). We can also observe that higher quality warranty does not always attract more subscription. This numerical example indicates when advertised quality H^*=0.6 and the average contribution rate $\bar{h}$ =0.0001, the system attract the larger number of subscription than H^*=0.8 and H^*=0.5.

This finding has an important managerial implication. Peer production users seek for "good enough" quality, not the best one. This also explains why the subscription population declines as H^*=0.8.

Finally, we discuss the profit of service provider. Substituting the price (1) and user population (2) into profit function, we can obtain the profit at different prices:

$$\pi_m{}^* = \begin{cases} \eta_0 VH^*/4 - K(\hat{\eta}) & \text{if } \eta_0 \geq 2\hat{\eta} \\ \hat{\eta}VH^*(1-\hat{\eta}/\eta_0) - K(\hat{\eta}) & \text{if } \hat{\eta} \leq \eta_0 < 2\hat{\eta} \\ 0 & \text{if } \eta_0 < \hat{\eta} \end{cases} \tag{3}$$

3.2.2 Quality strategy

As we can see, the price is positively related to the quality. In order to maximize profit, the platform provider must try to achieve the quality as high as possible. However, higher quality desires larger subscribers and higher individual contribution, which results in the reduction of the price. Therefore the platform provider faces the problem to choose an appropriate quality warranty. According to profit function (3), given a quality level $H^* = H'$ in which $\eta_0 \geq 2\hat{\eta}$, the strategy of choosing quality level to increase the quality until $H^* = H''$ such that condition $\eta_0 \leq 2\hat{\eta}$ is satisfied. Therefore, the objective function becomes

$$\underset{H}{Max}\ \pi_m = \hat{\eta}VH(1-\hat{\eta}/\eta_0) = \frac{\ln(1-H)}{\ln(1-\bar{h})}VH\left(1-\frac{\ln(1-H)}{\ln(1-\bar{h})\eta_0}\right)$$

Solving the first order condition $\frac{\partial \pi}{\partial H} = 0$, we can obtain the optimal quality warranty H^*,

$$\frac{\ln(1-\bar{h})\eta_0 - 2\ln(1-H)}{\left(\ln(1-\bar{h})\eta_0 - \ln(1-H)\right)\ln(1-H)} = \frac{1-H}{H} \tag{4}$$

3.2.3 Equilibrium results

From equations (1)-(4), we have the following equilibrium results of peer production system under the monopolistic market.

PROPOSITION 2. *When there is only one peer production platform provider,*

(i). the price, quality warranty, subscriptions, and the profit can be summarized as:

$$\begin{cases} p_m^* = VH_m^*(1-\hat{\eta}/\eta_0) \\ \eta_m^* = \hat{\eta} \\ \pi_m^* = \hat{\eta}VH_m^*(1-\hat{\eta}/\eta_0) - K(\hat{\eta}) \\ H_m^* \text{ is given by solving equation (4)} \end{cases} \tag{5}$$

(ii) the quality warranty has upper bound $H_m^* \leq 1-\left(1-\bar{h}\right)^{\eta_0/2}$ and the users enjoy exactly the same quality as advertised.

For the provider to provide service, the profit must cover his investment $K(\eta_k)$, which occurs due to the communication and coordination of the resource sharing activities. Investment decision should satisfy condition $K(\hat{\eta}) \leq \hat{\eta}VH^*(1-\hat{\eta}/\eta_0)$. The upper bound here has an important commercial implication. As we mentioned before, for a peer production to be succeed, it must be modular. In a Web 2.0 environment, internet has provided an excellent communication channel for contributors. A successful peer production enterprise must have low-cost integration which includes both quality controls over the modules and a mechanism for integrating the contributions into the finished product [4].

3.3 Duopolistic Pricing

3.3.1 Competition under homogeneous quality warranty

Obviously, given two homogeneous peer production providers, users always choose cheaper one. Although the fixed cost of peer production should be low, but it won't be zero anyway. Thus, finally, the equilibrium price decline to just cover investment cost and both providers make no profit. In equilibrium, each provider would face a demand equal to the half of the market demand described in monopolistic setting. Consequently, the equilibrium price can be obtained by solving the following equation:

$$\pi_c = p\eta - K(\eta) = p\frac{\eta_0}{2}(1-\frac{p}{VH}) - K(\eta) = 0 \qquad (6)$$

Solving (6), we can obtain the following results:

PROPOSITION 3. *Under homogeneous service quality condition, (i) if the platform investment $K(\cdot)$ is relatively low such that $K(\eta_c^*) \le VH\eta_0/8$, the equilibrium price, subscription, and quality warranty of each competitive provider will be*

$$\begin{cases} p_c^* = \dfrac{VH - \sqrt{(VH)^2 - 8KVH/\eta_0}}{2} \\ \eta_c^* = \dfrac{\eta_0}{2}\left(\dfrac{1+\sqrt{1-8K/(VH\eta_0)}}{2}\right) \\ H_c^* = 1-(1-\bar{h})^{\eta_c^*} \end{cases} \qquad (7)$$

(ii) If the platform investment $K(\cdot)$ is too high such that $K(\eta_c^*) > VH\eta_0/8$, then the peer production service won't emerge.

The impact of platform investment on the equilibrium results can be observed from condition $(VH)^2 - 8KVH/\eta_0 \ge 0$. Users create contents and providers assist and enable. However, if the assistance from cooperation is too costly for provider, or the peer production platform is too costly to be established and/or operated, then there may be only single service provider. Peer production usually faces the arguments of quality. If the investment is high enough, some providers may turn their head to traditional firm-based production model.

3.3.2 Competition under heterogeneous quality warranty

Now we consider two providers provide differentiated quality service, say a high quality service provider (with more service components) and low one (with less service components). Assume that high quality service provider offers quality warranty level H_h and the low quality service provider chooses quality warranty level H_l. The price of high quality service is p_h; the price of low quality service is p_h. The utility function of customer *i* become:

$$U_i = \begin{cases} v_iH_h - p_h & \text{if subcribe to high quality service} \\ v_iH_l - p_l & \text{if subcribe to low quality service} \end{cases} \qquad (8)$$

We assume the timing of the game stage as the competitive providers choose the quality level simultaneously in the first stage; in the second stage, both providers choose appropriate price of the service. Finally, after observing the quality warranty level and price, the customers choose a better service to subscribe if his/her utility $U_i \ge 0$.

Let $\hat{v}_1$ be the value of marginal user who is indifferent between taking services from the two providers. This implies $\hat{v}_1H_h - p_h = \hat{v}_1H_l - p_l$, or $\hat{v}_1 = \dfrac{p_h - p_l}{H_h - H_l}$. User *i* should prefer high quality service if $v_i \in [\hat{v}_1, V]$. Users with $v_i \in [0, \hat{v}_1]$ will prefer low quality service whenever he/she can receive non-negative utility. Let $\hat{v}_2$ be the value of marginal user who can achieve non-negative utility from subscribing to low quality service. We have $\hat{v}_2H_l - p_l \ge 0$, or $\hat{v}_2 \ge \dfrac{p_l}{H_l}$ and users with $v_i \in [\hat{v}_1, \hat{v}_2]$ will subscribe to low quality service. Consequently, the demand function of these two providers can be written as

$$\begin{cases} \eta_h = \left(1 - \dfrac{p_h - p_l}{V(H_h - H_l)}\right)\eta_0 \\ \eta_l = \left(\dfrac{p_h - p_l}{V(H_h - H_l)} - \dfrac{p_l}{VH_l}\right)\eta_0 \end{cases} \qquad (9)$$

Then, the profits of these providers become:

$$\begin{cases} \pi_h = p_h\left(1 - \dfrac{p_h - p_l}{V(H_h - H_h)}\right)\eta_0 - K(\eta_h) \\ \pi_l = p_l\left(\dfrac{p_h - p_l}{V(H_h - H_l)} - \dfrac{p_l}{VH_l}\right)\eta_0 - K(\eta_l) \end{cases} \qquad (10)$$

Solving $\dfrac{\partial \pi_h}{\partial p_h} = 0$ and $\dfrac{\partial \pi_l}{\partial p_l} = 0$ simultaneously, we get the best response price strategy:

$$\begin{cases} p_h = \dfrac{2VH_h(H_h - H_l)}{4H_h - H_l} \\ p_l = \dfrac{VH_l(H_h - H_l)}{4H_h - H_l} \end{cases} \qquad (11)$$

Plugging p_h and p_l into (10), the profit can be induced as following:

$$\begin{cases} \pi_h = \dfrac{4VH_h^{\ 2}(H_h - H_l)}{(4H_h - H_l)^2}\eta_0 - K(\eta_h) \\ \pi_l = \dfrac{VH_l H_h(H_h - H_l)}{(4H_h - H_l)^2}\eta_0 - K(\eta_l) \end{cases} \tag{12}$$

Next, we try to derive the optimal quality of H_h and H_l. Since $\dfrac{\partial \pi_h}{\partial H_h} == \dfrac{2H_l(H_l + 2H_h)}{(4H_h - H_l)^2} > 0$, the best response quality strategy of the high service provider is to set the price as high as possible, given his opponent's strategy. The best response quality strategy of the provider with lower quality level can be obtained by solving $\dfrac{\partial \pi_l}{\partial H_l} = 0$. Here, we get $H_l^* = 4/7 H_h$. Under this service quality, the demand for high and low quality service can be obtained as

$$\begin{cases} \eta_h = \dfrac{7}{12}\eta_0 \\ \eta_l = \dfrac{7}{24}\eta_0 \end{cases} \tag{13}$$

Substituting $H_l^* = 4/7 H_h$ into (11), the price can thus be obtained as:

$$\begin{cases} p_h = \dfrac{1}{4}VH_h \\ p_l = \dfrac{1}{8}VH_l \end{cases} \tag{14}$$

Similarly, the profits for the two providers under differentiated service quality can be obtained as:

$$\begin{cases} \pi_h = \dfrac{7}{48}VH_h\eta_0 - K(\eta_h) \\ \pi_l = \dfrac{7}{192}VH_l\eta_0 - K(\eta_l) \end{cases} \tag{15}$$

From (15), we know both service providers will set his quality as high as possible, satisfying the condition $H_l^* = 4/7 H_h$. In addition, the demand of each type of service will be sufficiently large to ensure the warranty of the service quality advertised. Therefore, denote $\sigma = \left(1 - \left(1 - \bar{h}\right)^{7\eta_0/12}\right) / \left(1 - \left(1 - \bar{h}\right)^{7\eta_0/24}\right)$ as the ratio of *actual* high quality service level to actual low quality service level. Since the service providers can advertise his service with a quality warranty level not larger than the actual quality level, the equilibrium differentiated quality warranty levels will be

$$\begin{cases} H_h = 1 - \left(1 - \bar{h}\right)^{\eta_h} \\ H_l = \dfrac{4}{7}H_h \end{cases} \quad \text{if } \sigma \geq \frac{4}{7} \tag{16A}$$

$$\begin{cases} H_h = \dfrac{7}{4}H_l \\ H_l = 1 - \left(1 - \bar{h}\right)^{\eta_l} \end{cases} \quad \text{if } \sigma \leq \frac{4}{7} \tag{16B}$$

(16A) indicates the situation that the provider with low quality offers higher quality than the quality warranty level he advertises. In situation (16B), the high quality provider provides higher quality that he advertises.

PROPOSITION 4. *Under differentiated service quality,*

(i) equilibrium subscription, price, profit, and quality warranty will be the results show in (13)-(16)

(ii) the demand, price, and profit of high quality service are more than those of low quality.

(iii)One of the two service providers offers higher quality warranty than advertised.

The best explanation to this observation is network externality. A situation in which the price users are willing to pay to gain access to a service is based on the number of other people who are currently using it is called network externality. When a service has positive network externality, market share and quality perceptions are positively correlated. Equation (13) also supports this opinion. As we can see, η_h is twice as high as η_l, that is, the demand for high quality service is much more than that of low quality one.

Figure 4-6 illustrate price, quality of service level and profit against user population η_0, where V=100, $\bar{h}$ =0.0001. For simplicity we drop the investment from profit on figure 6. Even though the average contribute rate is low, the quality can still be improved as user population grows. This indicates that for peer production to be successful, user participation is crucial.

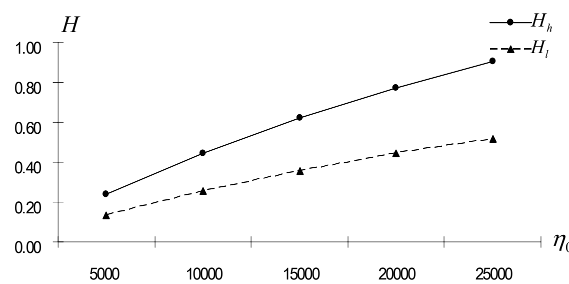

Figure 4. Quality as function of user population η_0

4. CONCLUSIONS

Peer production does change business models in some way, but it won't challenge the whole market system. There's a subcategory of things that can be produced in relatively fine-grained, modular units that are amenable to peer production model, and a lot of the most valuable products of the information economy can be produced this way [12]. In this paper, we develop a model to study the price and quality decision of peer production under monopolistic market and duopolistic competition. We find that when there is only one specific functional peer production in the market, higher individual contribution rate will help improve quality, and new users will be attracted and join this peer production. Because of increasing quality, profit will be raised. When there are two peer production providers in the market, the

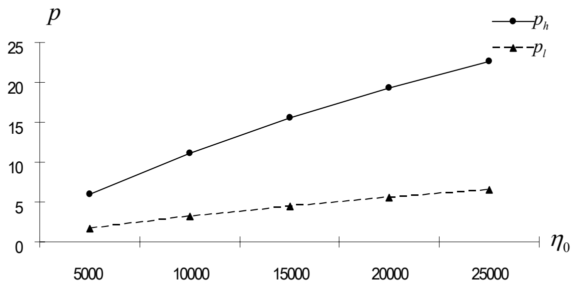

Figure 5. Equilibrium price as function of user population η_0

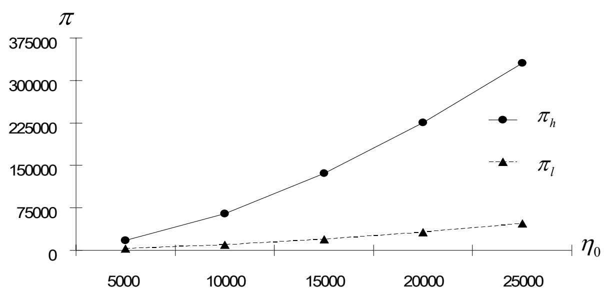

Figure 6. Profit as user population of user population η_0

peer production service won't emerge if the platform investment is too costly if both provide same quality level. If they differentiate service level, in the long run, the principle of differentiation always holds. Higher quality provider always attract more subscribers and generate higher revenue than lower quality one. One of the providers may provide higher quality than the quality warranty he advertises.

There are several directions for future research. We have assumed that everyone in the peer production communities will contribute and the contribution rate of peer production participants is equal. However, there are free riders and the degree of individual contribution varies. One possible extension is to take free riders into consideration. Another extension is to study the distribution of contribution rate. Currently, the platform investment is exogenous, it will be interesting to consider the capacity planning issue of the platform in which the number of the subscribers become a cost factor such that the platform provider need to deliberate an appropriate number of peer producers to subscribe in the peer production system.

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