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ECONOMIC INVESTIGATION OF PEER PRODUCED SERVICES

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Abstract

The main focus of Web 2.0 is on contents and services. In this paper, we propose a game theoretical model to study the business model of peer production based services from the viewpoint of peer participants. As the potential users of the services are free to join, the concern of a typical participant is to evaluate if the benefit from provisioning a variety of resources is worthy. Both self-organized (decentralized) and firm-based (centralized) configurations are investigated. The profit, network size and demand are also discussed. To ensure the efficiency, an incentive mechanism is proposed. We found that both market configurations are not socially optimal, and would face the recondite trouble of over provisioning or under provisioning. From the view of profit-seeking participants, they would prefer the self-organized market structure.

Keywords: Peer Production, Game Theory, Incentive, Web 2.0.

1 INTRODUCTION

The main focus of Web 2.0 business model is on contents and services. While most stated that a self-organized peer production community would be more efficient than traditional firm-based operations, this has to be carefully examined. There are two types of participants in Web 2.0 related system(s)/service(s): contributor and consumer. Contributors share and consumers request resource(s) at their free will. However, the service(s)/system(s) would face the uncertainty of the resource availability. Research has monetized the Web 2.0 related services and studied the pricing problem from the point of consumer (Li & Lee 2007), but the contributor-side is not investigated. Our paper will continue this part to complete the entire business model.

Experts-Exchange is a famous knowledge-sharing web platform that enables people to work together to solve their technology problems. This website catches the spirit of peer production system with slightly different ways. It requires subscription and provides searching, asking and collaborating mechanisms with payoff. Participants can ask questions and others thrive on solving. They compete to provide solutions, and the payoff is received once the solution is accepted. In (Li & Lee 2007), the participants subscribe to the peer production based service system to acquire resource(s) needed, meanwhile they also contribute resource(s) to the entire system. The main purpose of using this system is on the resource-acquiring services, and participants are not profit-seeking, that is, they won't receive any payoff by contributing. Our research tries to explore systems like Experts-Exchange from the opinion of those who strive for payoff. The self-organized (decentralized) and firm-based (centralized) settings are compared to help understand the characteristics.

In this paper, we try to examine the efficiency of both configurations, and an incentive mechanism is developed to enforce the efficiency. The equilibrium network size is also investigated here. Besides, we are interested in understand will over participating or under participating happen. By utilizing game theory, we model the behaviors of the participants and seek to find out how behaviors of

participants will be influenced by incentive mechanisms. Our research addresses the following questions:

- What can participants expect to gain payoff?
- What's the ideal network size for the system to be efficient?
- Which is the socially optimal configuration?

Besides, this study has the following salient features which differentiate it from the past literatures:

- The participants is not altruistic, they are rational and profit-seeking.
- We conduct a network size based expected payoff for participants.
- The existence of service broker is discussed.

The remainder of the paper is organized as follows. In section 2, we review the related literatures. The model of our paper is then described in section 3. Finally, section 4 provides concluding remarks and offers future research directions.

2 LITERATURE REVIEW

Peer-to-peer (P2P) is processes that purposely create value through the cooperation of peer participants. These processes are governed by the community of peers themselves, not controlled by traditional firm hierarchy. The existing literatures suggest that the peer participants tend to free-ride (or under provisioning) if the purpose of the participation is to share/exchange resource. In this paper, we discuss the engagement from a different point of view. In other words, the participants provide the resource for benefit-generating (for monetary or reputation purpose). Once provided resource is requested/ transferred, he/she receives the pre-defined payoff. It is obvious that, as more join the network, the quality of the resource pool becomes better, however, that will deteriorate in the incentive of peer participation in consequence of the competition degree also arise consequently.

P2P architecture is a type of network in which peer participants are equivalently capable of providing resources. What has been needed to facilitate the emergence of such peer to peer processes? The first requirement is a technological infrastructure that acts as participating platform. The second one is communication systems which allows for autonomous communication between peer participants. Third, the size of network should be large enough so that the requested resources can be easily found, and the contents pooled in the network should satisfy the expectation of peers.

As the participants are free to join the network, the concern of participants is if the benefit from serving a variety of resources is worthy, compared with the cost of resource investment. Besides, as a result of the decentralized and loosely self-enforced sharing, the content quality (resource availability) is argued frequently. When considering the quality of peer production, Linus's and Graham's Law are often quoted(Duguid 2006). These two laws also emphasize the notable concern of user participation, saying that if there are enough participants in peer production, the quality of contents can be assured.

The objective of Web 2.0 services is to maximize the collective intelligence of the skilled participants. Peer production was introduced to describe the new Web 2.0 model of economic production based on P2P community activities(Benkler 2002). A community is characterized as a group where individuals come together for a shared purpose or interest. Online communities, also known as virtual communities, are online social networks in which people with common interests interact to share information and knowledge(Chiu, Hsu et al. 2006). The challenges in forming a virtual community are the willingness to share with others and the member development(Koh & Kim 2004). It is important to explain why individuals are willing to or not to share with other community members when they have a choice.

Peer production is one of the realizations of P2P based system. It 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 the traditional firm-based or

market-based production. Peer participants depend on self-organized communities to produce a shared outcome (Tapscott & Williams 2006).

The pricing strategies of peer production related service has been studied (Li & Lee 2007) from the consumer side, in our research the viewpoints from peer participants are examined. Should users perceive the value of peer production and are willing to contribute. Identifying the motivations underlying the sharing behavior in virtual communities would assist both academics and practitioners gain insights into how to stimulate knowledge sharing in virtual communities. Free riding is one of the key problems that confront P2P systems(Feldman, Lai et al. 2004). The sharing behavior and incentives for contribution of peer participants were covered in other researches (Bagozzi & Dholakia 2006; Baldwin & Clark 2006; Hsu, Ju et al. 2007). Theories like Social Cognitive Theory, Social Capital Theory and Organizational Citizenship Behaviors are applied to help clarify sharing behavior (Koh & Kim 2004; Chiu, Hsu et al. 2006). However, the average contribution rate will drop to zero if the participants are rational(Nyborg & Rege 2003).

Generally speaking, peer production related services do not provide incentive for users to contribute. Consequently, users can obtain services without contributing. Eventually, the free-riding problem occurs. If there are no altruistic participants, the peer production won't emerge. The altruism does help(Vassilakis & Vassalos 2007), but this is not always the case. Motivating users to join the community is crucial to be successful. One of the critical success factors of peer production system is the availability of participants willing to contribute resources to the community. Research(Vassileva 2003) has shown that P2P tends to be overwhelmed by too much free riders, therefore, good incentive mechanisms are required. In our research, we investigate the incentive mechanism from the standpoint of peer participants.

In essence, the peer production related service is a distributed architecture, and most of studies on incentive mechanism were based on this. However, other researches have also shown that economic theory predicts the inefficient provision caused by free-rider, and calls for a central intervention(Krishnan, Smith et al. 2004). Our research covers the two configurations. First the decentralized setting is modeled, and then centralized one is also investigated to compare with.

3 THE MODEL

We assume a peer production system with resource providers acting rationally to maximize their benefit. However, to capture some of the real-life unpredictability in the behavior of users, we actively allow users to change their sharing behavior at free will. There are two configurations of service platform system: self-organized (decentralized) and firm-based (centralized). Resource requestors look for the desired resource(s) from the system and the participants compete each other on resource(s) provisioning to receive payoff. The payoff is pre-defined and well-known.

No managerial hierarchies exist in the self-organized system, participants won't be commanded to provision or not. The system builder is not profit-seeking and won't interfere in the operations and processes within the entire system. Besides, the subscription is free of charge. Participants and requestors interact arbitrarily to make request and provisioning. On the contrary, in the firm-based configuration the broker organizes and manages the operations of resource provisioning. The service broker coordinates the entire system operations, and those participants who subscribe to the system have to pay the admission. The provision decision of participants is restricted by their own ability and opportunity cost, and this is known to themselves before subscribing to specific system.

A resource request is sent to participants randomly for only one time once it is made, and the provisioning behavior is independent of other participants. There are slightly differences between two service configurations here. The requester in the self-organized system randomly selects one provider from those who respond to the request if there is more than one. After the resource is transferred, a payoff is received directly by the respondent. In contrast, in the firm-based one the service broker

organizes the provisioning processes and picks a respondent for the requestor. The participants pay the admission to and receive the payoff from the service broker.

Suppose that of n_0 potential participants, n subscribe to the peer production network for profit-seeking. While an ad hoc resource request is made, k participants respond. Once resource is transferred, he/she receives payoff (monetary reward or reputation credit) w . Let c_i be fixed cost for a typical participant i to provide a variety of resources with the probability α that a resource is satisfied by an ad hoc request, in which $0 \leq \alpha \leq 1$ and $c_i \in U[0, C]$. The demand of the resource request is λ . Both configurations are depicted in figure 1, and the parameters are summarized in table 1.

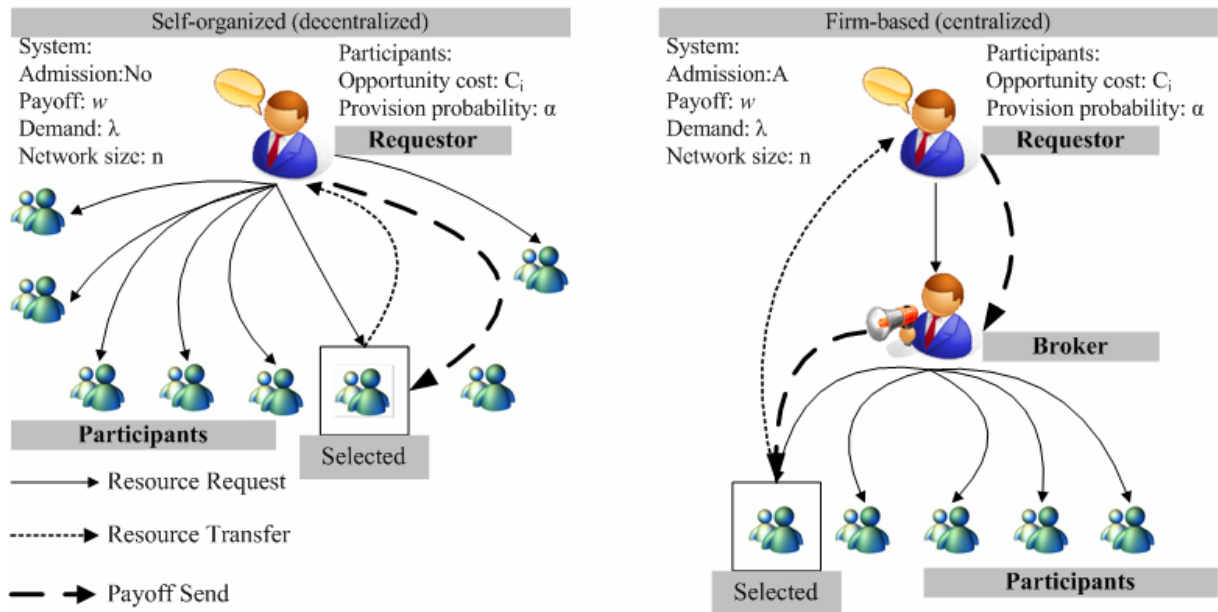


Figure 1. The self-organized and firm based systems and resource provisioning processes

Parameters	Description
n_0	Potential users of peer production systems
n	Number of participants in specific peer production system
k	Number of participants who possess resource(s)
c_i	Opportunity cost of participant i
α	Probability of resource providers responding to specific resource request
λ	Demand of resource request
w	Payoff of responding to specific resource request

Table 1. Parameters of model

Resource requestors of peer production system expect to get required resource(s) efficiently, however, the availability is far from certain. On the other hand, the purpose of peer participants is to make profit by providing resource(s), and what he/she can expect to earn is highly depended on others. We first start from the concern of resource requestors. When a request is made, it is broadcasted to all participants, and those who possess resource(s) answer the call and expect to get payoff from

provisioning. From the view of requestor, the probability of receiving required resource in an ad hoc request is

$$\sum_{k=0}^n \binom{n}{k} \alpha^k (1-\alpha)^{n-k}, 0 \leq k \leq n. \quad (1)$$

Thus we have the minimum resource availability

$$H(n, \alpha) = 1 - (1 - \alpha)^n. \quad (2)$$

From the viewpoint of resource providers, making profit is the most important thing they care. Suppose that of all the n participants, only k possess the requested resource, and they make their sharing decision independently. Thus, the probability of receiving payoff is

$$\alpha \sum_{k=0}^{n-1} \frac{1}{k+1} \binom{n-1}{k} \alpha^k (1-\alpha)^{n-1-k} = \frac{1 - (1-\alpha)^n}{n} = \frac{H(n, \alpha)}{n} \quad (3)$$

3.1 Self-organized and efficient network size

As the system is open, we are eager to know if over-provisioning or under provisioning will happen. That is, what is the network size, in other words, the number of participants in the peer production system under different setting? Since $H(n, \alpha)/n$ is decreasing on n , that is, $\partial H(n, \alpha) / \partial n \cdot n - H(n, \alpha) / n^2 < 0$ and $\partial H(n, \alpha) / \partial n < H(n, \alpha) / n$. As n is large enough and can be treated as continuous variable, the equilibrium number of peer participants n^e is thus given by solving

$$\frac{H(n, \alpha)}{n} = \frac{nC}{2n_0 w \lambda} \quad (4)$$

Compared to the equilibrium one, what is the network size under socially optimal condition? The social welfare is formulated as the aggregate utility of participants, which is

$$\max_n W = H(n, \alpha) \lambda w - nE(c_i) = H(n, \alpha) \lambda w - \frac{n^2 C}{2n_0} \quad (5)$$

Thus the efficient (socially optimal) network size n^w is given by solving

$$\frac{\partial H(n, \alpha)}{\partial n} = \frac{nC}{n_0 w \lambda} \quad (6)$$

As known from $\partial H(n, \alpha) / \partial n < H(n, \alpha) / n$, we have $n^w < n^e$.

PROPOSITION 1. Self-organized peer production will over provision resource(s).

This finding implies that if all the participants compete with each other, more resources are made available than can be consumed. Participants in a peer production related system are egoistic without an incentive. If there is no payoff for the resource providers, they are unlikely to share. In other words, the resource availability is based on altruism. If payoff is provided to those who respond to a resource request (s), a competitive market is thus formed.

3.2 Economic mechanism for enforcing an efficient market

To purposely prevent the market from over provisioning, we design a mechanism to enforce the efficiency. Suppose that to earn the payoff from providing resource(s), a resource provider has to pay

an admission A to join the peer production system first. Thus the decision of whether it is worth subscribing is made based on

$$\frac{H(n, \alpha)w\lambda}{n} - \frac{nC}{2n_0} - A = 0. \quad (7)$$

$\partial W/\partial n$ can be rewritten as

$$\frac{\partial W}{\partial n} = \frac{\partial H(n, \alpha)}{\partial n} w\lambda - \frac{nC}{n_0} = \left(\frac{H(n, \alpha)w\lambda}{n} - \frac{nC}{n_0} \right) - \left(\frac{H(n, \alpha)}{n} - \frac{\partial H(n, \alpha)}{\partial n} \right) w\lambda = 0 \quad (8)$$

, therefore $A = nC/2n_0 + (H(n, \alpha)/n - \partial H(n, \alpha)/\partial n)w\lambda|_{n=n^w}$. Thus, the admission is given as following

$$A = \left(H(n^w, \alpha) \left(\frac{1}{n^w} - \ln(1 - \alpha) \right) + \ln(1 - \alpha) \right) w\lambda + n^w C / 2n_0. \quad (9)$$

Here we are interested if the admission is positive or negative, that is to say, is there any chance that a peer production system has to pay to extend the network size? As $nC/2n_0 > 0$, the condition of

$\left(H(n^w, \alpha) \left(\frac{1}{n^w} - \ln(1 - \alpha) \right) + \ln(1 - \alpha) \right) w\lambda$ is now the determinant of admission fee..

PROPOSITION 2. The incentive mechanism always works regardless of the admission ($A > 0$) or compensation ($A < 0$), and both conditions are determined by the payoff.

The condition $\frac{\partial H(n^w, \alpha)}{\partial n^w} < \frac{H(n^w, \alpha)}{n^w}$ always holds and thus the admission is positively related to payoff. From our deduction we can easily observe that the sign of admission (A) is highly determined by w . If the system is over provisioned ($w > 0$) then the admission is positive, on the contrary the admission is negative. Positive admission prevents from over subscribing and thus over provisioning can be restrained. Compared to this, negative admission encourages the participants to subscribe so that the under provisioning can be improved.

Someone may argue that there exists negative payoff, i.e., the penalty will be placed on those who provide resource(s). If limited liability is imposed on participants, no one joins the system. The negative payoff is likely to be true only if the compensation has to be made to participants, i.e., $A < 0$.

From the viewpoint of business model, the decision of peer participants is made by observing the payoff. It is almost impossible to extend the network size by providing negative payoff. For the peer production to emerge positive payoff is required and thus charging the admission fee is the way to enforce the market efficiency.

3.3 A centralized peer production system

Up to now we assumed that the system is self-organized. What if it is firm-based? Suppose that peer production system is operated by profit-seeking service broker (for example, a service company) who searches resource provider(s) to satisfy resource request (s). The participants subscribe only when payoff covers both opportunity cost and admission. Consequently, the number of the participants subscribed in the system is given by solving

$$\frac{H(n, \alpha)w\lambda}{n} = \frac{nC}{2n_0} + A. \quad (10)$$

From the view of service broker, the objective is to maximize its own profit and the decision problem is now

$$\max_n \pi = nA = n \left(\frac{H(n, \alpha)w\lambda}{n} - \frac{nC}{2n_0} \right) = H(n, \alpha)w\lambda - \frac{n^2C}{2n_0}. \quad (11)$$

The equilibrium network size n^m can be obtained by solving $\partial\pi/\partial n = 0$,

$$\frac{\partial H(n, \alpha)}{\partial n} = \frac{nC}{n_0w\lambda}. \quad (12)$$

From (4), (6) and (12), $n^m < n^w < n^e$ is thus concluded.

PROPOSITION 3. In comparison to self-organized peer production system, firm-based under-provisions resource(s), and both configurations are not socially optimal.

From the viewpoint of participants, the payoff received is positively related to the resource(s) demand. The more he/she is selected as resource provisioning node, the more payoff he/she receives. Thus, participants are concerned about how often they will be selected. The minimum demand size (number of requests) that ensures a participant to be selected as the provision node at least once can be formulated as

$$\lambda = \sum_{k=1}^{\infty} k \left(1 - \frac{H(n, \alpha)}{n} \right)^{k-1} = \frac{n}{H(n, \alpha)}. \quad (13)$$

He/she can expect to be selected at least once only when the demand $\lambda \geq n/H(n, \alpha)$, and the demand of different configurations is ordered as $\lambda^m < \lambda^w < \lambda^e$.

Lower expected demand size means that a participant is selected to provide resource(s) in less numbers of requests. Psychologically, this seems to be easier to receive payoff than self-organized system, and that's the reason participants would like to join. However, this needs to further examine to be assured.

3.4 Participant's choice

From the perspective of participants, they would face the balancing problem between admission and competition. If they choose self-organized system, no admission is spent and thus less investment is required. However, the system attracts more competitors and the return on investment cannot be assured. In contrast, the admission is spent before they get payoff. Even so, because of smaller network size the competition from others can be reduced so that the investment can be recovered shortly. Aggressive participants are likely to choose self-organized system for the sake of low investment, and conservative ones would prefer firm-based system because of low competition. Nevertheless, rationally the choice can be made by comparing the investments of two structures.

Since the payoff, network size and cost are known to participants, which would the participants prefer? Within the first configuration, the payoff received is

$$\frac{H(n^e, \alpha)w\lambda}{n^e} - \frac{n^eC}{2n_0} \quad (14)$$

, and the second one is

$$\frac{H(n^m, \alpha)w\lambda}{n^m} - \frac{n^m C}{2n_0} - A = \left(\frac{H(n^m, \alpha)}{n^m} - \frac{H(n^w, \alpha)}{n^w} + \frac{\partial H(n^w, \alpha)}{\partial n^w} \right) w\lambda - \frac{C}{2n_0} (n^m - n^w) \quad (15)$$

So the decision is made by observing the difference of payoffs (14)-(15)

$$\left(\frac{H(n^e, \alpha)}{n^e} - \frac{H(n^m, \alpha)}{n^m} + \frac{H(n^w, \alpha)}{n^w} - \frac{\partial H(n^w, \alpha)}{\partial n^w} \right) w\lambda - \frac{C}{2n_0} (n^e - n^m + n^w) \quad (16)$$

The participants would prefer self-organized system if (16)>0, but the demand λ is unknown and it would be hard to make decision. However, under equal network size, $n^e = n^m$, the payoff difference is

$$\left(\frac{H(n^w, \alpha)}{n^w} - \frac{\partial H(n^w, \alpha)}{\partial n^w} \right) w\lambda - \frac{n^w C}{2n_0}. \quad (17),$$

As $\partial H(n^w, \alpha) / \partial n^w < H(n^w, \alpha) / n^w$, we have the following conclusion.

PROPOSITION 4. Given equivalent network size, the participants' choice depends on the fixed cost incurred.

Intuitively, participants would prefer the system in which they can easily be selected, thus the firm-based one may be better choice. However, our finding suggests a different result. If the fixed cost is low, say $C \approx 0$, self-organized one will be the choice. As we stated, the peer production system always face the problem of resource uncertainty. From the resource requestors' side, it would be easier to fulfil their requirement if there are enough participants. In providers' opinion, there is no extra investment to join the self-organized system, and there is no promise to make earning in a firm-based one. By reason of the profit uncertainty, the providers make decisions based on their fixed cost incurred. As a result, self-organized system will be a good starting point before they can make earning.

4 CONCLUSIONS AND FUTURE WORKS

In this paper we analyze the business model of peer production system from the viewpoint of peer participants who act as resource providers and expect to make money within the system. We find that both configurations are not socially optimal. To examine the efficiency, we design an admission fee mechanism. Both admission and compensation can gracefully work as an incentive. However, from the viewpoint of business, admission fee is more reasonable to be selected as enforcing mechanism. To verify the social welfare, a firm-based setting is also discussed. Comparing to self-organized one, under-provisioning is the result of centralized one. From the standing point of participants, self-organized setting is preferred even it faces the over provisioning problem.

There are several topics which need to be further studied. First, we have shown that both settings are not socially optimal. It would be interesting to develop a mixed business model to ensure the efficiency of market. Second, the payoff is pre-defined in our model. Investigating payoff based on different requests will complete the model.

References

- Benkler, Y. (2002). Coase's penguin, or linux and the nature of the firm. *The Yale Law Journal*, 112(3), 371-445.
- Chiu, C.-M., M.-H. Hsu, et al. (2006). Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories. *Decision Support Systems*, 42, 1872-1888.
- Duguid, P. (2006). Limits of self-organization: Peer production and "Laws of quality". *First Monday*.

- Feldman, M., K. Lai, et al. (2004). Robust incentive techniques for peer-to-peer networks. Proceedings of the 5th ACM conference on Electronic commerce, 102-111.
- Koh, J. and Y.-G. Kim (2004). Knowledge sharing in virtual communities: An e-business perspective. Expert Systems with Applications, 26, 155-166.
- Krishnan, R., M. D. Smith, et al. (2004). The impact of free-riding on peer-to-peer networks. Proceedings of the 37th Annual Hawaii International Conference on System Sciences, 10.
- Li, Y. M. and Y. L. Lee (2007). Pricing web 2.0 related services: Peer production. Proceedings of the Ninth International Conference on Electronic Commerce, 441-448.
- Nyborg, K. and M. Rege (2003). Does public policy crowd out private contributions to public goods. Public Choice, 115(3), 397-418.
- Tapscott, D. and A. D. Williams (2006). Wikinomics: How mass collaboration changes everything. New York, PORTFOLIO.
- Vassilakis, D. K. and V. Vassalos (2007). Modelling real p2p networks: The effect of altruism. Proceedings of the Seventh IEEE International Conference on Peer-to-Peer Computing, 19-26.
- Vassileva, J. (2003). Motivating participation in peer to peer communities. Engineering Societies in the Agents World III: Third International Workshop, ESAW 2002, Madrid, Spain, September 16-17, 2002: Revised Papers.