Promotion of Cooperative Behavior in C2C market:

Effect of Reputation Management System

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Abstract: We model an online consumer-to-consumer (C2C) market by employing the prisoner's dilemma. To discuss the characteristics of goods traded on a C2C market, we define temptation and contribution indexes based on the payoff matrix of the game. According to the results of the simulation with the model, we find that a positive reputation management system can promote cooperative behavior in online C2C markets. Moreover, we also find that such a system is especially effective for an online C2C market where expensive physical goods are traded, whereas a negative reputation management system is effective for an online C2C market where information goods are traded.

Keyword: Reputation Management System, C2C market, e-commerce, online market, Agent-Based Approach, Iterated Prisoner's Dilemma.

1. Introduction

Thanks to the spread of the Internet throughout society, we can now buy and sell online goods and information that could not easily exchanged in the past due to small demand. The online consumer-to-consumer (C2C) market is a new kind of transaction place made possible through the popularization of the Internet. Although such a market provides an effective transaction facility, it is susceptible to fraud, because of its anonymity and ease of entry and exit. Thus, the attractive features of online trading have led to an increased risk of cheating, e.g., receiving goods without paying for them or receiving payments without sending goods. In short, there is a temptation to cheat others. On the other hand, communication through the Internet promotes voluntary contributions. The open source community for Linux and BBSs of various genres are good examples. However, the free-rider is a problem in these communities. Generally in on-line transactions, a participant can receive services without contributing somehow, which is not an incentive for cooperation.

In this paper, we show that the prisoner's dilemma is a suitable model to deal with this problem. Before we describe the model though, we should briefly review pertinent research on how to identify trustworthy participants and promote cooperative behavior. Participants tend to enter and exit online C2C markets frequently. Employing reputation to form trust among participants has been studied by many researchers. Rensnick et al. (2000) pointed out that using reputation information was one of the best ways to promote mutual trust between participants. Dellarocas (2000) discussed the robustness of reputation systems against unfair evaluations by

malicious participants. Kollock (1999) provided a classification of positive and negative aspects concerning reputation information. Based on this classification, we will develop a model to analyze reputation management systems operationally. By employing an operational model, we can identify the conditions in which the reputation management system works efficiently.

2. Temptation and contribution in C2C markets

The Internet motivates users to contribute to online communities and tempts them to cheat of the transactions in those communities. It makes it easy for users to contribute to a community because of its low cost of communication, while it also tempts them to cheat on others because of its anonymity. In particular, ease of entry and exit may tempt users to receive goods without paying for them or to receive payments without sending goods. To promote efficient online transactions, we must give incentives to contribute and minimize the temptation to cheat. To explore viable systems for efficient online transactions, we formalize the situation according to game theory. In particular, we can define a stage in the online C2C transaction as the prisoner's dilemma.

2.1. Prisoner's Dilemma in a C2C market

A player who participates in a C2C online transaction always has an incentive to cheat on others (non-cooperation). In particular, a buyer may take goods from a seller without paying for them, and a seller may get a payment from a buyer without sending the goods to him or her.

The situation in C2C online transactions is representative of the prisoners' dilemma. If two player's cooperate, they can get the maximum total benefit. Yet one player cheating on the other is also a way to maximize self benefit. In its simplest incarnation, there are two players, and they cannot communicate with each other directly because they are in solitary confinement in a prison. Each player has two strategies, i.e., cooperation (C) and deception (D). We can consider a payoff matrix as shown in Table 1.

Table 1: Payoff matrix for prisoners' dilemma

		Action of player-2	
		C	D
Action of player-1	C	(S,S)	(W,B)
	D	(B,W)	(T,T)

The necessary conditions for the prisoners' dilemma are the following inequalities.

$$\begin{cases} B > S > T > W \\ 2S > B + W \end{cases} \quad (1)$$

In the prisoners' dilemma of a C2C online transaction, a seller can have two actions; i.e. he/she can cooperate with the buyer to give goods in exchange for payments or he/she can deceive him or her to get payments without sending goods. A buyer also can cooperate or deceive, i.e. pay for goods or get goods without paying for them. To explore viable policies to maximize cooperative behaviors and to eliminate non-cooperative

ones, we must define indexes concerning contribution and temptation based on the payoff matrix of the prisoners' dilemma.

2.2. Temptation

Taylor (1976) defined the index γ as level of temptation to cheat others.

$$\gamma = \frac{B-S}{B-T} \qquad (2)$$

When the denominator $B-T$ is small, the risk of cheating is small because there is only a small difference between the payoffs of the two situations, i.e., the case of (my action, the other's action) = (D,C) and (D,D). When $B-S$ is large, the incentive to cheat is large because there is a large difference between the payoffs of (D,C) and of (C,C). Hence, a large γ indicates a large temptation to cheat on others, whereas a small γ indicates a small temptation. The range of γ is (0,1), as defined in the inequalities (1).

2.3. Contribution

We define the index δ as the level of contribution as follows.

$$\delta = \frac{S-T}{S-W} \qquad (3)$$

When the denominator $S-W$ is small, the risk of cooperating is small because there is only a small difference between the payoffs of (C,C) and of (C,D). When $S-T$ is large, the incentive to cooperate is large because there is a large difference between the payoffs of (C,C) and of (D,D). Hence, a large δ indicates a strong motivation for contribution, whereas a small δ indicates a weak motivation for contribution. The range of δ is (0,1), as defined in the inequalities (1).

2.4. Boundary Conditions

Based on the in-equalities (1) we can derive the boundary conditions in terms of δ and γ as follows.

$$\begin{cases} \gamma < 1/(1+\delta) \\ 0 < \gamma < 1 \\ 0 < \delta < 1 \end{cases} \qquad (4)$$

Figure 1 illustrates the area where the PD conditions of (4) are satisfied. Surprisingly, by employing the indexes, we can see that the boundary conditions of prisoners' dilemma can be plotted on the two-dimensional plane instead of plotting regions for the inequalities (1) in a four-dimensional parameter space fro representing the payoff matrix of the game. The mathematical simplicity of the two indexes is of obvious benefit to study the meaning of contribution and reputation.

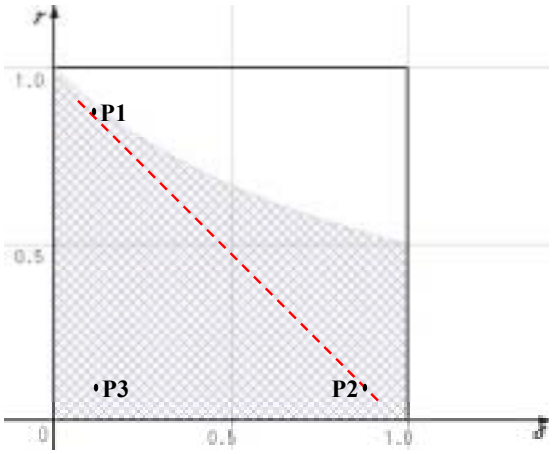

Figure 1: The area that satisfies the boundary conditions on the contribution (δ) and temptation (γ) plane

2.5 Characteristics of goods in a market

In the area around point P1, γ is large but δ is small. The payoff matrix for this area indicates there is a large gain to cheating and large loss to being cheated. We can interpret the situation as transactions of high-price goods. In the area around point P2, γ is small but δ is large. The payoff matrix for this area indicates there is an incentive for cooperation because there is a small difference between the gain of cooperating S and that of cheating B. Moreover the incentive tends to be larger because there is a large difference between S and T. We can interpret the situation as being like that of the open source community where participants try to share information. In the area around point P3, γ and δ are small. In this situation, the risk to cooperate tends to be large because the difference between W and T is large, although the temptation to cheat tends to be small because the difference between B and S is small. Hence, it is difficult to cooperate, even though there is no temptation to cheat.

Thus by employing two axes, we can describe the characteristics of goods in a C2C market. In the next section, we will analyze the behavior of our model. The behavior on the line ($\gamma + \delta = 1$) in Figure 1 will be useful to discuss the difference between physical goods and information. Based on this analysis, we will discuss the policy to develop the reputation management system.

3. Modeling Reputation Management System

To analyze and design a C2C online market, we developed our model based on an agent-based approach, because the analysis and design require detailed and dynamic explanations at the individual participants' level to exhibit social phenomena. Axelrod (1997) concluded that the agent-based approach would be effective for analyzing mechanisms that can promote global phenomena from local interactions between agents. By employing this approach, we describe C2C online transactions within the framework of the prisoners' dilemma in order to find the requisite conditions and market mechanism for promoting the emergence of cooperative behavior.

3.1. Procedure of Transactions

Our market model is for sellers and buyers dealing in goods through bids and awards. Transactions are performed by the following procedure.

1. The seller puts the "goods" which s/he has on the market.
2. The buyer chooses "goods" based on his or her preference (which is identical to “demand,” here).
3. The buyer matches the "supply" with the "demand."
4. The buyer chooses a transaction partner by checking the seller's reputation.
5. The seller chooses a transaction partner by checking the buyer's reputation.
6. If a transaction partner is chosen, they will trade.
7. The profits of the seller and the buyer are found by consulting the prisoner's dilemma pay-off matrix.
8. A new participant enters the market every turn.
9. The new participant copies the strategy of the participant who has the highest current profit.

Under these circumstances, if there is no system to promote cooperation, a participant who does not always cooperate could exploit a participant who always cooperates with everyone. To promote cooperation, one can embed a reputation information management system into the C2C online transaction.

3.2. Formulation of Reputation Management System

To model the reputation management system, we define reputation in terms of positive and negative evaluations of a participant based on Kollock (1999). For simplicity, the reputation we deal with is the number of cooperative and non-cooperative actions in deals on a market.

An action of agent-i during a time period t (A_t^i) can be either cooperation (C) or defection (D).

$$A_t^i = \{C, D\} \qquad (5)$$

A cooperative agent always chooses C, whereas a non-cooperative agent always chooses D. An agent with a tit for tat strategy selects his or her action based on the previous actions of the agent it is dealing with. A random agent cooperates or defects with others randomly. A transaction history (T_t^i) is recorded by the online transaction system.

$$T_t^i = \left\{ A_k^i \middle| k \in \{0,1,\cdots,t\} \right\} \qquad (6)$$

To make a deal, agents who want to buy bid on goods offered by other agents; the agent who has received bids awards the goods to one of them. A bid or an award is decided by each agent based on the reputation it calculates by using the historical records of the actions of others. Based on the historical record, an agent can calculate the number of cooperative and non-cooperative actions in a certain time span, i.e., $T_{C,t}^i, T_{D,t}^i$ respectively.

$$T_{C,t}^{i} = \left\{ k \middle| A_k^i = C, k \in \{t - Scope + 1, t - Scope + 2, \cdots, t\} \right\} \qquad (7)$$

$$T_{D,t}^{i} = \left\{ k \middle| A_k^i = D, k \in \{t - Scope + 1, t - Scope + 2, \cdots, t\} \right\} \qquad (8)$$

The reputation of agent(i) is calculated based on focus of reputation (α) as described in equation (9).

$$R_t^i = \alpha \left| T_{C,t}^i \right| - (1 - \alpha) \left| T_{D,t}^i \right| \qquad (9)$$

Positive or negative reputation systems can be described with α equaling 1 or 0, respectively. Based on the value calculated by (6), each agent makes his or her bid or award.

4. Simulation

Yamamoto et al. (2003) indicated the fundamental characteristics of reputation management systems in simulations with medium values of temptation and contribution, i.e., (γ,δ)=(0.4,0.6), and a variable the reputation cognitive parameter (α). According to their results, a positive reputation system can be more effective than a negative reputation system for an online transaction.

In this section, to discuss desirable reputation management system in terms of characteristics of goods on online C2C market, we will try to find what type of reputation management system can lead to the extinction of participants who cheat others. We will observe the behavior of the model on the $\gamma + \delta = 1$ line in Fig. 1. A large γ means that a market deals with expensive physical goods. A small δ means that a market is a kind of a community to exchange information and knowledge. we will focus on cases with a high rate of entrance and exiting ($\alpha = 30$), because we want to discuss the function of the reputation system.

The horizontal axes in Figs 2, 3, and 4 are δ. The vertical axes show average population after 200 simulation periods. The relation between γ and δ is $\gamma = 1 - \delta$. Figure 2 shows the behavior with a positive reputation management system ($\alpha = 1$).

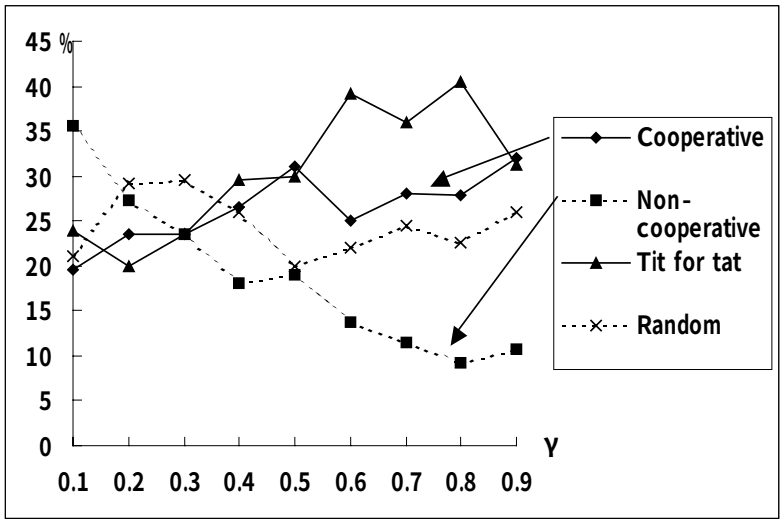

Figure 2: Trajectories of populations on γ+δ=1 when α is 1.0.

Figure 3 shows the trajectories of populations for four types of strategy when the market employs positive and negative reputation management systems (α =0.5). Figure 4 shows the trajectories of the populations when the market employs negative reputation management systems (α =0). All figures reflect the cooperative situation when δ is large. For example, a negative reputation management system can prevent non-cooperative behaviors when δ is 0.8, although the system can not prevent non-cooperative behavior when δ is 0.6.

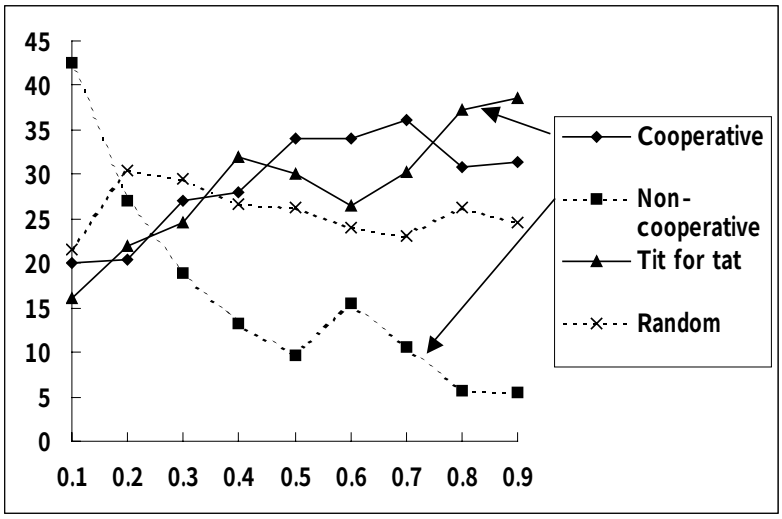

Figure 3: Trajectories of populations on $\gamma + \delta = 1$ when α is 0.5.

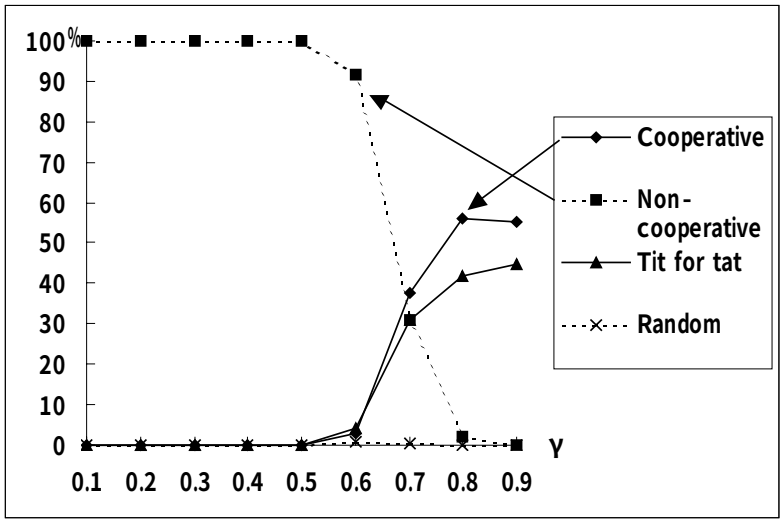

Figure 4: Trajectories of populations on $\gamma + \delta = 1$ when α is 0.0.

5. Discussion

According to Figs. 2 and 3, on the one hand, a positive reputation management system can prevent non-cooperative actions when there is a small to moderate temptation to cheat. On the other hand, Fig. 4 shows that the system can not prevent bad behavior when there is a large temptation. We thus find that a positive reputation management system is effective to promote good transactions in markets where expensive physical

goods are exchanged.

On the other hand, the positive reputation management system prevents transactions by newcomers, whereas the negative system does not. Hence, the negative system is effective when it can promote cooperation, because of the characteristics concerning newcomers. In the area of $\delta>0.7$ of Fig. 3, there are many participants with the cooperative strategy. In this area, temptation is low and contribution is high, i.e., large benefit to cooperate and low risk to be cheated. Knowledge sharing markets such as K-square(www.ksquare.co.jp) and Chienowa.com(chienowa.com) where participants exchange their knowledge and money with invisible hands are relevant examples. If someone “free-rides” on the other’s knowledge, the other might not suffer from it, because the other can still have his or her own information and knowledge despite the lack of compensation. Hence, in a online C2C knowledge market, a negative reputation management system would be better than positive one, because it can prevent non-cooperative actions, yet does not prevent transactions by newcomers to the market.

6. Conclusion

We showed the effectiveness of sharing information concerning reputation to ensure cooperative actions among participants in C2C online transactions by using an agent-based model in an experimental simulation. In a high turnover market that is typical of C2C online transactions of physical goods, a positive reputation system can be more effective than a negative reputation system. However, in a online C2C knowledge market, a negative reputation management system would be better than positive one because it does not prevent transactions by newcomers to the market.

We defined two indexes concerning temptation and contribution based on a payoff matrix, in order to deal with the characteristics of goods exchanged on C2C market. By employing the indexes, we can identify a viable policy to design an effective C2C market, because we can discuss what type of reputation management system is effective for trading certain goods, e.g. expensive physical goods or information goods.

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