(Preliminary draft)

Temptation and Contribution in C2C Transactions: Implications for Designing Reputation Management Systems

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Abstract: A reputation management system can promote trust in transactions in an online consumer-to-consumer (C2C) market. We model a C2C market by employing an agent-based approach. To discuss the characteristics of goods traded on the market, we define temptation and contribution indexes based on the payoff matrix of a game. According to the results of a simulation conducted 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.

Keywords: Reputation Management System, C2C market, Agent-Based Approach, Iterated Prisoner's Dilemma.

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1. Introduction

What is a suitable reputation management system for a C2C market? In a C2C market, we can now buy and sell various goods that could not easily be exchanged in the past due to small demand. However, in online markets, participants can easily enter and leave and it is easy to change one's identity. This feature invites a problem, which is increased risk of cheating in online trading, e.g., receiving goods without making payment or receiving payment without sending goods.

The reputation management system should provide a motivation for cooperation to a participant despite the volatile nature of online identities. The system also should be suitable for various transaction forms and goods. Furthermore, the system should not pose any barrier to entry, because it is the outstanding advantage of a C2C market that one can participate easily.

In this paper, we study efficient reputation management of the C2C market, because the most suitable reputation management seems to differ depending on the transaction form and the characteristics of goods. A reputation can be classified into positive and negative aspects concerning mutual reputation information (Kollock, 1999). The weight of influence assigned to positive and alternatively negative reputation is an important determinant in the reputation management system. The suitable weight seems to change with the transaction form, i.e., face-to-face or online, and the characteristics of goods. To design an efficient reputation management system for a C2C market, it is important to analyze the factors affecting the choice of the weight. To do so, we developed a model that expresses whether a market is online or offline by using the market turnover rate and expresses the characteristics of goods in terms of "temptation" and "contribution", because we should treat characteristics of goods and transaction forms seamlessly.

The essential elements that express a C2C transaction are characteristics of goods and transaction forms. Characteristics of goods in our study indicates information goods or physical goods. For example, information goods include software, knowledge about software, and so on. Physical goods include any physical item for sale: handbags, cars, food, etc. The transaction form could be online or offline. For example, online transactions include ones on eBay or ones dealing with used books on Amazon.com. Offline transactions include any kind of face-to-face trade.

Section 2 discusses the strengths of our model in comparison with previous works on trust and reputation. In section 3, we show that the prisoner's dilemma is a suitable model to deal with the online market. We introduce two indexes of "temptation" and "contribution" as the payoff matrix for the prisoner's dilemma to facilitate arguments about the characteristics of goods in the market. Section 4 and 5 review the development of our model of reputation management system on C2C market. Section 6 discusses our findings on reputation management systems for an online market. We suggest that a cooperative strategy is more viable than a tit-for-tat strategy when a reputation management system is employed. Finally, section 7 summarizes our study’s results and proposes a perspective to design a suitable reputation management system for online transactions.

2. Review of Past Works

Reputation formation has been extensively studied by many researchers. For example, in economics, Shapiro (1982) treated the properties of reputation as asymmetric information. To discuss reputation operationally, we define it based on the study of Wilson (1985) as “a person’s characteristic described by others based on his or her behavioral history."

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. Dellarocas (2000) discussed the robustness of reputation management systems against unfair evaluations by malicious participants. Kollock (1999) provided a classification of positive and negative aspects concerning reputation information. Based on this classification, Yamamoto et. al.,(2004) developed their model to analyze reputation management systems operationally. Yamamoto et. al.,(2004) did not consider various characteristics of goods traded on the market. We introduce temptation and contribution indexes to facilitate arguments about the characteristics of goods in the market seamlessly. By employing an operational model, we can identify the conditions under which the reputation management system works efficiently.

Axelrod (1984) used the notion of *the shadow of the future* to account for the evolution of cooperative behavior in the iterated prisoner's dilemma. The shadow of the future can be expressed as a probability for which a transaction might continue in the future. The shadow of the future is often used as a mechanism for evolution of cooperative behavior in game theory. In our model, we can refer to turnover rate as the shadow of the future. For example, a large shadow of the future corresponds to an offline transaction in which it is difficult to change one's identity, and a small shadow of the future corresponds to an online transaction in which it is easy to change one's identity. Our model enables us to discuss turnover rate as an essential element of a real-world market within the theoretical framework of the game theory.

Yao and Darwen (1999) have considered how reputation affects the evolution of cooperation using a neural network (NN) and genetic algorithm (GA) in the framework of the prisoner's dilemma with multiple choices, e.g., 64 choices of cooperation. Their contention is that multiple levels of cooperation is a more realistic model of the real world market. They pointed out that having more choices as to cooperative level also encourages mutual defection, but even here, reputation mitigates this so that (for games of reasonable length) the degree of choice has no effect on the dominance of cooperation. Other researchers have also used GAs for evolution of cooperation in the iterated prisoner's dilemma (Ashlock et. al., 1995)(Axelrod,1987)(Nowak and Sigmund,1998).

Expressing the learning mechanism by using an NN or GA is often used in social simulationa (Gilbert and Troitzsch, 1999). On the other hand, for modeling of social phenomena in the real world, both NN and GA have the weakness that is difficult to interpret the meaning of the variables inside the model as the element of a human interaction (or market) because of the complexity of the NN and GA mechanisms.

Axerlod (2003) pointed out that the KISS principle is important to simulation research, because the goal of a model is to enrich our understanding of fundamental processes that may appear in a variety of applications. To ensure the KISS principle, it is important to express a model only with essential variables. Moreover, previous studies did not consider the characteristics of goods or the forms of transaction in a market, even though these elements are important to designing a reputation management system for trustable transactions.

To consider transaction form and characteristics of goods, we developed a model that expresses whether a market is on-line or off-line according to market turnover rate and expresses the characteristics of goods according to "temptation" and "contribution". The strength of our model is the ability to determine which of the positive and negative reputation management systems are effective in terms of transaction form and characteristics of goods.

3. 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.

3.1 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 prisoner’s dilemma. In the prisoner’s dilemma, each player has two strategies, i.e., cooperation (C) and defection (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 prisoner’s 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 his or her partner 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.

3.2 Temptation and Contribution

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

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

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).

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

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

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).

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**

3.3 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 is 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.

4. Modeling C2C online transactions

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.

4.1 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 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 performs matching of "supply" and "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 term.
9. The new participant copies the strategy of the participant who has the highest current profit.

We summarize this transaction procedure in figure 2.

Figure 2: A transaction procedure on online market

By repeating such transactions, those participants who have a suitable strategy survive in the market as time progresses. We varied the parameters of the environment and reputation management system in the simulation. The simulation experiment explored the structure of the reputation management system for which cooperative actions would be stable. We then formulized the actions of participants and the reputation management system. An agent is to be a seller or a buyer who has strategic choices and trades autonomously.

4.2 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.

In our model, the agent comprises the strategies of transaction, goods to sell, goods to buy, range of allowable difference in goods between buyer and seller, focus on reputation, and length of history taken into account by the agent. The strategies of transaction are consistently cooperative, non-cooperative, tit for tat, and random.

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

$$A_t^i = \{C, D\} \quad (2)$$

A consistently 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.

$$T_t^i = \{A_k^i | k \in \{0, 1, \cdots, t\}\} \quad (3)$$

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.

$$T_{C,t}^i = \{k | A_k^i = C, k \in \{t - Scope + 1, t - Scope + 2, \cdots, t\}\} \quad (4)$$

$$T_{D,t}^i = \{k | A_k^i = D, k \in \{t - Scope + 1, t - Scope + 2, \cdots, t\}\} \quad (5)$$

The reputation of agent(i) is calculated based on the transaction history of agent i, the weight of influence assigned to positive and alternatively negative feedback is determined by the constant α.

$$R_t^i = \alpha \left|T_{C,t}^i\right| - (1 - \alpha)\left|T_{D,t}^i\right| \quad (6)$$

Positive or negative reputation management 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. We can describe a choice of agent between positive reputation and negative one with alpha ($0 \le \alpha \le 1$). The pure negative reputation management system, on the one extreme, can be described by alpha=0. On the other extreme, the pure positive reputation management system can be described by alpha=1. In an actual on-line market, a participant seems to employ a mixed choice between positive and negative reputation, therefore the system may be described as an intermediate system ($0 \le \alpha \le 1$).

We can change the initial number of agents with cooperative, non-cooperative, tit for tat, and random strategies. We also change a number of characteristics of goods, varieties of each characteristic, number of agents who enter and exit during each time period. Randomly chosen agents leave the market. The number of exit agents is described by a parameter "turnover rate". New entry agents employ the strategy of participant who achieved the highest current profit in the market. The number of entry agents is equal to the number of exit agents. In many cases the new participant enters a market after asking an acquaintance who has already participated in a market about what the market is like. If the acquaintance has high profits from that market, the new agent begins to carry out actions in the market. In contrast, if the acquaintance has low profits, the newcomer avoids the market. Byrne (1965) showed that a person gets acquainted with other persons who have similar attitudes and characters. In our model, therefore, a new participant selects the best current strategy in the market.

5. Simulation

Market flexibility is one of the important factors distinguishing an online transaction from a transaction in the real world. In our model, it is described as the number of agents entering and exiting within a certain time period. The markets of online transaction and real world can be described by low and high values of the parameter. The parameters concerning focus on reputation and length of history are the characteristics of the reputation management system. Table 3 shows the parameters and their values.

We ran simulations with moderate values of temptation and contribution, i.e. (γ, δ)=(0.4,0.6) while the reputation cognitive parameter (α) was varied, in order to identify the fundamental characteristics of reputation management systems. Based on the simulations, we could identify the difference in characteristics of effective reputation management systems for online and real C2C markets. We then varied the temptation and contribution parameters in order to study the relationship between characteristics of goods and type of reputation management system in an online C2C market.

Table 3: Experimental parameters

Initial number of agents for each strategy group	25
Duration	100 periods
Number of characteristics of goods	5 bits
Varieties of each characteristic	5 bits
Allowable difference in goods' characteristics	10 bits
Focus on reputation	Operational parameter [0,1]
Length of history	Operational parameter {0, 5, 10, 20}
Number of entrances and exits (turnover rate)	Operational parameter {10, 20, 30}
Temptation(γ)	Operational parameter [0,1]
Contribution(δ)	Operational parameter [0,1]

5.1 Effect of Reputation Management System

To find an effective strategy for each condition, we observed the populations of each strategy. A large population indicated the effectiveness of the strategy for the given condition. Offline and online market transactions were then examined to identify which reputation aspect, i.e. positive or negative, is effective to maintain cooperation among participants.

First, an offline market, which is represented by low rate (=10) of entrances and exits, was examined. Figure 3 shows the trajectories of population for four groups when there is no reputation management system in an offline market. The vertical axis shows the population of agents. The horizontal axis shows simulation time. This figure illustrates that the non-cooperative strategy becomes dominant. A market collapses in an environment where no reputation management system exists. Next, we introduced the reputation management system described in section 4.2 and performed the simulation over again.

Figure 3: Trajectories of population for a slow turnover rate and no reputation management system.

Figure 4 shows the trajectories of population for four groups when the entry and exit number is low (=10) and the focus on reputation is negative (α =0) in an offline market. The axes are the same as in Figure 3. This figure illustrates the effectiveness of the cooperative strategy in the negative reputation management system. The dominance of the cooperative strategy is also observed in offline markets with neutral (α =0.5) or positive (α =1.0) reputation management systems.

Figure 4: Trajectories of population for a slow turnover rate and negative reputation management system

Next, let us discuss an online market, which is represented by high rate (=30) of entrance and exits. Inevitably, the non-cooperative strategy becomes the dominant strategy in an online market without any reputation management system, the same as in an offline market. To overcome this problem, the use of negative reputation management system can prevent the growth of the population of participants with a non-cooperative strategy.

However, a negative reputation management system does not eliminate non-cooperative participants. A high entry and exit number is indicative of the environment of an on-line market. In such a situation, negative reputation management systems like the black list of a traditional market do not function effectively.

To improve on the negative reputation management system, a positive reputation management system can complement an negative system in an online market; that is, the reputation is rated both positively and negatively (α =0.5). A participant in such a market can clearly distinguish cooperative participants from non-cooperative ones. Furthermore, a participant who accumulates a high reputation is frequently selected as a transaction partner. He/She can get increasingly high profits. This system not only distinguishes and eliminates non-cooperative participants, but can evaluate a cooperative participant's positive reputation. This environment thus expresses a real C2C market.

To examine the effectiveness of the positive reputation management system, the negative reputation management system was removed from the online market, which means that the entry and exit number is high (=30) and the reputation is rated only positively (α =1). Accordingly, the participants could behave non-cooperatively and change their personal IDs. Nonetheless, the cooperative strategy becomes dominant. This indicates the effectiveness of a positive reputation management system in an on-line market.

Table 4 summarizes the results of the most effective strategies after 100 time periods in each situation.

Table 4: Effective strategy depending on market situation

Number of entrances and exits	Focus on reputation	Strategy	Frequency
Low =(10)	No reputation information	Non-cooperation	Anytime
	Negative (α =0)	Cooperation	Anytime
	Positive and Negative (α =0.5)	Cooperation	Anytime
	Positive (α =1.0)	Cooperation	Anytime
High (=30)	No reputation information	Non-cooperation	Anytime
	Negative (α =0)	Non-cooperation	Anytime
	Positive and Negative (α =0.5)	Cooperation	Often
	Positive (α =1.0)	Cooperation	Often

5.2 "Temptation" and "Contribution"

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 figure 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 (α =30), because we want to discuss the function of the reputation management system.

The horizontal axes in figures 5, 6, and 7 are δ. The vertical axes show average population after 200 simulation periods. The relation between γ and δ is δ =1-γ. Figure 5 shows the behavior with a positive reputation management system (α =1).

Figure 5: Trajectories of populations on $\gamma+\delta=1$ when α =1.0.

Figure 6 shows the trajectories of populations for four types of strategy when the market employs positive and negative reputation management systems (α =0.5). Figure 7 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 6: Trajectories of populations on $\gamma+\delta=1$ when α =0.5.

Figure 7: Trajectories of populations on $\gamma+\delta=1$ when α =0.0.

6. Discussion

We discuss our progress in understanding a reputation management system on the online market.

6.1 Discussion about "Temptation" and "Contribution"

According to the result of the simulation, positive reputation management system can work on online C2C market, although negative reputation management system can not. However, positive reputation management system prevents transaction by newly entering participant, because the participant has no positive reputation although many old participants have that much.

Moreover, it tends to be more difficult to implement positive reputation management system than to do that concerning negative reputation. It is big question whether positive reputation management system is always working on online C2C market or not. In another word, are desirable reputation management systems different depending on characteristics of goods which exchange on online C2C market? To find the answer, we will discuss the relationship between the characteristics of the goods and desirable reputation management system.

According to figure 5 and 6, on one hand, positive reputation management system can prevent non-cooperative action when there is small and middle temptation to cheat others. On the other hand, figure 7 shows that the system can not prevent the bad behavior when there is large temptation. We find that positive reputation management system is effective to promote good transactions on the market where expensive physical goods are exchanged.

However, on one hand, positive reputation management system is going to prevent transaction by new comers. On the other hand, negative reputation management system does not do that. Hence, negative reputation management system is effective when it can promote cooperation, because of the characteristics concerning new comers. In the area of δ>0.7 of figure 7, there are many participants with cooperative strategy. In the area temptation is low and contribution is high. This means high benefit to cooperate and low risk to be cheated. One of the examples of the market is knowledge sharing market where participants exchange their knowledge and money with invisible hand. For example, K-square and Chienowa.com are the markets. If someone would do free-ride 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 if other get them from him or her without compensation.

Hence, when we would be in a online C2C knowledge market, negative reputation management system would be better than positive that, because the negative reputation management system can prevent non-cooperative actions and it can not prevent transactions by new comers from outside of the market.

Table 5 compares the effectiveness of the reputation management systems for online C2C markets. A positive reputation management system is effective where participants exchange physical goods, e.g., eBay. The system is also effective in an online C2C knowledge market. However, it would be better to employ a negative reputation management system for a knowledge market, because the system does not prevent new comers' transactions.

Table 5: Comparison of Positive and Negative Reputation Management Systems

	Online market	
	Physical goods (Large temptation)	Information goods (Small temptation)
Positive reputation management system	Effective	Effective
	Effective, e.g. eBay's reputation management system	Effective but there is a barrier to entry
Negative reputation management system	Not effective	More effective
	Able to cheat others due to ease of entering and exiting from a market	Does not obstruct newcomers from participating Easy to implement

6.2 Consistently cooperative strategy versus tit-for-tat strategy

In the area which has large contribution and small temptation $(\delta = 0.9)$ of Figures 5, 6, and 7, the consistently cooperative strategy is more dominant than the tit-for-tat strategy.

According to inequalities (1) concerning the payoff matrix in Table 1, a player with a consistently cooperative strategy and a player with a tit-for-tat strategy get profit S from each other when they make a deal. On the one hand, when a player with a consistently cooperative strategy deals with a player with a non-cooperative strategy, he/she always gets profit W. Moreover, when a player with a tit-for-tat strategy deals with a player with non-cooperative strategy, he/she gets profit W at first. Subsequently, he/she gets profit T. Hence a tit-for-tat player tends to get higher profit than a cooperative player gets, because T is greater than W according to inequalities (1). Axelrod (1984) said that the tit-for-tat strategy is the most effective strategy based on his experiments on the iterated prisoner's dilemma. In evolutionary game theory, for cooperation to evolve, one needs punishment for cheating (Bender and Swistak, 2001). A non-cooperating player would be deterred by punishment. However, in a C2C market, a participant would probably rather not choose non-cooperative player as a transaction partner rather than punish him or her. Thus in a C2C market, non-cooperating players would be screened out by not being not chosen.

We suggest that a cooperative strategy is viable with a reputation management system, even if we face the repeated prisoner's dilemma situation. Why would we suggest that? First, it is difficult for a tit-for-tat player to make a deal because s/he takes on a bad reputation due to his or her non-cooperative actions after interacting with a non-cooperative player. Hence, no newcomer should employ a tit-for-tat strategy. Second, cooperative players can earn high reputations, because they can not enter into a chain of non-cooperative deals, although they might be cheated by a non-cooperative player. Moreover, they can make a lot of deals, because of their stable high reputations. Hence, they can decrease the probability to interact with a non-cooperative player, and thus, many newcomers tend to employ the cooperative strategy.

The tit-for-tat strategy is effective to render extinct non-cooperative players when there is a large temptation. However, the cooperative strategy is the best when there is a large contribution, even if a cooperative player can be cheated by a non-cooperative one. This result seems to indicate the possibility of the growth of communities trading information goods, e.g. open source, based on the altruistic behavior of participants.

6.3 Comparison between online and traditional markets

In a negative reputation management system, the cooperative strategy is effective when the turnover rate is low, as shown in figure 4. This reflects the effectiveness of the law punishing non-cooperative participants in the real world. In a society with a low turnover rate, non-cooperative actions lead to low reputations for which an affected participant would face difficulty in making transactions. Hence, a negative reputation management system in the real world makes non-cooperative participants leave a market and lets cooperative ones enter.

However, a negative reputation management system does not work when the turnover rate is high, because non-cooperative participants frequently come and go from a market. If a participant has a low reputation, he or she could re-enter as a new participant. Hence, cooperative participants can be exploited and they will disappear from a high turnover rate market with a negative reputation management system. A positive reputation management system can overcome this problem, because it counts cooperative actions. This means that it is beneficial for a participant to cooperate with others and to stay in the market for a long time. Furthermore, the system makes non-cooperative participants get out of it. According to a study by McDonald (2002), a seller who has a high reputation can sell his or her goods at a higher price compared with others who have the same goods.

7. 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 management system can be more effective than a negative reputation management 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.

In the market where expensive physical goods are exchanged, positive reputation management system is more effective than negative reputation management system. In the market where is little temptation, e.g. open source community and knowledge market, negative reputation management system is more effective than positive reputation management system, although it is online C2C market. The results indicate availability of negative reputation management system, which can promote cooperative behavior without preventing new comers' participation in a market.

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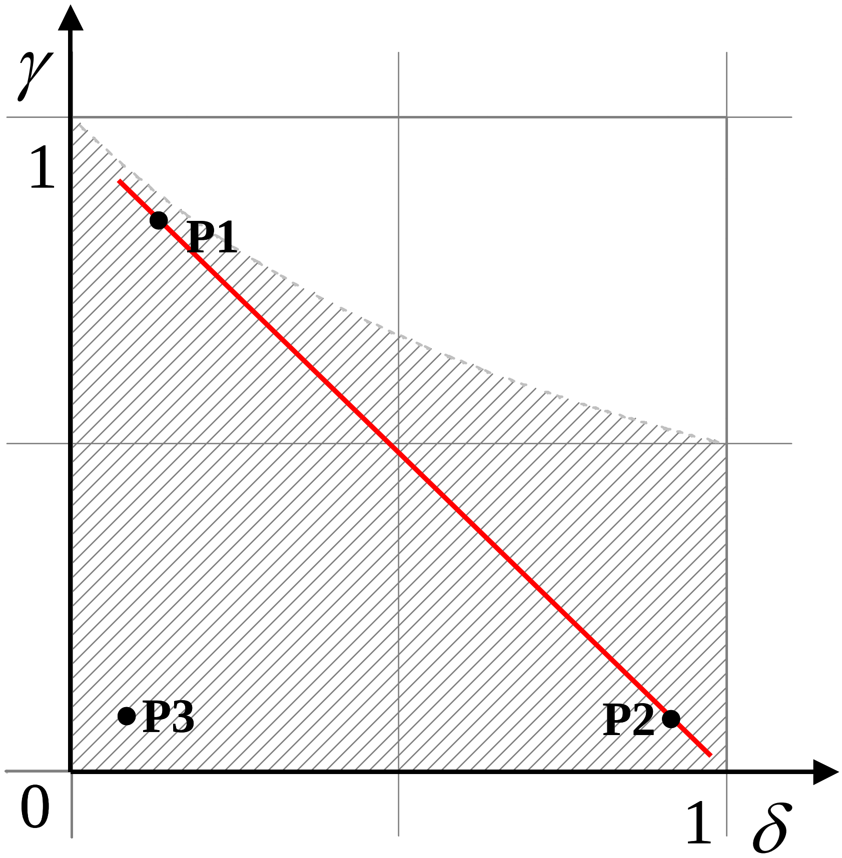

Figure 1: The area that satisfies the boundary conditions on the contribution (δ) and temptation (γ) plane

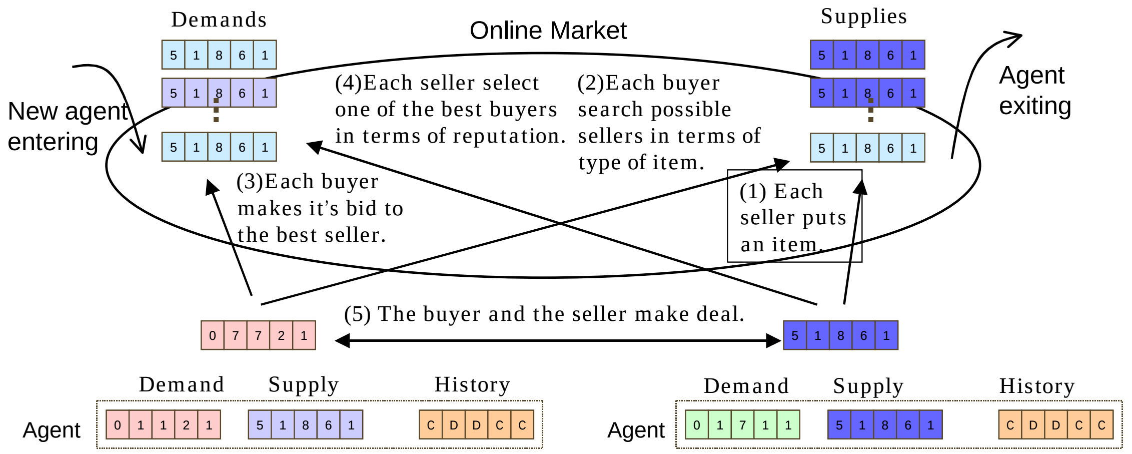

Figure 2: A transaction procedure on online market

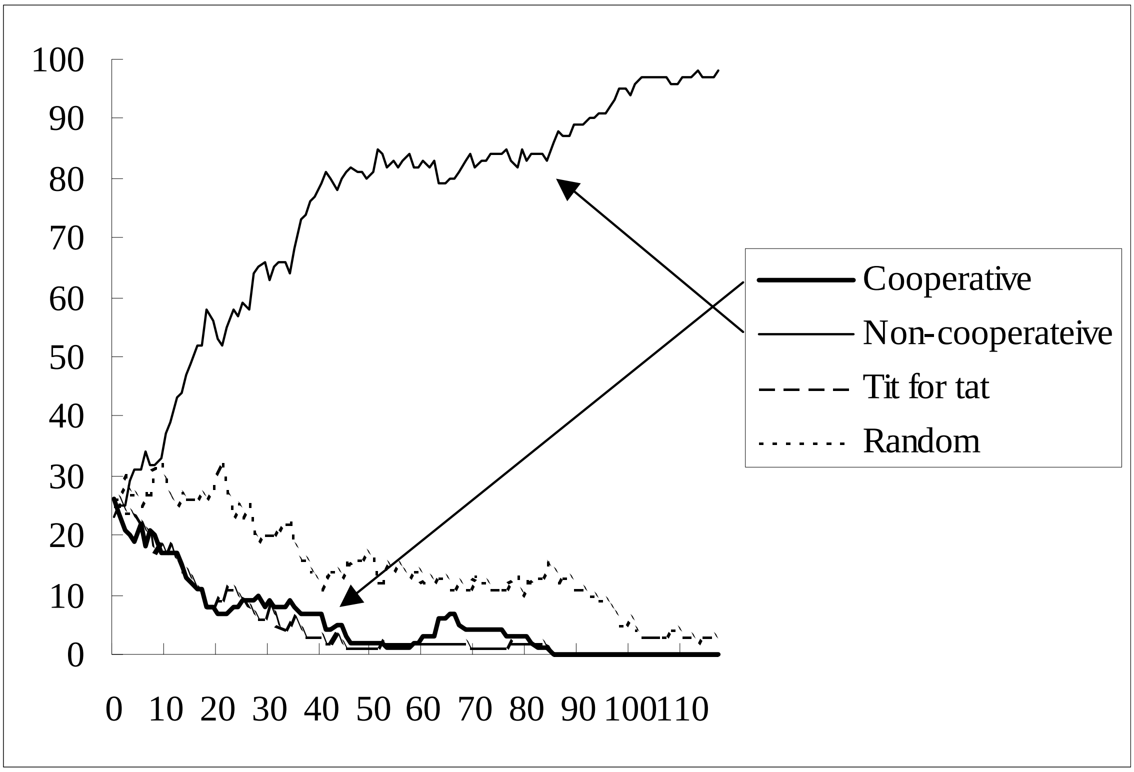

Figure 3: Trajectories of population for a slow turnover rate and no reputation system.

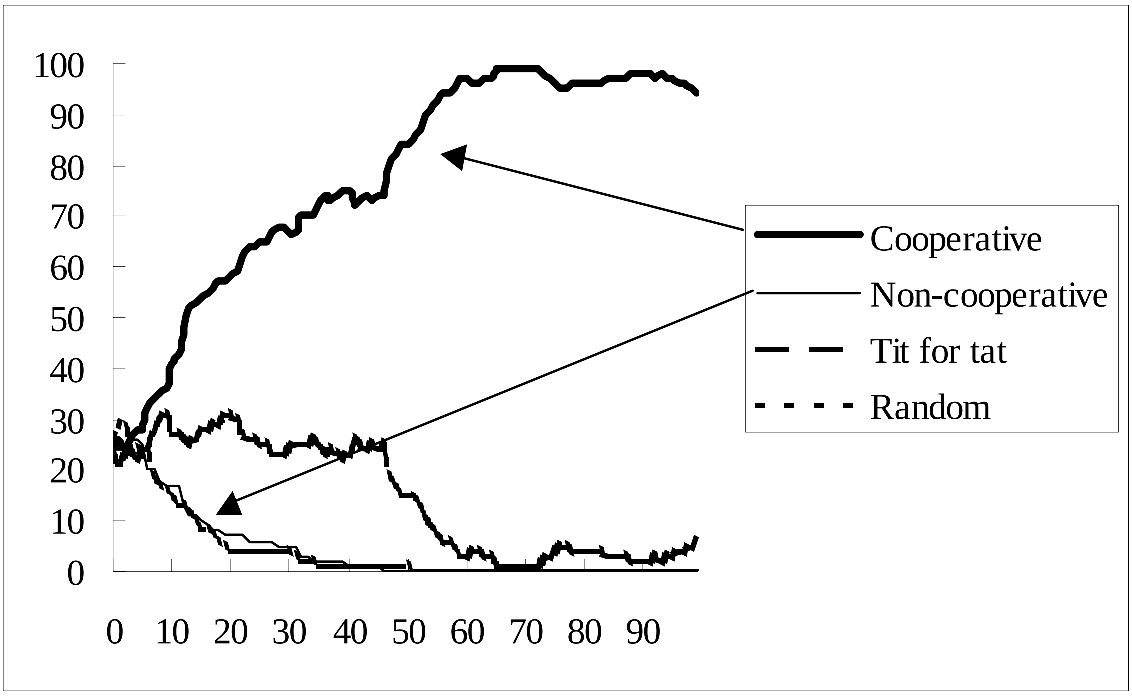

Figure 4: Trajectories of population for a slow turnover rate and negative reputation system

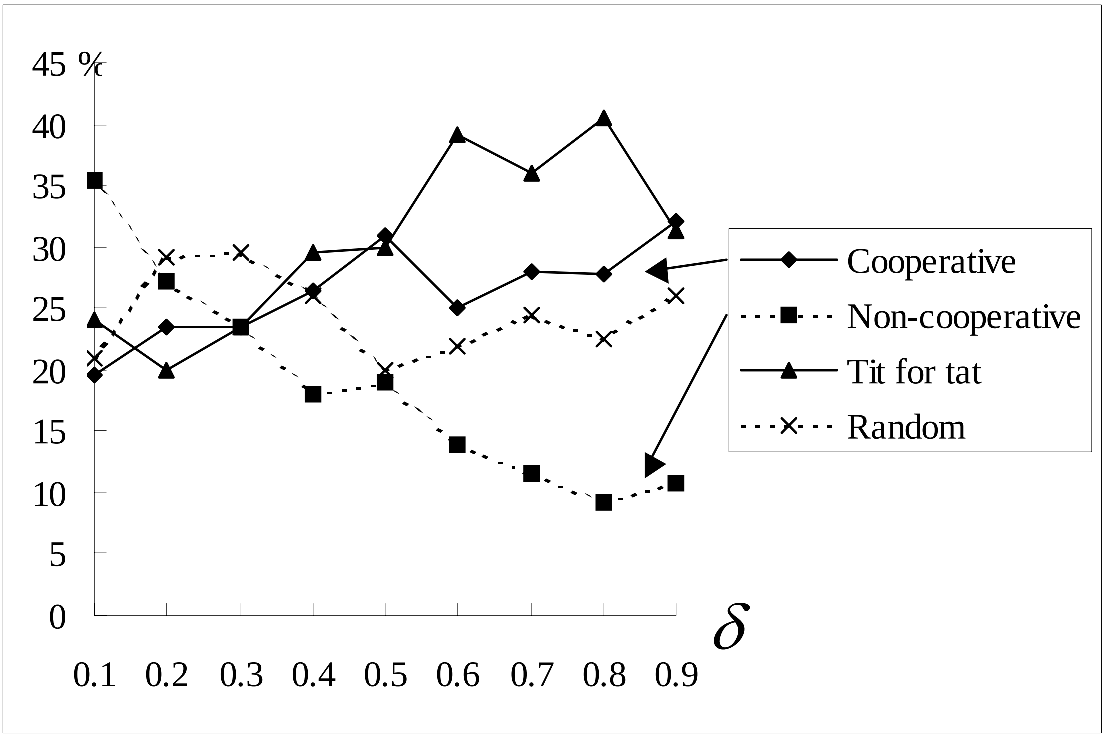

Figure 5: Trajectories of populations on $\gamma+\delta=1$ **when** α **=1.0.**

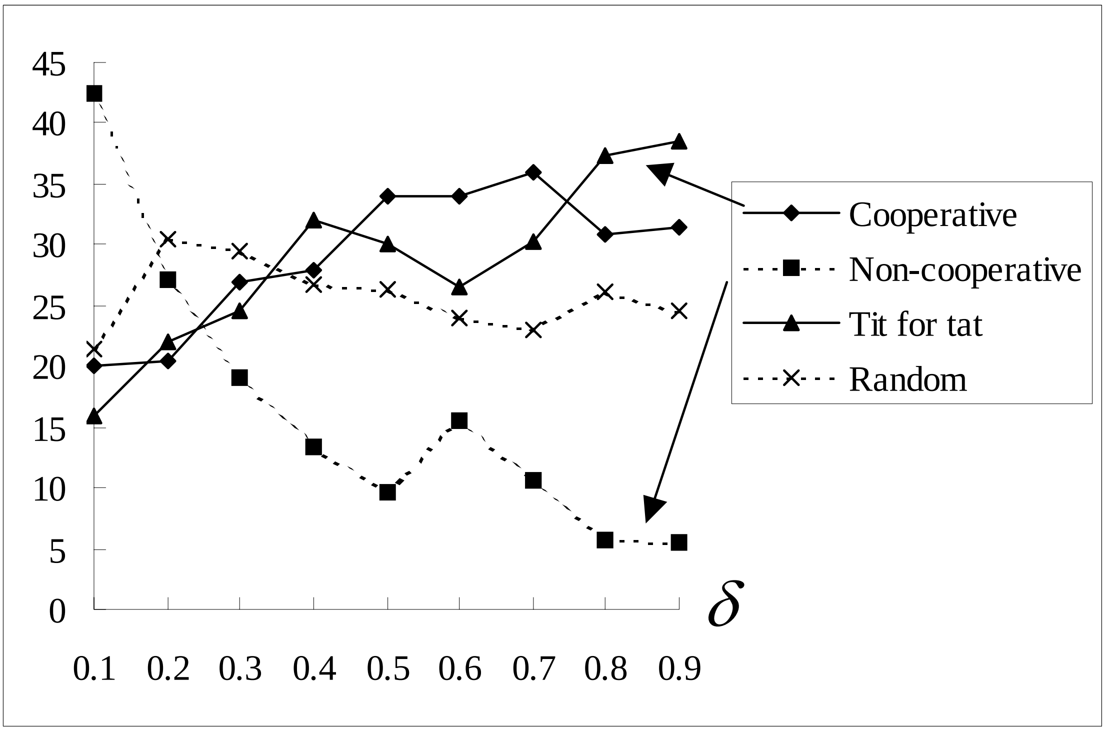

Figure 6: Trajectories of populations on $\gamma+\delta=1$ **when** $\alpha=$**0.5.**

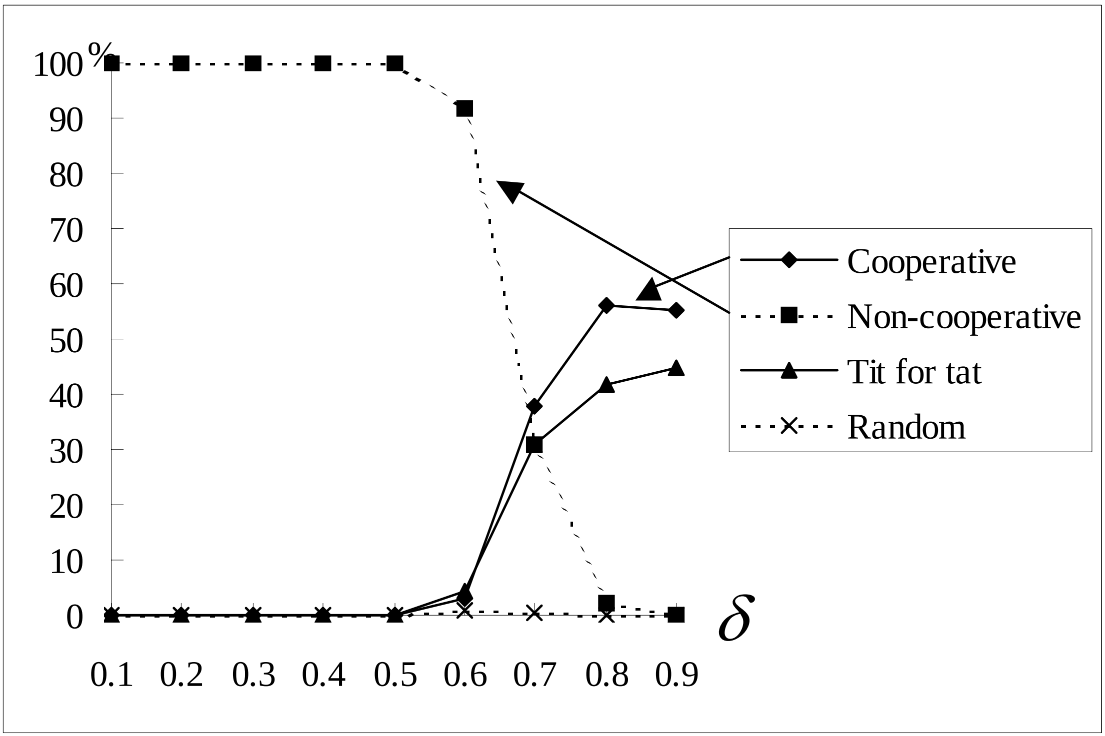

Figure 7: Trajectories of populations on $\gamma + \delta = 1$ when $\alpha = 0.0$.