Trust Formation in a C2C Market: Effect of Reputation Management System

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Abstract

The formation of trust among those participating in an on-line market is an important subject, especially in a C2C market that one can enter and leave easily and in which one can easily change one's identity. Whether participants can trust each other or not will influence the continuation of a market. We therefore discuss the formation of trust in on-line transactions. We believe that a reputation management system is the most effective system for trust formation system. We developed a computer simulation model that describes online transactions with a reputation management system used to share information concerning the reputations of consumers. Its design was based on an agent-based approach used in "prisoner's dilemma" game theory. Simulation results indicate that a positive reputation system can be more effective than a negative reputation system. The results should provide important suggestions useful in designing a reputation system for online transactions.

1. Introduction

The e-commerce market is growing rapidly, thanks in part to the ease at which participants can enter and exit, it's anonymity and ease of registration. However, these attractive features have led to a new problem, which is increasing risk of cheating in online trading, e.g., receiving goods without payment or receiving payment without sending goods, as there are incentives to get goods or payments without being forced to make corresponding the contribution.

A reputation management system can promote trust in transactions in an online consumer-to-consumer (C2C) market. 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. We study efficient reputation management of the C2C market

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. 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. 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.

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.

We introduced the basic reputation model in a previous paper (Yamamoto et al., 2003); in the present paper, we describe a detailed model and analyze the characteristics of a reputation management system.

2. Trust on Online transaction

Let us review the types of online transaction on the Internet in order to discuss the emergence of trust in C2C transactions. Based on this review, we will discuss the requirements of a reputation management system for online transactions.

There are two types of trust management system: the top-down type, e.g., one with a trusted third party, and the bottom-up type, e.g., one where participants share reputation information. We will discuss these systems in 2.2.1 and 2.2.2 and show that the bottom-up type is more effective than the top-down type for online transactions.

2.1 Online transactions

In an online transaction, business organizations (B) and consumers (C) are the main participants. The most successful kind of online transaction is the business organization to business organization (B2B) one, e.g., a supply chain management (SCM) system. B2B transactions on the Internet are similar to transactions made in other markets, except for the cost; B2B transactions tended to use on-line systems before the era of the Internet.

Another type of transaction is business organization to consumer (B2C). Bank transactions and online ticket sales are popular examples because they are exchanges of information instead of physical goods. Standardized goods, e.g., a book and a music compact disk (CD), are also popular goods exchanged in online transactions. Amazon.com is one of the successful examples and it shows us that B2C transactions have evolved because of the Internet. A new type of Internet-powered retailer has appeared, called the "Click & Mortar" retailer.

Distributors also have undergone large changes in the way they do business. For example, Dell assembles a computer on demand from a consumer. It is an example of a direct transaction between a maker and a consumer, and it is also an example of a intermediated transaction between suppliers of computer parts and consumers. The new type of intermediary is named the infomediary, which stands for an internet powered intermediary (Hagel and Singer, 1999).

Consumer and consumer (C2C) is another type of online transaction that has only just begun to be seen. The

Internet has helped C2C transactions to grow, because the network has removed the constraints in terms of distance and time and has provided opportunities for individuals to make deals with lots of others. Examples of the new market include eBay and Yahoo auction.

We will discuss C2C online transactions because of the big impact of the Internet on this kind of transaction. In online transactions, especially C2C, there is a larger risk of cheating, because it is easy for people to enter and exit the market and it's anonymous. The characteristics of an online transaction lead to incentives to get services, goods or money without making any corresponding contribution. This risky situation is a kind of Prisoner's Dilemma and is the reason our model based on this dilemma. We explain the dilemma in section 3.

2.2 Classification of Trust Formation

We have to pay more attention to how to form trust between participants in the online C2C market because the risk of cheating is larger there than in other markets. To deal with that risk, we must find ways to form trust between the participants in a market. We first classify reputation management systems into top-down and bottom-up management systems and then show that the bottom-up systems are more effective than the top-down systems.

Top-down management systems can provide safety mechanism to protect participants from cheaters because a third party in the exchange of goods and money can evaluate how well the buyer and seller meet certain qualification and can also provide transaction control procedures. Authorization for participation is an example of a qualification, and escrow service (explained in section 2.2.1) is an example of a transaction control procedure.

Bottom-up management system can also provide safety mechanisms because participants can identify good and bad participants by considering the ways the trustworthiness of those participants is evaluated by other participants. The feedback mechanism on eBay, for example, which is one of the famous and successful online auction services, is a bottom-up management system concerning trust.

2.2.1 Top-down trust management system

The trusted third party (e.g., a grading service or an escrow service) is a popular kind of top-down trust management system, but a grading service is not effective in C2C transactions even though it is effective in B2B transactions. Escrow, on the other hand, is effective because it can eliminate any possibility of cheating. Figure 1 shows how escrow can complete transactions by intermediating between the buyer and seller to prevent any cheating.

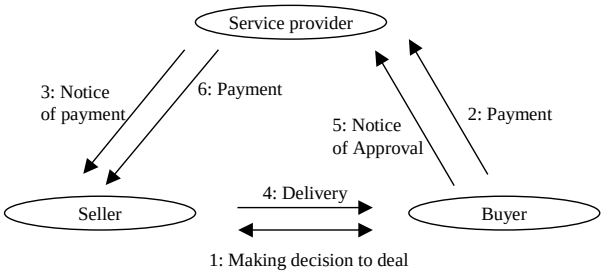

Figure 1: Overview of Escrow

The procedures of Escrow service are:

1. A seller and a buyer decide to deal for specified goods.
2. The buyer transfers money to the account of the escrow service company.
3. The escrow service company notifies the seller that the money has been transferred.
4. The seller sends the goods to the buyer.
5. The buyer notifies the escrow company that the goods arrived.
6. The escrow company transfers the money for the goods to the account of the seller.

Even though escrow is effective in C2C online transactions, there are three problems in its use. The first is its high cost. The second is the complexity of its procedure, which reduces the convenience of using the Internet. The third problem is its limited availability, which limits the areas in which transactions can be made.

Another example of top-down system is a legal system. It is the most trusted management system in many transactions, but we need a lot of money to maintain a legal system. Moreover, it is difficult to apply legal systems among multiple nations. Bakos and Dellarocas (2003) have shown that it costs more to maintain a legal system than it does to maintain reputations.

2.2.2 Bottom-up management system

A bottom-up management system lets participants circulate and share reputation information among themselves to promote cooperative behavior. Many researchers have investigated the ways that the exchange of reputation information builds trust among participants. Resnick et al. (2000) discuss the ways that reputations promote the formation of trust among the participants in an online market and a community. A bottom-up management system can also provide a safety mechanism in that participants can distinguish good offers from bad ones with respect to trust. For example, the feedback mechanism in eBay, which is one of the famous and successful online auction services, is a bottom-up management system with respect to trust.

Although many researchers understand the importance of reputation information in an online market, there is no model taking into account the characteristics of online transaction that stabilize cooperative behavior. We will therefore develop a model focused on reputation information as a key factor in the formation of trust between the participants in an online market. We will use the model to investigate how a reputation management system can promote cooperative behavior.

Participants can easily enter and leave an online C2C market. Bottom-up management not only reduces the cost of information management by eliminating the need for cost due to central information management, but can also deal with the frequent change of participants over time. In eBay's bottom-up management system, the participants evaluate each other. After a transaction between a buyer and a seller, they can evaluate each other in terms of good (1), so-so (0), and bad (-1). They can make deals with trusted participants because the results of the estimations are open to all participants. eBay is one of the successful examples of reputation management systems that let participants evaluate with each other and share the information.

Another example of a bottom-up system is one in which unorganized information passes by word-of-mouth, in other words, by rumor. We often observe that one rumor builds trusts in persons and organizations and that another rumor destroys this trust. Unorganized information exchanged by word-of-mouth, however, is not suitable for promoting effective transactions in a market because it could destroy that market.

2.3 Summary

In this section, we classify systems for trust formation into top-down and bottom-up systems. We summarize the classification in table 1. C2C market is a one of the examples of prisoners' dilemma situations.

Table 1: Framework of trust formation

System	Service	Strength	Weakness
Top down	Escrow	Flawless transaction of goods and payment	Cost per transaction Calculation of transaction cost might be difficult because of the characteristics of goods
	Legal	Strong enforcement The most trusted system	Difficulty in applying a legal system among multiple nations High management cost
Bottom up	Reputation	Low management cost Independent of outside systems	Entrance barriers for newcomers Conspiracy of malicious participants
	Word of mouth	Anyone can participate.	Difficulty of using management system for a market Information might be dubious.

3. 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 Prisoner's Dilemma, to find the requisite conditions and market mechanism for promoting the emergence of cooperative behavior.

3.1 Prisoner's Dilemma in C2C online transactions

A player who participates in a C2C online transaction always has an incentive to cheat on others (non-cooperation), because of the anonymity and ease of entry and exit from the transaction. On the one hand, a buyer may take goods from a seller without paying for them. On the other hand, 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 its simplest incarnation, there are two players, i.e. player-1 and player-2, 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 defection (D). We can consider a payoff matrix, as shown in Table 2.

Table 2: Payoff matrix for prisoner's dilemma

		Action of player-2	
		C	D
Action of player-1	C	S_1, S_2	W_1, B_2
	D	B_1, W_2	T_1, T_2

The necessary conditions for prisoner's dilemma are the following three inequalities (1).

$$\begin{cases} B_i > S_i > T_i > W_i \quad , i = 1,2 \\ 2S_1 > B_1 + W_1 \\ 2S_2 > B_2 + W_2 \end{cases} \tag{1}$$

In the prisoner's dilemma of a C2C online transaction, a seller can have two actions, i.e. cooperation with a buyer to give goods for his or her payments and defection with him or her to get payments without sending goods. A buyer also can cooperate or defect, i.e. paying for goods or getting goods without paying for them.

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.

An act of a seller / a buyer in C2C market and a payoff matrix of prisoner's dilemma correspond like table 3.

Table 3: correspondence payoff matrix and action of seller / buyer

		Buyer C	Buyer D
Seller	C	(S,S) (delivering Goods, paying)	(W,B) (delivering Goods, NOT paying)
	D	(B,W) (NOT delivering Goods, paying)	(T,T) (NOT delivering Goods, NOT paying)

3.2 A procedure of transaction on C2C market

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.

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 management system into the C2C online transaction.

3.3 Classification of Reputation

To model 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."

Kollock (1999) provided a classification of negative and positive aspects of information with which reputation management systems deal. A negative reputation system is to prohibit bad behavior by distributing the histories of badly behaving participants to all participants. It is possible to exclude a member from a community because of his or her bad behavior. The negative reputation system is a sort of black list system whose mechanism is one of exclusion. It is effective in real transactions; however, it seems to be not effective in online transactions, because of its anonymity and the ease by which people can enter and exit from an online market. Moreover, there is the possibility to distribute incorrect information to downgrade another's reputation.

What is a suitable reputation system for an online transaction? A positive reputation system seems to be the one, because it provides incentive to behave cooperatively. It also provides an incentive to stay in a market for a long time, because the system promotes one's good reputation, distributing his or her history concerning good behavior. However, there are two problems with the positive reputation system in an online transaction. The first problem is that it is hard to distinguish the difference between cooperative and non-cooperative participants. The second problem is the difficulty to establish a good reputation when participants frequently enter and exit from an online market. We will analyze which system is suitable for what type of market with our agent-based

model and describe the advantages and disadvantages of negative and positive reputation management systems.

3.4 Formulation

To model reputation management system, we define reputation in terms of positive and negative evaluation of a participant based on Kollock (1999). For simplification of the model, 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).

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

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.

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

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.

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

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

The reputation of agent(i) is calculated based on focus of reputation (α) as described in equation (6).

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

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.

3.5 Elements of Model

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 cooperative, non-cooperative, tit for tat, and random (Table 4).

Table 4: Agent elements

Properties of an agent	Types or meaning
Strategy of agent	Each agent has a choice of strategy: i.e., "cooperative strategy", "non-cooperative strategy", "tit for tat strategy" or "random strategy"
Goods to sell	Property of goods to sell is described by a string of bits
Goods to buy	Preference of agent (in case of a buyer) concerning goods to buy is described by a string of bits
Allowable difference in goods	Range of allowable difference for an agent between the posted goods (the goods to sell) and the goods to buy
A weight of choice between negative and positive	A weight of choice between negative reputation and positive one when an agent evaluate a partner
Length of history observed by agent	The length of history in transaction which an agent takes into account when the agent evaluates a partner

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. The entry/exit rules are randomly choosing which agent exits and selecting the agent who has the best current strategy outside of the online market as the entrant. 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.

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 a seller and a buyer who has a strategy in the inside of individual and trades autonomously.

4. Simulation Experiment

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, respectively. The parameters concerning focus on reputation and length of history are the characteristics of the reputation management system. Table 5 shows the parameters and their values.

Table 5: 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}

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.

First, we simulated the situation where a reputation management system does not exist. From the definition of the prisoner's dilemma, the non-cooperative strategy was expected to become dominant.

Figure 2 shows the trajectories of population for four groups when the entry and exit number is low and reputation management system does not exist. This figure illustrates that non-cooperative strategy becomes dominant. A market collapses in the environment where no reputation management system exists. Next, we introduced the reputation management system described in section 3.2 and performed the simulation over again.

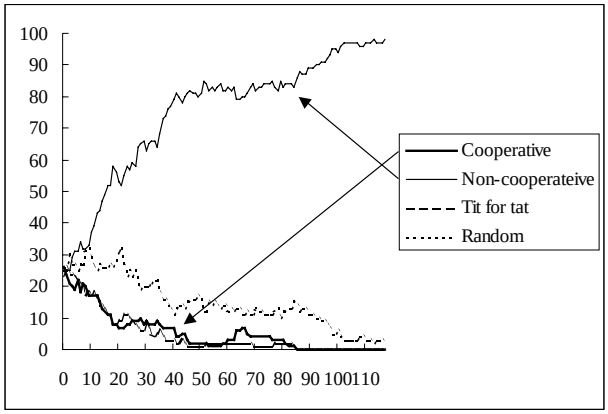

Figure 2: Trajectories of population for a slow turnover rate and no reputation system. The vertical axis shows the population of agents. The horizontal axis shows simulation time.

Figure 3 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). This figure illustrates the effectiveness of the cooperative strategy in the negative reputation system.

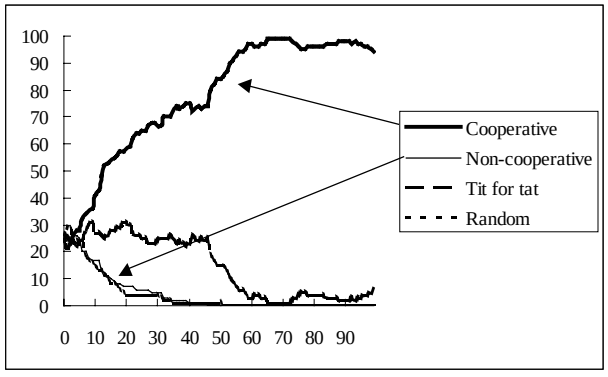

Figure 3: Trajectories of population for a slow turnover rate and negative reputation system. The axes are the same as in Figure 2.

Figure 4 shows the trajectories of population when the entry and exit number is high (=30) and the focus on reputation is negative (α =0). This figure illustrates the effectiveness of the non-cooperative strategy. A high entry and exit number is indicative of an environment of an on-line market. In such a situation, the negative reputation system could not eliminate non-cooperative participants. That is, negative reputation systems like the black list of a traditional market do not function effectively in an on-line market. Next, we checked if a positive reputation system functioned effectively in an on-line market. We determined whether a cooperative strategy is stable in a positive reputation system.

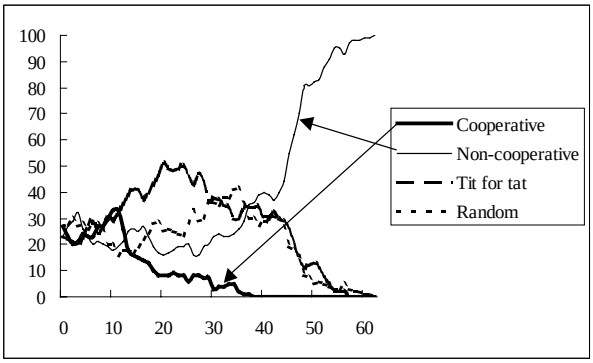

Figure 4: Trajectories of population for a high turnover rate and negative reputation system. The axes are the same as in Fig. 2.

Figure 5 shows the trajectories when the entry and exit number is high (=30) and the focus on reputation is both positive and negative (α =0.5). In this environment, a participant 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.

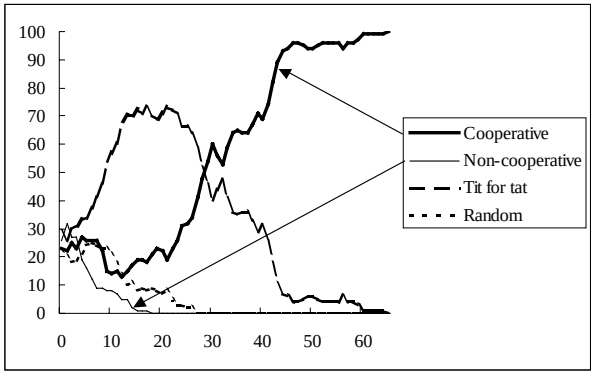

Figure 5: Trajectories of population for a high turnover rate and positive/negative reputation system. The axes are the same as in Fig. 2.

Figure 6 shows the trajectories when the entry and exit number is high (=30) and the focus on reputation is only positive (α =1). In this environment, a participant can behave non-cooperatively and change his or her ID. Nonetheless, the cooperative strategy becomes dominant. This indicates the effectiveness of a positive reputation system in an on-line market.

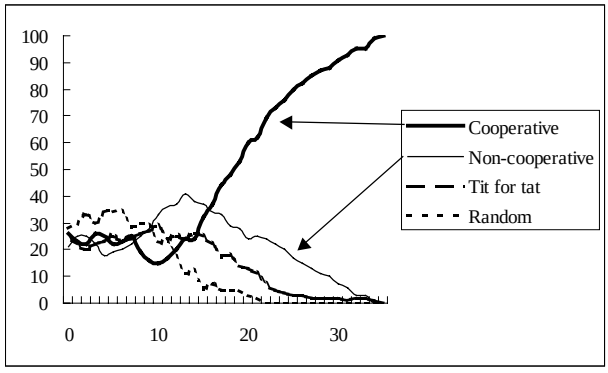

Figure 6: Trajectories of population for a high turnover rate and positive reputation system. The axes are the same as in Fig. 2.

5. Discussion

In a negative reputation system, the cooperative strategy is effective when the turnover rate is low, as shown in Figures 2, 3, 4, 5 and 6. 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 system in the real world makes non-cooperative participants leave a market and lets cooperative ones enter.

However, a negative reputation 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 system.

A positive reputation 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 buyer who has a high reputation can sell his or her goods at a higher price compared with others who have the same goods.

6. Conclusion

Using an agent-based model for our logical and virtual experiment, we showed the effectiveness of sharing information concerning the reputation of participants in C2C online transactions to promote cooperative actions. In such a high turnover rate market, a positive reputation system can be more effective than a negative reputation system. This means that we need a new framework to design institutions for the online transaction market, instead of the traditional framework designed to punish criminals. Moreover, it means that branding strategies will become more important in online markets than in

traditional markets.

However, a positive reputation system faces the problem that a new participant cannot make deals with others due to lack of reputation information. As a result, we observed the ineffectiveness of a positive reputation system on occasion. We will invent a new method to avoid the problem in future research.

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