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Embracing Information Asymmetry in C2C Online Transactions Using Signal Based Game Theory

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Abstract

The development of Internet technologies has promoted the popularity of e-commerce. C2C online transaction is one of the most significant part. However, with the characteristics of Internet such as technical complexity, openness, and virtualization, there exist more uncertainty and risks in online transactions, as well as information asymmetry. Besides, the influence factors of trust include not only the purchase intention of buyers and the reputation of the sellers, but also Internet-based trust and site quality. To this end, in this paper, we introduce a trust enhanced mechanism to effectively ensure the transaction by allowing complaining after purchasing unhonest products. Moreover, besides the cost of product itself, cost for sellers to accumulate credits, and cost for sellers to cheat, we also take into consideration the cost of trusting the website which sellers are affiliated to. We employ game theory to model the purchase process between buyers and sellers, and build a signal based game model tree.

Keywords: *C2C online transaction, Information asymmetry, game theory*

1. Introduction

The development of Internet technologies has changed the way of everyday life. According to the 33rd CNNIC (China Internet Network Information Center) report [1], by the end of 2013, the population of Internet users in China has reached to 618 millions, among which the number of new users is 53.58 millions. The coverage of Internet is 45.8%, and the growth is 3.7%. Online shopping is one of the most popular applications of Internet. According to [2], the online shopping market grows steadily and rapidly, and exhibits great market potential. On one hand, the total retail sales of social consumer goods in online shopping transactions are increasingly high. On the other hand, the penetration rate of online shopping users is 48.9%, which is 2.3% higher than the growth rate of Internet users. However, compared to other countries, the overall development of E-commerce still lags behind in China. One of the most significant factors is the lack of trust [3-5].

Recent years more and more attentions have been drawn to C2C (Customer-to-Customer) online transactions. However, the characteristics of C2C such as involving more entities, more uncertainty and greater risks, bring more efforts on the trust issues among customers [6]. From the economic perspective, trust is beneficial to reduce the cost of transactions and thus promotes the exchange. Trust is the belief or expectation after balancing between the transaction risk and expected return, formulated as the rational calculation after some expected gains [7].

Different from traditional trust, trust in online transactions comes from the Internet. With the characteristics of Internet such as technical complexity, openness, and virtualization, there exist more uncertainty and risks in online transactions, as well as information asymmetry [8]. For example, in addition to interpersonal trust, trust based on the Internet

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environment is more prominent. Besides, the influence factors of trust include not only the purchase intention of buyers and the reputation of the sellers, but also Internet-based trust and site quality.

To this end, in this paper, we propose an enhanced model using game theory [9] to analysis the trust and information asymmetry in C2C online transactions. Specifically, we consider multiple costs for online transactions, i.e., cost of product itself, cost of trusting the website, cost for sellers to accumulate credits, and cost for sellers to cheat. Second, we introduce a trust enhanced mechanism to effectively ensure the the transaction by allowing complaining after purchasing unhonest products. That is, after a buyer conducts a transaction and find out he/she has been cheated, he/she could resort to complain about the seller. In this way, sellers have to pay extra costs for cheating and thus the trust of online transactions can be enhanced.

The remainder of this paper is organized as follows. Section 2 reviews related work. In Section 3 we model the C2C online transactions between buyers and sellers using game theory. Then in section 4, we simulate some experiments. Finally, the paper is concluded in Section 5.

2. Related Work

In C2C online transactions, the variable risks lead to the lack of trust. From the perspective of psychology, network trust is a belief, expectation or feels that is cultivated within network individuals and the process of their psychological development [10]. Generally, there are two category of related work on network trust: relevant factors of network trust and modeling.

There are two types of factors related to network trust. (1) Technical factors, such as authentication, privacy protection and website performance. For example, Hoffman [11] believed that safety and privacy are the most important keys of network trust, and suggested public key encryption and third-party authentication to gain trust from customers. Corbitt, *et al.*, [12] considered technical dependability and the performance of website as the major factors, and proposed that the network trust should be built though technical methods. Belanger, *et al.*, [13] proposed to add third-party security and encryption to ensure the safety of Internet and improve network trust. (2) Non-technical factors, such as entity characteristics, moral principles, legal system, policy environment and enterprise goodwill. For example, Kini, *et al.*, [14] discovered that the more similar two individuals are, the more likely trust occurs between them. Abdul-Rahman, *et al.*, [15] and Gefen, *et al.*, [16] pointed out that interpersonal trust affects the trust upon website and sellers. Sultan, *et al.*, [17] found that the network trust is determined by the characteristics of website and customers such as the familiarity, purchase history, and chatting records. Yoon, *et al.*, [18] also discovered the relationship between the the previous satisfaction and network trust. Belanger et al. [13] believed that privacy and safety are the driven factors of network trust. Smith, *et al.*, [19] studied factors such as the lifetime of website, selection of products, online community, search engine and privacy. Grazioli, *et al.*, [20] found that the enterprise scale is also important to network trust, and can help with communication during transaction process.

There are some efforts on network trust modeling. Mayer [21] proposed a theoretical model, which includes perceived trustworthiness, trustor, and perceived risk. Based on Mayer's work, Mc Knight [22] proposed a modified model by introducing environmental factors and differentiate trusting intentions and trusting beliefs. Bhattacherjee, *et al.*, [23] concluded that customer trusting in websites is directly related with the intentions of being involved into network transactions. According to the types of entities involved in network transactions, there are five types of trust model: B2B (Business-to-Business) trust model [24], B2C (Business-to-Customer) trust model [25], C2C (Customer-to-Customer) trust model [26], G2P (Government-to-Public) trust model [27] and P2P trust model [28]. The

characteristics of each type are analyzed in [29]. McCole, *et al.*, [30] classified trustworthiness as: availability [31], competence [32], consistency [33], discreteness [34], fairness [35], integrity [36], loyalty [37], openness [34], promise fulfillment [38], and receptivity [39].

3. Modeling

During online transactions, sellers show the quality of their goods to buyers by credit rating. Suppose sellers selling products of good and bad qualities are S_G and S_B, and the costs for accumulating rating R are C_{GR} and C_{BR} respectively. If buyers buy products from S_G, and it turns out S_G is cheating, the cost of S_G being complained by customers is C_{GC}. If buyers buy products from S_B, and it turns out S_B is cheating, the cost of S_B being complained by customers is C_{BC}. The trust of the Internet website where the transactions are carried out is denoted as C_T.

Suppose a buyer B needs to buy a product from sellers. Due to information asymmetry, buyers does not know about the quality of sellers. Suppose buyers would choose S_G with probability p, and choose S_B with probability $1-p$. The price of product provided by S_G is P_G, and its cost is C_G and the value B gets is V_G. The price of product provided by S_B is P_B, and its cost is C_B and the value is V_B.

Indeed, we have the following assumptions in this paper.

Assumption 1: There are two entities involved in the online transactions: sellers and buyers, where sellers are signal senders and buyers are signal receivers. Note that we also include the trust of Internet as one of the cost of choosing sellers, *i.e.*, C_T.

Assumption 2: Buyers know nothing about the real quality of products claimed by sellers. The claimed quality of products can be inferred from the seller ratings. That is, seller rating R serves as the signal for purchase decision.

Assumption 3: The prices offered by sellers are same, regardless the credit rating. The buyers are responsible of the buying risks. However, bad sellers have the take the risks of being complained by consumers if they are cheating.

Assumption 4: The more better the quality of product is, the less it costs to gain higher rating, and the more value buyers would get. That is, $C_G > C_B$, and $V_G > V_B$.

Assumption 5: Buyers can choose to buy or not buy the product after the observation of sellers.

We introduce a trust enhanced mechanism by allowing sellers cheating and buyers complaining after purchasing unhonest products. Specifically, we consider the honesty of sellers and the after-purchase action of buyers. Using signaling game analysis [9] and Harsanyi transformation [40], we establish a signal based game model tree, as shown in Figure 2, where N denotes natural persons, U_S denotes the utility of sellers, and U_B is the utility of buyers. Compared with the basic model in Figure 1, we add two major branches: honesty and complaint judgments, to capture the cheating behavior of sellers and the complaining behavior of buyers if being cheated.

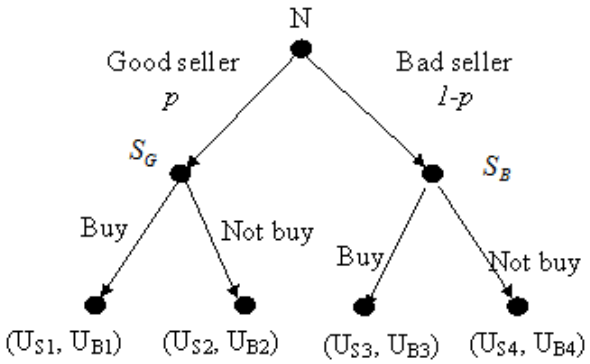

Figure 1. Basic Signal Based Game Model Tree

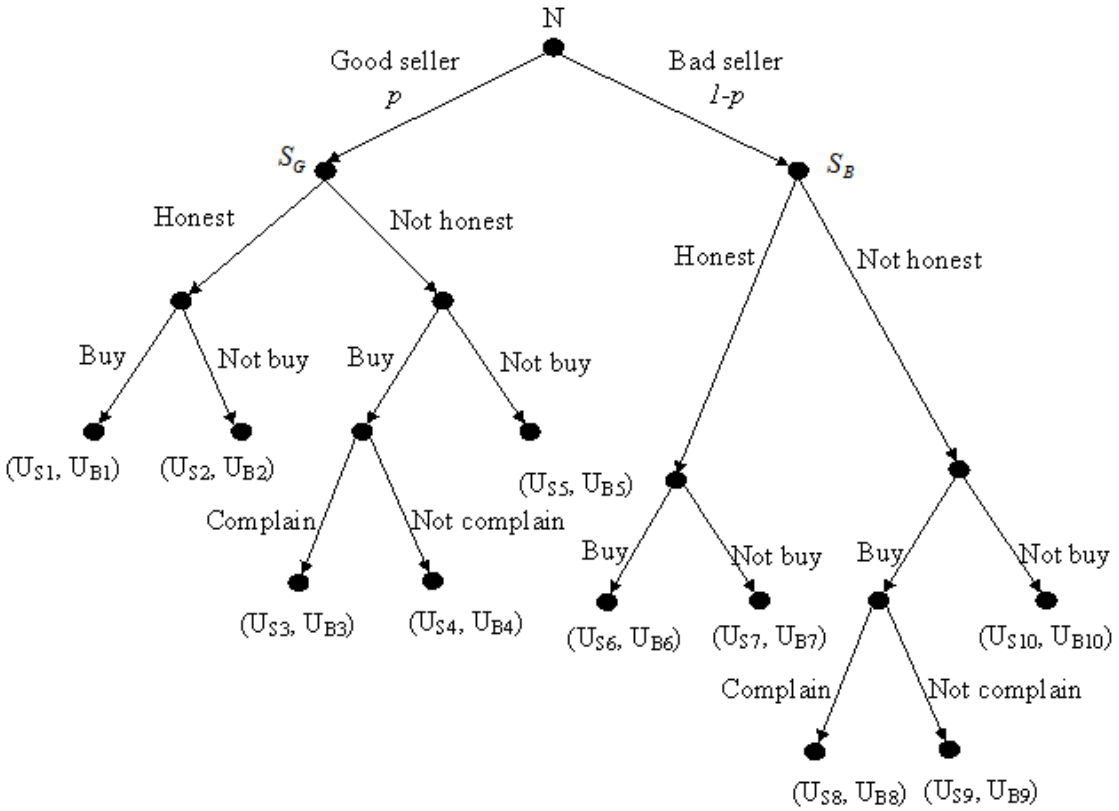

Figure 2. Proposed Signal Based Game Model Tree

Buyer B chooses good seller S_G with probability p, and bad seller S_B with probability $1-p$. For either situation, the actions of B have the following scenarios.

(1) Suppose B selects S_G, and the seller is honest. In this case, honest seller is selling good products. If B chooses to buy from S_G, the utility of B is $U_{B1}=V_G-P_G$, and the utility of S_G is $U_{S1}=P_G-C_G-C_{GR}-C_T$. If B does not buy, $U_{B2}=0$, and $U_{S2}=-C_{GR}-C_T$.

(2) Suppose B selects S_G, and the seller is not honest. In this case, the seller is cheating consumers by disguising inferior products as good ones. This means even if the seller has a high rating, he/she can still be selling defective products, and the rating is probably a forgery through some specific way such as hiring people to conduct fake

transactions and then giving extremely high evaluations. After the purchase, buyers could resort to complain and expose the cheating. If S_G is complained, S_G has to make amends for cheating, and the cost is C_{GC}. If B eventually chooses to buy from S_G and B complains, the utility of B is $U_{B3} = V_G - P_G$, and the utility of S_G is $U_{S3} = P_G - C_G - C_{GR} - C_T - C_{GC}$. If B buys from S_G without complaints, the utility of B is $U_{B4} = V_G - P_G$, and the utility of S_G is $U_{S4} = P_G - C_G - C_{GR} - C_T$. If B does not buy, $U_{B5} = 0$, and $U_{S5} = -C_{GR} - C_T$.

(3) Suppose B selects S_B, and the seller is honest. In this case, honest seller is selling good products even his/her rating is low. If B chooses to buy from S_B, the utility of B is $U_{B6} = V_B - P_B$, and the utility of S_B is $U_{S6} = P_B - C_B - C_{BR} - C_T$. If B does not buy, $U_{B7} = 0$, and $U_{S7} = -C_{BR} - C_T$.

(4) Suppose B selects S_B, and the seller is not honest. In this case, the low rating seller is selling inferior products. If B buys from S_B and B complains, the utility of B is $U_{B8} = V_B - P_B$, and the utility of S_B is $U_{S8} = P_B - C_B - C_{BR} - C_T - C_{BC}$. If B buys from S_B without complaints, the utility of B is $U_{B9} = V_B - P_B$, and the utility of S_B is $U_{S9} = P_B - C_B - C_{BR} - C_T$. If B does not buy, $U_{B10} = 0$, and $U_{S10} = -C_{BR} - C_T$.

In order to fulfill the signal role of R, the following requirements have to be satisfied:

$$\begin{cases} V_G - P_G \geq 0 & \text{(A)} \\ V_B - P_B \geq 0 & \text{(B)} \\ (P_G - C_G - C_{GR} - C_T) - (P_B - C_B - C_{BR} - C_T) \geq 0 & \text{(C)} \\ (P_G - C_G - C_{GR} - C_T) - (P_G - C_G - C_{GR} - C_T - C_{GC}) \geq 0 & \text{(D)} \\ (P_B - C_B - C_{BR} - C_T) - (P_B - C_B - C_{BR} - C_T - C_{BC}) \geq 0 & \text{(E)} \\ (P_G - C_G - C_{GR} - C_T - C_{GC}) - (P_B - C_B - C_{BR} - C_T - C_{BC}) < 0 & \text{(F)} \end{cases} \quad (1)$$

Equations (A) and (B) means the utility of buyers when purchase must be positive; Equation (C) means the utility of buying from honest good sellers should be higher than buying from honest bad sellers; Equation (D) means that when buying from good sellers, the utility of buying from honest sellers is higher than buying from unhonest sellers with complaints; Equation (E) means that when buying from bad sellers, the utility of buying from honest sellers is higher than buying from unhonest sellers with complaints; Equation (F) means that even if the unhonest sellers are complained, the utility of buying from bad sellers is higher than good sellers. The reason behind is that when choosing to buy from unhonest sellers, the expectation of bad sellers is lower than good sellers. Therefore, if get complained, the utility of bad sellers the buyers gain is better.

Suppose the probabilities of sellers be unhonest for S_G and S_B are r_1 and $1-r_1$, the probabilities of buyers to buy or not buy are r_2 and $1-r_2$, and the probabilities of buyers to complain is r_3. The expected utility of buyers is calculated as:

$$\begin{aligned} u_b = & p*r_1*[r_2*(V_G-P_G)+(1-r_2)*0] \\ & + p*(1-r_1)*\{r_2*[r_3*(V_G-P_G)+(1-r_3)(V_G-P_G)]+(1-r_2)*0\} \\ & + (1-p)*r_1*[r_2*(V_B-P_B)+(1-r_2)*0] \\ & + (1-p)*(1-r_1)*\{r_2*[r_3*(V_B-P_B)+(1-r_3)(V_B-P_B)]+(1-r_2)*0\} \end{aligned} . \quad (2)$$

Simplify the above equation, we have:

$$u_b = r_2*[p*(V_G-P_G)+(1-p)*(V_B-P_B)] . \quad (3)$$

Get the derivative for r_2,

$$\frac{\partial u_b}{\partial r_2} = p*(V_G-P_G)+(1-p)*(V_B-P_B)=0 . \quad (4)$$

Solve the above equation, we have:

$$p = \frac{V_B-P_B}{(V_B-P_B)-(V_G-P_G)} . \quad (5)$$

Typically, $p>0$, and $V_B-P_B \geq 0$, we have $V_B-P_B \geq V_G-P_G$. Therefore, for buyers, choosing sellers with lower ratings is always the best option.

Suppose there exist n sellers in the C2C e-commerce market, the price offered by each seller is $b_i (i=1,2,...,n)$, and the cost of each seller c_i is independent equally distributed within [0,1], and $c_i = c_p + c_R + c_T + c_c$, where c_p is the cost of the product, c_R is the cost for accumulating rating R, c_T is the cost of trusting the website where the seller is affiliated to, and c_c is the cost of being complained if the seller is cheating. Therefore, the utility of seller i is:

$$u_i = (b-c)\prod_{j\neq i} p(b_j > b) = (b-c)[1-\phi(b)]^{n-1} \quad (6)$$

where $p(.)$ denotes probability, b_j is the price offered by seller i, and $\phi(b)$ is the inverse function of b, meaning the cost of sellers offering price b. The objective here is to maximize Equation (6).

The first-order condition for optimizing Equation (6) is:

$$\begin{aligned} & [1-\phi(b)]^{n-1} - (b-c)(n-1)[1-\phi(b)]^{n-2}\phi(b) = 0 \\ & or \\ & [1-\phi(b)] - (b-c)(n-1)\phi'(b) = 0 \end{aligned} . \quad (7)$$

In equilibrium condition, we have $\phi(b)=c$. Solve Equation (7), we have:

$$b^*(c) = c + \frac{1-c}{n} . \quad (8)$$

Therefore, we can see that the offered price of sellers is higher than the cost. Besides, as the number of sellers grows, the price is decreasing. Specifically, when $n \to \infty$, $b^*(c) \to c$. That means when the number of sellers approaches infinity, the price is close to the cost. Therefore, in C2C transaction, the more sellers are involved to protect the benefits of buyers, the more trustworthy the transaction is.

4. Experiment

In this section, we design some simulation using Matlab. We use two synthetic sets to denote buyers and seller. For buyers, we suppose there exist no individual differences for e-commerce users. For sellers, we label users from three different groups of notations

$\{G \mid B, H \mid U, C \mid N\}$ to describe good or bad, honest or unhonest and being complained or not. For example, S_{GH} means honest good seller, and S_{BUC} means unhonest bad seller which is complained. Let buyer B randomly choose from the set $\{S_{GH}, S_{GUN}, S_{GUC}, S_{BH}, S_{BUN}, S_{BUC}\}$.

Figure 3 gives the curves of total utility of buyer and seller, where x axis denotes the number of transactions or selections, and y axis denotes the number of users involved in the transaction. We can observe that as the number of transactions and involved users increase, the total utility increase as well. Therefore, typically, the more users involved in C2C transactions and the more frequency the transactions occur, the more trustworthy the e-commerce environment is, and thus the more benefits both sides could get.

Besides, Figure 4 shows the curve of utility of seller. We can see that the more users involved, the more benefit the sellers can get. However, the utility curve seems to approach to a line, which is equal to the cost of products.

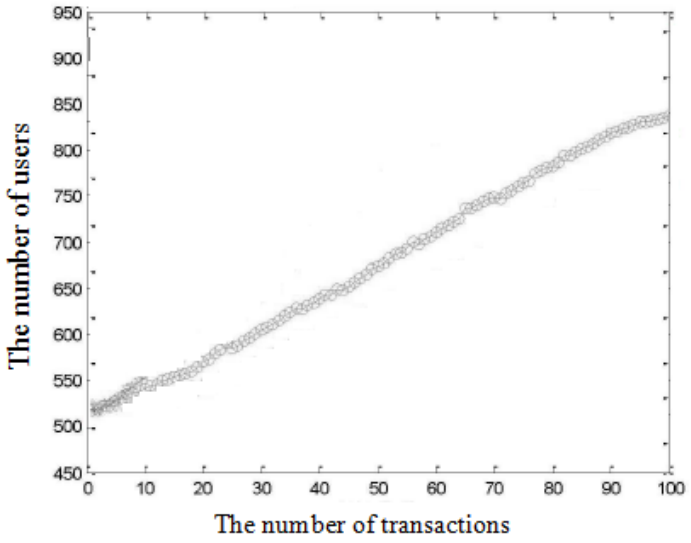

Figure 3. Total Utility Curve of Buyers and Sellers

5. Conclusion

In this study, we propose a method to model the C2C online transactions using game theory with consideration of information asymmetry. Specifically, information asymmetry is reflected in the situation of buyers knowing nothing about sellers but only the seller ratings. However, sellers (1) could be unhonest, and (2) if sellers are unhonest, they could be complained by customers. To this end, we introduce a trust enhanced mechanism by allowing sellers cheating and buyers complaining after purchasing unhonest products, and build a signal based game model tree to model the purchase process.

In future, we would like to consider more policies for C2C online transactions gaming, such as the return policy, and the influence from other buyers.

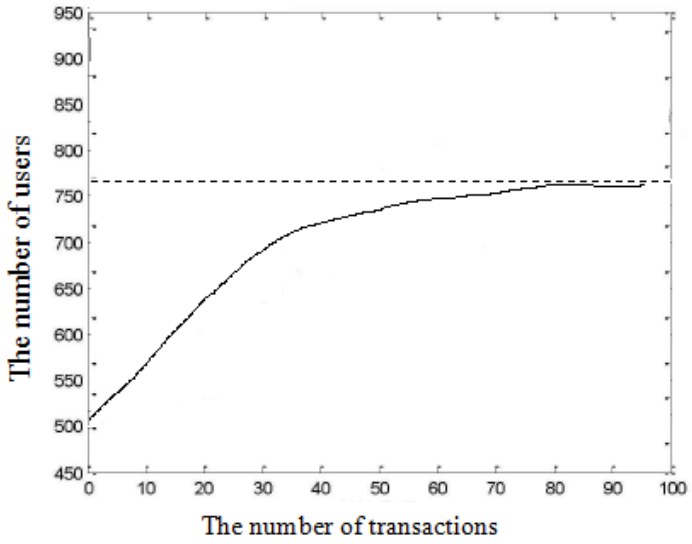

Figure 4. Utility Curve of Sellers

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