International Journal of u- and e- Service, Science and Technology
Vol.9, No. 11 (2016), pp.263-274
http://dx.doi.org/10.14257/ijunesst.2016.9.11.23

A Novel Trust Model in E-Commerce

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Abstract

This paper theoretically studied the issue of trust in E-Commerce business. Firstly, we established a dynamic game model to analyze conditions required for reaching a long-term equilibrium of trust, by introducing the concept of ESS equilibrium. Secondly, we designed a diffusion mechanism of trust with an algorithm, which helped us understand the process of how the stable equilibrium of trust would be reached. Our findings are as follows: (1) under unfavorable conditions like weak trust incentives, distrust in E-Commerce business is prevalent, even after a trust evaluating system has been established; (2) some factors, including payoff difference between honest traders and dishonest traders, the number of traders choosing the trust strategy and convenience of information exchange between traders, determine the diffusion process of trust in this business. With regard to the findings aforementioned and the sustainable development of E-Commerce business in China, we provide some policy suggestions, like increasing comparative advantage in payoffs received by honest traders, reinforcing regulation on entry permission, and investing more in technology or devices to promote information exchange between traders.

Keywords*: E-Commerce, Trust, Evolutionarily Stable Strategy Equilibrium, Dynamic Game, Diffusion*

1. Introduction

E-Commerce was introduced into China in late of the 1990s and has boomed recent ten years. However, further development of this new business has met a bottleneck of trust, that is the distrust between traders caused by internal uncertainty and fictitiousness in online trading [2-9] and [15]. Trust is one of key factors determining the sustained development of E-Commerce business in that trust between buyers and sellers eliminates uncertainty in trading and therefore decreases transaction costs, which helps to improve online trading efficiency. In China, where the overall social credit system has not been perfectly constructed [4], a third-party payment mechanism, which is relatively independent and easier to control, acts as the main online trust system of E-Commerce business. Taking C2C E-Commerce business in China as an example, TaoBao of Alibaba has activated "Alipay". However, distrust events in various forms still occur at high frequency in China, which include providing deceptive information or low-quality goods, delay of goods delivery, and non-fulfilment of after-sales service [8]. Why can not the problem of distrust in E-Commerce business be removed after trust systems have been built up? Do these systems fail to work in China? Or are there any blind spots about trust in E-Commerce business we have not yet learned?

Currently, a number of researchers [3-12] have adopted the method of game theory to study the trust issue in E-Commerce, deepening the understanding about the role trust between online traders plays in the development of E-Commerce business. With help of game theory, trading rules are designed for online exchange according to the real E-Commerce trading conditions and results of trades based on some criterion like Nash Equilibrium (hereafter NE) [5] are calculated, from which the importance of trust for E-

ISSN: 2005-4246 IJUNESST

Commerce business can then be identified. In the framework of game theory using NE, given some initial conditions like a market without trust systems, choosing distrust action is repeatedly proved as a dominating strategy, under which the result of equilibrium shows to be inferior to that when traders choose the trust strategy. As a result, lack of trust is proven to become a bottleneck for development of E-Commerce business.

However, does the theoretical result aforementioned still stand after relaxing the assumptions taken by game theory using NE? It is highly possible that online buyers or sellers may sometimes make some mistake and choose irrational strategy. Human beings are not computers but creatures with bounded rationality. Under most circumstances, they will calculate correctly costs and benefits of the behaviours they take, while they may also have wrong estimation and then choose irrational strategies with a possibility different from zero. Meanwhile, buyers and sellers are not fixedly matched in E-Commerce trading, which means traders may not know each other. Benefiting from modern network technology, online traders can choose anyone as their business partners. Therefore, buyers and sellers usually meet each other stochastically, with only limited information about the other's characteristics. Furthermore, trading is seldom a one-round game because many online buyers and sellers exchange goods several times a day, therefore the long-term but not short-term equilibrium in an online trading market with good or bad trust conditions should be scrutinized. The contribution of this work is to set up a new model of trust based on Evolutionarily Stable Strategy equilibrium (hereafter ESS equilibrium) rather than NE to interpret why distrust can't be removed with the existing trust systems in Chinese E-Commerce market, and to give suggestions for improving trust conditions in order to realize the sustained development of this new business in China.

This paper tries to provide a framework for theoretical study on the trust issue in E-Commerce business, which involves two tasks. One is to identify the conditions under which trust can be prevalent among online traders; the other is to explain the mechanism through which trust becomes prevalent. Accordingly, the research agenda of this paper involves both learning the conditions required for reaching the equilibrium of trust in E-Commerce business and studying the internal mechanism of trust diffusion among traders. A new model of trust for E-Commerce trade is designed, based on a more adequate equilibrium standard of ESS equilibrium. With the model, a diffusion mechanism of trust in E-Commerce business is originally pointed out. In our formulation, under some unfavourable initial conditions like a market with a high proportion of fly-by-night traders, a stable or long-term equilibrium of trust among online traders can by no way be realized, and some policies aimed at eliminating unfavourable conditions through promoting diffusion of trust should be put into practice. These policies include protecting honest traders by controlling market entry, promoting information exchange between individual traders, and creating a comparative advantage of trust by rewarding trust behaviour and penalizing distrust behaviour. Therefore, the reason why the existing trust systems like the third-party payment mechanism fail to work in China is not that they are ineffective, but maybe due to unfavourable market conditions underestimated by founders of these systems, which can be removed by the policies mentioned above.

2. Literature Review

Several researchers [15] have discussed the concept of online trust or trust in E-Commerce business from both economic and social reviews, which is nebulous and all-pervading [13] but can be integrated as the willingness of a party (a trustor) to be vulnerable to the actions of another party (a trustee) based on the expectation that the other party will perform a particular action expected by the trustor, irrespective of the trustor's ability to monitor or control the trustee. Trust in E-Commerce business is not a separated concept, but related to competence, responsibility, dependability, likeability and honesty, with help of which traders overcome perceptions of uncertainty and risk in online transactions [14]. Based on the previous studies aforementioned, the definition of

trust between a buyer and a seller in E-Commerce trades used by the theoretical research in this paper means that each party, expecting the other party will also abide by, will behave in deference to publicly accepted trading rules set up by E-Commerce websites. The definition of distrust is that the buyer or seller will behave in a way departure from trading rules. Two factors lead to a trader's distrust behavior: one is precaution of cheat, that is a trader will choose to be distrusting in order to avoid benefit losses when he or she anticipates that the counterpart will break trading rules; the other is benefit from cheating, that is a trader will prefer distrust to trust when he or she estimates that benefit from cheating the counterpart is beyond that he or she can gain from making a trade abiding by trading rules. The concepts of trust and distrust aforementioned will be used by the model in Part 4.

Game theory, a discipline studying individual decision-making mechanism in an environment people's decisions are influenced by each other and calculating equilibrium of decision-making, is now frequently used in study of online trust. Basic assumptions of the theory include that people are economically rational and egoistical, and always purchasing utility maximum under constraints. There are some key concepts usually used in game theory research, including player, action, information, strategy, payoff and equilibrium. In detail, a player refers to any agent involved in a game, an action is the behaviour taken by a player gaming with others, information includes game rules and the results of the game, strategies are a set of selectable actions, payoff is what a player can get from the game, equilibrium refers to stable results of the game that can be observed in reality.

Here we emphasize on the concept of equilibrium. Two kinds of equilibria are adopted in game theory literature at relative high frequency, *i.e.*, NE and ESS equilibrium. The former is defined as a result in which no one can improve his or her payoff given choices of other players, which means in NE every trader's behaviour is optimal because changing strategy can bring no extra benefit [5]. Theoretically speaking, NE is a concept of static equilibrium, which is limited to explain the trust issue in E-Commerce business. The latter, ESS equilibrium, is a long-term equilibrium for repeated games [1], defined as a result in which a group of individual players will dominate in the population when a certain percentage of members in this group have taken a certain strategy, which means in ESS equilibrium the evaluation or ideology of the dominating group will defeat that of any other group. ESS is a term derived from Biology and has become one of the essential concepts in the evolutionary game theory, which has been applied successfully in many other fields like Physics and Economics. Compared by the conventional game theory, the evolutionary game theory can analyse the behaviour of individuals in a more realistic environment, where players in a game are not always rational and learn to play the game through a process of trial and error in a dynamic or stochastic environment. Firstly defined by Smith and Price when they studied the Hawk-Dove gam, ESS equilibrium indicates a stable state in the process of the evolution and is an adequate equilibrium for evolutionary games. Based on Smith and Price's original research on ESS, the condition for realizing an ESS equilibrium in a 2×2 game (two kinds of players and two kinds of strategies) can be presented as follows: $U(I, p) > U(J, 1-p), \forall p \to 1$, where I and J are two strategies, the changeable p and $1-p$ are possibilities for players with bounded rationality to choose I and J respectively, $U(.)$ refers to the payoff a player receives from the game [1]. The concepts of player, action, information, strategy, payoff and ESS equilibrium mentioned above will be used by the model in Part 4.

Some Chinese researchers have studied the trust issue in Chinese E-Commerce business based on game theory using NE. Wang designs a model of game theory to prove that the trust relationship between users is essential for survival of E-Commerce business and suggests an individual trust system. Peng et al. set up a trust evaluation model for online traders based on game theory [12]. Cai and Jiang point out a solution for removing distrust in E-Commerce business by using an imperfect information game model [3].

However, conclusions derived from these researches aforementioned may be not robust because of neglecting limits in NE. The shape of trust between E-Commerce traders is a time-consuming dynamic process, thus models using NE may fail to do contribution to developing accurate explanation of when and how trust can remain dominating in the growth of E-Commerce business, though they are still able to explain why the trust issue is essential.

Meanwhile, as soon as the dynamic standard of ESS equilibrium rather than the static standard of NE is used in analysis of the trust issue in E-Commerce business, research should no longer stop at a static level emphasizing only on the equilibrium per se, but should also pay attention to the process of reaching the equilibrium. Suppose that the model based on game theory shows that choosing the trust strategy is the ESS equilibrium under certain conditions, but how the equilibrium is realized keeps unknown. In the process of reaching the equilibrium, trust diffusion among individual online traders is essential. If trust diffusion is partly blocked by some factors, the ESS equilibrium of trust may only be reached after an extremely long period of time. If trust diffusion is completely blocked, then the ESS equilibrium of trust may become only a theoretical outcome. Therefore, making clear the internal diffusion mechanism of online trust is really important not only for better understanding the equilibrium, but also for policy making aimed to improve the trust environment. Although the studies on trust diffusion are quite rare, the papers studying diffusion mechanism in other fields like social habit or convention, private information, and technology innovation [11] are rich and they provide this paper with important inspiration on how to set up a diffusion mechanism for online trust in E-Commerce business.

3. Methodology

First of all, we design a dynamic game model of trust for online trade in order to make clear the conditions under which the long-term equilibrium of trust can be reached. In this game model, there is an E-Commerce website with a trust evaluation system. Every trader, *e.g.,* a buyer or seller who makes business through the website, is a player. A player meets another player in one round of game, taking one of two actions as follows: dealing the transaction in deference to the trading rules, or dealing the transaction against the trading rules. The trading rules include provisions required for opening a trade account, quality of the goods for trade, pricing the goods for trade, finishing the payment and recording the traders' behaviours. These rules are constraints imposed by the E-Commerce website on traders in order to ensure fairness and security of the online transaction. Accordingly, there are two strategies a player can choose with positive probabilities, the trust strategy or abiding by the trading rules, and the distrust strategy or breaking the trade rules. To simplify the model, we assume that the deal will always be done, regardless of the strategies the two players will choose. Since the benefit of trust or the loss caused by distrust can't be fully reflected if there is no deal, this simplification is reasonable. After the deal has been done, both of the two players get their payoffs. If both of them choose the trust strategy, they can acquire a high level of payoff since the efficient and convenient online transaction meets instantly the demands of both the buyer and the seller. If one of them picks down the distrust strategy while the other carries through the trust strategy, then the distrusting player gains a benefit while the other suffers a loss. If both of the players choose the distrust strategy, then the payoffs they can get are lower than those when both of them choose the trust strategy, considering that one player may receive only half of the money, the other player may be sent a faulty good, and both of them are punished by the trust evaluation system. Furthermore, the information, including the trading rules, the probabilities a player will choose the two strategies, and the payoffs the two players can get after the deal has been done, is publicly known. In other words, every trader understands well the game before he or she takes part in. Players meet stochastically and repeatedly in the game, just like the real E-Commerce

trades. If one result of the game matches the condition of reaching an ESS equilibrium, this result becomes the final outcome. We then analyze when choosing the trust or distrust strategy will become the ESS equilibrium, which can provide theoretical explanation about why distrust behaviours are prevalent in Chinese E-Commerce business. The dynamic game model of trust aforementioned will be discussed in detail in Part 4.

Secondly, we set up a mechanism to interpret the process of trust diffusion in E-Commerce through assuming a specific exchange space distribution for online traders. In this exchange space, online traders exchange between each other the information about their strategies and payoffs according to a probability function determined by factors including their location in the space, and rough or smooth for information exchange. In order to identify clearly what on earth determines trust diffusion in E-Commerce business, we further calculate payoff functions for online traders and then provide an algorithm for the trust diffusion. With this algorithm, factors like the total number of traders choosing the trust strategy, rough or smooth for traders to exchange information and institution of trust incentives play main roles in trust diffusion of E-Commerce business. The diffusion mechanism of trust will be introduced in detail in Part 4 and Part 5.

4. A New Model of Trust

4.1. A Dynamic Game Model of Trust in E-Commerce

Assuming there is an E-Commerce website with a trust evaluation system, in which traders could be both buyers and sellers who buy or sell goods through the Internet. The trust evaluation system gives credit evaluation for individual traders based on historical records of trades they have made and then rewards or punishes the traders with regard to results of the evaluation, just like the current trust systems built up by E-Commerce websites in China. A trader can choose only one of two strategies in every round of trade, *i.e.*, trust or distrust, and we use T to indicate the trust strategy and NT for the distrust strategy. The trader will choose a strategy with a positive possibility less than one. Let p and $1-p$ are the possibilities for the trader to choose strategy T and NT, respectively. Two traders meet stochastically on the Internet and the deal is done regardless of their strategies. After the deal has been done, they get payoffs that are determined by their strategies. The payoff matrix is showed by Figure 1, in which each quadrant represents payoffs or utilities the two traders can gain from the trade between them. According to the method described in Part 3, Figure 1, can be explained as follows: (1) When trader i and trader j meet each other stochastically and both of them choose the trust strategy, they get a positive payoff of UT from the trade respectively, while they are given a positive payoff of UNT that is lower than UT when they both pick down the distrust strategy in the trade. (2) If trader i chooses the trust strategy and trader j chooses the distrust strategy, trader j will get a positive payoff of n while trader i suffers a negative one of $-n$, where n is used only to indicate the result of a zero-sum game, *e.g.*, $n+(-n)=0$, and thus n can be treated as a constant in the game. In order to simplify the model and the consequent analysis, we standardize the payoffs of the two traders as zeros, similar to the work of Boyer and Orléan. In fact, the standardization causes no real change in the results of the game model: without the standardization, the expected payoff received by the trader who chooses the trust strategy will be $U(T,p)=p\cdot UT+(1-p)(-n)$, and that received by the other trader who chooses the distrust strategy will be $U(NT,1-p)=p\cdot n+(1-p)\cdot UNT$, thus the sufficient and necessary condition for strategy T to achieve ESS equilibrium becomes $p\cdot UT>(1-p)\cdot UNT+n$, which only adds a constant compared with the condition $p\cdot UT>(1-p)\cdot UNT$ mentioned below.

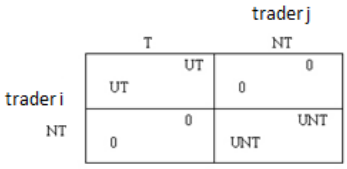

Figure 1. Payoff Matrix

To sum up, the payoff a trader can get in the game is:

(1) UT , when both she and the other choose strategy T ;

(2) 0, when she chooses strategy T and the other chooses strategy NT , or the opposite;

(3) UNT , when both she and the other choose strategy NT .

Given the payoff matrix above, the expected payoffs received by traders who chooses strategy T (the trust strategy) and strategy NT (the distrust strategy) are respectively

$$U(T,p) = p \cdot UT + (1-p) \cdot 0 = p \cdot UT \tag{1}$$

and

$$U(NT,1-p) = p \cdot 0 + (1-p) \cdot UNT = (1-p) \cdot UNT \tag{2}$$

According to the mathematical definition of ESS equilibrium mentioned in Part 2, the sufficient and necessary condition for strategy T to achieve ESS equilibrium is $U(T,p) > U(NT,1-p)$, $\forall p \to 1$. Adding Equation (1) and (2), the condition is converted into

$$p \cdot UT > (1-p) \cdot UNT \quad \forall p \to 1 \tag{3}$$

From Equation (3), trust between online traders in E-Commerce will become the equilibrium of dynamic game when the probability of choosing the trust strategy is beyond a certain threshold level, *i.e.*,

$$p > p^* = \frac{UNT}{UT + UNT}.$$

Before giving a theorem to describe the above fact, we first discuss a condition required for the theorem.

Condition One: $0 < UNT < UT$.

In the method described in Part 3, we assume $UNT < UT$. Here we explain the assumption in detail. Equipped with modern web technology, E-Commerce business incurs quite low exchange costs when traders trust each other. The costs may nevertheless be high when the traders choose the distrust strategy in that some extra expenditure must be paid in order to finish online exchange, including pecuniary costs required for monitoring trade by the third party, and time costs wasted in splitting a big exchange into several smaller ones in order to avoiding cheat. This implies the value of trust, which makes online trade more convenient and valuable. Meanwhile, since we assume the E-Commerce website owns a trust system, punishing distrust and encouraging trust, we have good reasons to assume that traders trusting each other will get more than those cheating the other. Therefore, the condition $0 < UNT < UT$ is reasonable. Under Condition One, we have the following theorem.

Theorem One: Under Condition One, the trust strategy can reach ESS equilibrium much easier than the distrust strategy, and thus trust between traders using E-Commerce business is the long-term equilibrium of the dynamic game.

Proof: Considering Equation (1) and (2), the barrier value required for the trust strategy to reach ESS equilibrium is $p^* = \frac{UNT}{UT + UNT}$, which means unless the possibility of

choosing the trust strategy is higher than the barrier value, *i.e.*, $p > p^* = \frac{UNT}{UT + UNT}$, the trust strategy will not reach ESS equilibrium. At the same time, however, the barrier value for ESS equilibrium of the distrust strategy is $1-p^* = \frac{UT}{UT + UNT}$. Since Condition One justifies $UT > UNT$, $p^* = \frac{UNT}{UT + UNT} < 1-p^* = \frac{UT}{UT + UNT}$ can stand. Therefore, the threshold level required for the trust strategy to reach ESS equilibrium is lower than that for the distrust strategy. The proof is done.

Theorem One indicates that if there is no extremely unfavourable factors, more and more online traders in E-Commerce business will take trust behaviour and the trust issue is then not a potential bottleneck for the development of E-Commerce.

Now we give some change to Condition One, introducing a certain unfavourable factor like a population with a high proportion of traders preferring to the distrust strategy. Then Condition One is converted into the following new condition.

Condition Two: $0 < UNT < UT$ and $1-p \in [\frac{UT}{UT + UNT}, 1]$.

Under Condition Two, payoff from choosing the trust strategy is still higher than that from choosing the distrust one, but now the probability of a trader picking down the distrust strategy lies into a dangerous interval, in which the market condition is unfavourable for survival of E-Commerce business as the following theorem implies.

Theorem Two: Under Condition Two, the distrust strategy will certainly reach ESS equilibrium and distrust between traders then becomes the long-term equilibrium of the dynamic game.

Proof: Considering the condition required for reaching ESS equilibrium and the condition $1-p \in [\frac{UT}{UT + UNT}, 1]$, we always have $U(T, p) < U(NT, 1-p)$, $1-p \to 1$, therefore ESS equilibrium of the distrust strategy is the result of the game. The proof is done.

Theorem Two provides a good explanation for the stylized fact why the trust issue has become a bottleneck for the development of E-Commerce business in China. China is a developing country where the credit environment needs great improvement [4], which will highly possibly result in some phenomena like information between online traders is asymmetric, the credit system for online trade is incomplete, and the trading culture can't act as a strong constraint on traders' distrust behaviours [8]. Although whether these conditions are real or not still needs further empirical study, they can really lead to some unfavourable market conditions like a high proportion of traders choosing the distrust strategy, under which exchange costs of online trading remain high and then the sustained development of E-Commerce business in China is blocked even after trust systems like the third-party payment mechanism have been built up by E-Commerce websites. Thus, some policies must be put into practice in order to remove these unfavourable market conditions through constructing a stable trust relationship between online traders.

4.2. The Diffusion Mechanism of Trust in E-Commerce

In the literature using the static standard of NE, diffusion mechanism of trust in E-Commerce is neglected because equilibrium of trust or distrust will be reached in no time and analysis on diffusion mechanism seems not necessary. As a result, relevant researches are quite rare. However, the ESS equilibrium of trust derived from the dynamic game model in this paper is no longer an instant result but will be reached through trust diffusion during a period of time. Therefore, studying the trust diffusion mechanism is a consequent objective for research after the game model of trust based on ESS equilibrium has been framed. We originate a diffusion mechanism as follow.

First, to simplify the analysis, we assume a specific "exchange space" for online traders as showed by Figure 2.

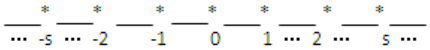

Figure 2. Exchange Space Distribution

The term "exchange space" refers to the degree to which traders can exchange information. The bigger the exchange space between two traders is, more difficult for them to exchange information and then set up trust relationship. As Figure 2, shows, every trader owners a definitive position like $i = 0, \pm 1, \cdots, \pm(s+1) \cdots$, and we assume traders choosing the trust strategy locate in the center interval $[0, s-1]$, while those choosing the distrust strategy ring about at the right and the left. Meanwhile, the probability for information exchange between traders is set as

$$mb^i = b^i \Big/ \sum_{i \geq 1}^{\infty} b^i \tag{4}$$

Where $0 \leq b < 1$ and $m = 1/\sum_{i \geq 1}^{\infty} b^i = (1-b)/b$. Here b refers to rough or smooth for a trader can exchange information between herself and another trader. According to Boyer and Orléan, the average distance of information exchange between investor $j = 0$ and any other investor at her right side is $T(b) = m\sum_{i>1}^{\infty} ib^i = \frac{1}{1-b}$, and $T(.)$ is an increasing function of b. Therefore, if $b = 0$, then $T(b) = 1$, meaning that the two traders can very easily influence each other through information exchange; while if $b = 1$, then $T(b) \to \infty$, implying that the two traders can hardly influence each other through information exchange.

Under the above assumptions, the distribution of payoffs among online traders in E-Commerce is as Figure 3. Since for some traders locating at the edge of the space, like $i = 0$ and $i = s-1$, the payoff from choosing the trust strategy is higher than that from choosing the distrust strategy, trust can be diffused from the group of trust to groups of distrust. Parameters including s (the total number of traders choosing the trust strategy), b (easy or difficult for traders to exchange information) and trust incentives ($UT - UNT$) determine the whole diffusion process of trust in E-Commerce.

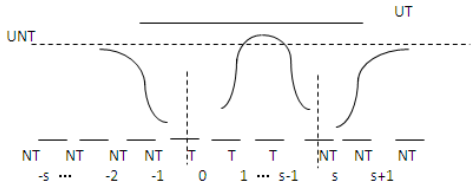

Figure 3. The Payoff Distribution among Online Traders

5. An Algorithm of Trust Diffusion

5.1. Payoff Functions of Online Traders

Assume that the total population of E-Commerce traders is P ($P \geq s+2$), where s is the number of traders choosing the trust strategy. We also assume "exchange space" for traders choosing the trust strategy is ρ_1 ($0 \leq \rho_1 \leq s-1$), "exchange space" for traders choosing the distrust strategy is $\rho_2 (\frac{P+s-2}{2} \geq \rho_2 \geq s)$ at the right side or $\rho_3 (\frac{s-P}{2} \leq \rho_3 \leq -1)$ at the left side. Then payoff functions of different traders are as follows [10].

5.1.1. Payoff Function of Traders Choosing the Trust Strategy: The payoff received by a trader locating in the point p_1 after he or she makes a deal with a left-side trader is

$$u_-(p_1) = \sum_{j=0}^{p_1-1} mb^{p_1-j}UT = (1-b^{p_1})UT,$$

while that with a right-side trader is

$$u_+(p_1) = \sum_{j=p_1+1}^{s-1} mb^{j-p_1}UT = (1-b^{s-1-p_1})UT.$$

Thus, the payoff function of the trader choosing the trust strategy with a position p_1 is

$$u(p_1) = \frac{u_-(p_1)+u_+(p_1)}{2} = UT \cdot \frac{2-b^{p_1}-b^{s-1-p_1}}{2}. \quad (5)$$

5.1.2. Payoff Functions of Traders Choosing the Distrust Strategy: The payoff received by a trader locating in the point p_2 after he or she makes a deal with a left-side trader is

$$u_-(p_2) = \sum_{j=\frac{s-P}{2}}^{-1} mb^{p_2-j}UNT + \sum_{j=s}^{p_2-1} mb^{p_2-j}UNT = [1-b^{p_2}(b^{-\frac{s-P}{2}}+b^{-s}-1)]UNT,$$

while that with a right-side trader is

$$u_+(p_2) = \sum_{j=p_2+1}^{\frac{P+s-2}{2}} mb^{j-p_2}UNT = (1-b^{\frac{P+s-2}{2}-p_2})UNT.$$

Thus, the payoff function of the trader choosing the distrust strategy with a position p_2 is

$$u(p_2) = \frac{U_-(p_2)+U_+(p_2)}{2} = UNT \cdot [\frac{2-b^{\frac{P+s-2}{2}-p_2}-b^{p_2}(b^{\frac{P-s}{2}}+b^{-s}-1)}{2}]. \quad (6)$$

Similarly, payoffs received by a trader locating in the point p_3 after he or she makes a deal with a left-side or right-side trader are respectively

$$u_-(p_3) = \sum_{j=\frac{s-P}{2}}^{p_3-1} mb^{p_3-j}UNT = (1-b^{p_3-\frac{s-P}{2}})UNT$$

and

$$u_+(p_3) = \sum_{j=p_3+1}^{-1} mb^{j-p_3}UNT + \sum_{j=s}^{\frac{P+s-2}{2}} mb^{j-p_3}UNT = [1-b^{-p_3-1}(1-b^s+b^{\frac{P+s}{2}})]UNT.$$

Thus the payoff function of the trader choosing the distrust strategy with a position m_3 is

$$u(p_3) = \frac{U_-(p_3)+U_+(p_3)}{2} = UNT \cdot [\frac{2-b^{p_3-\frac{s-P}{2}}-b^{-p_3-1}(1-b^s+b^{\frac{P+s}{2}})}{2}]. \quad (7)$$

5.1.3. Payoff Functions of Traders When the Population Is Infinite: If we relax the assumption on the population of E-Commerce traders, *i.e.*, letting $P \to +\infty$, then payoff functions of online traders are converted to

$$\begin{cases} u(p_1) = \dfrac{U_-(p_1) + U_+(p_1)}{2} = UT \cdot \dfrac{2 - b^{p_1} - b^{s-p_1-1}}{2}, & 0 \le p_1 \le s-1 \\ u(p_2) = \dfrac{U_-(p_2) + U_+(p_2)}{2} = UNT \cdot \dfrac{2 - b^{p_2}(b^{-s}-1)}{2}, & s \le p_2 \le \infty \\ u(p_3) = \dfrac{U_-(p_3) + U_+(p_3)}{2} = UNT \cdot \dfrac{2 - b^{-p_3-1}(1-b^{s})}{2}, & -\infty \le p_3 \le -1 \end{cases} \quad (8)$$

5.2. An Algorithm of Trust Diffusion

We then design an algorithm, simulating the diffusion mechanism of trust between online traders. There are four steps for the algorithm.

(1) At time τ, given that the population of traders is $P < +\infty$, the number of traders choosing the trust strategy is s_τ, and "exchange space" for them is $p_1 \in [0, s_\tau - 1]$. With regard to Equations (5), (6), and (7), the payoff functions of traders at the point 0 and $s_\tau - 1$ are both $UT(1 - b^{s_\tau - 1})/2$, while those of traders at the point -1 and s_τ are both $UNT(2 - b^{-1} - b^{s_\tau})/2$.

(2) Step (1) shows that the payoff received by the trader at the point 0 is higher than that received by the trader at the point -1. Since these two traders are next to each other in the "exchange space", it is convenient for them to exchange information about payoffs from deals. It leads to diffusion of trust from the trader at 0 to the trader at -1, motivated by traders' internal preference for higher payoffs (more is better than fewer). Similarly, preference for trust will be diffused from the trader at $s_\tau - 1$ to the trader at s_τ.

(3) At time $\tau + 1$, the number of honest traders is now $s_{\tau+1} = s_\tau + 2$, and "exchange space" for them is now $p_1 \in [-1, s_\tau]$. Return to Step One and repeat the diffusion of trust until $s_{\tau+N} = P$, where N refers to the times of diffusion happened among the online traders.

(4) Now the scale of online business becomes larger, for the diffusion of trust is undergoing among the traders. Thus we assume $P \to +\infty$ and return to Step (1). But now we use equation (8), and repeat Step (2) and Step (3).

6. General Discussion

A scrupulous investigation into the trust issue in E-Commerce business has been made in this paper. Based on ESS equilibrium, the paper sets up a dynamic game model of trust and finds that equilibrium of trust can hardly be reached under some unfavourable conditions like an initially high proportion of traders in the population choosing the distrust strategy, while distrust between online traders will retain as a long-term phenomenon baffling further development of E-Commerce business. Removing the unfavourable conditions and realizing the ESS equilibrium of trust in the real world are closely correlated to the process of reaching the equilibrium, which depends on trust diffusion. Thus a mechanism of trust diffusion in E-Commerce business and an algorithm for the mechanism are studied.

Like the literature in this field, this paper makes some assumptions in the theoretical analysis in order to reach succinct and meaningful results. These assumptions in this paper are general but not exceptive, derived directly from the game theory and the reality in China. Based on the assumptions, this paper discloses some new and important finding about the trust issue in E-Commerce business, that is even after the trust evaluation system has been set up, trust between online traders may still fail to be prevalent.

According to the existing literature, most of the researchers believe that the trust issue in E-Commerce business will be resolved after constructing trust or credit systems. Regarding the above finding of this paper, these researchers may be too optimistic. In fact, a complete solution of the distrust bottleneck constraining the development of Chinese E-Commerce business requires not only construction of trust system, but also improvement of market conditions related to convention, habit and faith in online trading. Furthermore, this paper learns the mechanism of trust diffusion in E-Commerce business, which is a new topic that has attracted little attention.

This paper has nevertheless some limitations, which need to be eliminated in future work. On the one hand, the theoretical results got by the dynamic game model of trust still lack empirical evidence. Data supporting Theorem One and Theorem Two in Part 4 are not yet available. Resultingly, the dynamic game model of trust based on ESS equilibrium pointed out by this paper needs careful test with the data from the reality. On the other hand, the specific exchange space used in the analysis of trust diffusion among online traders may be different from the reality and may have influence on the results. Looking at Figure 2, if the exchange space is not a linear space but a circle, that is online traders are located in a network like a circle, the payoff functions of the traders may be different from those in the case with the linear space. Although the linear space is commonly used in the studies on diffusion, whether the results about trust diffusion disclosed by this paper depend on the assumption of a linear exchange space or not needs further research.

7. Conclusions

In this paper, a new dynamic game model of trust is set up, which overcome the shortcoming of the literature and theoretically explain the conditions under which trust or distrust will become the long-term equilibrium in Chinese E-Commerce business as well as the mechanism through which the equilibrium of trust is reached. We find the fact that distrust between online traders has become a bottleneck for the development of E-Commerce business in China may be attributed to the unfavourable market condition, *i.e.*, a high proportion of traders preferring the distrust strategy to the trust strategy. And we also find the unfavourable market condition can be removed through implementing some policies like increasing investment in construction of trader screening system to keep dishonest dealers outside, increasing funds used for rewarding honest deal and punishing distrust deal, facilitating information exchange between different kinds of traders. With these findings, our research objectives pointed out in Part 1 are basically met, providing a framework for theoretical study on the trust issue in E-Commerce business. Now, many valuable researches remain to be finished, one of which is to find empirical evidence to justify the dynamic game model of trust through analysing the quantitative relationship between market conditions and distrust behaviours taken by online traders. Meanwhile, designing more adequate mechanisms of trust diffusion to shape better understanding about the process of reaching the long-term equilibrium of trust in E-Commerce business is also of great value.

References

[1] J. B. André and T. Day, "Perfect reciprocity is the only evolutionarily stable strategy in the continuous iterated prisoner's dilemma", Journal of Theoretical Biology, vol. 247, no. 1, **(2007)**, pp. 11-22.
[2] A. Bhattacherjee, "Individual trust in online firms: scale development and initial test", Journal of Management Information Systems, vol. 19, no. 1, **(2002)**, pp. 211-241.
[3] H. Cai and J. Jiang, "Game analysis on the problem of efficient third-part mechanism construction in Chinese C2C e-Commerce", Science & Technology Progress and Policy, vol. 24, no. 2, **(2007)**, pp. 172-175.
[4] China Daily. China in Urgent Need of Social Credit System [online]. Available: http://english.peopledaily.com.cn/200204/23/eng20020423_94569.shtml. **(2002)** April.
[5] J. C. Ely and O. Yilankaya, "Nash equilibrium and the evolution of preferences", Journal of Economic Theory, vol. 97, no. 2, **(2001)**, pp. 255-272.

[6] D. Gefen, "E-commerce: the role of familiarity and trust", Omega, vol. 28, no. 6, **(2000)**, pp. 725-737.
[7] D. L. Hoffman, T. P. Novak and M. Peralta, "Building consumer trust online", Communications of the ACM, vol. 42, no. 4, **(1999)**, pp. 80-85.
[8] J. Jiang, "Payment pattern and credit construction of Chinese C2C E-commerce", Northern Economy, vol. 5, no. 4, **(2007)**, pp. 99-100.
[9] M. K. O. Lee and E. Turban, "A trust model for consumer Internet shopping", International Journal of Electronic Commerce, vol. 6, no. 1, **(2001)**, pp. 75-91.
[10] J. Mao, X. Jin and J. Yuan, "Transition of Investment Strategies in the Security Market: A View of Evolution", China Economic Quarterly, vol. 4, no. 3, **(2005)**, pp. 707-738.
[11] N. Meade and T. Islam, "Modelling and forecasting the diffusion of innovation – A 25-year review", International Journal of Forecasting, vol. 22, no. 3, **(2006)**, pp. 519-545.
[12] L. Peng, Z. Chen and Q. Li, "Model and method for evaluating creditability of C2C electronic trade", ICEC'06, Fredericton, Canada, **(2006)**, pp. 244-249.
[13] S. Singh, "The social dimensions of the security of internet banking", Journal of Theoretical and Applied Electronic Commerce Research, vol. 1, no. 2, **(2006)**, pp. 72-78.
[14] J. E. Swan and J. J. Roberts, "Measuring dimensions of purchase trust of industrial sales people", Journal of Personal Selling and Sales Management, vol. 8, no. 1, **(2013)**, pp. 1-10.
[15] Y. D. Wang and H. H. Emurian, "An overview of online trust: Concepts, elements, and implications", Computers in Human Behavior, vol. 21, no. 1, **(2005)**, pp. 105–125.

