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AN EVOLUTIONARY GAME MODEL IN MOBILE BUSINESS COMMERCE CUSTOMER TRUST

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ABSTRACT

Customer's trust is the key element for mobile commerce's success. The formation and development of customer trust is an evolutionary process, which is effected by merchants' characteristics and their behaviors, customers themselves and the interaction between them. This research analyzes how to achieve the status of ESS with the effect of various factors on consumer trust based on evolutionary game theory, then simulates the process with the Netlogo software platform. It suggests that m-merchants should focus on the factors which generate more satisfaction and trust among customers, and for supervision and control, policies should be more scientific to effectively find and punish the business of the fraud, on the other hand, provides appropriate slack environment in order to facilitate rapid development of mobile commerce.

Keywords: *Mobile Commerce (M-Commerce); E-Commerce; Trust; Evolutionary Game; Netlogo Simulation; Data Mining*

1. INTRODUCTION

M-commerce (mobile commerce) utilizes all e-commerce advantages and combines them with the added benefit of enhanced flexibility and mobility. Mobile hardware, software and wireless technology enable m-commerce application which can transmit data quickly, locate a user position or conduct business anytime anywhere. The growth of m-commerce is noted by many companies. For example, the volume of payments made via PayPal from mobile devices will be total more than $3.5 billion in 2011. Ebay confirmed that 2011 will be its largest mobile shopping season to date with an expected $5 billion in mobile sales. In total, Forester Research predicts m-commerce to total $6 billion in revenue in 2011 and $31 billion in 2016, with a compounded annual growth rate of 39% from 2011 to 2016. M-commerce grows rapidly but remains small.

The lack of trust is one of the most frequently cited reasons for customers not using m-commerce[1,2]. Since we cannot assume that all participants in m-commerce are honest, the m-commerce system should provide enough mediated and stored information so that dishonest merchants, customers or other players can be found later. To cope with uncertainty in a mobile transaction environment, trust helps reduce fraud and potential risk and increase the likelihood of customers adopting m-commerce[3]. Trust is an important factor in the adoption of mobile services[4]. The success of m-commerce application depends on customers trust, for this technology trust and merchant trust is equally important in securing customer trust[5].

The role of trust has also been discussed with regard to online communities[6], online social networking[7] and user acceptance of virtual worlds[8]. While there has been a large amount of research on e-commerce trust, there has been comparatively very little that focuses on understanding m-commerce trust. This gap is important as m-commerce is not a simple extension of e-Commerce. M-commerce has its own technological infrastructure, new business models and value chain, and new value for consumers. Hence, it requires new thinking for its dissemination and adoption.

The development of trust is dynamic and evolutionary. The trust and trust actions are combined by people's motivations, which are sensitive to the system and strategy environments, not the individual motivations. From the micro level, the business activities of m-commerce take place in an environment

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with uncertainty and bounded rationality, in which the strategies of customers and merchants will affect each other and therefore affect the strategies of their respective group. Therefore, the repetitive games between customers and m-merchants can be regarded as the evolutionary game models. This essay will analyze the dynamic evolutionary process of customers' trust based on the Game Theory.

Our study focused on the issue of trust evolutionary in m-commerce. We proposed an evolutionary game model and examined the equilibrium status according to different payoff value.

2. LITERATURE REVIEW

Many scholars agree that customer trust is one of the key factors influencing various desirable outcomes for Internet stores, such as a positive influence on intentions to purchase[9], actual buying decisions[10], and intentions to repurchase[11].The importance of trust in m-commerce also deserves attention. The absence of physical products and possible long distances between customers and merchants make trust a critical element in establishing m-commerce relationships.

M-commerce application is location sensitive, time critical and the application is controlled by the user or network service provider[12]. Mobility, an advantage of wireless communication, gives a freedom of moving around while being connected to a network environment[13].These services can be accessed at anytime and anywhere. Every company entering the mobile marketplace has the same goal: leveraging this channel to create customer value. Transactions conducted in m-commerce is more vulnerable and uncertain than those in the traditional settings and therefore entails greater potential risk[14]. Trust is crucial in m-commerce, given the anonymous buyer-seller interactions and the lack of formal contractual agreements. It is crucial because gaining trust reduces fears and worries [1,15,16]. Trust facilitates business transactions between two parties in an impersonal economic environment in which the parties lack prior experience on mutual confidence[17].

Prior research has identified trust as a research issue in both e- and m-commerce[18]. Trust is a subjective belief that a party will fulfill his or her obligations according to the expectations of the trusting party. Quigley et al. defined trust as a belief that firm makes an effort to fulfill commitments, is honest, and does not seek to take unfair advantage of opportunities[19]. Richard et al. pointed out that trust has been conceptualized as a willingness to rely on exchange partners in whom one has confidence of their reliability and integrity[20]. Trust helps to reduce the social complexities surrounding a transaction since transactions involving electronic and m-commerce are characterized by uncertainty, anonymity, a lack of control and potential opportunism. In m-commerce, it is often required that personal as well as financial information to be exchanged among the transacting parties. Trust is then used to act as an informal control mechanism to minimize opportunistic behavior in order to decrease monitoring and other transaction costs.

M-merchant's characteristics (competence, benevolence and integrity)[21], regulatory policies[15], as while as mobile technology, such as trustworthy software[22], hardware, etc., affect the building of customer's trust. Trust not only facilitates loyalty through reducing perception of risk, but also through enhancing customer perceived value in a relationship built through frequent, positive two-way communication. Satisfaction affects customers' repeat trust towards the merchant in m-commerce [23]. M-merchants should focus on the factors which generate more satisfaction and trust among customers [24].

Social behavior involves the interaction of several individuals. Therefore within most social contexts the best thing to do depends on what others are doing. Evolutionary game dynamics is the application of population dynamical methods to game theory. The resulting population-based, `evolutionary' game theory has found many applications in non-biological fields like economics or learning theory. Evolutionary game theory deals with entire populations of players, all programmed to use some strategy (or type of behavior). Strategies with high payoff will spread within the population (this can be achieved by learning, by copying or inheriting strategies, or even by infection). The payoffs depend on the actions of the co-players and hence on the frequencies of the strategies within the population[25]. Rather than following the evolution of a population over time, one could use ideas from game theory to characterize the eventually stable endpoints of the evolutionary process. The concept of an evolutionarily stable strategy (ESS) attempts to capture the properties of these endpoints. That means no mutant strategy has greater fitness than the resident strategy[26]. In m-commerce, customer trust will affect the spontaneous behavior of customers. If merchants build

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mutual trust and customer relationships, merchants can increase customer commitment[27], and will get more customers, leading to an increasing market share. Then , although there are more cost to be honest than dishonest for m-merchants, they will be honest.

In the third section, we will build a model to analyze the evolution of customer trust based on evolutionary game theory. In the forth section, we will simulate the model with the Netlogo software platform..

3. THE MODEL BUILDING AND ANALYSIS

3.1 Construction of the Model

The m-commerce merchants and customers all have bounded rationality. They may consider the future deals so they will improve their own strategies to reach a balanced state instead of taking the one-time choice strategy. Since the strategies of m-merchants and customers may affect each other and those decision processes are uncertain and rationality bounded, the process can be analyzed according to the dynamic evolutionary game theory.

When the group of m-merchants and the group of customers deal with each other, the participants are one merchant and one customer, who change their strategies according to replicated dynamics mechanism. Each merchant(marked as M) and customer(marked as C) has independent decisions and they deal with each other by chance.

When C is buying a kind of goods or service provided by M, if C trusts M, he will buy it with the price p; if he doesn't trust M, he won't buy it.

The profit of M from each product is $p - c_i (i = 1, 2)$,in which p is the price of goods(or service), c_1 is the cost of goods provided for customers when M is honesty, and c_2 is the camouflage cost of M when he is dishonesty, $c_1 > c_2$.

V stands for the maximum benefit C can get, $V > p$. Due to various reasons, the goods or service provided by M may not satisfy C fully, λ is the level of satisfaction of C($0 \le \lambda \le 1$), λV is the real benefit C can get.

Behaviors Strategy: Assuming that the customers and merchants can choose strategies individually and repeat games in the market, the information in this game is asymmetric. C doesn't know whether M will keep his promise and how their deals go on; M doesn't know whether C can trust him and make the deal. The optional strategies for M are being honest or dishonest, and the optional strategies for C are to trust or distrust. When M chooses to be honest, he has to pay the cost c_1 ; and when he chooses to be dishonest, he has to pay for the camouflage cost c_2 . And when C chooses to trust, he has to pay for the goods(or service) with the price p . If C chooses to trust, M can get the profit of p ; and then if M chooses to be honest, C can get the maximum benefit V , and since the real benefit is related with the level of satisfaction λ $(0 \le \lambda \le 1)$, he can get λV finally; and if M chooses to be dishonest, the real benefit of C is $-V$.

When the third side-the Governance mechanism is considered, the dishonest behavior of M may be found and M may get punishments. Assuming the penalty amount to be c_3 and the probability of being found is θ . When C incur lose due to M, C can get compensation through appealing, and the compensation is set to be β times of p .

Assuming that in the group of customers, there are x percent of people choosing to trust, then there are $1-x$ percent of people who choose not to trust; and that in the group of m-commerce merchants, there are y percent of people choosing to be honest, then there are $1-y$ percent of people choosing to be dishonest.

According to the assumption above, we can get the payoff matrix as table1.

Table 1 Payoff Matrix

C \ M	Being Honesty (y)	Being Dishonesty ($1-y$)
Trust (x)	$\lambda V - p$, $p - c_1$	$-V - p + \theta\beta p$, $p - c_2 - \theta c_3$
Distrust ($1-x$)	$0, -c_1$	$0, -c_2$

M: mobile merchant; C: customer;
V : the maximum value the customer can get;
p : the price of the product or service ;
x : the percent of C choosing "trust" strategy;
y : the percent of M choosing "honesty" strategy
c_1 : the cost of m-merchant to be honest,
c_2 : the camouflage cost of m-merchan;
c_3 : the penalty amount to dishonesty m-merchant
λ : the level of customer satisfaction $(0 \le \lambda \le 1)$;
β : the multiple of compensation of price p
θ : the probability of founding dishonesty actions;

3.2 Behaviors Strategies of Customers

The profit of C when he chooses to trust:

$$U_{11} = y(\lambda V - p) + (1-y)(-V - p + \theta\beta p)$$
$$= y(\lambda V + V - \theta\beta p) + (-V - p + \theta\beta p)$$

The profit of C when he chooses not to trust:

$$U_{12} = 0$$

The average profit of the group of customers is:

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$$\overline{U_1} = xU_{11} + (1-x)U_{12}$$
$$= x[y(\lambda V + V - \theta\beta p) + (-V - p + \theta\beta p)] \quad (1)$$

Then the replicated dynamic equation is:

$$\frac{dx}{dt} = x(U_{11} - \overline{U_1})$$
$$= x(1-x)\left[y(\lambda V + V - \theta\beta p) + (-V - p + \theta\beta p)\right] \quad (2)$$

The replicated dynamic equation indicates the speed and direction of participants' leaning. When it is 0, the game has reached a relative stable balance.

$$\text{let}: \quad F(x) = \frac{dx}{dt} = 0$$

Then we can get:

$$x^* = 0, \text{ or } x^* = 1, \text{ or } y^* = \frac{p + V - \theta\beta p}{\lambda V + V - \theta\beta p}$$

According to the evolutionary equilibrium strategy, the equilibrium point should be able to resist small changes. If x is lower than x^*, $F(x)$ must be bigger than 0; and if x is higher than x^*, $F(x)$ must be smaller than 0. In other words, when the derivative of $F(x)$ is smaller than 0 at the point of x^*, we can get the "evolutionary equilibrium strategy"(ESS).

When we take the derivation of $F(x)$, we can get :

$$F'(x) = (1-2x)[y(\lambda V + V - \theta\beta p) + (-V - p + \theta\beta p)]$$

If

$$S_1 = \lambda V + V - \theta\beta p, \quad S_2 = V + p - \theta\beta p$$

When $S_1 > 0, S_2 > 0$,($\because y > 0, \ \therefore S_1, S_2$ are always positive or negative at the same time)

If $y > y^* = \dfrac{p + V - \theta\beta p}{\lambda V + V - \theta\beta p}$

Then

$$F'(x=0) > 0; F'(x=1) < 0$$

So, when $x^* = 1$, we get the equilibrium point.

If

$$y < y^* = \frac{p + V - \theta\beta p}{\lambda V + V - \theta\beta p}$$

Then

$$F'(x=0) < 0; F'(x=1) > 0$$

So, when $x^* = 0$, we get the equilibrium point .

The three phase diagrams in figure 1 show the dynamic tendency and stability of x in three situations where $S_1 > 0$.

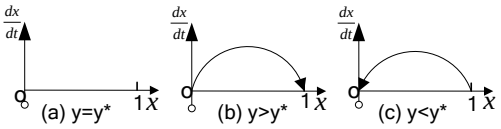

Fig. 1 The replicated dynamic phase of customers' trust where $S_1>0$

Where $S_1 < 0, S_2 < 0$

If

$$y > y^* = \frac{p + V - \theta\beta p}{\lambda V + V - \theta\beta p}$$

Then

$$F'(x=0) < 0; F'(x=1) > 0$$

So when $x^* = 0$, we can get the equilibrium point.

If $y < y^* = \dfrac{p + V - \theta\beta p}{\lambda V + V - \theta\beta p}$

Then

$$F'(x=0) > 0; F'(x=1) < 0$$

So when $x^* = 1$, we can get the equilibrium point.

The three phase diagrams in figure 3 show the dynamic tendency and stability of x in three situations where $S_1 < 0$.

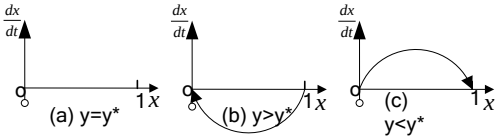

Fig. 2 The replicated dynamic phase of customers' trust where $S_1<0$

3.3 Behaviors Strategies of Merchants

Same as 3.2, we can get the average profit of the group of merchants is:

So,

$$\overline{U_2} = yU_{21} + (1-y)U_{22}$$
$$= y(x\theta c_3 - c_1 + c_2) + (xp - x\theta c_3 - c_2) \quad (3)$$

the replicated dynamic equation is:

$$\frac{dy}{dt} = y(U_{21} - \overline{U_2})$$
$$= y(1-y)(x\theta c_3 - c_1 + c_2) \quad (4)$$

We can get: $y^* = 0, y^* = 1, x^* = \dfrac{c_1 - c_2}{\theta c_3}$

$$F'(y) = (1-2y)(c_2 + x\theta c_3 - c_1)$$

① $x\theta c_3 - c_1 + c_2 > 0$, *that is*: $x > x^* = \dfrac{c_1 - c_2}{\theta c_3}$,

$$F'(y=0) > 0; F'(y=1) < 0$$

Then, we can get the equilibrium point: $y^* = 1$.

② $x\theta c_3 - c_1 + c_2 < 0$, *that is*: $x < x^* = \dfrac{c_1 - c_2}{\theta c_3}$

$$F'(y=0) < 0; F'(y=1) > 0$$

Then, we get the equilibrium point:

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$y^* = 0$.

The three phase diagrams of the dynamic tendency and stability of y in three situations are similar as figure 1.

4 THE COMPREHENSIVE ANALYSIS AND SIMULATION

4.1 The Comprehensive analysis

① Where $S1 > 0, S2 > 0,$ that means:

$$S_1 = \lambda V + V - \theta\beta p > 0,\ S_2 = V + p - \theta\beta p > 0$$

According to the comprehensive analysis of 2.1 and 2.2 in the dynamic system combined by (2) and (4), when $S_1 > 0$, the phase diagrams of replicated dynamics and stable process are as figure 3 and figure 4, which can provide 5 equilibrium point. $O(0,0)$ stands for the state in which customers don't trust and the merchants are not honest. $B(1,1)$ stands for the state in which customers choose to trust and the merchants are honest. These two points are the ESS point in this dynamic system. The two points $A(0,1), C(1,0)$ are unstable equilibrium points, and the $D(x^*, y^*)$ is the saddle point. Apart from their previous choices of strategies, it will take some time for the customers and merchants to reach stable strategy status. The way and state of their strategies are related with the payoff parameters of the system, which affect their choices by the comparisons between profits and costs.

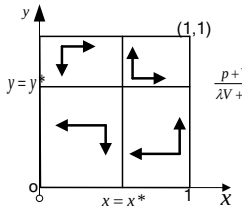

Fig.3 The replicated dynamics and stability of customers and merchants

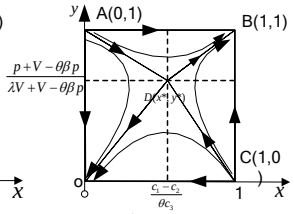

Fig. 4 The dynamic evolution of interacts of customers and merchants

In fig. 4, the broken line through the unstable equilibrium points $A(0,1), C(1,0)$ and the saddle point $D(x^*, y^*)$ can be regarded as the threshold of different models the system may get. When the original state starts from the area $OADC$, the system will end in the model (dishonesty , distrust), in which the merchants are dishonest and the customers distrust them, which is a bad locking; and when the original state starts in the area $ADCB$, the system will end in the model (honesty, trust), in which the merchants are honest and the customers trust them, which is an ideal condition.These two conditions are both the stable evolutionary conditions, in which any participants who take the other kind of strategy will die out in the evolution. Through the adjustments of parameters, the possibility of reaching the ideal Equilibrium State(honesty, trust) will be greater.

② Where $S_1 < 0, S_2 < 0$, that means:

$$\theta\beta p > \lambda V + V, \text{ and } \theta\beta p > \lambda V + p$$

It shows that when the dishonest behaviors are found by the regulators, the customers will get more than his expected utilities and all the costs.

According to the comprehensive analysis of 2.1 and 2.2 in the dynamic system combined by (2) and (4), when $S_1 < 0$, the phase diagrams of replicated dynamics and stable process are as figure 5 and figure 6, which can provide 5 balance points. $(0,0),(1,1),(0,1),(1,0)$ are all the unstable equilibrium points and (x^*, y^*) is the saddle point. In this situation, wherever the original state starts, the ESS can be hardly achieved. Generally speaking, once the customers are cheated by the merchants, the negative utility will be so influent that the enough compensation later can hardly make people to trust. In other words, if we just rely on the enhanced supervision and serious punishments, instead of the conscious activities of merchants, the m-commerce market can hardly reach the stable and balanced state. Thus, this condition should be avoided.

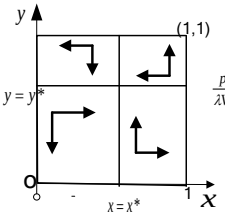

Fig.5 The replicated dynamics and stability of customers and merchants

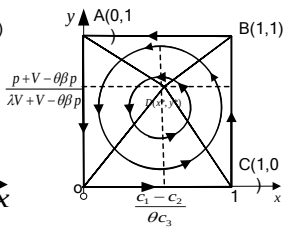

Fig. 6 The dynamic evolution of interacts of customers and merchants

Therefore, in common conditions, only when $S_1 > 0$, the real ESS can be really achieved, which means that the merchants should control the costs, lower the prices, improve the qualities of productions and provide goods and services with higher value-added rate in order to get the higher level of satisfaction; and the regulators should enhancing supervisions and punishments.

4.2 Simulate the Model

NetLogo is a software platform designed to make models for analysis on complex systems, an simulation environment with multi- participants which is based on the Agent. The basic structure of the system is the interactive Agent group, which is suitable for the simulation of complex system changing with time.

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The basic presumption of NetLogo models is that the space can be divided into different grids, each stands for a static agent. Many mobile agents are set in the two-dimensional space, and move independently. All the participants change respectively and the whole system changes with time. This research defines two kinds of agents (customers and mobiles) as customers or m-merchants on agent-based model. They follow certain action rules(see table 1 the payoff matrix) to make decisions according to their own qualities and outside environments and change their strategies through learning and imitating in the repeated games to improve their own profits so that they can reach the evolutionarily stable equilibrium. The model is made up with the game environment and agents. The outside environment of agents is designed to be the space in real life. The agents can move freely along any directions in the grids. Each agent, made up of qualities, behavior rules and learning algorithms, chooses to deal with one of the other kind of agent in the measurement cycle. Different kinds of agents choose strategies at the beginning by chance, and decide the strategies in the next t+1 time through learning according to the profit of this game.

Simulation process is as follows:

Assuming that the number of customers is 100, the number of m-merchants is 50, and set the other Parameters as follows:

$v = 10, p = 5,$
$c_1 = 4, c_2 = 2, c_3 = 10,$
$\lambda = 0.8, \theta = 0.5, \beta = 2$

Then we can get :

$x^* = 0.4, y^* = 10/13 \approx 0.77$

First of all, we assume the number of customers with "trust strategy" is 40 ($\leq$ The number of customers $\times$ x* = 40), and the number of m-merchants with "honesty strategy" is 38 ($<$ The number of moblie merchants $\times$ y* $\leq$ 38), then we can get the simulated image as chart (a), showing that the evolution equilibrium strategy is (distrust, dishonesty);then we will adjust different parameters(one at a time), the adjustments and results are in Table 2.

Table 2 The Adjustments of Parameters and the Results of Simulation

The Simulation Process	The adjustments of parameters	The Methods of Adjustments	Specific Data after Adjustments	The Results of Simulation (Fig. 7)
1	Initial Setup	The number of customers with "trust strategy"=40 The number of merchants with "honesty strategy"=38 $v = 10, p = 5$, $c_1 = 4, c_2 = 2, c_3 = 10$ $\lambda = 0.8, \theta = 0.5, \beta = 2$		(a)
2	λ	increase	0.9	(b)
		decrease	0.7	(a)
3	θ	increase	0.6	(b)
		decrease	0.4	(a)
4	β	increase	3	(b)
		decrease	1	(a)
5	c_1	decrease	3	(b)
6	c_2	increase	3	(b)
7	c_3	increase	11	(b)
		decrease	9	(a)
8	The number of customers with "trust strategy" and the number of merchants with "honesty strategy"	$x > x^*$ and $y > y^*$	(41,39)	(b)
		($x > x^*$ and $y=y^*$) or ($x = x^*$ and $y > y^*$)	(38,39); (39,38); (39,39); (40,37); (42,38);	(a)
			(39,40); (40,39) (43,38)	(b)

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5. CONCLUSIONS

5.1 Theoretical Implications

Our study resulted in several important findings. First, when the level of satisfaction λ is higher, y^* will be smaller, point D will move downwards, and the area $ADCB$ will be larger, which means the greater possibility of the ideal evolutionary stable strategy (ESS): (trust, honesty). In addition, when the price p is lower, or the value felt by customers is higher, y^* will be smaller, and the point D will also move downwards.

Second, when the costs of merchants c_1 decrease, or the camouflage costs c_2 increase, x^* will be smaller, point D will move leftwards, and the area $ABCD$ will be larger, which means the greater possibility of the ESS: (trust, honesty).

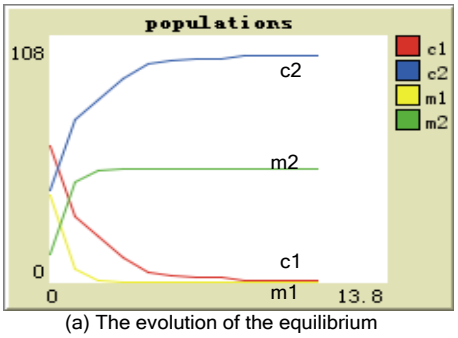
Third, When the regulators step up the investigations to improve θ, the probability of finding the dishonesty behaviors, or enhance the punishment c_3, x^* will be smaller, point D will move leftwards, and the area $ADCB$ will be larger, which means the greater possibility of the ESS (trust, honesty).

In addition, when θ, the probability of finding the dishonest behaviors by the regulators, is higher, y^* will also be smaller so that the point D will move downwards.

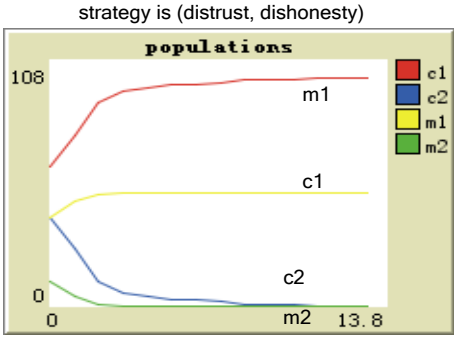
Fourth, If the initial x and y can be large enough at the beginning so that (x, y) can be in the area $ADCB$, it will be faster for the system to reach ESS. Two needs should be met: ①There are enough m-merchants who would like to be honest, which means y should be large enough. The superintend measures and policy supports provided by regulators will give merchants longer business expectation, causing y to be larger. ②There are enough customers who would like to trust merchants, which means x should be large enough. The active participates of merchants in the construction of credit system will be helpful to enlarge x.

5.2 Practical Implications

This study also has several practical implications. First, our study indicated that, for m-merchants in general, the results can help them to better develop customer trust in m-commerce. M-merchants should show their trustworthiness to customers. Interaction can send the information to customers that the m-merchant is ability, benevolence, integrity and predictability, which may strengthen the trusting beliefs of customers. The reputation construction through advertisements can also help to improve the trusting beliefs and promote the actions of purchasing. In addition, the privacy policy and the third party seals can make customers believe that the m-merchants will follow the commercial moralities(trusting beliefs--honesty) so that they would like to provide personal information to the m-merchants, and they would be more likely to share information (the trust behavior-- information sharing) in real life. This kind of belief depends on the qualities of seal. Satisfactions can positively effect customer trust which can lead to repurchase. M-merchants should focus on the factors which generate more satisfaction, such as enrich service concept, and enhance service quality et al.



(a) The evolution of the equilibrium strategy is (distrust, dishonesty)



(b) The evolution of the equilibrium strategy is (trust, honesty)

Notes:
c1: customers with “trust strategy”;
c2: customers with "distrust strategy";
m1: merchants with "honesty strategy";
m2: merchants with "dishonesty strategy"

Fig. 7 The Results of Simulation

Second, for supervision and control, the results can help them to formulate policies more scientific. If the regulatory agency can effectively find the business of the fraud and punish them, will greatly enhance the integrity of the proportion of businesses in the

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merchants group, but also enhance the confidence of users of mobile commerce. However, the punishment is too restrictive and severe that will dampen the enthusiasm of merchants and hinder the normal development of mobile commerce. Appropriate slack policies help to create a good beginning for m-commerce.

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