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Evolutionary Game Analysis of the Partners' Behavior in the Rural E-Payment Market of China

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Abstract: The rural e-payment market in China is becoming one of the important topics in the research field because of its contribution to the efficiency of fund flows in the economy. Further development of the rural e-payment market mainly depends on its partners' acceptance. In March 2020, 776.08 million people were using mobile payments in China. After the COVID-19 pandemic in China, the Payment and Clearing Association of China launched an action to encourage citizens to use mobile payments. In this article evolutionary game theory is presented. The benefits of e-payments between financial institutions and users are studied. Based on the analysis of the partners' selection of costs and profits as well as other factors, important conclusions were drawn. The growth of the rural economy is beneficial to the change of the partners' behavior in the rural e-payment market. Dynamic evolution of the partners' behavior makes the supply and demand for rural e-payment services consistent. In order to create more benefits, financial institutions will lead the move to merge the rural e-payment market with the China National Advanced Payment System. These research results are beneficial for its growth by developing strategies to encourage more partners to take part in the rural e-payment market in China.

Keywords: rural finance; financial services; payment market; evolutionary game theory

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1. Introduction

Electronic payments are used not only to develop the rural economy through the flow of funds but also to develop rural financing through innovation in financial services (Yang et al. 2005; Beck et al. 2015). It attracts more and more attention from the People's Bank of China, the government, and other organizations. It is a special kind of market because recently the rural e-payment market has developed very slowly, while e-payment has been widely used in the world (Yeung et al. 2015). Some researchers believe that it has been influenced by a dual economy (Knight and Song 1999).

Knowledge of the behavior of the game participants, in the form of probability estimates of individual strategies, will enable the player to rationalize his own behavior in the future. The player who can make better use of the information presented in this paper will increase the likelihood of his own success. Therefore, it will limit the risk of failure in the game.

In the two-player games under consideration, the bank is one of the parties. The presented empirical results reveal the frequencies of various strategies. Knowledge of the frequency, as an assessment of the probability of a specific strategy, will facilitate the banking institution's adaptation to the rules of the market game, allowing for the rationalization of decisions, and therefore reducing the risk of a wrong decision.

Rural institutions have a negative attitude towards the provision of financial services due to the limited number of users and their low economic activity. In rural development, the government uses limited financial resources to encourage the development of the e-payment market in the countryside. In the presented study, each of the partners develops strategies for participation in e-payments, using their strengths. The benefits of e-payments can be transferred between the parties, so there is a mechanism to balance the interests of all parties and encourage all of them to participate in e-payments. The People's Bank of China, which manages rural financial institutions, plays an important role in the study.

The study proposes a strategy for conducting macro-policy of the rural economy and rural finance. The results of the study are intended to help the People's Bank of China by setting the directions of this policy. Its aim is to encourage the use of e-payments by partners by showing them the mutual benefits of their use. Another benefit of the study is that it shows funding opportunities and further develops the finances of rural China.

The rural economy of China is described in Figure 1.

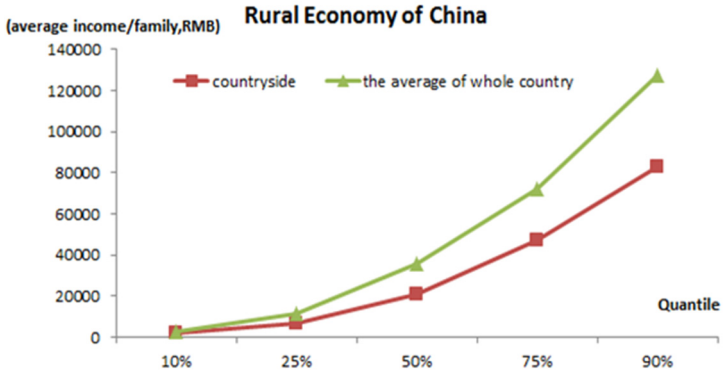

Figure 1. Rural economy of China. (Source: these data come from the report of home finance of China in 2019).

According to Figure 1, the economic level of the countryside is lower than that of the entire country. Therefore, financial services, such as e-payments, were excluded from the last years (Hsieh et al. 2013).

In order to develop rural e-payment services quickly, there are two ways: one is to adopt the model of the United States, Ireland, and other developed countries, which improve e-payment circumstances through hardware (Sun and Wang 2005; Csáki et al. 2013; Turban et al. 2015); the other is to learn from the pattern of underdeveloped countries, which improve e-payment circumstances through software (Donovan 2012; Ayo et al. 1970).

However, neither strategies are good at solving the problem, due to the special economic state of China (Yu et al. 2012). It is difficult for the countryside to have as ideal e-payment circumstances as developed areas do (Lok 2015). Moreover, there are many policies that limit the innovation of e-payment in the rural e-payment market, such as E-PESA (Qiang et al. 2011; Slade et al. 2013; Zhou et al. 2015).

At present, there are many types of research and innovations that have taken place in the rural e-payment market. In theory, many researchers have conducted research on e-payment services. Firstly, they focused their interest on the fund flow of rural e-commerce (Donovan 2012; Andreopoulou et al. 2014). Secondly, e-payment is a part of rural finance (Wonglimpiyarat 1970). The researchers sought to use e-payment to reduce the risk and to improve the efficiency of loans (Gogia and Agrawal 2016). Thirdly, the researchers wanted to improve rural e-payment conditions by improving the hardware and software (Slade et al. 2013; Singh et al. 2016).

In practice, many innovations have taken place in the rural e-payment market in recent years. We can distinguish them as follows: issuing special bank cards to citizens or migrant workers; providing Electronic Point of Sale (EPOS) and mobile bank services (Postal Savings Bank of China); permitting the Rural Credit Cooperatives (RCC) to use

CNAPS and to use the CUP (China Union Pay) system; and providing more financial services by demonstration area and demonstration project (People's Bank of China 2013).

However, the researches and innovations did not cause the rural e-payment market to develop more quickly. In 2015, more than 930 million people owned 2.22 billion payment cards. They used 309,000 automated teller machines (ATMs) and 6.38 points-of-sale POS systems. According to statistics published in early 2020 by the People's Bank of China (PBOC), the number of electronic payments processed by the country's banks increased by 6.3% in comparison to the same period in 2018. We observed that 62.1 billion electronic payments have been registered, that included approximately 30.7 billion mobile transactions. This represents a year-on-year increase of 73.6%. In March 2020, 776.08 million people were using mobile payments in China. After the COVID-19 pandemic in China, the Payment and Clearing Association of China (PCAC) launched an action on 28 February 2020 to encourage citizens to use mobile payments, online payments and quick response code payments (QR) to avoid the risk of COVID-19 infection.

Citizens hesitated to change their payment habits from using cash to using e-payments, because they initially could not imagine the direct benefit from using e-payments. Insufficient demand limited the supply in rural finance, the development of the rural market, and the rural economy as well. On the contrary, if there were some strategies that could balance the benefits of using rural e-payments among partners, both financial institutions and citizens would increasingly be attracted to taking part in the rural e-payment market. We can therefore imagine that more and more financial services would be provided and used in the rural market (Gan et al. 2016).

The evolutionary game model is a typical model which is good at analyzing the evolution of partners' behavior in an interaction circumstance (Weibull 1997). It can be dated back to the researches of Fisher, Hamilton, and Trivers (Vincent and Brown 2005). They used the evolutionary game model to analyze the biological relationship (Pacheco et al. 2006). They thought that the evolution of biological relationships had been taking place now and then (Hodgson and Huang 2012; Wu et al. 2015). The evolutionary game theory was formed during the research of Smith and Price when they developed the evolutionarily stable strategy (Taylor and Jonker 1978) which was used to analyze the behavior of partners in a supply chain (Xiao and Yu 2006) to study the risk management of finance (Su and Lu 2015; Zhao et al. 2015; Evstigneev et al. 2016), and to study the innovations of institutions and industry evolution, etc. (Fan et al. 2013; Elsner et al. 2014).

In order to encourage more partners to provide or to use financial services, in this article an evolutionary game model to research the partners' dynamic behavior in the rural e-payment market is presented. It analyzes different equilibrium results and explores financial services in supply-use ways between citizens and financial institutions. This research is useful for financial institutions in adjusting the strategies of developing the rural e-payment market. It is also meaningful for the development of the rural payment market, by engaging financial services in the supply and the demand.

2. The Evolutionary Game Model of the Rural E-Payment Market

In traditional economies, cash is one of the main payment tools in the countryside (Lipton 1976). With the development of modern agriculture, remote payments and large payments are increasingly needed to support agricultural business. E-payment has obvious advantages to cash in many aspects; however, the rural e-payment market cannot be developed without partners, and especially without the peasants. In order to accelerate the development of the rural e-payment system, the evolutionary game model is used to analyze the partners' behavior. From the perspective of financial services, financial institutions belong to the supply side and peasants belong to the demand side.

2.1. Description of the Problem

Unlike payments using cash, each e-payment needs more than two types of partners for the transaction to be completed. Both peasants and financial organizations are the main

partners of the e-payment market and rural e-payments are used to speed up cash flow and to support the rural economy (Zhu et al. 2016). The government also joined the e-payment market, because its goal was to help develop the rural economy through e-payment. All partners' behavior in e-payment market is described following.

2.1.1. The Government in Rural E-Payment

E-government tends to make government management flat (Huang et al. 2013). On one hand, e-payment helps the government to enhance the capability of the service for peasants and through the e-payment system, different kinds of corresponding subsidies were assigned to peasants directly. The subsequent financial information can help the government to govern the rural e-payment. On the other hand, e-payment helps the government acquire more financial information in order to innovate economic institutions. Thus, it is useful for developing the rural economy. As such, the government prefers to give subsidies for developing the rural e-payment market.

2.1.2. Financial Institutions in Rural E-Payment

During the period of 1998–2007, rural finance was almost undeveloped due to the influence of the rural economy. In 2007, there was a policy that emphasized the position of rural finance in the rural economy. Since then, much money has been invested to develop the rural e-payment market, which was used to improve the efficiency of funds transfers in the rural economy. Financial institutions also provide many financial services, such as EPOS, mobile banking, and others. E-payment is a kind of low-cost financial service (Conning and Udry 2007) and therefore, financial institutions want to gain more benefits from these financial services and to provide further financial services.

2.1.3. The Peasants in Rural E-Payment

On one hand, in order to meet the requirements of modern agriculture in funds transfers (Gogia and Agrawal 2016), peasants want to use e-payments. On the other hand, there is a hidden cost when they adapt themselves to using e-payment services. More convenient and secure e-payment services could reduce the peasants' costs associated with changing payment tools. During this period, the peasants always select an optimal strategy to use cash or e-payment and moreover, the peasant's decision process is also a game process.

Based on the above analysis, we can conclude that the rural e-payment market is the result of an evolutionary game in the payment methods of both financial institutions and peasants. Financial institutions provide a payment service that is used to meet peasants' demands. Further, peasants' opting for e-payment services will affect the financial services. Assuming that e-payment is more optimal in comparison to cash, all the partners' behavior is affected by the profitable outcome of e-payment, since they act rationally. The profit from the e-payment can be assigned by the transaction fee distributed among the partners. As soon as the profit belongs to the financial institutions, the financial institutions prefer to improve the quality of their financial services. On the contrary, when the profit belongs to peasants, they begin to prefer using e-payments. Investment on the part of the government and the e-payment externalities will bring more profit to the e-payment market.

3. The Theory of Evolutionary Game

Game theory is one of the most important tools in the economic theory field. The partners of the game adjust their strategy now and then because they receive more and more information in the process of the cognition of things. Their decisions tend to be stable.

There are two kinds of assumptions of the learning rate in the game (Erev and Roth 1998). One is the repeated game of a participant who has a quick learning ability (Cripps 2015). This is called an optimal dynamical reflection. The other is an evolutionary game of participants who learn slowly in dynamic circumstances (Mailath 1998). Rural e-payment is more suitable when using the second assumption. Then, there is a competition between

two participants (financial institutions and the peasants), labeled as participant A and participant B, respectively. The two participants are not perfectly rational and each participant has two types of strategies (positive or negative towards rural e-payment). The participants are assumed to be heterogeneous. The payoff matrix is shown in Table 1.

Table 1. The payoff matrix of the partners.

Type		Participant B	
		Strategy 1	**Strategy 2**
Participant A	strategy 1	a, a	b, c
	strategy 2	c, b	d, d

If both partners use strategy 1, the reward for both participants is represented by variable a. If both use strategy 2, the reward for both participants is represented by variable d. If participant A uses strategy 1 and participant B uses strategy 2, the payoffs for participants A and B are b and c. If participant A uses strategy 2 and participant B uses strategy 1, the payoffs for participants A and B are represented by variables c and b.

Payoffs for participants A and B are asymmetric. Following others in the evolutionary game model, we suppose that variable x represents the probability to use strategy 1 for participant A. Then $(1 - x)$ corresponds to the probability to use strategy 2 by participant A. We use the variable y to denote the probability for participant B to use strategy 1. So $(1 - y)$ means the probability to use strategy 2 by participant B.

According to the game theory, when participant A makes different choices, his expected payoff is described as follows:

$$U\_1 = ay + b\ (1 - y);\ U\_2 = cy + d\ (1 - y)(U\_1 \text{ is strategy1 } U\_2 \text{ is strategy 2})$$

The mean return of participant A is computed as:

$$U^{-} = U\_1x + U\_2\ (1 - x) \tag{1}$$

Then the replicated dynamic equation F(x) of participant A is:

$$F(x) = dx/dt = x(U\_1 - U^{-}) = x(1 - x)[y(a - c) + (1 - y)(b - d)] \tag{2}$$

"As soon as "F("x")"= 0, the stable solution for participant A is as follows:"

$$x\hat{}* = 0,\ x\hat{}* = 1,\ y\hat{}* = ((d - b))/((a - b - c + d))^3$$

If the strategy of participant A is stable, it has the following characters:

If $x < x^*$, x has the trend to change to x^*. I.e., $x \to x^*$, $dx > 0$. In other words, x changes following the time t in the same direction. $F(x) > 0$;

If $x > x^*$, x has the trend to change to x^*. I.e., $x \to x^*$, $dx < 0$. In other words, x changes following the opposite direction of time t. $F(x) < 0$.

So, $F(x\hat{}*) = 0$, $x\hat{}*$ is a stable strategy.

Similarly, it is the same for the stable solution of participant B.

The Evolutionary Game Model of Rural E-Payment

Hypothesis 1. *On the rural e-payment market, there are two partners—financial institutions (the banks) and citizens (the users). They are replaced by marks 'S' and 'N'. Both of them have the chance to use strategy 1 (cooperation) and strategy 2 (noncooperation) freely. Their strategies are continuous in space.*

Hypothesis 2. *According to the government leadership of the rural economy, the government gives some policies to protect and support e-payment. Besides, with the development of e-payment, there*

are some profits coming from the network and information, in this research named as:π_FS,π_FN (π_FS > 0,[π]_FN > 0).

Hypothesis 3. *Benefits of the supplier and the user in cash (no cooperation in e-payment) are namedπ_S0,[π]_N0. The change of their payment method from cash to e-payment needs costs. These costs are named C_S0 > 0, C_N0 > 0. Specifically, the financial organization provides an e-payment service, but the user does not adopt it. The users will pay for the cost C_SN (C_SN > 0) of a cash transaction because they found that it is not convenient in payment (e.g., credit card is free when it is used on POS, but a transaction fee needs to be paid when one obtains cash and then uses the cash to pay).*

Hypothesis 4. *As a kind of financial service, all participants are active in changing their payment method from cash to e-payment and they will gain profit Δπ_S and Δπ_N (Δπ = Δπ_S + Δπ_N (Δπ_S > 0, Δπ_N > 0)).*

Hypothesis 5. *Before e-payment was used in the countryside, let us suppose that the probability of financial organizations has the probability x to provide an e-payment service. Thus, they have the probability (1 − x) to use cash. The users have the probability y to use an e-payment, and the probability (1 − y) to use cash.*

Based on these assumptions, each participant's profit can be described as follows:
Both sides choose e-payment.
The payoff of the supplier is:

$$\pi\_SH\hat{}1 = \pi\_GS + \pi\_FS + \Delta\pi\_s + \pi\_S0\text{-}C\_S0$$

The payoff of the user is:

$$\pi\_NH\hat{}1 = \pi\_GN + \pi\_FN + \Delta\pi\_N + [\pi]\_N0\text{-}C\_N0$$

Financial institutions provide an e-payment services, but users do not adopt them.
The payoff of the supplier is:

$$\pi\_SH\hat{}2 = \pi\_GS + \pi\_S0\text{-}C\_S0$$

The payoff of the user is:

$$\pi\_ND\hat{}2 = \pi\_N0\text{-}C\_SN$$

The users want to use an e-payment service, but the financial institution does not provide it.
The payoff of the supplier is:

$$\pi\_SD\hat{}3 = \pi\_S0$$

The payoff of the user is:

$$\pi\_NH\hat{}3 = \Delta\pi\_N + [\pi]\_N0\text{-}C\_N0$$

Both participants do not use e-payment.
The payoff of the supplier is:

$$\pi\_SD\hat{}4 = \pi\_S0$$

The payoff of the user is:

$$\pi\_ND\hat{}4 = \pi\_N0$$

As such, their game matrix is shown in Table 2.

Table 2. The payoff matrix of the partners in rural e-payment.

Type		Participant B	
		Strategy 1	**Strategy 2**
Participant A	strategy 1	a, a	b, c
	strategy 2	c, b	d, d

If the financial institutions provide e-payment services, the expected payoff of the supplier is:

$$U\_SH = y\pi\_SH\hat{}1+(1 - y)\pi\_SH\hat{}2 \quad (3)$$

If the financial institutions do not provide e-payment services, the expected payoff of the supplier is:

$$U\_SD = y\pi\_SD\hat{}3 + (1 - y)\pi\_SD\hat{}4 \quad (4)$$

Therefore, the mean expected payoff of the financial institutions is:

$$U^{-} = x^{*}U\_SH + (1 - x)U\_SD \quad (5)$$

By solving the formulas above, this research obtains the supplier's dynamic replication equation of the financial institutions, as follows:

$$F(x) \triangleq dx/dt = x(U\_SH\text{-}U^{-}) = x(1 - x)[y(\pi\_FS + \Delta\pi\_s) - (C\_S0 - [\pi]\_GS)] \quad (6)$$

Computing the users' strategy in the same process, this research obtains the users' dynamic replication equation, as follows:

$$F(y) \triangleq dy/dt = y(U\_NH\text{-}U^{-}) = y(1 - y)[x(\pi\_GN + \pi\_FN + C\_SN) - (C\_N0\text{-}\Delta\pi\_N)] \quad (7)$$

For the financial institutions in the game on the condition of $dx/dt = 0$, their stable solution of the dynamic replication equation is as follows.

$$x\hat{}^{*} = 0, \text{ or } x\hat{}^{*} = 1, \text{ or } y\hat{}^{*} = (([C\_S0\text{-}\pi]\_GS))/((\pi\_FS + \Delta\pi\_s))(x \text{ is any value})$$

For the action of the users in the game on the condition of $dy/dt = 0$, the users' stable strategy is as follows: $y\hat{}^{*} = 0$, or $y\hat{}^{*} = 1$ or $x\hat{}^{*} = ((C\_N0\text{-}\Delta\pi\_N))/((\pi\_GN + \pi\_FN + C\_SN))(y$ is any value).

The replicated dynamic Equations (6) and (7) describe the two partners' strategy changing process. According to the theory of local stability of a Jacobian Matrix, there are five singular points:

$$O(0, 0), A(1, 0), B(0, 1), C(1, 1), D(XD, YD).$$

where XD and YD and can be calculated as follows:

$$X\_D = ((C\_N0\text{-}\Delta\pi\_N))/((\pi\_GN + \pi\_FN + C\_SN)), Y\_D = (([C\_S0\text{-}\pi]\_GS))/((\pi\_FS + \Delta\pi\_s))$$

where x and y are both probabilities of the partners' strategy. Therefore, $[0 < X]\_D < 1$, $0 < Y\_D < 1$.

Among these five points, both point O and point C are stable strategies of the evolutionary game. At point O, both partners of the rural e-payment choose the strategy of not using e-payment. I.e., both of them use cash. Point C means that both partners of the rural e-payment use e-payment. The financial institution provides a convenient e-payment method and the users like using the e-payment. In practice, financial institutions have

more interest in developing e-payment services. Therefore, XD > YD. The result of the partners' evolution is described in Figure 2.

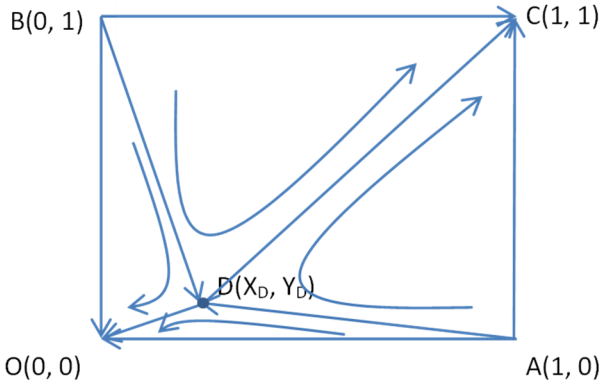

Figure 2. The evolutionary game of partners in the rural e-payment.

Figure 2 indicates that there are two equilibriums in the evolution. Both partners in the rural e-payment will not change their strategy at these positions. In these equilibriums, both of the partners use the same strategy—they both are positioned positively or negatively towards the rural payment market. In practice, until 2007, cash was widely used when the rural e-payment was underdeveloped. This equilibrium was broken because the government has invested much money to develop the rural e-payment market. More and more financial services have been provided and more and more users have accepted e-payment.

In the results of the game equilibrium, the partners' e-payment strategy has been decided by their initial state (x, y). When a point (x, y) is in the area SADBC, both the financial institutions and users are positive about using e-payment. On the contrary, if point (x, y) is in the area SADBO, this indicates that there is no e-payment market.

4. Model Analysis

Research on the change of the key point (XD, YD) of the partners' strategy in rural e-payment leads to the following conclusion:

$$X\_D = ((C\_N0-\Delta\pi\_N))/((\pi\_GN + \pi\_FN + C\_SN)),\ Y\_D = (([C\_S0-\pi]\_GS))/((\pi\_FS + \Delta\pi\_s)).$$

The initial state of rural e-payment.

At first, all partners used cash; however, with the development of e-payment services in urban areas and with the development of rural economics, more and more advantages of e-payment services attracted rural financial organizations and the government. All of the partners also have the intention to change their payment method to some extent. The financial institutions change their initial probability of developing e-payment services due to the investments of the government. Users also change their initial probability of using e-payment services due to the influence of the rural economy. As soon as the partners' strategy was in SADBC, both the financial institutions and the users are positioned positively towards e-payment. On the contrary, they are negative to rural e-payment.

Influence of Other Factors in the E-Payment Environment

The development of the modern e-payment system in urban areas has had a great effect on the rural e-payment system. As a kind of information service, C_S0, and C_N0 decrease in this process. At the same time, π_GS, π_GN, π_FS, π_FN, C_SN $\Delta\pi\_N$ and $\Delta\pi\_S$ are increasing. Therefore, XD and YD become smaller and the key point (XD, YD) is close to O(0, 0). The area of SADBC becomes larger. As soon as the partners' strategy is in SADBC, the financial institutions and the users are positive towards e-payment. It means that the payoff matrix is: $\pi\_SH\hat{}1 > \pi\_SD\hat{}3$ and $\pi\_NH\hat{}1 > \pi\_ND\hat{}2$. The value of $\pi\_SH\hat{}2$, $\pi\_SD\hat{}4$ and

π_NH^3, π_ND^4, is affected by Δπ_N, C_N0 and π_GS, C_S0. The partners will change their strategy according to the value of [π]_SH^2, π_SD^4 and π_NH^3, π_ND^4. Besides, at the beginning of the rural e-payment, C_N0 [and C]_S0 were very large. Therefore, the payoff of the partners in the evolutionary game of rural e-payment indicates the following information: π_SH^2<π_SD^4 and π_NH^3<π_ND^4. Both the financial institutions and the users are positioned negatively towards the e-payment, i.e., they prefer to use cash. This was the optimal strategy for the partners in the initial state.

There are some data that record the history of rural e-payments. As one of the e-payment tools, a payment card was issued in the countryside in 2007. An e-banking service was first used in the countryside in May 2005. Following on from that, rural financial institutions began to issue credit cards in the countryside in 2008. It is now more than 25 years later from when the first credit card was issued in China. At present, there are many financial organizations taking part in the rural e-payment market and they provide various kinds of financial services. Many demonstration projects have been implemented that have conducted rural e-payments. EPOS and mobile payments improve the circumstances of rural e-payment services (Guo et al. 2015; Hou et al. 2016) and both the numbers and the money processed in e-payment transactions have increased very quickly.

5. Data Simulation

In the payoff matrix of the rural e-payment game, the benefit of the partners was influenced by the benefit of other partners, because they were part of the e-payment benefit. The environment of the rural e-payment market is also an important factor Since the influence of the modern payment system will increase the profit from rural e-payments (Schreiner and Colombet 2001).

The development of the rural economy will reduce the users' initial cost of using an e-payment while many factors will influence the evolutionary game of the rural e-payment market. In this research, the program MATLAB 2012b was used to simulate the behavior of the partners in the rural e-payment market and to assess the partners' strategy in certain e-payment circumstances. MATLAB® is a programming platform designed specifically for engineers and scientists to analyze and design systems and products that transform our world. The heart of MATLAB is the MATLAB language, a matrix-based language allowing the most natural expression of computational mathematics. It allows users to analyze data, develop algorithms and create models and applications.

First, according to the level of a rural e-payment, this research under the certain circumstances of that rural e-payment is given as follows. We can conclude for the financial institutions under an e-payment circumstance: C_S0 = 15, π_GS = 9, Δπ_s = 8, and π_FS = 7.

For the users' payment environment, π_FN = 6, π_GN = 3, Δπ_N = [1, C]_N0 = 5, and C_SN = 2. The key point is (Xd, Yd) = (0.3636, 0.4). In this special circumstance, this research obtained a different evolution game result in the rural e-payment, by changing the financial institution strategy. The track of the evolution result is described in Figure 3.

According to the same theory, this research obtained a different evolution game result in the rural e-payment, by changing the user strategy in this special circumstance. The track of this evolution result is described in Figure 4.

Figures 3 and 4 indicate the following information: the result of the evolutionary game in the rural e-payment is not only decided by the special state of the rural e-payment (i.e., the key point), but also by the initial state of both partners' strategies. In Figure 3, the users always adopt a fixed strategy (probability = 0.4) at the initial state of the rural e-payment. With the change of the financial institution's strategy (their probability of developing rural e-payment has changed from 0.1 to 0.9, the users adjust their strategy to use a rural e-payment in the evolutionary game as well. Moreover, the financial institution's strategy changed the results of the evolutionary game in the rural e-payment.

This means that the rural e-payment market can develop by encouraging financial institutions to provide more financial services. In Figure 4, the financial institution always adopts a fixed probability = 0.4 at the initial state of the rural e-payment. With the change

of the users' strategy (their probability of using a rural e-payment changes from 0.1 to 0.9), the financial institutions adjust their strategy to develop rural e-payment services as well. The users' strategy also changes as the result of the evolution game in rural e-payment. This means that the users' demand for rural e-payments will change the financial strategy to develop the rural payment market.

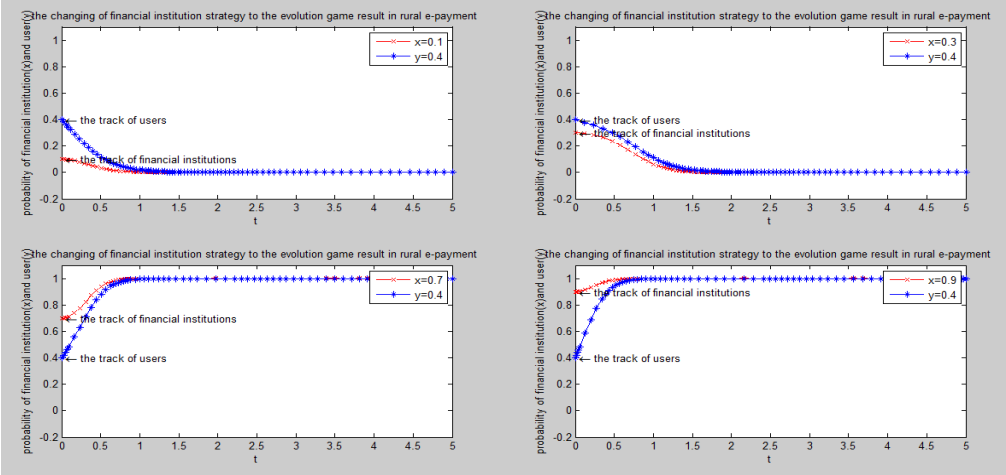

Figure 3. The result of the changing of the financial institution's strategy to the evolution game in the rural e-payment.

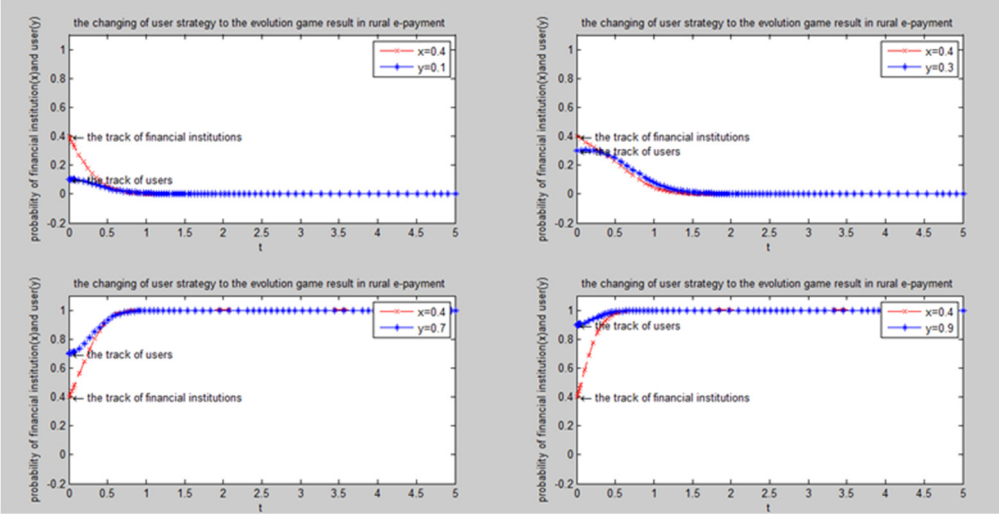

Figure 4. The result of the changing of the users' strategy to the evolution game in the rural e-payment.

With the change of the rural payment environment, the payoffs of the partners also changes. The payoff will be influenced by the partners' strategy. Given the initial cooperation strategy as follows, the research indicates that under new conditions this changed from:S_{sn0} to S_{sn1}, S_{sn0} to S_{sn2}, S_{sn0} to S_{sn3}, just as the data before, S_{sn0}, S_{sn1}, S_{sn2} and S_{sn3} were defined as follows: S_{sn0} =(C_{S0} = 15, π_{GS} = 9, $\Delta\pi_s$ = 8, π_{FS} = 7, π_{FN} = 6, π_{GN} = 3, $\Delta\pi_N$ = 1, C_{N0} = 5, C_{SN} = 2); S_{sn1} = (C_{S0} = 14, π_{GS} = 11, $\Delta\pi_s$ = 7, π_{FS} = 4, π_{FN} = 6, π_{GN} = 3, $\Delta\pi_N$ = 1, C_{NO} = 5, C_{SN} = 2); S_{sn2} = (C_{S0} = 15, π_{GS} = 9, $\Delta\pi_s$ = 8, π_{FS} = 7, π_{FN} = 7, π_{GN} = 4, $\Delta\pi_N$ = 4, C_{NO} = 14, C_{SN} = 3); S_{sn3} = (C_{S0} = 14, π_{GS} = 11, $\Delta\pi_s$ = 7, π_{FS} = 4, π_{FN} = 7, π_{GN} = 4, $\Delta\pi_N$ = 4, C_{NO} = 14, C_{SN} = 3).

When the conditions of the rural e-payment change, the track of the rural e-payment evolution is described in Figure 5.

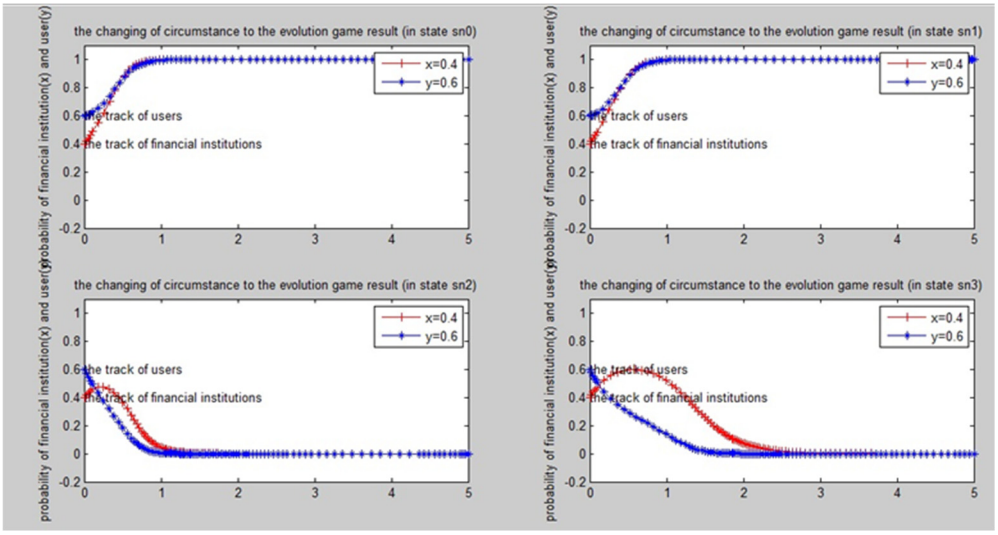

Figure 5. The track of the rural e-payment evolution due to the changing of circumstances.

Figure 5 indicates that the track of the evolutionary game changes with the circumstances. Both partners did not change their strategies at the initial stage. Different conditions made the partners take different tracks in the evolutionary game. Given the partners' strategies as a fixed probability to adopt e-payments (user = 0.4, financial institution = 0.6), the research brings different evolutionary results under different circumstances. All the partners adopt rural e-payments in this state. As soon as the conditions change, all the partners adopt negative strategies in the rural e-payment market. This means that the e-payment circumstances can change the result of the evolutionary game of the rural e-payment market.

6. Conclusions and Suggestions

Before e-payment development, cash was widely used in the settlement. With the development of the economy, e-payments have gained more advantages than cash; however, there is some cost for the participant when changing payment tools. According to the theoretical analysis, both cash and e-payments are equilibriums in the evolutionary game of rural e-payments. In other words, users will not deviate from cash to e-payment, if the financial institutions cannot support e-payments. At the same time, financial institutions have no interest in improving their e-payment service when users do not use it. As such, rural e-payment services develop very slowly while both partners have negative attitudes towards e-payments; however, it is worth noting that e-payments are the basis of the rural economy. They are very valuable for the development of modern agriculture. Investment and guidance provided by the government does change the partners' strategy and a new equilibrium in the evolutionary game of rural e-payments can be achieved.

From the research presented above, the following conclusions can be drawn:

(1) According to evolutionary game analysis, in this research in the development of rural e-payments, it is efficient to change the user's initial strategy. In this strategy, the payoff of the users can be increased by reducing the cost and by increasing the demand. For example, allow the users to acquire more knowledge about e-payments, reassign the benefits for the users and help them identify more e-payment demand in the rural economy. In this way, the users will prefer to use rural e-payments and change their probability of using e-payments to a higher value. Then, the result of the evolutionary game is predisposed to become fact that all partners are positively positioned towards rural e-payment services.

(2) The result of the evolutionary game will change with the case of financial institutions changing their initial strategy. In order to develop rural e-payment services quickly, financial intuitions must provide many e-payment services. The users will then change

their strategy to use e-payment services as well. A good e-payment circumstance makes users feel that using an e-payment is more convenient than using cash. The positive attitude of the acquirer in e-payment services will encourage more users to adopt them.

(3) Changing the partners' conditions will assist rural e-payment services in developing quickly. The government is important for the rural e-payment market. On one side, it has a close relationship with users through guiding the rural economy. As a partner in the rural economy, their behavior in using e-payments will punish users who do not use e-payments, due to agricultural fund transactions. As such, users need to change their strategy to take part in the e-payment market. On the other side, in order to develop modern agriculture, the government needs to improve facilities, especially in information circumstances, such as encouraging users to use mobile phones, etc. This will reduce the partners' costs of using e-payments. The benefit of e-payments will be increased and reassigned to the partners of rural e-payments. All partners will feel more positive towards rural e-payments by encouraging their benefits.

Additionally, reassignment of the cost and the profit will change the partners' behavior regarding e-payments. Just as in the example of the modern payment system, users can use e-payments freely and at the first stage get rewarded. This is an efficient way to attract users to use e-payments because it encourages partners to accept the e-payments. In practice, balancing the cost and the profit among the partners of e-payments is very important as well. Many financial institutions have already issued special cards for users to reduce their costs of e-payment.

Last but not the least, in order to reduce the cost of e-payments, rural e-payments will share the services of the modern payment system. The service of the modern payment system is enhanced because it extends to the countryside. All partners can gain more profit by using e-payments, because of the externalities in the information economy.

In order to develop modern agriculture and the rural economy, the e-payment market is very necessary for the countryside; however, rural e-payments have developed very slowly. Based on the above, this research finds that rural e-payments can be widely used with the following strategies:

(1) As a kind of information service, rural e-payment services are a low-cost payment. Financial institutions should provide more chances for the user to take part in the e-payment market as follows: firstly, by issuing special kinds of payment cards or special kinds of accounts to users, in order for them to use e-payments at low cost. Users can therefore gain get some direct profit for using e-payments; secondly, financial institutions can provide more financial services based on e-payments. These financial services can help users become more familiar with the potential benefits of using e-payments. As soon as users realize that their economy is very closely related to those financial services, they cannot refuse to use e-payments. The financial institutions can then adjust the incentive measures after the rural e-payment market has been formed. In this process, the users' profit from e-payments which can also be adjusted by using other financial services. Thirdly, according to agricultural businesses, financial institutions should provide more financial services. Simplifying the process of using e-payments and personalization of the service can help users feel that the process of using e-payments is more convenient.

(2) E-payment is a kind of financial service that accelerates funds flow. It is valuable to the rural economy. As such, the government is obligated to guide the user's behavior into using e-payments. They can provide many chances for users to use e-payments in their economic activities. On one hand, improving the users' information capability, by use of training and announcements, can assist users to adapt themselves to these kinds of information services. In this way, many financial services can be understood and used by users. On the other hand, building a secure circumstance for users to use e-payments is important as well. E-payments are expressed and finalized by digital information. It indicates that users trust financial institutions and the government.

(3) As the management institution of commercial banks, the People's Bank of China (PBA) should have some policies to guide rural financial institutions in developing e-payment services. Compared to the urban areas, many people live in the countryside and many agricultural products need to be transacted. Therefore, e-payment services are very valuable for the countryside. According to the rural economy demand, the modern payment system also can be extended to the countryside and many funds can be transferred to the countryside and then used to develop modern agriculture.

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