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ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (20): 5466-5471, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.5466.5471

Research of Mobile Payments Business Model in China Based on the Evolutionary Game Theory

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Abstract: The rapid development of mobile payment industry is inseparable from effective business models, the formation and choice of its business model become one of the focus issues. This article assumes that the mobile operators and financial institutions in the mobile payment industrial chain are limited rationality and establishes asymmetric replicator dynamics on cooperation and competition of the initiative for the mobile operators and financial institutions by using the evolutionary game theory. Obtaining the evolutionary trend of mobile payment business model and the parametric conditions to different business models that need to meet by analyzing and studying this model, it provides guiding recommendations for mobile operators and financial institutions to make the best strategy in the mobile payment industrial chain.

Key words: Mobile payment, business model, evolutionary game

INTRODUCTION

The rapid development of mobile Internet sets off a wave of mobile payment. According to iResearch by the end of 2011, the number of Chinese mobile payment users was 190 million and market transaction volume amounted to RMB 48.14 billion, up 133% year on year, which increased tremendously. Expected by the end of 2013, Chinese mobile payment transaction scale will be more than RMB 200 billion and the number of mobile payment users will reach to 480 million (Wang, 2011). Development and prosperity of the mobile payment industry requires accurate positioning of the various members, rational division of labor and the most optimal allocation of resources in the industry chain. For the mobile payment industry chain, it includes equipment manufacturers, mobile telecom operators, financial institutions, payment balcony providers, business organizations and end-users. The cooperative and competitive relationships among the members of the industry chain determine its complexity and variability. Among them, the main is the coopetition relationship among mobile operators, financial institutions and the third-party payment operators (Liu and Fang, 2009). The three parties hope to become the leader in the mobile payment industrial chain, lead the industry's development and realize the maximization of their respective benefits, resulting in a variety of different business models. How the business models of China's mobile payment evolves and how to choose the most appropriate business model under different circumstances will be the focus of this study.

BUSINESS MODELS OF CHINA'S MOBILE PAYMENT

At present, Chinese mobile payment has four main business models: the mobile operates dominated, financial institutions dominated, the third party mobile payment service provider dominated, as well as cooperative operation of mobile operators and financial institutions dominated. Chinese scholars mainly focused on the enumeration of various mobile payment business models, compared the advantages and disadvantages of them and presented recommendations. Li *et al.* (2011) proposed some appropriate solution and prevention measures on the basis of analyzing and comparing existing security issues for all aspects of mobile payment operation mode. Lin and Chen (2010) analyzed four existing foreign mobile payment business models and proposed a mode suitable for our national situation. Men and Song (2007) selected five indicators, such as business richness, the level of credit and security, Interconnection, business promotion rate, payment amount and so on, to simply evaluate different business models of mobile payment services, but

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did not make a in-depth quantitative research. Chinese scholars more concerned about the mobile payment business model, but little quantitative research, therefore, the research conclusions were based on the qualitative description. According to the industrial structure theory, the industry competition game situation is composed of upstream and downstream enterprises in industrial chain and industry structure, which determines enterprise's business model (Men and Song, 2007). So, the cooperation and competition of the initiative for each body in mobile payment industry chain plays an important role in the development of its business model. In China in the past two years, the govement has gradually strengthened the supervision of third-party payment and has enhanced the threshold of the third-party payment service provider to entry in the industry and the business model of the third party mobile payment services provider-dominated rarely achieved success. Therefore, this study mainly considers the influence of the game of the dominance for mobile operators and financial institutions on mobile payment business model. This thesis, by using evolutionary game theory and the quantitative business model, mainly discusses the impact that different strategy combinations mobile operators and financial institutions adopt in the dominance of industrial chain on Chinese mobile payment business model, as well as the evolutionary path of different business models.

EVOLUTIONARY GAME OF MOBILE PAYMENT BUSINESS MODEL

Evolutionary game theory started with limited rationality, took group as the research object and combined the game theory with dynamic evolution process. It looked at the adjustment process of group behavior by the "survival of the fittest" evolutionary theory and adopted local dynamic method from group to individual to analyze the decision behavior of participants, thus the conclusion can be more accurately described human behavior in reality (Liu and Gao, 2006). The complex network system on the composition of members of the mobile payment industrial chain is similar to the biological ecosystem, so we use evolutionary game theory to study cooperation and competition of the initiative for the mobile operators and financial institutions.

Model description: Model assumptions and symbols are as follows.

It is assumed that in the system of mobile payment industry chain, two leading force-the mobile operators group M (China Mobile, China Unicom, China Telecom) and the financial institutions group F (banks related to the financial industry, bank card associations and Financial regulatory authorities)-play a game of dominance (Jiang, 2008). In the game, strategy combinations of both sides are SM = {H (cooperation), J(competition)} and SF = {H (cooperation), J (competition)}, respectively. The system is formed and evolved spontaneously by the principle of "natural selection" (Wang and Meng, 2004). On the premise that the mobile operators group and financial institutions group are limited rationality, they constantly select and adjust their strategies in order to maximize the interests of their own group.

Suppose that (SMH, SFH)-(cooperation, cooperation) is the business model of cooperative operation of mobile operators and financial institutions-dominated; a party selects a cooperative strategy and another party chooses a competitive strategy which wins dominance, therefore, (SMH, SFJ)-(cooperation and competition) is the business model of financial institutions dominated; similarly, (SMJ, SFH)-(competition, cooperation) is the business model of mobile operators dominated. If both parties choose a competitive strategy and do not make any compromise, mobile operators will not get the support of financial institutions and can not be carried out mobile payment services because of the limitation of monetary policy, at the same time, financial institutions also be unable to carry out mobile payment services without the mobile operators as a communication channels, thus the income of the two sides are zero.

Parameter settings. It is assumed that superscript indicates the different business models: superscript H denotes the cooperative business model, superscript M denotes the buesiness model dominated by the mobile operators, superscript F denotes the business model dominated by financial institutions; subscript M and subscript F respectively denote mobile operators group and financial institutions group. Therefore, π_M^H and π_F^H are the payoffs mobile operators and financial institutions obtain when they choose the cooperative model; π_M^M and π_F^M are the payoffs mobile operators and financial institutions obtain when they choose the model of mobile operators dominated. π_M^F and π_F^F are the payoffs mobile operators and financial institutions obtain when they choose the model dominated by financial institutions. π_M^0 and π_F^0 are the payoffs mobile operators and financial institutions obtain when they choose the competitive strategy. If Mobile payment service is regarded as a product, Q (p) = a-bp denotes the market demand function of mobile payment products, where p is the unit price of the mobile payment products, a (a>0) and b (b>0) are the coefficient of market-determined. f and e are the traffic price and account fee which the unit mobile payment

product produces; z is the cost of the unit mobile payment product of financial institutions renting the mobile operator's network. C (Q) {c(Q) = uQ(P) } is the cost of developing the mobile payment products and u (u>0) is the constant coefficients; β (0<β<1) is the coefficient of income distribution in the cooperative operation model of mobile operators and financial institutions.

In this study, we analyze many scholars'reseach on income constitution between the mobile operators and financial institutions in the mobile payment business, combine with our own understanding and divide the main benefits and costs of the mobile operators and financial institutions into the following sections: SP commissions {pQ (P)}, communication data traffic fees {fQ (P)}, account fees {eQ (P)}, network use or rental costs {zQ (P)}, development costs {C(Q)}. It is given that p, Q, f, e, z, (p+f+e-u)Q, (p+e-z-u)Q (p+f-u)Q and (p+e-z-u)Q are greater than zero.

It is assumed that the probability of the mobile operators group to choose the cooperative strategy is x and the probability to choose the competitive strategy is 1-x; the probability of financial institutions group to choose the cooperative strategy is y and the probability to choose the competitive strategy is 1-y.

Model building: Based on the above assumptions, we can get the payoff matrix of evolutionary game model of mobile payment business model, as shown as in Table 1.

Through the above analysis, element assignments in the table are as follows:

$$\pi_M^H = \beta\pi^H = \beta(pQ + fQ + eQ - \mu Q),$$
$$\pi_F^H = (1-\beta)\pi^H = (1-\beta)(pQ + fQ + eQ - \mu Q)$$
$$\pi_M^M = pQ + fQ - \mu Q, \pi_F^M = 0$$
$$\pi_M^F = fQ + zQ, \pi_F^F = pQ + eQ - zQ - \mu Q$$
$$\pi_M^0 = 0, \pi_F^0 = 0$$

Note that π^H denotes the total revenue in the cooperation mode.

Replicator dynamic model and its evolutionary stable strategy: According to the payoff matrix on cooperation and competition of the initiative for the mobile operators and financial institutions, this study first analyzes the mobile operators group.

The expected revenue to take the cooperation strategy: $E_{MH} = y\pi_M{}^H + (1-y)\pi_M{}^F$

The expected revenue to take the competition strategy: $E_{MJ} = y\pi_M{}^M$

The average expected revenue:

$$\overline{E_M} = xE_{MH} + (1-x)E_{MJ}$$

Table 1: Evolutionary game model payoff matrix

Mobile operators	Financial institutions: Cooperation (x)	Financial institutions: Cooperation (y)
	$\pi_M{}^H$, $\pi_F{}^H$	$\pi_M{}^F$, $\pi_F{}^F$
	$\pi_M{}^M$, $\pi_F{}^H$	$\pi_M{}^0$, $\pi_F{}^0$

Therefore, the replicator dynamic equation of the mobile operators:

$$F(x) = \frac{dx}{dt} = x\left(E_{MH} - \overline{E_M}\right) = x(1-x)(E_{MH} - E_{MJ})$$
$$\frac{dF(x)}{dx} = (1-2x)(E_{MH} - E_{MJ})$$

If $T(\beta) = \pi_M^H - \pi_M^F - \pi_M^M = \beta\pi^H - \pi_M^F - \pi_M^M$ then E_{MH}-E_{MJ} = T (β)y+$\pi_M{}^F$ when T (β) = 0, if F (x) = 0, then there are two stable points (x = 0, x = 1);

When T (β)≠0, then there are following cases:

- When:

$$y = -\frac{\pi_M^F}{T(\beta)}$$

then F (x) = 0, that is, no matter what x is, it is always in a stable state

- When:

$$y \neq -\frac{\pi_M^F}{T(\beta)}$$

then there are two stable points (x = 0, x = 1)

And since the evolutionary stable strategy requires:

$$\frac{dF(x)}{dx} < 0$$

the following three conditions are discussed.

If $\pi_M^H > \pi_M^F + \pi_M^M$ for $\pi_M{}^F$>0, then:

$$y > -\frac{\pi_M^F}{T(\beta)}$$

and E_{MH}-E_{MJ}>0£¬so x = 1 is the evolutionary stable equilibriuni point;

If $\pi_M^M < \pi_M^H < \pi_M^F + \pi_M^M$ for T (β)<0 and:

$$-\frac{\pi_M^F}{T(\beta)} > 1$$

then:

$$y < -\frac{\pi_M^F}{T(\beta)}$$

and E_{MH}-E_{MJ}>0, so x = 1 is the evolutionary stable equilibrium point;

If $\pi_M{}^H<\pi_M{}^M<\pi_M{}^F<\pi_M{}^M$, for T (β)<0 and:

$$0 < -\frac{\pi_M^F}{T(\beta)} < 1$$

so when:

$$y > -\frac{\pi_M^F}{T(\beta)}$$

then E_{MH}-E_{MJ}<0, so x = 0 is the evolutionary stable equilibrium point; when:

$$y < -\frac{\pi_M^F}{T(\beta)}$$

then E_{MH}-E_{MJ}>0, so x = 1 is the evolutionary stable equilibrium point.

Similarly, the financial institutions group is analyzed. The expected revenue to take the cooperation strategy: $E_{FH} = x\pi_F{}^H + (1\text{-}x)\pi_F{}^M$

The expected revenue to take the competition strategy: $E_{FJ} = x\pi_F{}^F$.

The average expected revenue:

$$\overline{E_F} = yE_{FH} + (1-y)E_{FJ}$$

Therefore, the replicator dynamic equation of the financial institutions:

$$F(y) = \frac{dy}{dt} = y\left(E_{FH} - \overline{E_F}\right) = y(1-y)(E_{FH} - E_{FJ})$$

$$\frac{dF(y)}{dy} = (1-2y)(E_{FH} - E_{FJ})$$

Since, $E_{FH} - E_{FJ} = x\pi_F^H + (1-x)\pi_F^M - x\pi_F^F = \left(\pi_F^H - \pi_F^M - \pi_F^F\right)x + \pi_F^M$ and for $\pi_F{}^M = 0$, then $E_{FH} - E_{FJ} = x\pi_F^H - x\pi_F^F = \left(\pi_F^H - \pi_F^F\right)x$

If:

$$K(\beta) = \pi_F^H - \pi_F^F = \left(-\pi^H\right)\beta + \left(\pi^H - \pi_F^F\right)$$

then:

$$E_{FH} - E_{FJ} = xK(\beta)$$

If K (β) = 0, then F (y) = 0, that is, no matter what y is, it is always in a stable state,

If K (β)≠0, then there are following cases:

- If x = 0, then F (y) ≡0, that is, no matter what y is, it is always in a stable state
- If x≠0, then there are two stable points (y = 0, y = 1).

And because the evolutionary stable strategy requires:

$$\frac{dF(y)}{dy} < 0$$

the following two conditions are discussed:

- If $\pi_F{}^H>\pi_F{}^F$, then K (β)>0, for x>0 and E_{FH}-E_{FJ}>0, so there is a evolutionary stable equilibrium point (y = 1)
- If $\pi_F{}^H<\pi_F{}^F$, then K (β)<0, for x>0 and E_{FH}-E_{FJ}<0, so there is a evolutionary stable equilibrium point (y = 0)

Analysis of model results: Integrated analysis of the above evolutionary game model, the system ultimately tends to be three stable business modes after a long evolution of the mobile operators and financial institutions, as shown in Table 2.

Table 2: Analysis of system evolution and stability

	Conclusion		
Parametric condition	p-z-u	f+z-u	β
Cooperative operation of sides-dominated	<0		$\left(\frac{p+f-u}{p+f+e-u}, \frac{f+z}{p+f+e-u}\right)$
Financial institutions-dominated operation		<0	$\left(\frac{p+2f+z-u}{p+f+e-u}, 1\right)$
	≥0	≥0	$\left(\frac{p+f-u}{p+f+e-u}, 1\right)$
	≥0	<0	$\left(\frac{p+f-u}{p+f+e-u}, \frac{p+2f+z-u}{p+f+e-u}\right)$
	<0	≥0	$\left(\frac{f+z}{p+f+e-u}, 1\right)$
	<0	<0	$\left(\frac{f+z}{p+f+e-u}, \frac{p+2f+z-u}{p+f+e-u}\right)$
	>0		$\left(\frac{f+z}{p+f+e-u}, \frac{p+f-u}{p+f+e-u}\right)$
Mobile operators-dominated operation	≥0		$\left(0, \frac{f+z}{p+f+e-u}\right)$
	<0		$\left(0, \frac{p+f-u}{p+f+e-u}\right)$

Through the above comprehensive analysis, we arrive at the following conclusions:

- In the game on cooperation and competition of the initiative for the mobile operators and financial institutions, the system will ultimately tend to be three evolutionary stable strategies (i.e., three kinds of business models): The business model of cooperative operation of mobile operators and financial institutions dominated, the business model of mobile operators dominated operation, as well as the business model of financial institutions dominated operation. This conclusion is consistent with the general development trend of today's mobile payment business model, which verifies the three mainstream business models. This study obtains the parametric conditions to different business models that need to meet by analyzing and studying this model and chooses the different business models based on these parametric conditions under the actual situation, which provides the reasonable suggestion and basis for mobile operators and financial institutions to make the best strategy decision
- The size of the income distribution coefficient (β), p-z-u and f+z-u has an important effect on the evolutionary stable strategy and the three parameters to meet the different conditions will make the system tend to be different evolutionary stable strategies. In all cases, conditions to meet inequalities about p-z-u and f+z-u can be transformed into the inequality about the cost of the unit mobile payment product of financial institutions renting the mobile operator's network (z), therefore, the cost (z) has a tremendous impact on the evolutionary stable strategy. If the cost (z) is more than the commission financial institutions received, it will choose the cooperative strategy, otherwise it will choose a competitive strategy. Therefore, the cost (z) has a direct impact on the strategies adopted by financial institutions and has an indirect affect on the evolutionary stable strategy
- There is a strong correlation between the coefficient of income distribution (β) and the account fee of the unit mobile payment product (e). It is found that the upper and lower boundary of:

$$\beta\left(\frac{p+2f+z-\mu}{p+f+e-\mu}\right)$$

$$\frac{p+f-\mu}{p+f+e-\mu} \text{ and } \frac{f+z}{p+f+e-\mu}$$

contain the account fee of the unit mobile payment product (e) which is negatively correlated with β. This is because the coefficient of income distribution (β) appears in the cooperation operation mode of both sides, the higher account fee of the unit mobile payment, the more likely it is that the financial institutions choose a competitive strategy, the greater the likelihood of the business model of financial institutions dominated operation and thus the mobile operators predict the income distribution coefficient (β) appeared in the cooperation operation mode of both sides will not large

- The market demand of mobile payment services {Q (p)} has no effect on the evolutionary stable strategy. After above study, it is founded that the market demand of mobile payment services {Q (p)} has no effect on the income distribution coefficient (β) and the evolutionary stable strategy. Because the market demand {Q(p)} exists in any kind of business model and is a condition shared by all business models, which does not affect the choice of business model, will not affect the system's final evolutionary stable strategy

CONCLUSION

This study, by using the evolutionary game theory based on bounded rationality, studies that the evolutionary process of cooperation and competition of the initiative for the mobile operators and financial institutions in the mobile payment industrial chain. The study finds that the system will eventually tend to be the three evolutionary stable strategies (three mobile payment business models): The business model of cooperative operation of both sides dominated, the business model of mobile operators dominated operation, as well as the business model of financial institutions dominated operation and concludes that the parametric conditions to different business models that need to meet. By judging the relationship among Service provider or business commission, traffic charges of communication data, account service fees, private network use or rental costs, as well as the input costs, it provide a reference for mobile operators and financial institutions to choose the best strategy and the most appropriate business model. This article believes that it is much more likely to occur in the model of financial institutions dominated operation, due to the clearing and settlement issues, the mobile operators can only be carried out micropayment business, hindering the further promotion of its mobile payment. The cooperation model of both sides dominated, from the perspective of Market demand, resource sharing and long-term interests, is the best business model that needs to be actively promoted. In this study, this study provides a reliable theoretical basis for it to be better applied in realities in the future.

Quantitative analysis in the text puts forward new ideas and methods for studying mobile payment business model and provides an important reference for mobile operators and financial institutions to choose the decision and the business model of mobile payment. Of course, this model should be further improved, such as according to the actual situation, considering the other parameters that affect the system and on this basis by simulation to makes the model more be truly simulated, reflect and applied to the reality. At the same time, due to intricate relationships among different subjects in mobile payment industrial chain, building a multi-game model will be the next focus of the study.

ACKNOWLEDGMENTS

This study was supported in part by a grant from Society Science Foundation of China Ministry of Education (Grant No. 11YJA630016), Society Science Foundation of China (Grant No. 12XGL015).

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