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# Evolutionary Game Analysis of New Rural Financial Model under the Background of "Internet +"

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**Abstract:** ***In this paper, through literature review and theoretical analysis, we re-clarify the relationship between traditional financial enterprises and Internet financial enterprises in the development of financial model, considering the total loan, interest rate, income distribution rate, cooperative costs and other factors, so as to build a mathematical model, and use evolutionary game theory, numerical analysis. And the evolutionary game phase diagram method is used to measure the competition and cooperation decision between the traditional financial enterprises and the Internet enterprises, so as to find out what factors affect the choice of competition and cooperation strategy and how much influence the decision-making of enterprises, and put forward a general model. Furthermore, considering the expansion model that the variable cooperative cost varies with the size of the selected strategy part, a two-dimensional dynamic system is constructed which is in line with the actual situation and the new financial development strategy. Then the parameters are assigned according to different situations to verify the results. Finally, according to the results, we put forward optimization proposals for different enterprises. This is not only conducive to enriching and improving the theoretical system of the new type of finance, but also to guiding enterprises to a favorable direction of development.***

**Keywords:** Evolutionary game, financial model

## 1. Research Background

During the national financial work conference held in July 2017, the government has repeatedly stressed that one of the core tasks of finance is to "serve the real economy, reduce the financing cost of the real economy", and explicitly put forward "supporting agriculture, rural areas and small and micro enterprises, and transforming and expanding the whole industrial chain of agriculture". In August 24th, the central bank issued the report on China's rural financial services (2016), referring to promoting the development of Inclusive Finance, encouraging the traditional financial industry and emerging Internet financial service providers to improve their service level by using the existing digital technology. On the one hand, the Internet needs finance in the rural areas. On the other hand, with the popularity of the Internet, the rural area has become a big market suitable for the survival and development of the Internet financial enterprises from the information poor area. The CNNIC report shows that as of June 2017, the number of rural netizens reached 201 million, accounting for about 1/3 of Internet users, while the popularity rate of rural Internet increased to 34%. Some internet financial institutions with exploratory spirit, such as ant suit, Jingdong finance, and one mu Tian, have expanded their business to the countryside, helping the countryside establish a sound financial system and providing more convenient and secure agricultural supply chain financial services, such as the "Beijing Agricultural Loan" of Jingdong, which provides a variety of rural supply chains. Financial services mode, such as providing sales platform for agricultural products and selling loans to repay loans. Data show that as of the end of March 2017, the number of "three rural" users of ant gold clothing in payment, insurance and credit services reached 163 million, 140 million and 42 million 50 thousand respectively. Jingdong finance has now covered 1700 counties and 300 thousand administrative villages in China.

At the same time, because China's agricultural production is dominated by small farmers, there is a general lack of intensive management, while the traditional financial institutions provide relatively short loan time, and the repayment time and quota are not flexible. Generally, the repayment period is not more than 15 months, which is obviously not applicable to agricultural products with long planting period. Secondly, the interest rate of agricultural medium and long term loans is generally 5%, which is higher than that of 4.35% of the bank's one-year loan interest rate. In addition, without the help of precise information, extensive lending forms are not conducive to mobilizing the enthusiasm of farmers, and it is also very difficult for them to establish brands and open markets, and at the same time lead to the lack of high-quality agricultural products. For traditional financial institutions, whether they conform to the background of the times or be forced by internet financial companies, it is particularly important to transform their business models and increase their own innovation. In particular, absorbing new technologies and integrating traditional businesses with the Internet is a key step in transformation.

## 2. Literature Review

1) Competition and cooperation between new rural finance and traditional finance

Yao (2006) [1] thinks that the credit cooperatives' "dominance" caused by the withdrawal of commercial banks, the rural credit market is highly oligopoly, which affects the process of rural financial reform, and the substitution of informal finance to formal finance in the rural market is higher. Zhang Zhengping et al. (2017) tested with text mining and provincial panel data. The expansion of new rural financial institutions can significantly improve the development level of Inclusive Finance. The key is to play an important role in market competition and financial supervision, and guide all kinds of rural financial institutions to compete orderly. Wu Jinlong (2015) [2]

believes that encouraging Internet financial enterprises to enter the rural financial market can play a "catfish effect". The transformation of traditional financial institutions will promote financial Internet and business diversification, and guide strategic cooperation between traditional financial enterprises and Internet financial enterprises, which will help the common development of financial institutions. Shan (2016) [3] established the Hotelling model of Internet banking and traditional banking game, and studied the three stages of Internet finance from entry to competition to cooperation. It is believed that breaking the monopoly pattern of traditional banking industry will help the two sides compete for differences and improve the quality of service so as to achieve mutual benefit and win-win results. Zhang Haixia (2016) [4] used evolutionary game theory to analyze the cooperation strategies of both sides, and drew a stable strategy to promote long-term cooperation between the two sides.

2) About the development of new financial institutions
He Yingyuan (2016) [5], from an environmental point of view, uses empirical research to prove that the rural economic environment, financial environment, policy environment and credit environment play a positive role in the development of new rural financial institutions, and significantly reduce their vulnerability. Gao Xiao Guang [6] (2015) thinks that the registered capital is low, the threshold is low, and the policy risk is high. The problem of asymmetric interest is the problem that restricts the development of the new rural financial model.

3) about the transformation of traditional financial enterprises
Xu Erming and others [7] (2016) apply the theory of institutional change to analyze the mechanism of traditional finance to Internet financial changes. It is believed that the emergence of Internet financial enterprises has broken the old system, will become a supplement to the traditional financial institutions after the transformation, and form a new financial order; Cao Shaoxiong (2013)[8] thinks banks should be When we recognize the inadequacy and conform to the trend, we should actively utilize the advantages of the Internet to carry out business innovation and process reengineering to rebuild its value. Zheng Zhilai (2015)[9] believes that the path of "Internet +" impact on traditional finance is similar to that of the retail industry. Internet banking has a significant impact on commercial banks in the three major businesses of debt business, intermediate business and asset business. Traditional banks need to optimize their own transformation and merge with the "Internet +" development.

## 3. Models and Strategies

### 3.1 Model Establishment

Considering the traditional agricultural bank and Internet financial institution as rational people, as the independent interest subjects, according to their objective function, the maximization of income is taken as the basis for decision making. Under the condition of limited rationality, the game between the two sides is a repeated game process of mutual learning and adjustment strategy, so the evolutionary game model can be used. Model is used to simulate it.

Assuming that both sides of the game are agricultural bank and Internet financial institution, the Agricultural Bank of China can choose to cooperate with the Internet financial institutions, share information and market, and also choose to build an online platform independently. Similarly, Internet financial enterprises can choose to cooperate with the agricultural bank or independently promote the rural loan business. Therefore, the strategic space for the Agricultural Bank is {cooperation, not cooperation}. The strategic space of Internet financial institutions is {cooperation, not cooperation}. At t time, the proportion of Agricultural Bank's choice of "cooperation" strategy is x (T) ($0<x(T)<1$), and the proportion of Internet financial institutions choosing "cooperation" strategy is y (T) ($0<y(T)<1$). The income matrix is as follows:

(1) When the two parties choose the "self built platform" strategy, they will bear the cost of construction and get incremental revenue. For the Agricultural Bank, recessive income represents a more convenient loan channel for customers, a smaller loan risk and a good reputation brought about by the benefiting agriculture policy. For Internet financial companies, hidden income represents more revenue from loan customers than offline customers, and good customers of offline stores. Experience brings trust and benefits.

(2) When one side chooses the "cooperation" strategy and the other side chooses the "self built platform" strategy, the partner who chooses to cooperate will not be able to continue to cooperate or choose to build their own platform. At this point, the party will face losses caused by the aggravation of competition, while the other party will enjoy the benefits from the expansion of the market share. Hidden income.

(3) When the two parties choose the "self built platform" strategy, both sides maintain the original market size and enjoy incremental revenue. Beta and gamma represent the magnitude of the impact.

**Table 1**

| Meaning and explanation | 符号 |
|---|---|
| Agricultural Bank's original income | $R_1$ |
| Original income of Internet enterprises | $R_2$ |
| Incremental gains from cooperative acquisition | ΔR |
| Profit sharing of credit cooperatives under cooperative mode | α |
| Revenue sharing of platforms under cooperation mode | $1-\alpha$ |
| Construction cost of Agricultural Bank of China alone | $C_1$ |
| Construction costs of Internet companies when they build separately | $C_2$ |
| Cooperating with the Bank of Agriculture | $C_1-\beta_1 x$ |
| Costing of Internet financial companies | $C_2-\beta_2 y$ |
| Additional benefits generated by the Bank of agriculture in building platforms | $\pi_1$ |
| Hidden income from extra revenue generated by Internet companies | $\pi_2$ |
| Competition gains of agricultural banks in Internet cooperation | $L_1$ |
| Competition gains of Internet companies when agricultural bank chooses cooperation | $L_2$ |
| Credit loss | P |

From this, we can get the payment matrix of the two sides game.

| | | Internet Financial Enterprises | |
|---|---|---|---|
| | | cooperation(y) | Build platform(1-y) |
| Agricultural Bank | cooperation(x) | $R_1+\alpha\Delta R-(C_1-\beta_1 x)$ | $R_1$ |
| | | $R_2+(1-\alpha)\Delta R-(C_2-\beta_2 y)$ | $R_2+\Delta R-C_2$ |
| | Build platform(1-x) | $R_1+\Delta R-C_1$ | $R_1-C_1$ |
| | | $R_2$ | $R_2-C_2$ |

### 3.2 System ESS evolution path

Agricultural Bank, The effectiveness of adopting the strategy of cooperation is: :

$$U_{11}=y[R_1+\alpha\Delta R-(C_1-\beta_1 x)]+(1-y)R_1$$

The effectiveness of the strategy of "self built platform" is:

$$U_{12}=y(R_1+\Delta R-C_1)+(1-y)(R_1-C_1)$$

The replication dynamic equation of Agricultural Bank is:

$$F(x)=x(1-x)(U_{11}-U_{12})=x(1-x)\{y[\beta_1 x-(1-\alpha)\Delta R]+C_1\}$$

Internet Financial Enterprises. The utility of choosing a cooperative strategy is:

$$U_{21}=x[R_2+(1-\alpha)\Delta R-(C_2-\beta_2 y)]+(1-x)R_2$$

The effectiveness of the strategy of "self built platform" is

$$U_{22}=x(R_2+\Delta R-C_2)+(1-x)(R_2-C_2)$$

The dynamic equation of replication is:

$$G(x)=\frac{dy}{dt}=y(1-y)(U_{21}-U_{22})=y(1-y)\{x[\beta_2 y-\alpha\Delta R-C_2]+C_2\}$$

Solving the equation system, we get five parts Equilibrium point为（0,0），（1,0），（0,1），（1,1），（$x^*, y^*$）。

### 3.3Analysis of system evolution stability strategy

According to the Frideman method, the evolutionary stability strategy can be derived from the Jacobian matrix of the system.

$$=\begin{Bmatrix}\frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y}\\ \frac{\partial G(y)}{\partial x} & \frac{\partial G(y)}{\partial y}\end{Bmatrix}=\begin{Bmatrix}a_{11} & a_{12}\\ a_{21} & a_{22}\end{Bmatrix}$$

$$a_{11}=(1-2x)\{y[\pi_1+\alpha r(D_E+D_R)-r_R(D_R+d_1-d_2)]-(\pi_1+r_R d_2-C_1)\}$$

$$a_{12}=x(1-x)[\pi_1+\alpha r(D_E+D_R)-r_R(D_R+d_1-d_2)]$$

$$a_{21}=y(1-y)[\pi_2+(1-\alpha)r(D_E+D_R)-r_E(D_E+d_2-d_1)]$$

$$a_{22} = (1-2y)\{x[\pi_2 + (1-\alpha)r(D_E + D_R) - r_E(D_E + d_2 - d_1)] - (\pi_2 + r_E d_1 - C_2)\}$$

| Equilibrium point | $a_{11}$ | $a_{12}$ | $a_{21}$ | $a_{22}$ |
|---|---|---|---|---|
| (0,0) | $-(\pi_1 + r_R d_2 - C_1)$ | 0 | 0 | $-(\pi_2 + r_E d_1 - C_2)$ |
| (0,1) | $\alpha r(D_E + D_R) - r_R(D_R + d_1) + C_1$ | 0 | 0 | $\pi_2 + r_E d_1 - C_2$ |
| (1,0) | $(\pi_1 + r_R d_2 - C_1)$ | 0 | 0 | $(1-\alpha)r(D_E + D_R) - r_E(D_E + d_2) + C_2$ |
| (1,1) | $-[\alpha r(D_E + D_R) - r_R(D_R + d_1) + C_1]$ | 0 | 0 | $-[(1-\alpha)r(D_E + D_R) - r_E(D_E + d_2) + C_2)]$ |
| $(x^*, y^*)$ | 0 | A | B | 0 |

At a point of equilibrium, if fit the condition : $\det J > 0$, $\mathrm{tr} J > 0$; Then copy the dynamic equation Equilibrium point is the Stable point。When the value and the value of the determinant given in the table are satisfied, (0,0)(0,1)(1,0)(1,1), The point is the ESS of the system. Because of the complexity of the evolution of the system and the analysis of the existing scenarios, we get the following theorem

Theorem 1: if$0 < x^* < 1, 0 < y^* < 1$, $(1-\alpha)r(D_E + D_R) > r_E(D_E + d_2) - C_2$ $\alpha r(D_E + D_R) > r_R(D_R + d_1) - C_1$, There must be a stable point at this time(1,1), It is possible to exist. Stable point(0,0), Prove as follows:

**Table 4**

| $\pi_1 + r_R d_2 > C_1$, $\pi_2 + r_E d_1 > C_2$ | | | | $\pi_1 + r_R d_2 > C_1$□ $\pi_2 + r_E d_1 < C_2$ | | | |
|---|---|---|---|---|---|---|---|
| Equilibrium point | Det J | Tr J | stability | Equilibrium point | Det J | Tr J | stability |
| (0,0) | + | - | ESS | (0,0) | - | Unknown | saddle point |
| (0,1) | + | + | noStable point | (0,1) | - | Unknown | saddle point |
| (1,0) | + | + | noStable point | (1,0) | + | + | noStable point |
| (1,1) | + | - | ESS | (1,1) | + | - | ESS |
| $\pi_1 + r_R d_2 < C_1$, $\pi_2 + r_E d_1 < C_2$ | | | | $\pi_1 + r_R d_2 < C_1$ $\pi_2 + r_E d_1 > C_2$ | | | |
| Equilibrium point | Det J | Tr J | stability | Equilibrium point | Det J | Tr J | stability |
| (0,0) | + | + | noStable point | (0,0) | - | Unknown | saddle point |
| (0,1) | - | Unknown | saddle point | (0,1) | + | + | noStable point |
| (1,0) | - | Unknown | saddle point | (1,0) | - | Unknown | saddle point |
| (1,1) | + | - | ESS | (1,1) | + | - | ESS |

When the profit gained from cooperation is greater than the incremental revenue gained by the construction platform, both sides will choose the cooperation strategy. However, when the hidden income plus the benefit of separate construction, the two sides may adopt the "self built platform" strategy. At this time, no has the only effective strategy, and the convergence direction of the system depends on the initial of both sides. State, that is, market share and interest rate.

Theorem 2:

When

$0 < x^* < 1, y^* > 1$,

$(1-\alpha)r(D_E + D_R) > r_E(D_E + d_2) - C_2$ ,

$\alpha r(D_E + D_R) < r_R(D_R + d_1) - C_1$时, Stable point may be the (0,0) or (0,1), and when $\pi_1 + r_R d_2 < C_1$ $\pi_2 + r_E d_1 > C_2$, there is no Stable point. Prove as follows:

$\pi_1 + r_R d_2 > C_1$ $\pi_2 + r_E d_1 > C_2$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| (0,0) | + | - | ESS |
| (0,1) | + | Unknown | saddle point |
| (1,0) | + | + | noStable point |
| (1,1) | - | Unknown | saddle point |

$\pi_1 + r_R d_2 > C_1$ $\pi_2 + r_E d_1 < C_2$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| (0,0) | - | Unknown | saddle point |
| (0,1) | + | - | ESS |
| (1,0) | + | + | NoStable point |
| (1,1) | - | Unknown | saddle point |

$\pi_1 + r_R d_2 < C_1$ $\pi_2 + r_E d_1 < C_2$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| (0,0) | + | + | NoStable point |
| (0,1) | + | - | ESS |
| (1,0) | - | - | NoStable point |
| (1,1) | - | Unknown | saddle point |

$\pi_1 + r_R d_2 < C_1$ $\pi_2 + r_E d_1 > C_2$ no Stable point

| Equilibrium point | Det J | Tr J |
|---|---|---|
| (0,0) | - | Unknown |
| (0,1) | - | Unknown |
| (1,0) | - | Unknown |
| (1,1) | - | Unknown |

Theorem

2: when $0 < x^* < 1, y^* > 1$,

$(1-\alpha)r(D_E+D_R) > r_E(D_E+d_2) - C_2$ ,

$ar(D_E+D_R) < r_R(D_R+d_1) - C_1$时Stable point may be the

(0,0)or (0,1), and when

$\pi_1 + r_R d_2 < C_1 \ \ \pi_2 + r_E d_1 > C_2$, there is no Stable

point, Prove as follows:

Prove as follows

$$\pi_1 + r_R d_2 > C_1 \ \pi_2 + r_E d_1 > C_2$$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| ( 0,0) | + | - | ESS |
| ( 0,1) | + | Unknown | saddle point |
| ( 1,0) | + | + | noStable point |
| ( 1,1) | - | Unknown | saddle point |

$$\pi_1 + r_R d_2 > C_1 \ \ \pi_2 + r_E d_1 < C_2$$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| ( 0,0) | - | Unknown | saddle point |
| ( 0,1) | + | - | ESS |
| ( 1,0) | + | + | No Stable point |
| ( 1,1) | - | Unknown | saddle point |

$$\pi_1 + r_R d_2 < C_1 \ \ \pi_2 + r_E d_1 < C_2$$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| ( 0,0) | + | + | No Stable point |
| ( 0,1) | + | - | ESS |
| ( 1,0) | - | - | NoStable point |
| ( 1,1) | - | Unknown | saddle point |

$\pi_1 + r_R d_2 < C_1 \ \ \pi_2 + r_E d_1 > C_2$no Stable point

| Equilibrium point | Det J | Tr J |
|---|---|---|
| ( 0,0) | - | Unknown |
| ( 0,1) | - | Unknown |
| ( 1,0) | - | Unknown |
| ( 1,1) | - | Unknown |

Theorem3: when $x^* > 1, 0 < y^* < 1$,

$(1-\alpha)r(D_E+D_R) < r_E(D_E+d_2) - C_2$ ,

$ar(D_E+D_R) > r_R(D_R+d_1) - C_1$, 时, system Stable point

maybe ( 0,0) or( 1,0) ; and when

$\pi_1 + r_R d_2 > C_1 \ \ \pi_2 + r_E d_1 < C_2$, there is no Stable

point。Prove as follows: $\pi_1 + r_R d_2 > C_1 \ \pi_2 + r_E d_1 > C_2$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| ( 0,0) | + | - | ESS |
| ( 0,1) | - | Unknown | saddle point |
| ( 1,0) | - | Unknown | saddle point |
| ( 1,1) | + | + | noStable point |

$$\pi_1 + r_R d_2 > C_1 \ \ \pi_2 + r_E d_1 < C_2$$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| ( 0,0) | - | Unknown | saddle point |
| ( 0,1) | + | - | ESS |
| ( 1,0) | - | Unknown | saddle point |
| ( 1,1) | + | + | noStable point |

$$\pi_1 + r_R d_2 < C_1 \ \ \pi_2 + r_E d_1 < C_2$$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| ( 0,0) | + | + | NoStable point |
| ( 0,1) | + | - | ESS |
| ( 1,0) | + | - | ESS |
| ( 1,1) | + | + | NoStable point |

$$\pi_1 + r_R d_2 < C_1 \ \ \pi_2 + r_E d_1 > C_2$$

| Equilibrium point | Det J | Tr J | stability |
|---|---|---|---|
| ( 0,0) | - | Unknown | saddle point |
| ( 0,1) | - | Unknown | saddle point |
| ( 1,0) | + | - | ESS |
| ( 1,1) | + | + | noStable point |

## 4. Conclusion

Through the analysis of evolutionary game model, we can see that the equilibrium state of new rural financial institutions and traditional rural financial institutions depends on the respective investment cost C1 and C2, cooperation credit and reputation loss P, cooperation income increment R and cooperative income distribution ratio alpha. In order to maintain long-term cooperation, the key is to reduce input costs, increase cooperation credit and reputation losses, enhance the benefits after coordination, and rationally coordinate the proportion of earnings. In order to promote long-term and stable cooperation between the two sides, this study makes the following recommendations.

(1) Reduce the cost of cooperation based on comparative advantage. The new rural financial institutions and the traditional rural financial institutions should base on different organizational characteristics and comparative advantages to carry out cooperation between the two sides, thereby reducing the cost of cooperation between the two

sides. To this end, the new rural financial institutions should give full play to the regional advantages of local financial institutions and the information superiority close to farmers, focusing on providing targeted financial services to farmers and small and micro enterprises in rural areas. We should optimize the way of guarantee and repayment, and gradually establish and improve the regular credit risk assessment system and the credit cycle incentive system. The traditional rural financial institutions should provide financial services for the middle and high-end customers in the countryside to scale up and industrial chains, and adopt the form of packaged loans and joint loans to support the rural characteristic industries.

(2) Develop financial innovation and create revenue increments. The new rural financial institutions should cooperate with the traditional rural financial institutions mainly based on the Agricultural Bank to carry out financial products and services that can meet the reasonable needs of local customers, and jointly promote standardized insurance, financial management, guarantee and other products and services. In view of the characteristics of the rural credit market, the participants in the industrial chain, commodity circulation and service provision are deeply excavated, using the mutual funds, logistics and information to excavate market opportunities, and design financial products suitable for the rural market. In addition, the two sides should actively promote the exchange and settlement business, securities agency business and other multi-level banking agency business, absorb diversified and high-quality customer groups, thereby creating an incremental revenue R.

(3) Coordinate the proportion of earnings and improve the efficiency of cooperation. Income ratio alpha is not only related to collaborative investment, but also related to the risks borne by both sides in the process of cooperation. The new rural financial institutions and traditional rural financial institutions will face the problems of credit risk of rural customer groups and systemic risks of agricultural industry, and so on, so as to strengthen the operational risks and credit faced by cooperation. Risk and legal risk management, and confirm the proportion of cooperation income according to the risks undertaken in the cooperation process. We should strengthen the construction of laws and regulations on Inclusive Finance in rural areas, clarify the main body and responsibilities of Inclusive Finance and the legal status of the partners, formulate a unified and coordinated two-tier supervision mechanism, improve the punishment intensity of cooperative credit and reputation P, and reduce the cooperation process between new rural financial institutions and traditional rural financial institutions. The information asymmetry makes the two sides choose cooperation strategy to achieve a win-win situation under the condition of information sharing.

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