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# Study on the Credit Evolution Game of Companies and Banks

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***Abstract*—Eration between the socialist market economy is about to become one of the important trend. This paper discusses the theory of evolution, under the condition of the method of game theory, research of the bank and enterprise of cooperative behavior evolution law and set up normally bank and evolutionary game model of enterprise and enterprise can't pay the mortgage under the circumstance of asymmetric game model, study the equilibrium respectively, clear cooperation balanced decision factors, namely cooperation initial cost of the need to pay, cooperation by their income and against the contract price and to assume responsibility, won and reality fitting evolution stable strategy, bank and enterprise both sides also provides some reference reference. Based on this, puts forward how to make sure the enterprise of effective measures to pay the mortgage, to bank and enterprise puts forward the good faith cooperation is the best way to achieve a win-win both sides.**

***Keywords*— Put your keywords here, keywords are separated by comma.**

## I. INTRODUCTION

As market competition intensifies, more and more enterprises find your growth cannot leave with key stakeholders。As a partnership. So-called major stake holders is to the enterprise development and the management have a significant impact on the organization.

Slam the door completely rational assumption evolutionary game theory, integrating the idea of rational economics and evolutionary biology, and the game.Combination of theoretical analysis and the dynamic evolution process analysis. On the one hand, it to bounded rationality and capacity to learn instead of the traditional game theory.About subject completely rational assumption, closer to the reality; He, on the other hand, in a dynamic equilibrium and framework for the analysis of system.Reach equilibrium process, thus a more accurate description of the development and change of system [1-2].

For the relationship between Banks and enterprises, if Banks to provide loans to enterprises, enterprises will obtain greater development space. At the same time, enterprises in the process of working with Banks there may be some man-made factors, lead to can't according to the ideal state of cooperation, this time bank will be charged to regulators such as the law in pursuit of their legitimate interests. This paper will stand in the Angle of the objective, and in fact under the background of cooperation by using evolutionary game theory analysis, to help enterprises overcome difficulties to improve their competitive strength to increase revenue, at the same time, provide reference for the bank to select the most appropriate strateg.

## II. THE ESTABLISHMENT OF THE EVOLUTIONARY GAME MODEL BETWEEN BANKS AND ENTERPRISES:

### *A. A. Model Assumptions*

*1) Game*:Assume that the game parties are bounded rationality, and divided into two categories, namely loans to Banks and corporate sector need to loans.

*2) Behavior Strategy:* the strategy for Banks, can agree to the loan can not agree to the loan, as a result, the strategy choice set for B = {agreed to loan, do not agree to the loan}; And for enterprises to apply for A loan, it also has two options: to apply for A loan and do not apply for A loan, the strategy choice set hypothesis as A = {to apply for A loan, do not apply for a loan }.

*3) BehaviorSstrategy Proportion:* assume that at the beginning of the game, the probability of enterprises to apply for a loan is p, the probability of not to apply for a loan is 1 - p; The probability of bank agreed to loan for q, don't agree to the loan of the probability of 1 – q.

*4) Income Matrix:* argues that under the condition of cooperation both by their own revenue M and N respectively; Both cooperation respectively under the condition of extra income m1 and n1; If the company is willing to apply for a loan and the bank is not willing to lend to each other, in this case enterprise need to pay the cost of basic m2; Also, if the bank willing to lend to enterprises and has no intention to apply for a loan, the bank need to pay the cost of basic n2 [3-5]. Such as a series of table 1:

TABLE 1

PAYOFF MATRIX

| **Enterprise（A）** | **ICBC （B）** | |
|---|---|---|
| | **To apply for a loan** | **Do not apply for a loan** |
| **To apply for a loan** | $M+m_1,N+n_1$ | $M-m_2,N$ |
| **Do not apply for a loan** | $M,N-n_2$ | M,N |

### *B. Analysis and Establishment of the Evolutionary Game Model of Banks and Enterprises*

Based on the above assumptions and pay-off matrix, to (Y for cooperation, N for no cooperation)

$$U_1(Y) = q(M + m_1) + (1 - q)(M - m_2) = (M - m_2) + q(m_1 + m_2) \quad (1)$$

Take not to apply for a loan strategy companies expect profits for:

$$U_1(N) = qM + (1 - q)M = M \quad (2)$$

By (1) and (2) the average expected profits for enterprises:

$$U_1 = pU_1(Y) + (1 - p)U_1(N) = pq(m_1 + m_2) - pm_2 + M \quad (3)$$

Therefore, the enterprise choice loan replicated dynamic equation is:

$$F(p) = dp/dt = p(U_1(Y) - U_1) = p(1 - p)[q(m_1 + m_2) - m_2] \quad (4)$$

Similarly, (B) choose to agree to the loan bank of expected return as follows:

$$U_2(Y) = p(N + n_1) + (1 - p)(N - n_2) = (N - n_2) + p(n_1 + n_2) \quad (5)$$

When Banks do not agree to the loan of the expected return as follows:

$$U_2(N) = pN + (1 - p)N = N \quad (6)$$

Thus, by (1) and (2) the bank agreed to loan the average income of:

$$U_2 = qU_2(Y) + (1 - q)U_2(N) = pq(n_1 + n_2) - qn_2 + N \quad (7)$$

Choose to agree to the loan of replicated dynamic equation is:

$$F(q) = dq/dt = q(U_2(Y) - U_2) = q(1 - q)[p(n_1 + n_2) - n_2] \quad (8)$$

Equation (1) and equation (2) describes the group dynamic evolutionary system, the stability of the equilibrium can be made of the Jacobin matrix of the system of local stability analysis. The Jacobian matrix of the equation is:

$$J = \begin{vmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{vmatrix}$$

The Jacobian matrix of the system is

$$\begin{cases} J_{11} = dF(p)/dp = (1 - 2p)[q(m_1 + m_2) - m_2] \\ J_{12} = dF(p)/dq = p(1 - p)(m_1 + m_2) \\ J_{21} = dF(q)/dp = q(1 - q)(n_1 + n_2) \\ J_{22} = dF(q)/dq = (1 - 2q)[p(n_1 + n_2) - n_2] \end{cases} \quad (9)$$

By the formula (3), the Jacobian matrix of the determinants for:

apply for a loan strategy companies expect profits for:

$$detJ = (1 - 2p)(1 - 2q)[q(m_1 + m_2) - m_2][p(n_1 + n_2) - n_2] - pq(1 - p)(1 - q)(m_1 + m_2)(n_1 + n_2) \quad (10)$$

Matrix trace as follows:

$$trJ = (1 - 2p)[q(m_1 + m_2) - m_2] + (1 - 2p)[p(n_1 + n_2) - n_2] \quad (11)$$

By copying is dynamic equation (4) shows that only when $q = \frac{m_2}{m_1 + m_2}$ p = 0, 1 or , enterprise group selection strategy of enterprises the proportion is stable; Replication is a dynamic equation (8) shows that only when q = 0, 1 or 2 bank group selection strategy of the proportion of bank is stable. Therefore, we know there are five balance system O(0,0),A(0,1),B(1,0),C(1,1), $D(\frac{n_2}{n_1 + n_2}, \frac{m_2}{m_1 + m_2})$

Because of the $m_2 < m_1, n_2 < n_1$ ,so $m_2 < m_1 + m_2, n_2 < n_1 + n_2$.

Local stability analysis of the dynamic system as shown in table 2:

TABLE 2

| Balance point | J determinant and symbols | | J signs and symbols | | stability |
|---|---|---|---|---|---|
| **p=0,q=0** | $m_2n_2$ | + | $-m_2-n_2$ | - | ESS |
| **p=0,q=1** | $m_1n_2$ | + | $M_1+n_2$ | + | instability |
| **P=1,q=0** | $m_2n_1$ | + | $M_1+n_1$ | + | instability |
| **P=1,q=1** | $M_1n_1$ | + | $-m_1-n_1$ | - | ESS |
| $p = \frac{n_2}{n_1 + n_2}$ $q = \frac{m_2}{m_1 + m_2}$ | $\frac{-m_1m_2n_1n_2}{(n_1 + n_2)(m_1 + m_2)}$ | – | 0 | | saddle point |

The balance Jacobi determinant and trace analysis of the symbol

Copy the above dynamic process in the plane representation is shown in figure 1:

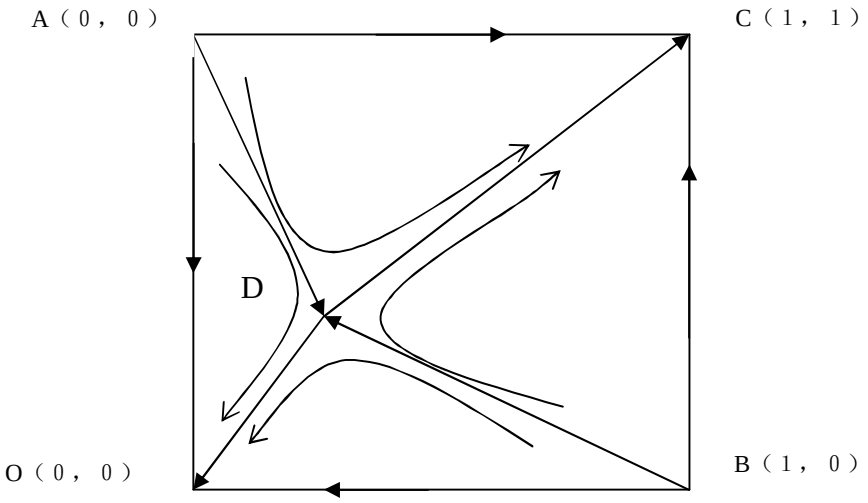


Figure 1 The dynamic evolution process between enterprise and bank bank

C. The Numerical Example and The Result Analysis

Quadrilateral ACBD area $S = 1 - \frac{1}{2}\left(\frac{n_2}{n_1 + n_2} + \frac{m_2}{m_1 + m_2}\right)$

Set up enterprise A and bank B cooperation in this game. Among them, not cooperative benefits respectively is M = 1, N = 2, excess earnings cooperation $m_1 = n_1 = 0.8$ respectively, and the other parameter $m_2 = n_2 = 0.2$,

Point D calculation for (0.2, 0.2). Therefore, regional ACBD covers an area of 0.8.

To sum up, in fact borrowing system is mixed cooperation or not, this will greatly increase the dynamics of the system. At the same time, some of the key factors in the system of decide the direction of system evolution, should be taken into consideration seriously. Concrete analysis, such as: visible from the figure 1 and an example, definable regional ADBC into fact participants cooperation area, regional AOBD is not cooperative, the ADBC and AOBD area is 1, the sum of the cooperation zone depends on the area of D point position. The ADBC area, the greater the system converges to the equilibrium probability of B. In this way, the whole market cooperation members will also be increased. Point D($\frac{n_2}{n_1 + n_2}, \frac{m_2}{m_1 + m_2}$)when they fall on a straight line can be drawn from the bottom-left of the AB system will converge to the equilibrium O, when upper right point D on AB system will converge to point C.

Secondly, in addition to the influence of the payoff matrix, D point position and participants choose cooperation needed to pay the initial cost of $m_2$ and $n_2$.

## III. There is A Third Party to Participate in Fact Loan Game Model

The model without considering the regulation and oversight of the law, but the actual situation general would not be so simple. If the enterprise (A) no mortgage payments, the bank can through legal prosecution. In the above model we plus the supervision of the law: to evade punish in loan enterprises, not in time at this point, assuming R enterprise suffers a loss, bank loan recall cost cost K [6-7].

Default earnings matrix as table 3:

TABLE 3

REGULATORS IN FACT THE BENEFIT MATRIX OF BOTH PARTIES

| **Enterprise（A）** | **ICBC（B）** | |
|---|---|---|
| | **Agree to the loan** | **Do not agree to the loan** |
| **Apply for loan** | M'-R,N'-K | M-$m_2$,N |
| **Do not apply for a loan** | M,N-$n_2$ | M,N |

The M'= M + $m_1$, N' = N + $n_1$.The probability of enterprises to apply for a loan is p, the probability of not to apply for a loan of 1 - p; The probability of bank agreed to loan for q, don't agree with the probability of loan for 1-q.

A corresponding profit function, respectively:

$$U_1(Y) = q(M - R) + (1 - q)(M - m_2) = q(M - M - R + m_2) + M - m_2 \quad (12)$$

$$U_1(N) = qM + (1 - q)M = M \quad (13)$$

B average income of the corresponding function as follows:

$$U_2(Y) = p(N-K) + (1-p)(N-n_2) = p(N-N-K+n_2) + N - n_2 \quad (14)$$

$$U_2(N) = pN + (1-p)N = N \quad (15)$$

By type (12), (13), (14), (15) companies and Banks average function are:

$$U_1 = pU_1(Y) + (1-p)U_1(N) = pq(M-M-R+m_2) - pm_2 + M \quad (16)$$

$$U_2 = qU_2(Y) + (1-q)U_2(N) = pq(N-N-K+n_2) - qn_2 + N \quad (17)$$

Companies choose to apply for a loan, the bank choose to agree to the loan of dynamic differential equations are:

$$\begin{cases} F(p) = p(U_1(Y) - U_1) = p(1-p)[q(M-M-R+m_2) - m_2] \\ F(q) = q(U_2(Y) - U_2) = q(1-q)[p(N-N-K+n_2) - n_2] \end{cases} \quad (18)$$

Similarly, by copy proportion type dynamic equation to get the stable point location is respectively:

$$q = \frac{m_2}{m_1 - R + m_2}$$

P=0 , 1 , ; q=0 , 1 ,

$$p = \frac{n_2}{n_1 - K + n_2}$$

$$J = \begin{vmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{vmatrix}$$

The Jacobin matrix of the system is

Table 4

$$\begin{cases} J_{11} = (1-2p)[q(m_1 - R + m_2) - m_2] \\ J_{12} = (M-M-R+m_2)p(1-p) \\ J_{21} = (N-N-K+n_2)q(1-q) \\ J_{22} = (1-2p)[p(n_1 - K + n_2) - n_2] \end{cases} \quad (19)$$

Jacobin matrix corresponding determinant determinant and trace respectively as follows:

$$Det(J) = (1-2p)[q(m_1 - R + m_2) - m_2](1-2q)[p(n_1 - K + n_2) - n_2] - pq(1-p)(1-q)(m_1 - R + m_2)(n_1 - K + n_2) \quad (20)$$

$$Tr(J) = (1-2p)[q(m_1 - R + m_2) - m_2] + (1-2p)[p(n_1 - K + n_2) - n_2] \quad (21)$$

Local stability analysis results such as the following two tables 4 and 5:

THE BALANCE OF JACOBIN MATRIX DETERMINANT AND TRACE

| | Det(J) | Tr(J) |
|---|---|---|
| **O:P=0,q=0** | $m_2 n_2$ | $-m_2 - n_2$ |
| **A:P=0,q=1** | $(m_1 - R)n_2$ | $m_1 - R + n_2$ |
| **B:P=1,q=0** | $(n_1 - K)m_2$ | $n_1 - K + m_2$ |
| **C:P=1,q=1** | $(m_1 - R)(n_1 - K)$ | $-(m_1 - R) - (n_1 - K)$ |
| **D:** $P = \frac{n_2}{n_1 - K + n_2}$ $Q = \frac{m_2}{m_1 - R + m_2}$ | $\frac{-m_2 n_2 (n_1 - K)(m_1 - R)}{(n_1 - K + n_2)(m_1 - R + m_2)}$ | 0 |

TABLE 5

ALL KINDS OF CASES, LOCAL STABILITY ANALYSIS OF DYNAMIC SYSTEM TABLES

| Serial number | Conditions | O | A | B | C | D |
|---|---|---|---|---|---|---|
| 1 | $m_1 > R, n_1 > K$ | ESS | instability | instability | ESS | saddle point |
| 2 | $m_1 > R, n_1 < K$ | ESS | instability | saddle point | saddle point | not in the area |

| | | | | | | |
|---|---|---|---|---|---|---|
| **3** | $m_1 < R, n_1 > K$ | ESS | saddle point | instability | saddle point | not in the area |
| **4** | $m_1 < R, n_1 < K$ | ESS | saddle point | saddle point | instability | not in the area |

The table 3 shows that for the case 1 there are two kinds of stable strategy is O (0, 0) and C (1, 1), tend to work in the last two C (1, 1) balance analysis (with a) model; For case 2 and 4 with one side or both sides of the total revenue is less than the cost, so in the end both sides choose cooperation in O (0, 0) point reached equilibrium.

## IV. RESULTS AND MEASURES:

A knowable by the model, when the bank and enterprise cooperation is greater than when not in cooperation with the proceeds of income, so they will choose cooperation; When or, bank and enterprise party choose cooperation when the need to pay and the other party and without the cooperation intention, so eventually both choose not to cooperate.

By model analysis shows that when the bank and enterprise cooperation benefits outweigh the costs, when the legal supervision departments to join an analysis such as model, so the final selection; Or when Banks and companies a party to the legal department to pay costs outweigh the benefits of cooperation, so both eventually chose not to cooperation; When Banks and companies for legal department to pay the cost of the revenues are greater than their door apparently both choose not to cooperate in the end[8-9].

With the above analysis, in order to avoid enterprise delinquent loans, should take the following measures:

*1)Eimprove The Legal Consciousness of The Enterprise Itself.* Enterprise itself not opportunistic, increase their interest in and don't damage the interests of others, at the same time, the government should pay attention to the legal propaganda, to improve the legal consciousness of everyone.

*2) The Increase of Delinquent Loans is punishing.* Establish stricter punishment and strictly guarantee the implementation of the regulations, make the default don't even have the corporate sector to realize such losses are irreparable.

*3) Improve The Fact of Cooperation Consciousness.* Are Banks and companies realize that friendly cooperation with each other is powerful for double method should be to avoid the unnecessary loss.

Also, this article has certain defects, because there is no research to the evolution of the cooperative game analysis, the research will make persistent efforts[10].

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