Evolution Model and Simulation of Profit Model of Agricultural Products Logistics Financing

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Abstract. Agricultural products logistics financial warehousing business mainly involves agricultural production and processing enterprises, third-party logistics enterprises and financial institutions tripartite, to enable the three parties to achieve win-win situation, the article first gives the replication dynamics and evolutionary stability strategy between the three parties in business participation, and then use NetLogo simulation platform, using the overall modeling and simulation method of Multi-Agent, established the evolutionary game simulation model, and run the model under different revenue parameters, finally, analyzed the simulation results. To achieve the agricultural products logistics financial financing warehouse business to participate in tripartite mutually beneficial win-win situation, thus promoting the smooth flow of agricultural products logistics business.

1. Introduction

Agricultural products logistics finance is a new business for financial institutions for agricultural products logistics[1]. Finance is a comprehensive third-party logistics service platform[2]. Profit model refers to the enterprise to achieve the purpose of profit to take the method. Because some characteristics of agricultural products make the industry more complex than other enterprises[3,4].

2. Agricultural Product Logistics Financial Financing Warehouse Profit Model Evolutionary Game Model Construction

Evolutionary game theory emphasizes that both sides are based on continuous learning, imitation and other dynamic processes to find the most suitable for their own behavior strategy, and finally gradually converge on the dynamic game stability point[5]. The theory is more close to the real life, the behavior of the three parties is a dynamic learning, imitation of the evolution process, is based on the three parties are bounded rational economic man, which can build an evolutionary game model for analysis.

2.1. Evolution Game Model Parameter Setting

In order to carry out quantitative research, the relevant evolutionary game model parameters are set.

The actual value of the pledge: $S$; The high part of the pledge: $\Delta S_1$; The low part of the pledge: $\Delta S_2$; Pledge rate: $X$; Loan interest rate: $Y$; Financial institutions choose the cost of supervision: $M + \Delta m$; Conversely, the cost is $M$; Financial institutions to give agricultural products production and processing enterprises incentives: $G_1$; On the contrary, punishment: $D_1$; Financial institutions to give third-party logistics enterprises incentives: $C_2$; n the contrary, punishment: $D_2$; When the two sides conspiracy, agricultural production and processing enterprises will give the other incentives: $E$ [6,7].
The probability of agricultural production and processing enterprises choose the trustworthy: \( a \); the probability of the third party logistics enterprises choose to keep the contract: \( b \); The probability of financial institutions choose to supervise: \( c \). At the same time agreed that \( 0 \leq a, b, c \leq 1 \) [8].

2.2. Three-dimensional Evolutionary Game Payment Matrix

Financial financing of the three-way evolutionary game payment matrix as shown below.

| Financial Institutions | Compliance | Missed contract | Supervision | Compliance | Missed contract |
|------------------------|------------|-----------------|-------------|------------|-----------------|
| Agricultural production and processing enterprises | Trustworthy | \( C_1, C_2, S \bar{X} Y - (M + \Delta m) \) | \( C_1, C_2, S \bar{X} Y - (M + \Delta m) \) | \( C_1, \Delta S_2, (S - \Delta S_2) X Y - M \) |
| Dishonesty | \( (S + \Delta S_1) X - S - D_1, \) | \( -D_1, -D_2, -(M + \Delta m) \) | \( (S + \Delta S_1) X - S, \) | \( C_2, -M \) |
| | \( C_1 \) | \( C_1 \) | \( H_{11}, H_{12} \) | \( H_{13}, H_{14} \) |

3. Multi-Agent Modeling of Profit Model Evolutionary Game Simulation Analysis

In order to simplify the complexity of the triadic evolutionary game analysis, the article analyzes from six kinds of situations

3.1. Financial Institutions Choose Regulatory Strategy

| Third party logistics enterprises | Compliance | Missed contract | Supervision | Compliance | Missed contract |
|----------------------------------|------------|-----------------|-------------|------------|-----------------|
| Agricultural production and processing enterprises | Trustworthy | \( C_1, C_2 \) | \( C_1, \Delta S_2 - D_2 \) | \( H_{11}, H_{12} \) | \( H_{13}, H_{14} \) |
| Dishonesty | \( (S + \Delta S_1) X - S - D_1, \) | \( -D_1, -D_2 \) | \( H_{21}, H_{22} \) | \( H_{23}, H_{24} \) |

In order to simplify the description of the problem, we changed the above payment matrix to the following pattern. Where the formula in the table above corresponds to the value of the letters in the table right.

The expected return of trustworthiness and dishonesty of agricultural products production and processing enterprises is \( U_{11}, U_{21} \) and average earnings is \( \bar{U}_1 \) [9,10], the dynamic equation as follows:

\[
F(a) = \frac{da}{dt} = a(U_{11} - \bar{U}_1) = a(1 - a)(U_{11} - U_{21}) = a(1 - a)(H_{11} - bH_{21} - H_{23} + bH_{23})
\]

The third party logistics enterprise performance and loss of the expected income is set to \( V_{11}, V_{21} \) and average earnings is \( \bar{V}_1 \), the dynamic equation is:

\[
F(b) = \frac{db}{dt} = b(V_{11} - \bar{V}_1) = b(1 - b)(V_{11} - V_{21}) = b(1 - b)(aH_{12} + H_{22} - aH_{22} - aH_{14} + aH_{24} + aH_{24})
\]

1) when \( H_{11} > H_{21}, H_{12} > H_{14} \), through the analysis of the historical data of the relevant enterprises, according to the actual significance of each parameter, in which each parameter is quantified set:

| Table 3.2 Parameter quantization settings | Table 3.3 Specific numerical results |
|------------------------------------------|-----------------------------------|
| \( S \) | \( \Delta S_1 \) | \( \Delta S_2 \) | \( X \) | \( Y \) | \( C_1 \) | \( C_2 \) | \( D_1 \) | \( D_2 \) | \( h_{11} \) | \( h_{12} \) | \( h_{13} \) | \( h_{14} \) | \( h_{21} \) | \( h_{22} \) | \( H_{23} \) | \( H_{24} \) |
| 1000 | 100 | 100 | 0.95 | 0.1 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 40 | -15 | 60 | -60 | -60|

And then calculate the probability of two types of agents are:

\[
a_0 = \frac{(H_{24} - H_{22})/(H_{12} - H_{14} + H_{24} - H_{22}) = 1.2 \; ; \; \; b_0 = (H_{11} - H_{21})/(H_{21} - H_{23}) = 2.6667}
\]

results are shown below.
The final evolution strategy of the game is \( a^* = 1, b^* = 1 \). In the case of financial institutions to choose the regulation, agricultural production and processing enterprises choose to trust third-party logistics enterprises choose to fulfill the strategy. For agricultural production and processing enterprises, if the valuation of the high value \( \Delta S_1 \) is larger, in order to enable enterprises to choose to lose confidence, but because of the high incentives \( C_1 \) given by financial institutions, as well as financial institutions to do not trust the enterprise is also very high punished \( D_1 \), so after the balance of agricultural production and processing enterprises choose to trust the strategy to obtain a higher income.

For third-party logistics companies, the same only when the valuation of the low value \( \Delta S_2 \) of the pledge is very large, the enterprise has the incentive to choose to lose, but the financial institutions to give high incentives \( C_2 \), and financial institutions to give non-compliance business punishment \( D_2 \) is also high, so after the trade-offs of third-party logistics companies choose to achieve a higher income strategy. In the actual situation, according to the different initial situation to decide.

2) When \( H_{11} > H_{21}, H_{12} < H_{14} \), through the analysis of the historical data of the relevant enterprises, according to the actual significance of each parameter, in which each parameter is quantified set:

In Table 3.1, you can get:

| Table 3.4 Parameter quantization settings | Table 3.5 Specific numerical results |
|------------------------------------------|------------------------------------|
| \( s \) | \( \Delta S_1 \) | \( \Delta S_2 \) | \( x \) | \( y \) | \( C_1 \) | \( C_2 \) | \( D_1 \) | \( D_2 \) | \( h_{11} \) | \( h_{12} \) | \( h_{13} \) | \( h_{14} \) | \( h_{21} \) | \( h_{22} \) | \( h_{23} \) | \( h_{24} \) |
| 1000 | 100 | 100 | 0.95 | 0.1 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |

And then calculate the probability of two types of agents are:

\[ a_0 = \frac{(H_{24} - H_{22})}{(H_{12} - H_{14} + H_{24} - H_{22})} = 0.8 ; \quad b_0 = \frac{(H_{11} - H_{23})}{(H_{21} - H_{23})} = 1.7778 \], results are shown below.

3) When \( H_{11} < H_{21}, H_{12} > H_{14} \), through the analysis of the historical data of the relevant enterprises, according to the actual significance of each parameter, in which each parameter is quantified set:

In Table 3.1, you can get:

| Table 3.6 Parameter quantization settings | Table 3.7 Specific numerical results |
|------------------------------------------|------------------------------------|
| \( s \) | \( \Delta S_1 \) | \( \Delta S_2 \) | \( x \) | \( y \) | \( C_1 \) | \( C_2 \) | \( D_1 \) | \( D_2 \) | \( h_{11} \) | \( h_{12} \) | \( h_{13} \) | \( h_{14} \) | \( h_{21} \) | \( h_{22} \) | \( h_{23} \) | \( h_{24} \) |
| 1000 | 100 | 100 | 0.95 | 0.1 | 20 | 60 | 20 | 60 | 20 | 60 | 20 | 60 | 20 | 60 | 20 | 60 |

And then calculate the probability of two types of agents are:

\[ a_0 = \frac{(H_{24} - H_{22})}{(H_{12} - H_{14} + H_{24} - H_{22})} = 1.2 ; \quad b_0 = \frac{(H_{11} - H_{23})}{(H_{21} - H_{23})} = 0.8889 \], results are shown below.
We get the evolution strategy of the game is $a^* = 0, b^* = 1$. In the case of the choice of supervision by the financial institution, the agricultural production and processing enterprises choose to lose confidence, and the third party logistics enterprises choose the performance strategy. For agricultural production and processing enterprises, if the value of the assessment of the high value $\Delta S$ of the collateral in order to make enterprises have the incentive to choose a dishonesty, but because the financial institutions to give the reward $C_1$ is very low, and financial institutions to give credit is not trustworthy business $D_1$ is also very low, so that agricultural products production and processing enterprises in the choice of dishonesty when the reward is far less than the enterprise through the loss of income $C_2$, so after the trade-offs in agricultural production and processing enterprises choose a credit strategy to obtain higher returns.

4) when $H_{11} < H_{21}, H_{12} < H_{14}$, through the analysis of the historical data of the relevant enterprises, according to the actual significance of each parameter, in which each parameter is quantified set:

In Table 3.1, you can get:

Table 3.8 Parameter quantization settings

| $S$  | $S_1$  | $S_2$  | $Y$   | $Y_1$ | $Y_2$ | $C_1$ | $C_2$ | $D_1$ | $D_2$ |
|------|--------|--------|-------|-------|-------|-------|-------|-------|-------|
| 1000 | 100    | 100    | 0.95  | 0.1   | 20    | 20    | 20    | 20    | 20    |

And then calculate the probability of two types of agents are: $a_0 = (H_{24} - H_{22})/(H_{12} - H_{14} + H_{24} - H_{22}) = 0.4$; $b_0 = (H_{11} - H_{23})/(H_{21} - H_{23}) = 0.8889$, the final results are shown below. $(a, b)$ respectively to a certain $(a_0, b_0)$ as the center to take four different initial values, the final results as shown below.
Ultimately get the evolution of the game strategy for the stability of two points, \( a^* = 0, b^* = 1 \) and \( a^* = 1, b^* = 0 \), agricultural production and processing enterprises may choose to trust or trustworthy strategy, third-party logistics companies may choose to perform or contract. For agricultural production and processing enterprises, when the financial institutions to give the reward \( C_1 \) is far less than the enterprise choose to obtain the proceeds dishonesty, agricultural production and processing enterprises will choose a dishonesty strategy; This is the third party logistics companies choose to fulfill the premise of compliance There will be so much revenue, but when the third party logistics companies also choose to miss, the enterprise will face a high penalty \( D_1 \) to pay, then agricultural production and processing enterprises will choose the trustworthy strategy.

3.2. Financial Institutions Choose Non-regulatory Strategies

Table 3.10 Payment matrix of agricultural products production and processing enterprises and third party logistics enterprises

| Third party logistics enterprises | Compliance | Missed contract | Compliance | Missed contract |
|----------------------------------|------------|----------------|------------|----------------|
| Agricultural production          |            |                |            |                |
| and processing enterprises       |            |                |            |                |
| Trustworthy                      | \( C_1 - C_2 \) | \( C_1 - A_2 \) | \( H_{31} - H_{32} \) | \( H_{33} - H_{34} \) |
| Dishonesty                       | \( (S + \Delta S_1)X - S - C_2 \) | \( (S + \Delta S_1)X - S - E, E \) | \( H_{41}, H_{42} \) | \( H_{43}, H_{44} \) |

\( \text{① when } H_{31} > H_{41}, H_{32} > H_{44}, H_{44} > H_{42}, \text{ the evolutionary strategy of game is } a^* = 1, b^* = 1; \) \( \text{② when } H_{31} > H_{41}, H_{32} < H_{44}, H_{44} > H_{42}, \text{ the evolutionary strategy of game is } a^* = 1, b^* = 0; \) \( \text{③ when } H_{31} < H_{41}, H_{32} > H_{44}, H_{44} > H_{42}, \text{ the evolutionary strategy of game is } a^* = 0, b^* = 1; \) \( \text{④ when } H_{31} < H_{41}, H_{32} < H_{44}, H_{44} > H_{42}, \text{ the evolutionary strategy of game is } a^* = 1, b^* = 0; \) \( \text{⑤ when } H_{31} > H_{41}, H_{32} > H_{44}, H_{44} < H_{42}, \text{ the evolutionary strategy of game is } a^* = 1, b^* = 1; \) \( \text{⑥ when } H_{31} > H_{41}, H_{32} < H_{44}, H_{44} < H_{42}, \text{ the evolutionary strategy of game is } a^* = 1, b^* = 0; \) \( \text{⑦ when } H_{31} < H_{41}, H_{32} > H_{44}, H_{44} < H_{42}, \text{ the evolutionary strategy of game is } a^* = 0, b^* = 1; \) \( \text{⑧ when } H_{31} < H_{41}, H_{32} < H_{44}, H_{44} < H_{42}, \text{ the evolutionary strategy of game is } a^* = 0, b^* = 1. \)

3.3. Third-party Logistics Companies Choose to Implement the Strategy

Table 3.11 Payment matrix of agricultural products production and processing enterprises and financial institutions

| Financial Institutions | Supervision | Not supervised |
|------------------------|-------------|----------------|
| Agricultural production and processing enterprises |            |                |
| Trustworthy            | \( C_1, SXY - (M + \Delta m) \) | \( C_1, SXY - M \) |
| Dishonesty             | \((S + \Delta S_1)X - S - D_1, - (M + \Delta m)\) | \((S + \Delta S_1)X - S, - M\) |

\( \text{① when } I_{31} > I_{23}, \text{ evolutionary strategy: } a^* = 1, c^* = 0; \) \( \text{② when } I_{31} > I_{21}, I_{31} < I_{23}, \text{ evolutionary strategy: } a^* = 0, c^* = 0; \) \( \text{③ when } I_{31} < I_{21}, \text{ evolutionary strategy: } a^* = 0, c^* = 0. \)

3.4. Third-party Logistics Enterprises Choose Missed Strategy

Table 3.12 Payment matrix of agricultural products production and processing enterprises and

| Financial Institutions | Supervision | Not supervised |
|------------------------|-------------|----------------|
| Agricultural production and processing enterprises |            |                |
| Trustworthy            | \( C_1, (S - \Delta S_2)XY - (M + \Delta m) \) | \( C_1, (S - \Delta S_2)XY - M \) |
| Dishonesty             | \(-D_1, - (M + \Delta m)\) | \((S + \Delta S_1)X - S - E, E\) |

\( \text{① when } I_{43} < I_{33}, I_{43} > I_{41}, \text{ evolutionary strategy: } a^* = 1, c^* = 0; \) \( \text{② when } I_{43} < I_{33}, I_{43} < I_{41}, \text{ evolutionary strategy: } a^* = 1, c^* = 0; \) \( \text{③ when } I_{43} < I_{33}, I_{43} < I_{41}, \text{ evolutionary strategy: } a^* = 1, c^* = 0. \)
3.5. Production and Processing Enterprises in Agricultural Products Choose the Strategy of Trustworthiness

Table 3.13 Payment matrix for third party logistics companies and financial institutions

| Financial Institutions | Supervision | Not supervised | Supervision | Not supervised |
|------------------------|-------------|----------------|-------------|----------------|
| Third party logistics enterprises | Compliance | $C_2 - SYY - (M + \Delta m)$ | $C_2 - SY - M$ | $J_{11} - J_{12}$ | $J_{13} - J_{14}$ |
|                         | Missed contract | $\Delta S_2 - D_2 (S - \Delta S_2 SY)$ | $\Delta S_2$ | $J_{21} - J_{22}$ | $J_{23} - J_{24}$ |

1. when $J_{11} > J_{21}, J_{13} > J_{23}$, evolutionary strategy: $b^* = 1, c^* = 0$ ; 2. when $J_{11} > J_{21}, J_{13} < J_{23}$, evolutionary strategy: $b^* = 0, c^* = 0$ ; 3. when $J_{11} < J_{21}, J_{13} < J_{23}$, evolutionary strategy: $b^* = 0, c^* = 0$ ;

3.6. Agricultural Production and Processing Enterprises Choose to Lose Confidence Strategy

Table 3.14 Payment matrix for third party logistics companies and financial institutions

| Financial Institutions | Supervision | Not supervised | Supervision | Not supervised |
|------------------------|-------------|----------------|-------------|----------------|
| Third party logistics enterprises | Compliance | $C_2 - (M + \Delta m)$ | $C_2 - M$ | $J_{31} - J_{32}$ | $J_{33} - J_{34}$ |
|                         | Missed contract | $-D_2 - (M + \Delta m)$ | $E - (S + \Delta S) - M$ | $J_{41} - J_{42}$ | $J_{43} - J_{44}$ |

1. when $J_{41} < J_{33}$, the evolutionary strategy of game is $b^* = 1, c^* = 0$ ;

4. Conclusions

In the logistics innovation more and more important today, agricultural logistics innovation concern, corporate strategy to become a key factor restricting their own innovation. In the financing mode, the tripartite main body due to different interests, will inevitably occur game behavior. Finally, the strategies of the main bodies in cooperation should be drawn up, and reasonable suggestions should be given to the respective strategies to achieve tripartite win-win situation.

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