Research on game cooperation strategy of supplier and retailer information sharing

Debao Dai1 and Yanyan Shi2

1School of Management, Shanghai University, Shanghai 200444, China
2 School of Management, Shanghai University, Shanghai 200444, China
Corresponding author’s e-mail: 18621800975@163.com

Abstract: Information sharing between suppliers and retailers is an effective way to improve the overall benefits of the supply chain. This paper uses game theory to construct an evolutionary game model of whether or not suppliers and retailers cooperate in information sharing. The research results show that the key factors affecting the selection of cooperation strategies between the two parties are risk costs and market revenue increments. The proposal for improving the cooperation between the two parties is to strengthen supply chain cooperation, establish a comprehensive information-based supervision platform, and rationally distribute income.

1. Introduction
The government introduced a series of policies to support e-commerce development and promote the rapid development of e-commerce in China. According to monitoring data from the China Electronic Commerce Research Center, in the first half of 2017, China’s e-commerce transaction scale reached 13.35 trillion yuan, a year-on-year increase of 27.1%. Compared with traditional enterprises, the current market competition mode is transformed into supply chain competition. To improve supply chain competitiveness, it is necessary to improve the efficiency and coordination of supply chain nodes. However, there is always a bullwhip effect in the supply chain when demand information is consumed. When passing to upstream companies in the supply chain, companies in the supply chain cannot achieve effective information sharing, distorting information and misleading managers' decisions, and reducing the benefits of the supply chain.

Supply chain information sharing means that retailers share demand information with suppliers and reduce the bullwhip effect so that all parties can formulate best strategies and improve the efficiency of the supply chain. There are a large number of scholars in China who study the game strategy between suppliers and supply chain optimization. However, there is little research on the game relationship between suppliers and retailers in the e-commerce environment.

Linlin Dai (2013) aims at the cooperation and risk issues of order information sharing between core manufacturing companies and suppliers in the supply chain, establishes order sharing strategies and revenue functions, and optimizes the interests of the core manufacturing companies and suppliers, so that the supply chain cooperation The system is more stable [1]. Aiguo Tian (2016) proposed a series of measures to improve the level of e-commerce services for retail e-commerce's logistics system, including optimizing logistics systems and simplifying customs clearance, thus effectively improving consumers' experience in sea-surfing [2]. Yisheng Shan (2016) set out from the choice of procurement mode, proposed the selection basis for suppliers under different procurement modes, and further
optimized the optimization of procurement management in the supply chain environment [3]. In view of the above information, this paper studies the choice of cooperation strategy between suppliers and retailers based on the level of information sharing in the e-commerce environment, and establishes a game model by establishing a cooperation strategy between suppliers and retailers to analyze the influencing factors that influence the choice of cooperation strategy between the two parties. Based on this, related suggestions were made.

2. The construction of evolutionary game model

2.1 Problem Description

Question assumptions: A is a supplier; B is a retailer.

Assumption 1: Limited rationality. Assume that all players of supplier A and retailer B are bounded rational in the game process, and they will continue to learn and adjust their own behavioral strategies based on the results of the previous game [4].

Assumption 2: Participants. What Supplier A and Retailer B conduct is a dynamic evolutionary game.

Assumption 3: Game strategy. The supplier can choose to share information with the retailer, that is, choose cooperation, and record it as strategy A1, or choose not to share information with the retailer, that is, do not cooperate, and record as strategy A2, and the supplier will adopt the cooperation strategy A1 with the probability of x. The probability of 1-x adopts the non-cooperative strategy A2; similarly, the retailer may choose to cooperate with the supplier, is strategy B1, or may choose not to cooperate with the supplier, is strategy B2, and the retailer may cooperate with the probability of y. The probability of the strategy B1, 1-y adopts the non-cooperative strategy B2.

From the above three hypotheses, we can get the revenue matrix under the different strategies of supplier A and retailer B.

| Cooperation Strategy | B1: Cooperation (y) | B2: No Cooperation (1-y) |
|----------------------|---------------------|-------------------------|
| A1: Cooperation (x)  | (W_{A1}^A, W_{B1}^B) | (W_{A2}^A, W_{B1}^B)     |
| A2: No Cooperation (1-x) | (W_{A2}^A, W_{B2}^B) | (W_{A1}^A, W_{B2}^B) |

2.2 Variable Assumptions

Both suppliers and retailers adopt a non-cooperative strategy, that is, when the information does not share the strategy, the respective revenue is recorded as U_{A}, U_{B}, and the cooperation strategy adopts both parties to increase revenue as V_{A} and V_{B}. When V_{A} and V_{B}>0, the suppliers and the retailer's cooperation strategy can bring economic benefits to itself and outperform the non-cooperative strategy. When V_{A} and V_{B}<0, the cooperation strategy cannot bring higher economic benefits to both parties. When only one partner of the supplier and retailer adopts a cooperation strategy, he or she will generate a certain risk cost when selecting a cooperation strategy, which is denoted as C_{A} and C_{B}.

Through the above description, we can get the respective benefits of the two sides of the game under different strategies:

- \( W_{11}^{A} = U_{A} + V_{A} \)
- \( W_{12}^{A} = U_{A} - C_{A} \)
- \( W_{21}^{A} = U_{A} \)
- \( W_{22}^{A} = U_{A} \)
- \( W_{11}^{B} = U_{B} + V_{B} \)
- \( W_{12}^{B} = U_{B} \)
- \( W_{21}^{B} = U_{B} - C_{B} \)
- \( W_{22}^{B} = U_{B} \)
2.3 Evolutionary Game Model Design

Based on the revenue matrix of Table 1, the replication dynamic equations for suppliers and retailers can be constructed. According to the revenue matrix, the expected return value of the supplier's choice of cooperation strategy is:

\[ Z_{11} = y \cdot W_{11}^A + (1 - y)W_{12}^A = y(V_A + C_A) + U_A - C_A \]  

The expected return value of the supplier's choice of non-cooperative strategy is:

\[ Z_{12} = y \cdot W_{21}^A + (1 - y)W_{22}^A = U_A \]  

According to the income under the above two strategies, the average fitness of suppliers can be calculated:

\[ Z_A = x \cdot Z_{11} + (1 - x)Z_{12} = x[y(V_A + C_A) - C_A] + U_A \]  

From the above equation, the supplier's replication dynamic equation is:

\[ F(x) = x(Z_{11} - Z_A) = x(1 - x)[y(V_A + C_A) - C_A] \]  

Similarly, the retailer's replication dynamic equation is:

\[ F(y) = y(1 - y)[x(V_B + C_B) - C_B] \]  

3. Evolutionary Game Analysis of Suppliers and Retailers

3.1 The Evolutionary Game Strategy of Suppliers

According to the supplier's replication dynamic equation, let \( F(x) = 0 \), and \( x_1 = 0, x_2 = 1, y' = C_A / (V_A + C_A) \). When \( y' = C_A / (V_A + C_A) \), all \( 0 \leq x \leq 1 \) are stable. At this time, the probability of the supplier's choice of cooperation strategy in the equilibrium of the mixed strategy is the willingness of the supplier to choose the cooperation strategy. When \( y' \neq C_A / (V_A + C_A) \), \( x_1 = 0 \) and \( x_2 = 1 \) are stable states in which the supplier chooses to cooperate or not cooperate. First, \( F(x) \) is derived, \( F(x)' = (1 - 2x) [y(V_A + C_A) - C_A] \). When \( x < C_A / (V_A + C_A) \), \( x_1 = 0 \) makes \( F(x)' < 0 \). In this case, \( x_1 = 0 \) is a non-cooperative strategy that is the supplier's evolutionary stabilization strategy; when \( y > C_A / (V_A + C_A) \), \( x_2 = 1 \) makes \( F(x)' < 0 \). At this time, \( x_2 = 1 \) is the cooperation strategy is the supplier's evolution stability strategy.

![Figure 1. Supplier replication dynamic phase diagram](image)

3.2 Evolutionary Game Strategy of Retailers

According to the retailer's replication dynamic equation, let \( F(y) = 0 \), and get \( y_1 = 0, y_2 = 1, x' = C_B / (V_B + C_B) \). When \( x' = C_B / (V_B + C_B) \), all \( 0 \leq y \leq 1 \) are stable. At this time, the probability \( x \) of the retailer's choice of cooperation strategy under the equilibrium of the mixed strategy is the willingness of the supplier to choose the cooperation strategy. When \( y' \neq C_B / (V_B + C_B) \), \( y_1 = 0 \) and \( y_2 = 1 \) are two stable states of the retailer. Similarly, \( F(y) \) is derived with respect to \( y \) to obtain \( F(y)' = (1 - 2y) [y(V_B + C_B) - C_B] \). When \( x < C_B / (V_B + C_B) \), \( y_1 = 0 \) That is, the non-cooperative strategy is the retailer's evolutionary stability strategy;
when $x > C_B/(V_B + C_B)$, $y_2 = 1$, is the cooperation strategy is the evolutionary stability strategy of the retailer.

Figure 2. Retailer replication dynamic phase diagram

4. Analysis of Evolutionary Stability and Stability Factors

4.1 Revenue increase

According to the above analysis, when the risk costs $C_A$ and $C_B$ produced by suppliers and retailers do not change, the greater the increments $V_A$ and $V_B$, the smaller the $x'$ and $y'$, and the two sides choose a cooperation strategy. The greater the odds are, the smaller the incremental gains of suppliers and retailers are, and the greater the chance of both parties choosing a non-cooperation strategy. The practical significance is that when suppliers and retailers achieve information sharing cooperation, the greater the increment in market returns they receive, the more beneficial the parties are to cooperation. However, when the proportion of income between the two parties is seriously out of balance in the cooperation process, the party with a small proportion of benefits will withdraw the cooperation relationship with the other party. Therefore, how to achieve effective distribution of benefits in the cooperation process between the two sides of the game is a continuous and stable cooperation between the two parties. The main conditions for going down.

4.2 Risk costs

The greater the risk cost $C_A$ and $C_B$, the larger the $x'$ and $y'$, the smaller the chance of the two parties choosing a cooperation strategy, and vice versa. Its practical significance is that the risk costs incurred by suppliers and retailers in the process of information sharing are affected by many factors such as their own companies and the external environment. When the cost of risk exceeds the controllable scope of suppliers and retailers, the chance of cooperation between the two parties is smaller.

5. Conclusions and Recommendations

This paper studies the strategy choices of information sharing behaviors of suppliers and retailers in the e-commerce environment, and uses evolutionary game method to construct an evolutionary game model of competition and cooperation between suppliers and retailers, and analyzes the two-party selection strategy under different conditions. The research results show that from the aspect of economic benefits, both parties of the game will choose cooperative strategies to improve their economic benefits under the conditions of high cooperative income and low cooperation cost; whether the two sides choose the cooperation strategy is influenced by many factors. After combining its own characteristics and changing market demands, it can be more rational to choose cooperation strategies.

(1) Strengthen supply chain cooperation. In the supply chain system, the retailer can directly obtain market information, but the supplier's demand information obtained for various reasons is inaccurate, and even produces large deviations. The bullwhip effect will be gradually amplified in the e-commerce context. The supplier can pay retailers a certain amount of information rewards to incentivize retailers' information-sharing behaviors, maximize the balance of demand under the premise of information sharing, strengthen the cooperation relationship between suppliers and retailers, and increase the overall
efficiency of the supply chain.

(2) Reasonable distribution of income. In the process of cooperation between retailers and suppliers, if the distribution of benefits is not balanced, there will be situations in which one party requests to withdraw cooperation or disagreement due to disparity in the income gap. Therefore, the two parties need to rationally distribute the cooperation proceeds and formulate a series of regulations to protect the interests of both parties, so that there will be a more long-term cooperation.

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