Research on Factors Influencing the Cooperation between Operators and Systems Integrators in IOT

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Abstract: The internet of things (IOT) is called as another information industry revolution, which is following the computer, Internet and mobile communication network. But there are many obstacles for the development of our country's IOT. Among them, the contradiction between fragmentation of the application requirements and product supply scale is the bottleneck of our IOT development. And the contradiction's root lies in the unclear business model of IOT. Based on the existing IOT business model research, this paper has studied the cooperation mode selection between operators and system integrators which were the two core enterprises of IOT industry and analyzed various factors affecting competitive-cooperative relationship in detail to lay a theoretical foundation for the establishment of IOT industry chain cooperation by pattern evolutionary game theory. The result shows that within a certain extent, more shareable resources lead to larger probability of cooperation. However, the probability of cooperation will gradually decrease if the distribution of shareable resources exceeds the extent.

1 INTRODUCTION

Through decades of accumulation, the technology development of domestic IOT industry has leaped into front ranks in the world and now exerts significant influence. Compared to other developed countries, IOT in China possesses the first-mover advantage. However, in order to fully implement IOT, accelerating the promotion of our IOT products and applications throughout the world, we are faced with many technical problems and management issues. Among these difficulties, one dominant and imperative issue to tackle with in the development of IOT industry is the conflict between fragmentation of application requirements and product supply scale. The challenge of the development of IOT lies not only in technical problems, but also in market scale applications. On the one hand, the deficiency of scale-industry application seriously impedes the forming of IOT in medicine industry and the breakthrough and standardization of core technology, which results in low participation and investment in every link of the supply chain. On the other hand, only when scaling supply is realized can we reduce cost. And finally it helps to form a benign mechanism of development and motivates market development. It takes a new business model to resolve this conflict. The key to breaking through the bottleneck of IOT development lies in integrating fragmentation application and achieving economic scale (Tan, 2010).

This paper investigates the innovation of IOT business model from the perspective of operators and system integrators, studying the cooperation between them under the IOT environment. By analyzing critical factors influencing cooperation, this paper constructs a cooperative evolutionary game model. The analysis of the result will provide a theoretical basis for the strategic cooperation between operators and system integrators, and also offer important reference for scale of IOT.

2 STUDIES ON IOT COOPERATION MODE

Domestic scholars investigate business cooperation model of IOT from the angle of operators. Yongbo Tang proposes that if the development of IOT agrees with operators transition concept, it will effectively promote the operators progress in the aspects such as technique, product and customer development. By analyzing domestic and foreign business models, the IOT business models are classified into four categories, namely Channel Model, Cooperation Model, Proprietary Model, and Customized Model (Yunxia Zhang, 2010). From the perspective of

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operators, IOT business models are classified into three categories, namely Cooperative Development, Independent Promotion, Independent Development, Cooperative Promotion and Customization (Pengfei Fan, 2012); Another method classifies them into Channel Model, Cooperative Development and Promotion, Plat-form Operation Model, Applied Service Model and Industry Union Model (Zhuoxian Li, 2011). There are four modes of IOT: the government BOT mode, channel accompanied with cooperation mode, advertising mode and proprietary mode (Pengfei Fan, 2012). In the network era, the strategy operator business model should be more diverse and flexible. Besides, the operation strategy of business model for the telecom operators should be divided into flow pipeline mode, optimized mode with cooperation and independent open mode (Weijia Zhu, 2014). On the basis of extensive market research and summary of the research findings of available literature, this paper summarizes the cooperative modes in IOT into five categories: Channel Model, Cooperative Development Model, Independent Development Model, Independent Enterprise implementation Model, Customized Model.

The first three models are principal while the other two are auxiliary, coexisting with the principal models. Among the three principal models, Channel Model is a passive model which disagrees with the strategy choices of game players. Therefore, this paper mainly discusses the choice between cooperative development and non-cooperative development.

3 CONSTRUCTION OF EVOLUTIONARY GAME MODEL

3.1 Parameters and Model Construction

This paper mainly considers the evolutionary game relations between operators (denoted by 1) and system integrators (denoted by 2). We assume that there are only two strategies for both of them: cooperate to develop new products or develop independently. Furthermore, we assume the following parameters: $\frac{\pi_1}{\pi_2}$ denotes normal revenue of operators and system integrators without considering new product development respectively. $\Delta\pi$ denotes the excessive return obtained when both of them choose to cooperate in developing new products and succeed. β is the excessive revenue allocation coefficient, which denotes the ratio of excessive revenue being allocated to operators, thus the ratio of excessive revenue being allocated to system integrators is $1-\beta$ .The account of β depends on both sides resources input and revenue contribution. $\frac{\Delta\pi_1'}{\Delta\pi_2'}$ denotes the revenue gained in independent development of operators and system integrators. α_i (i =1, 2) denotes the shareable resources and abilities of company i, thus the total input of resources during the cooperation $C=\alpha_1+\alpha_2\gamma_i$ (i=1, 2)is the learning coefficient of company i, which describes the ability of learning from the other side in technologies, experiences and so on. Thus during the cooperation operators and system integrators could respectively obtain $\gamma_2\alpha_{3-i}$ (i=1, 2) economic values from learning. (i=1, 2) is betrayal benefit which denotes the revenue company i obtains after betraying cooperation; f is penalty coefficient, by assuming both sides in the games have the same penalty coefficient, we come to their penalty cost for betraying would be $f\alpha_i$.

3.2 The Solving of the Model

It is assumed that the probability of operators choosing cooperation is x, thus the probability of choosing noncooperation is $1-x$. Therefore, operators obtain V_1^H expected benefit when choosing cooperation, and obtain V_1^N expected benefit when choosing noncooperation and the average benefit is $\overline{V}_1$. We assume the probability of system integrators choosing cooperation is y, thus the probability of choosing noncooperation is $1-y$. Therefore, system integrators obtain V_2^H expected benefit when choose cooperation, and obtain expected benefit when choose noncooperation, and the average benefit is $\overline{V}_2$. All of these functions are shown bellows:

$$\begin{aligned}\overline{V_1} &= xV_1^H + (1-x)V_1^N \\ &= \pi_1 + y(E_1 - f\alpha_2) + x(\Delta\pi_1' - \alpha_1 + f\alpha_1) + \\ & xy(\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - \Delta\pi_1' - f\alpha_1 - E_1)\end{aligned} \quad (1)$$

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$$\begin{aligned}\overline{V_2} &= yV_2^H + (1-y)V_2^N \\ &= \pi_2 + x(E_2 - f\alpha_1) + y(\Delta\pi_2^{'} - \alpha_2 + f\alpha_2) + \\ &xy(\gamma_2\alpha_1 + f\alpha_1 + (1-\beta)\Delta\pi - \Delta\pi_2^{'} - f\alpha_2 - E_2)\end{aligned} \quad (2)$$

According to the replicated dynamic equation of evolutionary game theory, we can derive two replicated dynamic equations shown as bellow. Operators' replicated dynamic equation:

$$\begin{aligned}\frac{dx}{dt} &= x(V_1^H - \overline{V_1}) \\ &= x(1-x)[(\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - \Delta\pi_1 - f\alpha_1 \\ &- E_1)y - (\alpha_1 - \Delta\pi_1^{'} - f\alpha_1)]\end{aligned} \quad (3)$$

System integrators' replicated dynamic equation:

$$\begin{aligned}\frac{dy}{dt} &= y(V_2^H - \overline{V_2}) \\ &= y(1-y)[(\gamma_2\alpha_1 + f\alpha_1 + (1-\beta)\Delta\pi - \Delta\pi_2 - f\alpha \\ &- E_2)x - (\alpha_2 - \Delta\pi_2^{'} - f\alpha_2)]\end{aligned} \quad (4)$$

According to the stability theorem of differential equation and the replicated dynamic equations of evolutionary game theory, the following condition must satisfy:

$$\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - \Delta\pi_1^{'} - f\alpha_1 - E_1 > 0 \quad (5)$$

$$\gamma_2\alpha_1 + f\alpha_1 + (1-\beta)\Delta\pi - \Delta\pi_2^{'} - f\alpha_2 - E_2 > 0 \quad (6)$$

Operators replicated dynamic equation indicates that only when $y = \frac{\alpha_1 - \Delta\pi_1^{'} - f\alpha_1}{r_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - \Delta\pi_1^{'} - f\alpha_1 - E_1}$ or $x = 0{,}1$, there is a consistent ratio of operators to total operators of the group using cooperation strategy.

System integrators' dynamic equation indicates that only when $x = \frac{\alpha_2 - \Delta\pi_2^{'} - f\alpha_2}{r_2\alpha_1 + f\alpha_1 + \Delta\pi - \beta\Delta\pi - \Delta\pi_2^{'} - f\alpha_2 - E_2}$ or $y = 0{,}1$, there is a consistent ratio of operators to total system integrators of the group using cooperation strategy.

Hence, the system has 5 partial equilibrium points. According to Friedman's method, when a group's dynamic evolutionary process is described by a derivative equation system, the equilibrium point can be analyzed by the Jacobian matrix obtained via the system in order to find out the stability (Friedman, 1996). To make the equation clearer, we assume

$$x = \frac{\alpha_2 - \Delta\pi_2^{'} - f\alpha_2}{\gamma_2\alpha_1 + f\alpha_1 + \Delta\pi - \beta\Delta\pi - \Delta\pi_2^{'} - f\alpha_2 - E_2} = \frac{N}{M} \quad (7)$$

$$y = \frac{\alpha_1 - \Delta\pi_1^{'} - f\alpha_1}{\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - \Delta\pi_1^{'} - f\alpha_1 - E_1} = \frac{H}{G} \quad (8)$$

The system's Jacobian matrix is shown as follows:

$$J = \begin{bmatrix}(1-2x)(Gy-H) & x(1-x)*G \\ y(1-y)*M & (1-2y)(Mx-N)\end{bmatrix} \quad (9)$$

The trace of this Jacobian matrix is:

$$trJ = (1-2x)(Gy-H) + (1-2y)(Mx-N) \quad (10)$$

Then we analyze the stabilities of these equilibrium points by using the partial stability analysis method for Jacobian matrix, and find out the relationships among impact factors. From the results shown above, we can draw out the phase diagram describing the evolutionary game on cooperation-noncooperation choice between operators and system integrators. Phase diagram of the evolutionary game between operators and system integrators. The system has 5 equilibrium points. The broken line made up of unsteady equilibrium point B (1, 0), D (0, 1) and saddle point E indicates that the system converges to various critical lines. When initial status falls in the upper right corner of the broken line, the system converges into (1, 1), which means both operators and system integrators will choose the cooperation strategy. If initial status falls in the lower left corner of the broken line, the system converges into (0, 0), which means both operators and system integrators will choose the noncooperation strategy (Matthew and Alison, 2002).

If $\frac{\beta_2\alpha_2\text{-f}\alpha_2\text{-}\Delta\pi_2^{'}}{\gamma_2\beta_1\alpha_1\text{-}\Delta\pi_2^{'}\text{-f}\alpha_2\text{+f}\alpha_1\text{-E}_2} = \frac{\beta_1\alpha_1\text{-f}\alpha_1\text{-}\Delta\pi_1^{'}}{\gamma_1\beta_2\alpha_2\text{-}\Delta\pi_1^{'}\text{-f}\alpha_1\text{+f}\alpha_2\text{-E}_1} = \frac{1}{2}$, the system has identical probability converging into both strategies. In other words, the areas to the right and to the left of broken line BED are equal ($S_{ABED} = S_{BCDE}$).

If $\frac{\beta_2\alpha_2\text{-f}\alpha_2\text{-}\Delta\pi_2^{'}}{\gamma_2\beta_1\alpha_1\text{-}\Delta\pi_2^{'}\text{-f}\alpha_2\text{+f}\alpha_1\text{-E}_2} \neq \frac{\beta_1\alpha_1\text{-f}\alpha_1\text{-}\Delta\pi_1^{'}}{\gamma_1\beta_2\alpha_2\text{-}\Delta\pi_1^{'}\text{-f}\alpha_1\text{+f}\alpha_2\text{-E}_1}$, the probabilities of converging into two strategies are different, the difference depends on many factors.

3.3 Factors Analyses

By analyzing the phase program, we come to these following conclusions. The long-term stable statuses throughout the evolutionary process between operators and system integrators could be cooperation or noncooperation; which ESS point the long-term evolutionary process will converge to depends on the

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initial status are given; the initial revenues for operators and system integrators will not influence the stable equilibrium of evolutionary process. Nevertheless, different initial values and variations of some parameters in the revenue functions will converge the evolution system into different equilibrium points in the long-term (Lee, 2007).

Although the Pareto optimality appears when both operators and system integrators choose the cooperation strategy, (1,1) and (0,0) are all stable points, so which condition will the evolutionary result converges to relies on the areas of area I and area II (S_{ABED} and S_{BCDE} , respectively). If $S_{ABED} < S_{BCDE}$, operators and system integrators have more probability to choose cooperation than noncooperation; if $S_{ABED} > S_{BCDE}$, operators and system integrators have less probability to choose cooperation than noncooperation; If $S_{ABED} = S_{BCDE}$, the system has the same probability for convergence for both strategies. Apparently, we can easily derive the areas equations for S_I, S_{II} from Fig. 1 as follows:

$$\begin{aligned} S_I &= S_{ABED} \\ &= \frac{1}{2}\Big(\frac{\alpha_2 - \Delta\pi_2^{'} - f\alpha_2}{\gamma_2\alpha_1 + f\alpha_1 + (1-\beta)\Delta\pi - \Delta\pi_2^{'} - f\alpha_2 - E} \\ &+ \frac{\alpha_1 - \Delta\pi_1^{'} - f\alpha_1}{\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - \Delta\pi_1^{'} - f\alpha_1 - E_1}\Big) \\ &= \frac{1}{2}\Big(\frac{N}{M} + \frac{H}{G}\Big) \\ S_{II} &= S_{BCDE} \\ &= \frac{1}{2}\Big(\frac{\lambda_2\alpha_1 + f\alpha_1 + (1-\beta)\Delta\pi - \alpha_2 - E_2}{\gamma_2\alpha_1 + f\alpha_1 + (1-\beta)\Delta\pi - \Delta\pi_2^{'} - f\alpha_2 - E} \\ &+ \frac{\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - \alpha_1 - E_1}{\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - \Delta\pi_1^{'} - f\alpha_1 - E_1}\Big) \\ &= \frac{1}{2}\Big(\frac{M-N}{M} + \frac{G-H}{G}\Big) \end{aligned} \tag{11}$$

We can analyze those factors influencing the cooperation choice between operators and system integrators by changing them into factors influencing the areas of II , because the impact factors of areas of II share the same tendency with that of cooperation strategy, and have opposite tendency with the impact factors of noncooperation strategy. We find 11 impact factors of area II from formula (11), so in the following part will analyze their influences on the stable strategies of evolutionary process.

3.3.1 Shareable Resources

Only if companies' resources are complementary, will they choose to cooperate in developing new products. Thus under a certain condition, more investment of resources means stronger desire to cooperate.

According to formula (11), we derivate S_{II} by α_1, α_2 as follows:

$$\frac{\partial S_{II}}{\partial \alpha_1} = \frac{1}{2}\Big[\frac{(\gamma_2 + f)(M-N)}{M^2} - \frac{G - Hf}{G^2}\Big] \tag{12}$$

$$\frac{\partial S_{II}}{\partial \alpha_2} = \frac{1}{2}\Big[\frac{Nf - M}{M^2} + \frac{(G-H)(\gamma_1 + f)}{G^2}\Big] \tag{13}$$

When $\frac{(\gamma_2+f)(M-N)}{M^2} > \frac{G-Hf}{G^2}$, $\frac{\partial S_{II}}{\partial \alpha_1} > 0$, thus S_{II} is a monotone increasing function of α_1. In another word, the more resources operators share, the larger S_{II} will be and the more possible for this system to converge into C(1,1); when $\frac{(\gamma_2 + f)(M-N)}{M^2} < \frac{G-Hf}{G^2}$, $\frac{\partial S_{II}}{\partial \alpha_1} < 0$, thus S_{II} is a monotone decreasing function of α_1. In another word, the areas II will decrease as the resources shared by operators increase. Similarly, system integrators see the same condition.

3.3.2 Independent-Developing Revenue (Noncooperation Revenues)

According to the analyses, we conclude that if the excess return operators and system integrators earn in cooperation be higher than the revenue they earn from betraying, the more revenues they earn from noncooperation, the larger the possibility of their choosing cooperation will be. According to formula (11), we derivate S_{II} by $\Delta\pi_1^{'}, \Delta\pi_2^{'}$ as follows:

$$\frac{\partial S_{II}}{\partial \Delta\pi_1^{'}} = \frac{1}{2} \times \frac{G-H}{G^2} = \frac{\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi - (\alpha_1 + E_1)}{2G^2} > 0 \tag{14}$$

$$\frac{\partial S_{II}}{\partial \Delta\pi_2^{'}} = \frac{1}{2} \times \frac{M-N}{M^2} = \frac{\gamma_2\alpha_1 + f\alpha_1 + (1-\beta)\Delta\pi - (\alpha_2 + E_2)}{2M^2} > 0 \tag{15}$$

Generically, if the excessive return operators obtain under cooperation strategy (that is total revenue of learning from system integrators, punishing system integrators' betray and succeeding in cooperation) is higher than the sum of its devotion costs and probable betrayal revenue, in another word, if the opportunity revenue is larger than the opportunity cost, or if $\gamma_1\alpha_2 + f\alpha_2 + \beta\Delta\pi > (\alpha_1 + E_1)$, we have

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$\frac{\partial S_{II}}{\partial \Delta\pi_1^{'}} > 0$, so S_{II} is a monotone increasing function of $\Delta\pi_1^{'}$. At this time, the areas of S_{II} will increase with the increasing of probable noncooperation revenue, and the system will have larger probability to converge into C (1, 1), which means operators are more likely to strengthen cooperation. Or we can come to these conclusions: the more revenue operators could obtain from noncooperation, the more resources they need to input, and the higher risks they will encounter. At this time, operators could choose the optimal strategy no matter what strategy the system integrators choose. Similarly, system integrators see the same condition.

3.3.3 Learning Coefficient

If the devotion costs of operators (system integrators) is larger than the sum of noncooperation revenue and probable revenue from punishing system integrators' (operators') betrayal, the probability of operators (system integrators) choosing cooperation will increase as learning coefficient increases. Reasons are shown as follows. According to formula (11), we derivate S_{II} by γ_1, γ_2:

$$\frac{\partial S_{\mathrm{II}}}{\partial \gamma_1} = \frac{\alpha_2}{2} \times \frac{H}{G^2} = \frac{\alpha_2}{2} \times \frac{\alpha_1 - (\Delta\pi_1^{'} + \mathrm{f}\alpha_1)}{G^2} > 0 \quad (16)$$

$$\frac{\partial S_{\mathrm{II}}}{\partial \gamma_2} = \frac{\alpha_1}{2} \times \frac{N}{M^2} = \frac{\alpha_1}{2} \times \frac{\alpha_2 - (\Delta\pi_2^{'} + \mathrm{f}\alpha_2)}{M^2} > 0 \quad (17)$$

If $\alpha_1 > \Delta\pi_1^{'} + f\alpha_1$, then $\frac{\partial S_{II}}{\partial \gamma_1} > 0$, so S_{II} is a monotone increasing function of γ_1. In another word, the higher the learning coefficient is, the larger areas of S_{II} will be. It means that if the operators resource input is larger than the sum of their noncooperation revenue and probable revenues from punishing system integrators' betray penalty, they tend to strengthen the cooperation to obtain excess return because the cost of choosing betrayal strategy is much higher. Hence, the higher operators' learning coefficient is, the higher the economic value operators will obtain from their cooperative partners and the quicker operators would recover their investment, and the higher excess return they will obtain. At this time, the operators will have larger probability to strengthen cooperation, and this system will have larger probability to converge into C (1, 1). Similarly, the system integrators see the same choices.

3.3.4 Betrayal Revenue Coefficient

Because of the asymmetric information, if one side in the game chooses the cooperation strategy while the other one chooses noncooperation, the probability of the noncooperation side betraying will increase as his probable betrayal revenue increases, and the increase of betrayal revenue also leads to the decrease of probability of cooperation establishment in the long-term evolutionary game. Reasons are shown as bellows. According to formula (11), we derivate S_{II} by E_1 and E_2:

$$\frac{\partial S_{\mathrm{II}}}{\partial E_1} = \frac{1}{2} \times \frac{-H}{G^2} = \frac{\Delta\pi_1^{'} + \mathrm{f}\alpha_1 - \alpha_1}{2G^2} < 0 \quad (18)$$

$$\frac{\partial S_{\mathrm{II}}}{\partial E_2} = \frac{1}{2} \times \frac{-N}{M^2} = \frac{\Delta\pi_2^{'} + \mathrm{f}\alpha_2 - \alpha_2}{2M^2} < 0 \quad (19)$$

we have $\frac{\partial S_{II}}{\partial E_1} < 0$ because $H > 0$, so S_{II} is a monotone decreasing function of E_1. In other words, with the betrayal revenues E_1 increase, areas of S_{II} will decrease, and the probability of this system to evolution into A (0, 0) will increase. It means that if the sum of operators' noncooperation revenue and probable revenue from punishing system integrators' betrayal is less than the resources they input throughout cooperation, the increase of betrayal revenue coefficient will lead to increase of operators' betrayal benefit, then further increase the probability of operators choosing the betrayal strategy.

3.3.5 Betrayal Penalty Coefficient

To maintain cooperation, both sides in the game will choose to consistently raise the betrayal penalty coefficient to lower the probability of betraying. Hence, the betrayal penalty coefficient is set up corresponding to betrayal revenue. The higher betrayal penalty coefficient is, the higher betray costs will be, and the less probability for both sides to choose betray strategy is, then both sides in the game will have larger probability to choose cooperation strategy. Reasons are shown as follows. According to formula (11), we derivate S_{II} by f:

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$$\frac{\partial S_{II}}{\partial f}=\frac{1}{2}[\frac{\alpha_1 M+(\alpha_2\text{-}\alpha_1)N}{M^2}+\frac{\alpha_2 G+(\alpha_1\text{-}\alpha_2)H}{G^2}]$$
$$=\frac{1}{2}[\frac{\alpha_1(M\text{-}N)+\alpha_2 N}{M^2}+\frac{\alpha_2(G\text{-}H)+\alpha_1 H}{G^2}]>0 \quad (20)$$

From the relation of M, N, G and H we can conclude that $\frac{\partial S_{II}}{\partial f}>0$, so S_{II} is a monotone increasing function of f. In another word, the higher the betrayal penalty coefficient is, the larger areas of S_{II} will be, and the larger the probability of system to evolution into C (1, 1), so both sides will have larger probability to choose the cooperation strategy. In the multi-stage game, any betrayal behaviour of either side will lower the probability of cooperation establishing in the next stage. However, because the market requirements are changing all the time, there is always cooperation necessity for operators and system integrators to launch new product to satisfy new requirements of customers, and obtain excess return. So the only choice for them is to establish cooperation by raising the betrayal penalty coefficient and increasing the betray cost so that significantly decrease the betrayal possibility.

3.3.6 Excessive-revenue Allocation Coefficient

Keep the other coefficients unchanged, there is an optimal excessive-allocation coefficient who can achieve double-wins between operators and system integrators, where the probability of both sides choosing cooperation strategy will reaching maximum. According to formula (11), we derivate S_{II} by β:

$$\frac{\partial S_{II}}{\partial \beta}=\frac{1}{2}[\frac{-N*\Delta\pi}{M^2}+\frac{H*\Delta\pi}{G^2}] \quad (21)$$

Apparently, there is no monotonic relation between β and S_{II}. Hence, we second-order derivate S_{II} by β:

$$\frac{\partial^2 S_{II}}{\partial \beta^2}=-\frac{N*\Delta\pi^2}{M^3}-\frac{H*\Delta\pi^2}{G^3}]<0 \quad (22)$$

Let $\frac{\partial S_{II}}{\partial \beta}=0$, namely $\frac{N*\Delta\pi}{M^2}=\frac{H*\Delta\pi}{G^2}$, S_{II} has maximum value. At this time, the system has the largest probability to evolution into C (1, 1), thus operators and system integrators have the largest probability to establish cooperation.

4 CONCLUSIONS

The main contribution of this paper is that it applies the evolutionary game theory to the study of cooperation model selection between operators and system integrators, and it constructs an evolutionary game model on cooperation strategy and noncooperation strategy between operators and system integrators. The result shows that within a certain extent, more shareable resources lead to larger probability of cooperation, but, the probability of cooperation will gradually decrease if the distribution of shareable resources exceeds the extent. It also shows that the independent-developing coefficient, learning coefficient and penalty coefficient are all proportional to the probability of cooperation. That is to say, increasing any value of these coefficients could promote the cooperation. On the other hand, betrayal revenue is inversely proportional to the probability of cooperation. Therefore, the higher the betrayal revenue is, the lower the probability of long-term cooperation establishment will be. Last but not least, there is an optimal excessive return allocation coefficient to maximize the probability of cooperation. It means that a fair and reasonable revenue allocation mechanism will promote the cooperation establishment in this system.

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