Research on the stability of supplier-influencer alliance based on stochastic evolutionary game

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Abstract. This study examines the evolutionary equilibrium in supplier-influencer alliances, considering variables like excess earnings distribution, punishment intensity, and incurred costs. Incorporating white noise and the Ito stochastic differential equation, we use Matlab simulations to analyze alliance stability under parameter variations. Our results offer insights for the live streaming e-commerce industry.

Keywords: Alliance stability; White noise; Stochastic evolutionary game.

1 Introduction

In recent years, the vigorous development of live streaming e-commerce and the Internet celebrity economy has prompted the transformation of the cooperation mode between suppliers and Internet celebrities, from traditional third-party intervention to direct cooperation, thereby simplifying the transaction process and improving efficiency. However, this new alliance model also faces stability challenges. Due to the existence of internal and external random disturbance[1], the strategy choice of alliance members becomes uncertain, which brings a potential threat to alliance stability[2]. In addition, the live streaming e-commerce industry is also facing a series of problems such as unsound laws and regulations, uneven product quality, frequent vicious competition, insufficient after-sales service, and difficulties in consumer rights protection[3].

At present, the research in the field of live streaming e-commerce mainly focuses on two aspects: regulatory mechanism[4] and evolutionary mechanism[5]. Although existing studies have put forward suggestions on strengthening legislation, using technological means to regulate behavior, and exploring the evolutionary game model of government-consumer cooperation regulation[6], few studies have focused on the stability of the alliance between suppliers and Internet celebrities. At the same time, most of the existing studies discuss the evolution process based on the deterministic model[7], ignoring the random disturbance factors in the real situation.

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2 Analysis of Stochastic Evolutionary Game Model

In Table 1, Suppose that the basic income of the supplier operating alone is $\mathrm{R_a}$, the basic income of the Internet celebrity operating alone is $\mathrm{R_b}$, the cost of compliance is $\mathrm{C_1}$, and the cost of violation is $\mathrm{C_2}$, the effort level of the Internet celebrity is $\mathrm{e_1}$ when the supplier provides "genuine products", the effort level of the Internet celebrity is $\mathrm{e_2}$ when the supplier provides "imitation products", the influence factor of the Internet celebrity's reputation on the reward received is a, when the Internet celebrity "complies with the rules", The natural traffic f_1 with the increase of brand word-of-mouth effect, the natural traffic f_2 with the increase of brand word-of-mouth effect and the traffic conversion rate β with one party choosing "compliance" and the other party choosing "violation", the penalty F for the party choosing "violation", the penalty coefficient γ, one party choosing "compliance", and the other party choosing "compliance". The other party chooses "violation", the speculative profit H of the "violation" party is selected, the total excess profit L obtained by the supplier and the Internet celebrity simultaneously "abide by the rules", the excess profit distribution ratio k, and the loss S caused by the user loss caused by the "violation" of both parties.

Table 1. Game payoff matrix

Game agent strategy	Influencers follow the rules	Internet celebrity violation
Suppliers provide genuine products	$\mathrm{R_a} + \beta f_1 - \mathrm{C_1} + kL$ $\mathrm{R_b} + \alpha \mathrm{e_1} - \mathrm{C_1} + (1-k)L$	$\mathrm{R_a} + \beta f_2 - \mathrm{C_1} + \gamma F$ $\mathrm{R_b} + \alpha \mathrm{e_1} + H - \mathrm{C_2} - \gamma F$
Suppliers provide imitation products	$\mathrm{R_a} + \beta f_1 + H - \mathrm{C_2} - \gamma F$ $\mathrm{R_b} + \alpha \mathrm{e_2} - \mathrm{C_1} + \gamma F$	$\mathrm{R_a} + \beta f_2 - \mathrm{C_2} - \mathrm{S}$ $\mathrm{R_b} + \alpha \mathrm{e_2} - \mathrm{C_2} - \mathrm{S}$

In the model, the two suppliers participating in the game, the influencer, make strategy choices according to their wishes. Assuming that the probability of the supplier choosing to provide the "genuine" strategy is x, the probability of the supplier choosing to provide the "imitation" strategy is $1-x$; The probability of the influencer choosing the "compliance" strategy is y, then the probability of the influencer choosing "violation" is $1-y$.

According to the replication dynamic equation, the evolutionary game model of vendor-influencer can be established as follows:

$$F(x) = \frac{dx}{dt} = x(1-x)[\mathrm{C_2} - \mathrm{C_1} + \gamma F + \mathrm{S} + y(kL - H - \mathrm{S})] \tag{1}$$

$$F(y) = \frac{dy}{dt} = y(1-y)\{\mathrm{C_2} - \mathrm{C_1} + \gamma F + \mathrm{S} + x[(1-k)L - H - \mathrm{S}] \tag{2}$$

To describe the evolution process of vendor-influencer alliances more accurately, it is necessary to adjust the original evolutionary game model. Therefore, combined with stochastic analysis theory, the random disturbance term of white Gaussian noise is introduced into the replicated dynamic equation, and the influence of randomness on alliance evolution is considered, so that the deterministic model is transformed into a stochastic model, and the evolutionary game model in this paper is further improved. Modify the replication dynamic equation as follows:

$$dx(t) = [C_2 - C_1 + \gamma F + S + y(kL - H - S)]x(t)dt + \sigma x(t)d\omega(t) \quad (3)$$

$$dy(t) = \mathrm{C}_2 - \mathrm{C}_1 + \gamma F + \mathrm{S} + x[(1-k)L - H - \mathrm{S}]y(t)dt + \sigma y(t)d\omega(t) \quad (4)$$

The above (2) and (3) are one-dimensional random differential equations in the form of Itô, and $d\omega(t)$ is Gaussian white noise in the usual sense, which reflects the disturbance caused by random factors in the system. The Gaussian white noise coefficient σ represents the degree of disturbance, where the greater the σ, the more the system is affected by the random disturbance.

3 Simulation Analysis

Based on the above model analysis, to verify the rationality of the measurement indicators, this section analyzes the influence of excess income distribution ratio k, penalty intensity F, and cost C on the strategy selection of each subject in the vendor-internet celebrity alliance.

3.1 Proportion of Excess Income Distribution

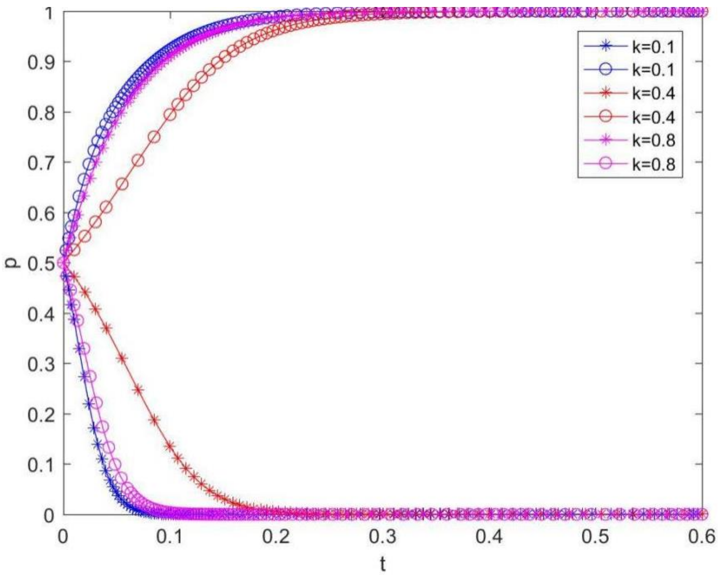

Fig. 1. The stability evolution of alliances under different distribution ratios of excess returns

It can be seen from Fig. 1 that the proportion of excess income distribution k is proportional to the proportion of compliance. When the excess income distribution ratio k is small, the supplier will tend to have a lower compliance ratio. When the excess income distribution ratio k is large, the supplier will tend to have a higher compliance ratio, that is, choose to provide a "genuine products" strategy; Internet celebrities will tend to have a lower proportion of compliance, that is, choose the "violation" strategy. Therefore, a relatively fair proportion of excess income distribution helps maintain the stability of the vendor-influencer alliance.

3.2 Intensity of Punishment

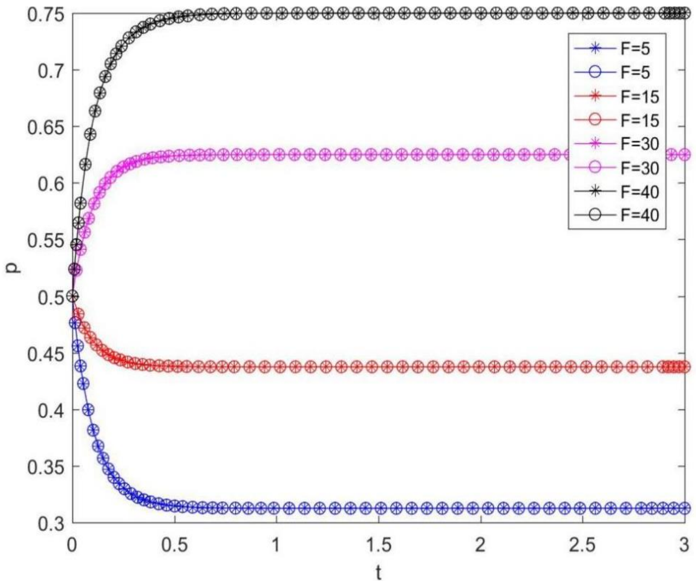

Fig. 2. Stability evolution of alliance under different punishment intensities

It can be seen from Fig. 2 that the severity of punishment is proportional to the proportion of compliance. When the punishment of the "rule-abiding" party on the "rule-breaking" party is relatively small, the alliance members are more inclined to lower the proportion of rule-abiding. When the "rule-abiding" party punishes the "rule-breaking" party more heavily, the alliance members are more inclined to the high rule-abiding ratio, that is, the suppliers choose to provide "authentic products" and the Internet celebrities choose "rule-abiding" strategies. When the proportion of compliance is greater than 0.5, the intensity of punishment is proportional to the approaching speed of compliance ratio. Therefore, the punishment does not need to be set too large, as long as the setting is reasonable, it can better maintain the stability of the vendor-net celebrity alliance.

3.3 Pay the Cost

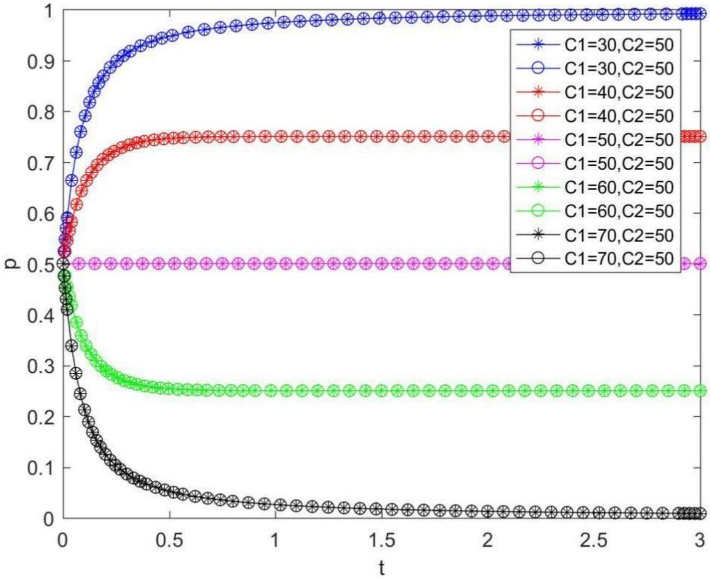

Fig. 3. Stability evolution of alliance under different costs

It can be seen from Fig. 3 that The cost is inversely proportional to the compliance ratio. When the cost of "compliance" is relatively small, alliance members are more inclined to a high compliance ratio. When the compliance ratio is greater than 0.5, the cost is inversely proportional to the approaching speed of the compliance ratio. Therefore, a relatively reasonable cost is conducive to maintaining the stability of the vendor-influencer alliance.

4 Conclusion

Based on the stochastic evolutionary game, this paper simulates the decision-making evolution mechanism of alliance member suppliers and Internet celebrities and analyzes the influence of parameter changes on the stability of the vendor-internet celebrities alliance. The conclusion is as follows:

The proportion of excess income distribution k is proportional to the proportion of compliance; The severity of punishment is proportional to the proportion of compliance; The cost to pay is inversely proportional to the proportion of compliance.

The innovation of this paper lies in that: in the existing research, most scholars pay attention to the alliance relationship between Internet celebrities and platforms, but lack of in-depth research on the stability of the alliance between suppliers and Internet celebrities. In addition, most of the current literature discusses the evolution process based on deterministic models, ignoring the disturbance factors in the actual situation.

Reference

1. Chen, L. (2021). Driving factors, effect analysis and countermeasures of the development of china's live broadcast platform. China Finance and Economic Review, 10(1), 102-116. doi:10.1515/cfer-2021-0006.
2. Xiang J H. (2021). Research on the problems and governance of live E-commerce based on blockchain technology. Proceedings of Business and Economic Studies, 4(2). doi: 10. 26689/pbes.v4i2.2097.
3. Cobb, L., & Watson, B. (1980). Statistical catastrophe theory: An overview. Mathematical Modelling, 1(4), doi:311-317. 10.1016/0270-0255(80)90041-X.
4. Wu, B., Cheng, J., & Qi, Y. (2020). Tripartite evolutionary game analysis for "Deceive acquaintances" behavior of e-commerce platforms in cooperative supervision. Physica A: Statistical Mechanics and its Applications, 550, 123892. doi:10.1016/j.physa.2019.123892.
5. Lv, J., Yao, W., Wang, Y., Wang, Z., & Yu, J. (2022). A game model for information dissemination in live streaming e-commerce environment. International Journal of Communication Systems, 35(1), e5010. doi:10.1002/dac.5010.
6. Wu, J., & Wang, Y. (2021). Research on the Decision-Making Mechanism of Live Commerce Supply Chain Based on Three-Party Evolutionary Game. doi:10.20944/preprints202105.0504.v1.
7. Friedman, D. (1991). A simple testable model of double auction markets. Journal of Economic Behavior & Organization, 15(1), 47-70. doi:10.1016/0167-2681(91)90004-H.