

A Novel Evolutionary Game Model of the Behavior of Stakeholders in the Field of E-commerce Live Broadcasting

Dandan Qi¹, Jingwen Fang², Mingliang Li³, Ping Han²

¹Heilongjiang Cultural Big Data Theory Application Research Center, Harbin University of Commerce, Harbin, China

²School of Economics, Harbin University of Commerce, Harbin, China

³West China Biomedical Big Data Center, West China Hospital, Sichuan University, Chengdu, China

Received: March 8, 2021. Revised: August 5, 2021. Accepted: August 25, 2021. Published: August 26, 2021.

Abstract: When economic entities are facing severe tests, the live broadcast sale is booming with its own advantages. However, at the same time, it is also facing a series of problems such as lack of anchor credit, numerous fakes, and weak platform supervision. In the process of quantitative research on live delivery of goods, various difficulties will be encountered, such as information asymmetry between subjects and untrue data sources. Therefore, This paper establishes an evolutionary game model between the anchor, the consumer, and the anchor and the live broadcast platform, and explores its equilibrium state, and performs numerical simulation analysis on this basis. Discuss and analyze the main factors that influence the strategic choice of the evolutionary body, deepen the understanding of the live broadcast industry, so as to promote the correct understanding of the live broadcast industry and related fields, and put forward reasonable and effective suggestions and countermeasures for regulating the development of the live broadcast economy.

Keywords:—live streaming, evolutionary game, anchor, consumer, numerical simulation

I. INTRODUCTION

With the rapid development of business, various online marketing methods have emerged one after another, such as Taobao's Double Eleven, JD's 618 and so on. In the fiercely competitive market conditions, live broadcast sales have emerged. On major live broadcast platforms, anchors have begun to become the main force leading people to consume with their eloquence, professionalism, and influence. This new marketing method makes up for the shortcomings of online shopping, allowing consumers to feel the details and quality of the product without leaving home. In 2017, the national transaction volume of live broadcast sales was more than 30 billion, and in 2019 it was more than 400 billion. In 2020, it will exceed one trillion yuan this year. It is expected that it will exceed two trillion yuan next year. In the seemingly ordinary live broadcast sales process, behind it is the result of the joint efforts of directors, broadcast assistants, supply chain, after-sales service, and traffic operations. There is a complete industrial chain. It is not

difficult to see that consumers will rely more on professional and authentic anchors, and at the same time, the ability of the anchors to carry goods also determines their income and popularity. Only by continuously improving the quality of the goods brought can we gain the trust of consumers and at the same time gain the possibility of consumers to buy back. At the same time, in recent years, major broadcasters have used their own strong sales capabilities to live broadcast to help farmers, do public welfare undertakings, and use their influence to contribute to the country and society. As an important pillar connecting consumers and anchors, the live broadcast platform can not only provide a communication platform but also play a role in maintaining the stability of the market. At present, the main live streaming platforms that focus on bringing goods are Taobao, JD, Mogujie, etc. They not only provide places for live streaming, but also provide goods from the supplier. However, with the rapid development of the live broadcast economy in recent years, there are also various problems. The anchors exaggerate the quality of their products to deceive consumers. Some platforms allow the anchors' behavior to cause damage to consumer rights and ultimately affect the reputation of the entire industry.

The research on the participants in the live streaming economy mainly involves consumers, merchants, streaming anchors and live streaming platforms. In the competition between consumers and merchants, Mao Wenjuan and Chen Yuelan included the buyer in the platform's social responsibility governance system, and explored how to realize the benign interaction of social responsibility among the platform entities by constructing an evolutionary game model of the platform, the seller, and the buyer [1]. Yu Desheng and Li Xing built a dynamic evolutionary game model between merchants and consumers under the background of big data "killing familiarity", and put forward countermeasures and suggestions on this basis to strengthen consumers' awareness of rights protection [2]. In terms of competition among merchants, Bao Lijiang and others analyzed the impact of click farming behavior on merchant competition, constructed a game model, and analyzed the impact of click farming based on the competition between

two merchants [3].

Chen Ting, Hou Wenhua, and Zhang Xinxin proposed how to determine their product positioning under the mode of concessionary sales promotion [4]. In terms of live broadcast platforms, Zhong Dan's master's thesis summarized some of the current difficulties faced by web live broadcast platforms: violations of laws and regulations have been repeatedly prohibited, platform content quality is uneven, user stickiness is not enough, and traffic conversion rate is low [5]. Yang Yali pointed out in her master's thesis that the relationship between the anchor and the platform is a strategy of relying on cultural capital to rely on economic capital [6]. In this situation, the webcast platform has a dominant function, and the effectiveness of the role of the Internet celebrity anchor depends on the planning and design of the platform. In terms of live streaming delivery, Zheng Hongge analyzed the internal development principles of live streaming delivery, and believed that live streaming delivery was a kind of commodity aesthetic education to achieve efficient consumption [7]. Consumers use this kind of commodity aesthetic education to ensure aesthetic guidance, create and realize self-identity. At the same time, there are many shortcomings behind this kind of commodity aesthetic education, and there is a hidden crisis. Zhao Ruohan started an in-depth study on the positive and negative effects of live streaming on marketing with the reasons for the continued popularity of live streaming [8]. Zhao Li and Zhang Ling analyzed the status quo of live delivery economy, established an evolutionary game model between anchors and consumers, and put forward summaries and suggestions based on the status quo [9]. Shen Baogang believes that the main driving factor for the development of live streaming is the encouragement at the national level. At the same time, there are also problems such as lack of anchor credit, vague industry thresholds, weak supervision, and uneven distribution of benefits. On this basis, targeted opinions and countermeasures are put forward [10]. From the perspective of Li Jiaqi's popularity, Niu Yanxiao and Song Shenglei explored the mode of online celebrity live-streaming delivery, understand its profit model, and on this basis, put forward suggestions to push the network live-streaming delivery out of the bottleneck [11]. From the perspective of using evolutionary game analysis, Li Yabing and Zhang Jiarui established a game model between the network supervision department, the live broadcast platform, and the live broadcast user, and obtained that the standard development of the live broadcast platform is inseparable from the punishment and incentives of the supervision department, and is related to punishment. The intensity is in an inverted U-shaped correlation, and it is positively correlated with the incentive intensity [12]. Zhang Li, Wang Xiangxiang, and Li Jiabin realized that in today's increasingly developed online shopping, there are many problems in the e-commerce ecosystem, which requires enhanced supervision. They introduced consumer complaints into the game among the core groups of the e-commerce ecosystem, and established a three-party game model for e-commerce platforms, consumers, and merchants. In the end, the merchant's choice of "integrity" is closely related to the consumer's choice of "complaint", and countermeasures and suggestions are put

forward on this basis [13]. Guo Yiming used the evolutionary game model in his master's thesis to study the regulatory issues in shared bicycles. Incorporate the government, enterprises, and consumers into the game system, and analyze the role played by each game subject in the development of the shared bicycle standard [14]. Tian Yingdong builds a three-party game model for e-commerce platforms, online marketing companies, and consumer groups in the marketing market to analyze the role of coupons in marketing [15].

Through literature review, it is not difficult to see that the current research on live broadcast delivery has its own focus, but in general there are still deficiencies. On the one hand, most of the research on live broadcast sale is based on the surface, and does not dig deep into the internal interest mechanism of all parties. On the other hand, there are very few researches on the interest relationship between consumers, live broadcast platforms and streaming anchors in the existing research from the perspective of game theory. Different from traditional static games, evolutionary games do not require the players of the game to be rational people, and they have a strong advantage for the players who have incorrect research information. Therefore, this paper analyzes the optimal strategy of each subject by establishing an evolutionary game model between the three parties, and uses matlab to simulate, and on this basis, proposes corresponding measures and suggestions.

II. THE EVOLUTIONARY GAME BETWEEN CONSUMERS AND ANCHORS

A. Analysis of the Main Body of the Game

Consumers are individuals who pursue maximum utility, but they cannot grasp all the information about the product due to various reasons when they watch the live broadcast to purchase items. Under the economic conditions of live streaming, consumers mainly decide whether to buy goods through the description of the goods by the anchor and on-site display. Anchors sell products on the platform. Their understanding of product quality and performance is more comprehensive than consumers. However, in order to increase sales, they may not choose to truthfully disclose all product information. What's more, some anchors will provide false information to disrupt consumers and conduct false live broadcasts. An evolutionary game model is established for the two, and the two sides of the game are set as consumers and anchors.

B. Model Assumptions and Parameter Settings

There is information asymmetry between consumers and anchors, and consumers cannot grasp all the information about the product. The following hypotheses are put forward for the game between consumers and anchors:

- (1) Consumer strategic behavior: buy or not buy
- (2) Anchor strategy behavior: standard live broadcast or live broadcast against discipline

Table 1. The setting and significance of the main parameters of the game

Game party	parameters	Index explanation		(Opportunity cost when purchasing other goods)
Parameters that involve the anchor	R_1	Normal income of anchors		
	R_2	Excess revenue from a disciplinary broadcast	F	Compensation benefits received by consumers for rights protection in the case of purchase of fake goods
	C_2	Loss of expected benefits due to long-term disciplinary violations		
	C_1	Platform fines for disciplinary broadcasting		
	S	Standardize platform rewards for live streaming		
Parameters involving consumers	r	Discounts for consumers to buy live-room merchandise		
	C_3	Losses suffered by consumers in purchasing false goods in a disciplinary broadcast		
	Q	The basic benefits that consumers do not buy		

According to the basic hypothesis and parameter settings of the model, the income matrix of consumers and anchors can be obtained as table2. When the host with the goods chooses the standard live broadcast and the consumer purchases the goods in the live broadcast room, he can not only get the normal income (R_1) but also the reward (S) given by the live broadcast platform. At this time, the consumer can get a discount for the purchase of goods (r). When consumers do not buy, the anchors who can standardize the live broadcast can only get the normal live broadcast income (R_1), and the consumers can get the opportunity cost (Q) of buying other goods. The main source of income obtained when the host with goods chooses the illegal live broadcast is the anchor's income (R_1) plus the additional income(R_2) brought by the illegal live broadcast minus the platform penalty and reputation loss. When consumers buy goods in a live broadcast room with goods in violation of disciplines, consumers can get the preferential (r) obtained by purchasing the goods and the compensation income (F) obtained by rights protection, and at the same time suffer the loss (C_3) caused by buying fake products.

Table 2. The income matrix of the evolutionary game between the anchor and the consumer

		Consumers	
		Buy (x)	Not buy (1-x)
anchors	standard live broadcast (y)	(R_1+S, r)	(R_1, Q)
	live broadcast against discipline (1-y)	$(R_1+R_2-C_1-C_2, r-C_3+F)$	$(R_1+R_2-C_1-C_2, Q)$

C. Construction and Analysis of Evolutionary Model

Suppose that the probability of consumers choosing to buy is x, and the probability of consumer choosing to not buy is 1-x; the probability of an Internet celebrity anchor choosing to standardize live-streaming sales is y, and the probability of illegal live-streaming selling is 1-y; and $0 \leq x \leq 1, 0 \leq y \leq 1$.

The expected income of the live broadcaster who chooses to standardize the live broadcast of the goods is E_A , the expected income of the live broadcaster who sales the goods in violation of discipline is E_B , the average expected income of the anchor is \bar{E}_y .

$$\begin{aligned}
 E_A &= x(R_1+S) + (1-x)R_1 \\
 E_B &= x(R_1+R_2-C_1-C_2) + (1-x)(R_1+R_2-C_1-C_2) = R_1+R_2-C_1-C_2 \\
 \bar{E}_y &= yE_A + (1-y)E_B
 \end{aligned} \tag{1}$$

At the same time, we can get the expected return when

consumers choose to buy or not and the average expected return of consumers. They are represented by E_C, E_D, \bar{E}_x respectively.

$$\begin{aligned}
 E_C &= yr + (1-y)(r-C_3+F) = r + (1-y)(F-C_3) \\
 E_D &= yQ + (1-y)Q = Q \\
 \bar{E}_x &= xE_C + (1-x)E_D
 \end{aligned} \tag{2}$$

It is further obtained that the dynamic equations of replication under consumer choice purchase and anchor choice standard live broadcast delivery are $F(x)$ and $F(y)$ respectively.

$$\begin{aligned}
 F(x) &= \frac{dx}{dt} = x(1-x)[y(C_3-F) + F-C_3+r-Q] \\
 F(y) &= \frac{dy}{dt} = y(1-y)[C_1+C_2-R_2+xS]
 \end{aligned} \tag{3}$$

To make the evolutionary game system reach an equilibrium state, $F(x) = \frac{dx}{dt} = 0$ and $F(y) = \frac{dy}{dt} = 0$

must be satisfied at the same time. After solving: $x_1=0, x_2=1, x_3=(C_1+C_2-R_2)/(-S), y_1=0, y_2=1, y_3=(C_3-F+Q-r)/(C_3-F)$. From this, the following five equilibrium points can be obtained: $(0,0); (0,1); (1,0); (1,1); [(C_1+C_2-R_2)/(-S), (C_3-F+Qr)/(C_3-F)]$

D. Stability Analysis of Equilibrium Point

Evolutionary game theory is derived from the theory of biological evolution. Unlike general game theory, the two sides of the game in this model do not require complete and completely rational information, which is more in line with the reality. For the stability analysis of the equilibrium point, the current commonly used method is to use the Jacobian matrix to analyze. Through the $F(x)$ and $F(y)$ obtained above, we can get the Jacobian matrix J

$$J = \begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} \end{bmatrix} = \begin{bmatrix} (1-2x)(r - Q + yC_3 - yF - C_3 + F) & x(1-x)(C_3 - F) \\ y(1-y)S & (1-2y)(C_1 + C_2 + xS - R_2) \end{bmatrix} \quad (4)$$

To meet the condition of the equilibrium point of the evolutionary game, $tr(J)$ of the matrix must be less than 0, and $det(J)$ of the matrix must be greater than 0. Substituting the desired equilibrium point $(0,0), (0,1), (1,0), (1,1), ((C_1+C_2-R_2)/(-S), (C_3-F+Q-r)/(C_3-F))$ into the Jacobian matrix J , and calculating the corresponding $tr(J), det(J)$, the results obtained are shown in the table 3.

Table 3. The $tr(J)$ and $det(J)$ of the Jacobian matrix of the game system between consumers and anchors

Equilibrium point	det(J)	tr(J)
(0,0)	$(r-Q-C_3+F)(C_1+C_2-R_2)$	$r-Q-C_3+F+C_1+C_2-R_2$
(0,1)	$-(r-Q)(C_1+C_2-R_2)$	$r-Q-(C_1+C_2-R_2)$
(1,0)	$-(r-Q-C_3+F)(C_2+S+C_1-R_2)$	$-(r-Q-C_3+F)+(C_1+C_2+S-R_2)$
(1,1)	$(r-Q)(S+C_1+C_2-R_2)$	$-(r-Q)-(S+C_1+C_2-R_2)$
$((C_1+C_2-R_2)/(-S), (C_3-F+Q-r)/(C_3-F))$	$(1-x)(1-y)(C_1+C_2-R_2)(-r+Q+C_3-F)$	0

E. Numerical Simulation

In order to verify the construction of the above model, use matlab2018 for numerical simulation. Parameter calculation of consumers and anchors is as follows.

The income obtained by the anchor standard live broadcast is the monthly salary plus the commission. According to the official introduction of Xiao hongshu, the anchor commission = sales * commission rate * 0.8, because the live broadcast platform will extract 0.2 as the platform service fee and commission based on the commission received by the anchor. The rate is negotiated by the anchor and the merchant, and most of the commission rate is 20%. The average monthly salary of the anchor is 11,220 yuan, and the average annual salary is 134,620,000. According to the statistics of iiMedia.com, the number of Taobao anchors in 2019 is 20,000, and the number of live broadcast anchors on each platform is about 100,000 in 2020, so the total salary is 13.464 100 million yuan. The average annual sales of live streaming products are 3.26 billion yuan, so the anchor commission is 521.6 million yuan. $R_1=3.26 \text{ billion} * 20\% * 80\% + 13.464 = 1868$ million. The revenue from the illegal live broadcast is about 20% of the sales, $R_2=3.26 \text{ billion} * 20\% = 652$ million. The expected loss of profits caused by long-term violations of the live broadcast accounted for about 10% of sales, $C_2=32.6 * 10\% = 326$ million. According to Kuaishou ABC's three types of illegal content account penalty rules, the platform fines for illegal live broadcasts are approximately 1% of sales, $C_1=32.6 * 1\% = 332.6$ million. The platform rewards obtained by standardizing the live broadcast are about 20% of the

turnover, $S=32.6 * 20\% = 652$ million. Consumers get a discount of 30% of the sales for purchasing live broadcast products, $r=32.6 * 30\% = 978$ million. Set the loss (C_3) that consumers suffer from buying fake products in the illegal live broadcast, the basic income (Q) that consumers don't buy, and the compensation income (F) that consumers receive from protecting their rights as 2.5 billion, 600 million, and 1.1 billion, respectively.

Table 4. Local equilibrium point stability analysis under initial parameters

Equilibrium point	Det(J)	tr(J)	Stability Analysis
(0,0)	+	-	ESS
(0,1)	+	+	Instability
(1,0)	+	+	Instability
(1,1)	+	-	ESS
(0.45,0.73)	-	0	Saddle point

Game process and simulation between consumers and anchors is as follows. Based on the data analyzed above, combined with the established game model. The consumer's replication dynamic equation is $F(x)$ and the host's replication dynamic equation is $F(y)$

$$F(x) = x(1-x) [y(C_3 - F) + F - C_3 + r - Q] = x(1-x)(14y - 10.22)$$

$$F(y) = y(1-y) [C_1 + C_2 - R_2 + xS] = y(1-y)(6.52x - 2.934) \quad (5)$$

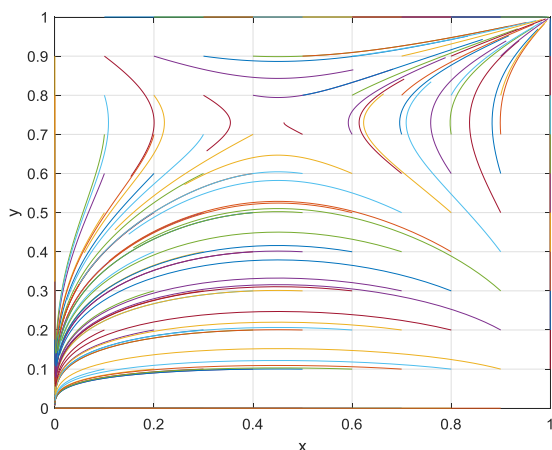
According to the copy dynamic equation and parameter settings, x^* and y^* are obtained.

$$x^* = (C_1 + C_2 - R_2) / (-S) = 0.45$$

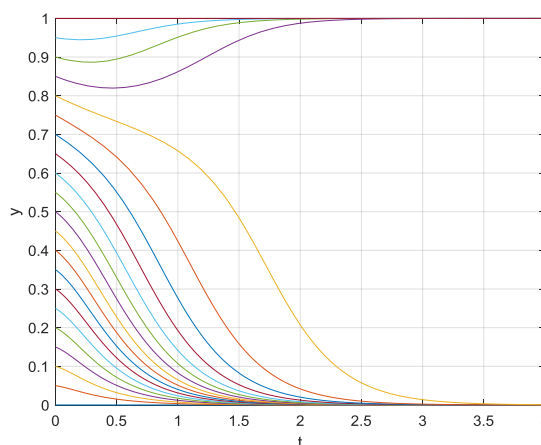
$$y^*=(C3-F+Qr)/(C3-F)=0.73 \quad (6)$$

Input the above parameters and equations into matlab for simulation to get a) to d) diagrams. The Fig.1a shows that when the initial values of x and y are 0 and the loop step size is set to 0.1, the dynamic evolution path of the game between the consumer group and the anchor group is obtained as shown in the Fig.1a. At the same time, set the probability x when the consumer chooses to buy to be 0.3, 0.5 and 0.7 respectively, observe the evolution equilibrium trend of the anchor group, and obtain the evolution path as shown in Fig. 1b, Fig. 1c and Fig. 1d.

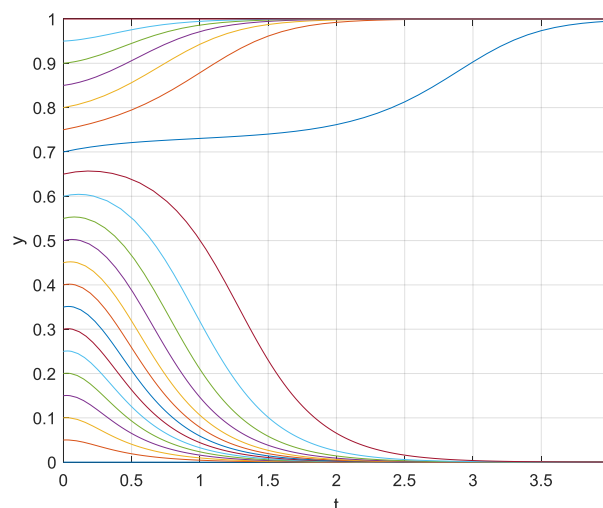
In the Fig.1a, it is not difficult to see that in the upper right area of the saddle point (0.45, 0.73), all paths evolve toward (1, 1) (buy, standard live broadcast), and on the lower left side of the saddle point, all paths are toward (0, 0) (not buy, live broadcast against discipline). And under the current level of parameters, the game between the two is more inclined to evolve in the direction of (0, 0). In the Fig.1b, when the probability of consumers choosing to buy is 0.3, more than 85% of the anchor group needs to choose standard live broadcast, then the game system will move towards the optimal evolution path (1, 1) (purchase, standard live broadcast). In the Fig.1c, when the probability of consumers choosing to buy is 0.5, more than 70% of the anchor group choose standard live broadcast, and the game system will evolve towards (1, 1) at this time. In the Fig.1d, the probability that consumers choose to purchase the goods in the live broadcast room is 0.7. At this time, more than 55% of the anchor groups need to choose the standardized live broadcast, and the game system will evolve towards the optimal path (1, 1). It is not difficult to see from in the Fig.1 that under the current parameter level, consumer decision-making can have an impact on the anchor group decision-making, but the effect is not obvious.



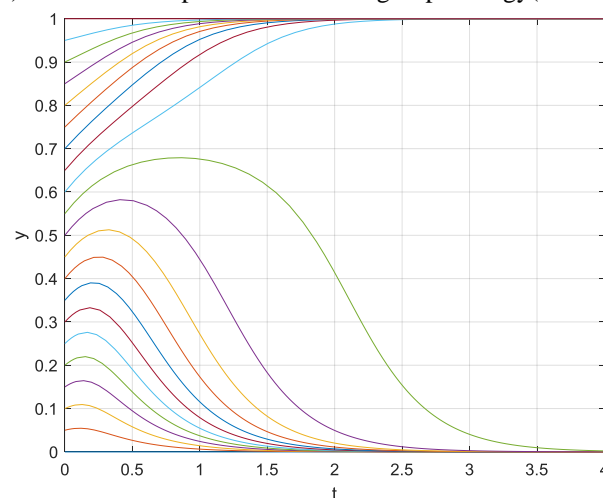
a) The dynamic evolution process group of both parties



b) The evolution process of anchor strategy(m=0.3)



c) The evolution process of anchor group strategy(m=0.5)



d) The evolution process of anchor group strategy(m=0.7)

Fig.1 The simulation of the evolutionary game between the anchor and consumers

III. THE EVOLUTIONARY GAME BETWEEN THE ANCHOR AND THE LIVE BROADCAST PLATFORM

A. Analysis of the Main Body of the Game

For the live broadcast platform, the goal is still to maximize profits. While building the platform to obtain benefits, they are also responsible for monitoring and maintaining the stability of the platform. They are rewarded for excellent anchors who can adhere to the standard live broadcast, and give fines for ignoring the platform requirements. The anchor who deceived consumers was punished. If the live broadcast platform allows the host to grow wildly, market failure will occur, undermining the stability of the platform's existence, causing consumers to gradually lose trust in the platform, leading to a decline in revenue. Based on this, most platforms are willing to act as regulators to maintain market stability, the difference is whether to choose active or negative regulation. Of course, the live broadcast platform's choice of active supervision requires a certain amount of manpower and material resources. Compared with other sales methods, the threshold for live broadcasts to bring goods is lower, so strong supervision is required. In the evolutionary game between the anchor and the live broadcast platform, the anchor can still choose standard live broadcast or live broadcast against discipline. The strategy of the live broadcast platform includes active or negative supervision.

B. Model Assumptions and Parameter Settings

Assumptions:

- (1) Two strategies for anchors: standard live broadcast or live broadcast against discipline
- (2) Two strategies for live broadcast platforms: active supervision or negative supervision

Table 5. Live broadcast platform and anchor game system related parameters set

Game party	parameters	Index explanation
	R_1	Normol income of achors
	R_2	Excess revenue from a disciplinary broadcast
Parameters that involve the anchor	C_2	Loss of expected benefits due to long-term disciplinary violations
	C_1	Platform fines for disciplinary broadcasting
	S	Standardize platform rewards for live streaming
Parameters that involve a live platform	L_0	The normal income generated by the daily operation of the platform
	L_1	The various costs of active supervision
	L_2	The cost of negative supervision caused by the decline of the credit of the e-commerce system
	L_3	Platform reputation accumulation income brought by active supervision

According to the assumptions and parameter settings of the model, the income matrix of the anchor and the live broadcast platform can be obtained as follows.

Table 6. The income matrix of the evolutionary game between the anchor and the live broadcast platform

		Anchor	
		Standardize live broadcasts(m)	live broadcast against discipline (1-m)
Live broadcast of platform	Active supervision(n)	$(L_0-L_1+L_3, R_1+S)$	$(L_0-L_1, R_1+R_2-C_1-C_2)$
	Negative supervision(1-n)	(L_0, R_1)	$(L_0-L_2, R_1+R_2-C_2)$

C. Construction and Analysis of Evolutionary Model

Assuming that the probability that the live broadcast platform chooses active supervision is n , the probability of negative supervision is $(1-n)$; The probability that the anchor chooses to standardize the selling is m , and the probability to choose the illegal selling is $(1-m)$. $0 \leq n \leq 1, 0 \leq m \leq 1$

The expected income of the live broadcast platform under

active supervision is E_1 , the expected income of the live broadcast platform under negative supervision is E_2 , the average expected income of the live broadcast platform is E_n . The expected income of the standard live broadcast is E_3 , the expected income of the live broadcast with the host in violation of discipline is E_4 , the average expected income of the anchor is E_m .

$$\begin{aligned}
 E_1 &= m(L_0 - L_1 + L_3) + (1-m)(L_0 - L_1) = L_0 - L_1 + mL_3 \\
 E_2 &= mL_0 + (1-m)(L_0 - L_2) = L_0 - L_2 + mL_2 \\
 E_n &= nE_1 + (1-n)E_2 \\
 E_3 &= n(R_1 + S) + (1-n)R_1 \\
 E_4 &= n(R_1 + R_2 - C_1 - C_2) + (1-n)(R_1 + R_2 - C_2) \\
 E_m &= mE_3 + (1-m)E_4
 \end{aligned} \tag{7}$$

Based on the above, you can write the dynamic equation of the replication of the live broadcast platform and the anchor.

$$F(n) = \frac{dn}{dt} = n(E_1 - E_n) = n(1-n)(L_2 - L_1 - mL_2 + L_3) \tag{8}$$

$$F(m) = \frac{dm}{dt} = m(E_3 - E_m) = m(1-m)(nS - R_2 + C_2 + nC_1)$$

To make the evolutionary game system reach an equilibrium state, $F(n) = \frac{dn}{dt} = 0$, $F(m) = \frac{dm}{dt} = 0$ must be

Table 7. The tr(J) and det(J) of the Jacobian matrix of the live broadcast platform and the anchor game system

Equilibrium point	det(J)	tr(J)
(0,0)	$(L_2-L_1)(-R_2+C_2)$	$L_2-L_1-R_2+C_2$
(0,1)	$(L_3-L_1)(R_2-C_2)$	$L_3-L_1+R_2-C_2$
(1,0)	$-(L_2-L_1)(S-R_2+C_2+C_1)$	$L_1-L_2+S-R_2+C_2+C_1$
(1,1)	$-(L_1-L_3)(S-R_2+C_2+C_1)$	$L_3-L_1-(S-R_2+C_2+C_1)$
$((R_2-C_2)/(S+C_1), (L_1-L_2)/(L_3-L_2))$	$-(1-m)(1-n)(L_1-L_2)(R_2-C_2)$	0

It can be seen from the above that a stable equilibrium point ESS should satisfy: $\det(J)>0$, $\text{tr}(J)<0$. As shown in the figure, at the equilibrium point $((R_2-C_2)/(S+C_1), (L_1-L_2)/(L_3-L_2))$, $\text{tr}(J)$ of the matrix is equal to 0, so this point is not an equilibrium point. In the process of discussing the stability of the remaining four equilibrium points, it is necessary to consider the magnitude and the positive and negative conditions of each parameter.

E. Numerical Simulation

Parameter calculation of live broadcast platform is as follows. The daily income of the live broadcast platform is mainly drawn from the anchor's commission, and the commission is drawn at a rate of 20% of the anchor's commission. Therefore, it can be seen from the above that $L_0=3.26 \text{ billion} * 20\% * 20\%=1304 \text{ million}$. The cost of active supervision accounts for 10% of average annual sales, $L_1=3.26 \text{ billion} * 10\%=326 \text{ million}$. Negative supervision caused the credit recovery cost L_2 of the credit decline of the e-commerce system. Take the famous anchor Simba selling fake bird's nest as an example, recall all the bird's nest products sold in Xinxuan's live broadcast room, and first assume the responsibility of returning one compensation and three compensations. First refund compensation of 61.983 million yuan, $L_2=0.62 \text{ billion}$. The accumulated revenue L_3 of

satisfied at the same time. After solving: $n=0, n=1, n=(R_2-C_2)/(S+C_1); m=0, m=1, m=(L_1-L_2)/(L_3-L_2)$. From this, the following five equilibrium points can be obtained $(0,0);(0,1);(1,0);(1,1);((R_2-C_2)/(S+C_1), (L_1-L_2)/(L_3-L_2))$.

D. Stability Analysis of Equilibrium Point

According to (8), the Jacobian matrix J can be obtained.

$$J = \begin{bmatrix} \frac{\partial F(n)}{\partial n} & \frac{\partial F(n)}{\partial m} \\ \frac{\partial F(m)}{\partial n} & \frac{\partial F(m)}{\partial m} \end{bmatrix} \tag{9}$$

$$= \begin{bmatrix} (1-2n)(L_2-L_1-mL_2+mL_3) & n(1-n)(L_3-L_2) \\ m(1-m)(S+C_1) & (1-2m)(nS-R_2+C_2+nC_1) \end{bmatrix}$$

Substituting the equilibrium point $(0,0);(1,0);(1,1)((R_2-C_2)/(S+C_1), (L_1-L_2)/(L_3-L_2))$ into the Jacobian matrix, find the $\det(J)$ and $\text{tr}(J)$ of the corresponding matrix as shown in the table 7.

platform reputation brought about by active supervision is approximately 600 million.

Table 8. Local equilibrium point stability analysis under initial parameters

Equilibrium point	Det(J)	tr(J)	Stability Analysis
(0,0)	+	-	ESS
(0,1)	+	-	Instability
(1,0)	+	-	Instability
(1,1)	+	-	ESS
(0.476,0.49)	-	0	Saddle point

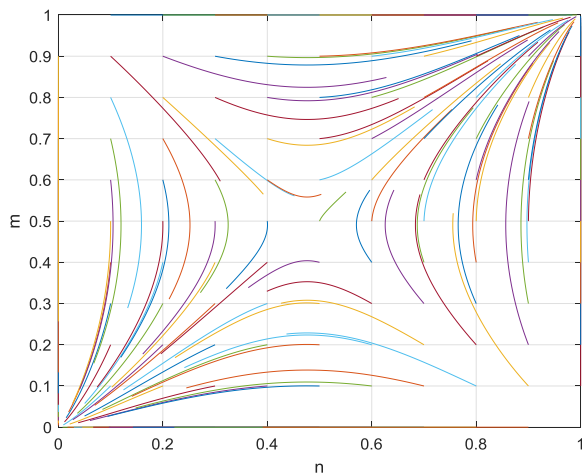
The game process and simulation of the live broadcast platform and the host with goods is as follows. According to the above data, the dynamic replication equation of the live broadcast platform can be obtained as $F(n)$, with anchor's copy dynamic equation $F(m)$.

$$F(n) = n(1-n)(L_2 - L_1 - mL_2 + L_3) = n(1-n)(5.38m - 2.46) \quad (10)$$

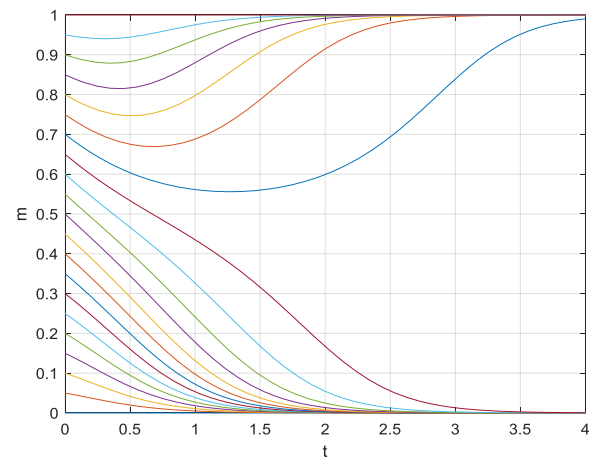
$$F(m) = m(1-m)(nS - R_2 + C_2 + nC_1) = m(1-m)(6.846n - 3.26)$$

Input the above parameters and equations into matlab for simulation to get Fig. 2a to d. The Fig. 2a shows that when the initial value of m and n is 0 and the loop step is set to 0.1, the dynamic evolution path of the game between the live broadcast platform and the host group is obtained as shown in Fig. 2a. At the same time, set the probability n when the live broadcast platform chooses active supervision to be 0.3, 0.5, and 0.7 respectively. Observe the evolution equilibrium trend of the anchor group, and obtain the evolution path as shown in Fig. 2b, Fig.2c and Fig. 2d.

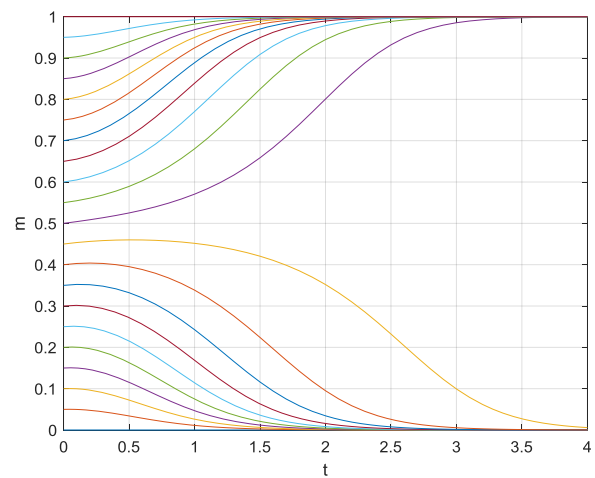
In Fig. 2a, it is not difficult to see that in the upper right area of the saddle point (0.476, 0.49), all paths evolve toward (1, 1) (active supervision, standard live broadcast), and on the lower left side of the saddle point, all paths are toward (0, 0) (negative Supervision, live broadcast against discipline) evolution. In Fig. 2b, when the probability that the live broadcast platform chooses active supervision is 0.3, only if more than 70% of the anchors choose standard live broadcast, the system will evolve towards (1, 1) (active supervision, standard live broadcast). In Fig. 2c, when the probability that the live broadcast platform chooses active supervision is 0.5, as long as half of the anchors choose to standardize the live broadcast system, they can evolve toward the optimal path. In Fig. 2d, the probability that the live broadcast platform chooses active supervision is 0.7. At this time, as long as more than 25% of the anchors are willing to regulate the live broadcast, the system can evolve toward the optimal path. It is not difficult to see that under the current level of parameters, the active supervision of the live broadcast platform has a more obvious impact on whether the live broadcast of the anchor group is regulated.



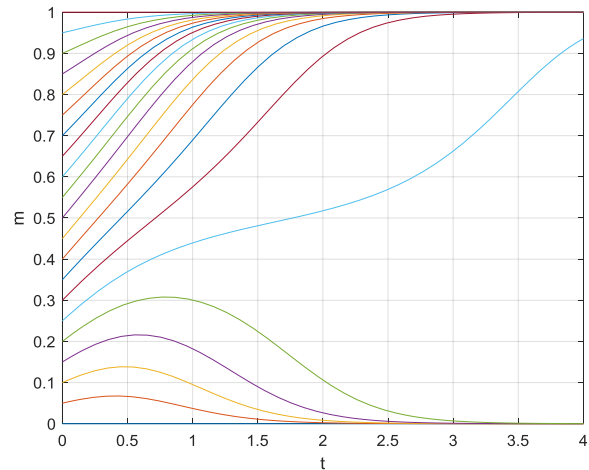
a) The dynamic evolution process of both parties



b) The evolution process of anchor group strategy(m=0.3)



c) The evolution process of anchor group strategy (m=0.5)



d) The evolution process of anchor group strategy (m=0.7)

Fig.2 The simulation of the evolutionary game between the anchor and the live broadcast platform

IV. CONCLUSION AND COUNTERMEASURES

In the simulation futures, live broadcast sales will still play a pivotal role in people's lives. The development of e-commerce is based on the establishment of a trust

mechanism between merchants and consumers. To break through the development bottleneck of live broadcast delivery, credit is still the key. The solution of credit problems cannot only rely on moral constraints, but more importantly, rules and regulations. Based on the above analysis, we mainly propose countermeasures and suggestions for the long-term and sustainable development of live streaming in the future from the perspectives of anchors, consumers, and live broadcast platforms.

At present, live broadcast sales are still an emerging industry, and the threshold to be an anchor is low, and there are not many anchors with strong professional capabilities. Therefore, if the anchor wants to increase his income and at the same time make the market reach the Pareto optimal state, what he needs most is to improve his professional knowledge and morality. Due to the low threshold of being an anchor, every anchor is faced with fierce competition. In order to stand out from the many anchors, it depends on professionalism and integrity. For example, Li Jiaqi and Wei Ya did not have such a strong ability to sale goods from the beginning. It is precisely because they continue to improve their professional capabilities and the credibility of real live broadcasts gradually accumulates, and they eventually become major anchors with higher influence and social status.

Consumers need to continuously improve their ability to distinguish. The quality of live broadcast products is uneven, and all kinds of counterfeit and inferior products cannot be prevented. As consumers, we should not pay for these products. Actively report to relevant departments and complain to the platform to reduce the chance of others being deceived. The supervision of anchors is not the responsibility of the platform. As a direct beneficiary of live broadcasts, they can make full use of the dissemination effect of the network information platform, let the market play a role, and increase credit damage caused by false live broadcasts.

It is pretty sure that with the positive development prospects of live broadcast sales, if we want to achieve long-term and healthy development, we cannot always proceed with preferential and low-cost strategies. Instead, we must balance the interests of the platform, anchors, and consumers to achieve the benefits of participants. "Positive Sum Game". As a bridge connecting anchors and consumers, the platform is an important part of the cargo-carrying economy and bears huge supervision responsibilities. First of all, the platform must raise the threshold for anchors to settle in, and set periodic assessment standards for anchors. Through the evolutionary game analysis between the live broadcast platform and the host, it is not difficult to see that the fines and rewards imposed on the host during the active supervision of the platform are important factors that determine the evolution direction of the game system. Therefore, in addition to setting up corresponding rules and regulations, the platform should also appropriately increase rewards for excellent real-selling anchors and punishments for fake live broadcasts, so as to increase the real live broadcast revenue and the cost of fake live broadcasts from

the perspective of the platform. The standard to distinguish between true and false can be achieved through consumer reviews or complaints and the results of periodic assessments, so that consumers are also included in the regulatory system.

V. ACKNOWLEDGEMENTS

This work is supported by National Social Science Foundation (Project No. 19CMZ032), Young Innovative Talents of Harbin University of Commerce (Project No. 019CX49).

REFERENCES

- [1] Mao Wenjuan; Chen Yuelan. Evolutionary Game Analysis of Platform Social Responsibility Governance from the Perspective of Incentive Mechanism. *Business Research*. 2020 (09): 77-87
- [2] Yu Desheng; Li Xing. Research on the Dynamic Evolutionary Game of Consumers and Merchants' Big Data "Clearing". *Price Theory and Practice*. 2019 (11): 131-134
- [3] Bao Lijiang; Zhong Weijun; Mei Shu'e. The impact of order-swiping behavior in e-commerce platforms on competition among merchants. *System Engineering Theory and Practice*: 1-24
- [4] Chen Ting; Hou Wenhua; Zhang Xinxin. Product positioning decision of competitive enterprises under the rebate promotion model. *Soft Science*. 2019 (12): 76-83
- [5] Zhong Dan. Research on the Communication Strategy of Web Live Platforms from the Perspective of Scene Theory. *Hubei University*. 2018 (02)
- [6] Yang Yali. Analysis of anchor action strategies in live webcast from the field of vision. *Sichuan Academy of Social Sciences*. 2019 (12)
- [7] Zheng Hong'e. Live Broadcasting: "Commodity Aesthetics Education" under the Eyeball Economy. *People's Forum*. 2020 (18): 60-62
- [8] Zhao Ruohan. Analysis on the Marketing Value of Live Broadcasting. *Commercial News*. 2020 (32): 34-35
- [9] Zhao Li; Zhang Ling; Shen Yujie; Yang Tao; Zhang Zhongxiao. Interactive analysis of live delivery behavior based on evolutionary game model. *Modern Marketing (Business Edition)*. 2020(09): 138-139
- [10] Shen Baogang. Analysis of the business model of live streaming and delivery of goods and its standardized development. *Theory Monthly*. 2020 (10): 60-67
- [11] Niu Yanxiao; Song Shenglei. Exploring the business model of online celebrity live streaming. *China Agricultural Accounting*. 2020 (05): 32-33
- [12] Li Yabing, Zhang Jiarui. The evolutionary game of webcasting governance strategies—Based on the perspective of stakeholders [J]. *Economics and Management*. 2020(02): 25-31
- [13] Zhang Li; Wang Xiangxiang; Li Jiaxin. The dynamic evolutionary game of the credit mechanism among core populations in the e-commerce ecosystem. *Operations Research and Management*. 2020 (04): 97-105
- [14] Guo Yiming. Research on the evolutionary game of shared bicycle stakeholders. *Lanzhou University of Finance and Economics*. 2019 (08)
- [15] Tian Yingdong; Yang Wensheng; Wang Yameng; Li Juan. Research on the Evolutionary Game of Decision-making Behavior of Participants in the Electronic Coupon Marketing Market. *Soft Science*. 2020 (08): 128-137
- [16] Christopher Allen Pramono, Adler Haymans Manurung, Pantri Heriyati, Wibowo Kosasih, "Analysis of The Influence of Entrepreneurship Capability, Agility, Business Transformation, Opportunity on Start-Up Behavior In E-Commerce Companies In Indonesia During The Covid 19 Pandemic". *WSEAS Transactions on Business and Economics*, vol. 18, pp. 1103-1112, 2021
- [17] Suyan Zhang, Wei Zhao, An Income Distribution Method for Stakeholders of Modern Apprenticeship based on Game Theory, *WSEAS Transactions on Circuits and Systems*, ISSN / E-ISSN: 1109-2734 / 2224-266X, Volume 19, 2020, Art. #33, pp. 305-310

**Creative Commons Attribution License 4.0
(Attribution 4.0 International, CC BY 4.0)**

This article is published under the terms of the Creative Commons Attribution License 4.0
https://creativecommons.org/licenses/by/4.0/deed.en_US