Retraction

Retracted: The Influence of the Network Evolutionary Game Model of User Information Behavior on Enterprise Innovation Product Promotion Based on Mobile Social Network Marketing Perspective

Mathematical Problems in Engineering

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] T. Liu, X. He, X. Guo, and Y. Zhao, "The Influence of the Network Evolutionary Game Model of User Information Behavior on Enterprise Innovation Product Promotion Based on Mobile Social Network Marketing Perspective," *Mathematical Problems in Engineering*, vol. 2022, Article ID 1416488, 12 pages, 2022.

Research Article

The Influence of the Network Evolutionary Game Model of User Information Behavior on Enterprise Innovation Product Promotion Based on Mobile Social Network Marketing Perspective

Tingting Liu ,[1] Xiaofei He ,[2] Xin Guo ,[1] and Yi Zhao [2]

[1]*School of International Trade and Economics, Shanghai Lixin University of Accounting and Finance, Shanghai 200030, China*
[2]*School of Management, Shanghai University of Engineering Science, Shanghai 201620, China*

Correspondence should be addressed to Xiaofei He; m030120514@sues.edu.cn

User information behavior is an important factor affecting the promotion effect of enterprises' innovative products on mobile social networks. To provide insights as to how enterprises can better promote innovative products, this paper conducts a quantitative study of its internal function. We introduce a network evolutionary game model based on the Bass model, first to describe the background of the mobile social network, then to simulate the diffusion process of the social network and the user's decision-making game behavior during promotion of enterprises' innovative products, and finally to simulate the promotion effect on innovative products and solve for the conditions for the best innovative product marketing effect and the model are simulated from multiple angles. Our simulation results show that mobile social network marketing in the initial stage of product promotion has a significant impact on the promotion effect of innovative products. When user feedback is poor, advertisement diffusion has an obvious effect on product promotion. In mobile social networks, the proportion of positive feedback from users has a greater impact on the product promotion effect, while the proportion of negative feedback has a smaller impact on the product promotion effect. The impact of negative reviews is time sensitive. According to the simulation results, we propose several suggestions to improve the promotion effect of enterprises' innovative products on mobile social networks.

1. Introduction

According to the 48th Statistical Report on Internet Development in China, the total number of Internet users in China reached 1.01 billion in June 2021, and mobile social networks such as Weibo and WeChat are becoming the main platforms through which the public spreads information and shares resources. The multiple attributes that allow mobile social networks to spread information and share resources has brought public attention to mobile social network marketing. Therefore, product marketing using mobile social networks triggers the participation of many users and provides the public with multiple dimensions for evaluating related products. The dissemination and influence of mobile social networks have gradually increased, and mobile social

network platforms have gradually become the earliest accepted platforms for emerging things, so using mobile social networks to publicize innovative products has gradually become more mainstream. User information behavior has a significant impact on the promotion effect of enterprises' innovative products [1]. User information behavior in mobile social networks mainly includes information acquisition, creation, interaction, and utilization. The public will comment or provide positive feedback on innovative products promoted by enterprises, and other users will learn from these reactions and change their attitude towards the products, which affects the promotion and marketing effect [1]. Under the influence of a strong network, user-generated content, especially negative content, will have a negative impact on innovative products and even on the innovation

of enterprises [2–4]. Therefore, there is a need to study the relevant mechanisms of user information behavior and their effect on enterprise innovative product promotion, as well as to identify the influence of changes in user information behavior on enterprise product promotion and product innovation promotion [5–8].

In recent years, the influence of economic globalization has continued to increase, China's economic development has accelerated, market competition has grown stronger, and companies have introduced new products to increase innovation and research and development. In the face of fierce market competition, enterprises must effectively promote their innovative products in order to convert them into economic benefits. At a time when mobile social networks have become the main force of advertising communication, the trend of public opinion on innovative products expressed on mobile social networks will have a significant impact on product promotion. Therefore, it is extremely important for enterprises to understand how to address public opinion or negative feedback on mobile social networks, as well as how to promote innovative products more effectively on mobile social network platforms and convert them into economic benefits.

In order to further study the influence of user information behavior on the promotion effect of enterprises' innovative products, it is necessary to simulate different user information behaviors using control variable methods. Existing studies mostly focus on the impact of negative user information behavior on enterprise product promotion: the number [3], intensity [2], and release time [9] of negative comments all affect users' purchase intentions. Negative evaluations will also change the emotional utility of users and thus change their information behavior, which will have a negative impact on the effect of product promotion [10–12] and increase the negative impact of product promotion. From the perspective of user information behavior, users' willingness to share will also have an impact on the product promotion effect of enterprises. Sharing advertising information helps to strengthen communication and contact; moreover, users can get satisfaction from such sharing, thereby generating positive feedback and enhancing the product promotion effect [13]. In summary, we assume that user information behavior will be found to have different degrees of influence on the promotion effect of enterprises' innovative products when considered from multiple perspectives.

From the perspective of research methods, most existing studies have considered the promotion effect of innovative products by selecting a single variable of user information behavior, such as comments' sentiment polarity [14], users share for [15–17], or mobile social network use time [18–20]. There are few studies on the synergistic effect of multiple user information behaviors on the product promotion effect. In addition, most existing studies use questionnaire surveys, qualitative studies, or case studies. Quantitative analysis of scientific systems is relatively lacking; its complex evolutionary process has not been well-depicted and -described, so it is difficult for corporate marketing planners to evaluate the effect of social advertising and take corresponding

measures. At the same time, some scholars used evolutionary game model to describe the complex evolutionary system of abandoned medical supply chain [21] and green supply chain [22] under the condition of decision-maker's bounded rationality and provided some enlightenment. Based on the above discussion, this paper establishes a Bass model-based network evolutionary game model that is suitable for examining the promotion and diffusion characteristics of enterprises' innovative products under the influence of user information behaviors. This paper also simulates the influence of different user information behaviors on the promotion of enterprises' innovative products against the background of mobile social networks, as well as conducting simulation analysis. Using a formula to describe the promotion effect, this paper conducts a quantitative study of how user information behavior affects the promotion effect of enterprises' innovative products. In this way, we are able to provide strategic suggestions for the marketing of innovative products and for improving enterprises' reputation. These suggestions are made with reference to the diffusion effect of innovative products and can be used to convert innovative products into economic benefits to promote the innovation and development of enterprises.

2. Model Construction: The Influence of User Information Behavior on the Promotion Effect of Enterprises' Innovative Products

2.1. User Information Behavior in the Promotion of Innovative Products of Enterprises. User information behavior refers to mobile social network users' information acquisition, creation, interaction, and utilization via mobile social networks. Mobile social networks are used as a medium for promoting enterprises' innovative products. The generation of user information behavior in the promotion of mobile social networks is a result of the mutual influence and interaction of many individual users, which is called "group behavior" in this context. According to group dynamics, group behavior will be affected by environmental changes and group member behavior changes. The formation of group behavior is a game process and is affected by the psychological state and motivation of group members. Group members will compare their own behaviors with group behaviors and update their own strategies accordingly [23].

When mobile social networks promote enterprises' innovative products, users' positive actions and comments will make enterprises' innovative products seem more favorable to other users. However, unanimous praise can generate doubts and resistance among users, as this seems inconsistent with reality [24, 25]. Therefore, negative comments are typical on most social platforms. In the face of both positive and negative comments, users will form a game in their hearts. At this time, users will seek more information to determine their final decision scheme and create information connections with other users around them [26]. The users' final behavioral decision is formed by considering the information offered by one or more users; under the

influence of these users, they may subsequently update their own policy according to the information update obtained. Users will then comment or take positive action according to a certain probability, which will affect the subsequent information behavior of other users. For example, it affects the number of likes and positive and negative comments in the advertisements of enterprise innovative products in mobile social networks, which in turn affects the promotion effect of mobile social networks. The formation process of group behavior under mobile social network promotion advertising influences the impact of user information behavior on the mobile social network promotion effect. If users are regarded as different nodes and the influence of information behavior between users is regarded as the line connecting these nodes, then network evolutionary game theory can fully examine the influence of surrounding nodes on the central node. Based on the above discussion, this paper builds a network evolutionary game model to describe the impact of user information behavior on enterprise innovative product promotion from the perspective of mobile social network marketing.

2.2. Theoretical Basis of a Network Evolutionary Game.
The essential elements of a network evolutionary game are the participants, the strategies adopted by each participant, the benefit functions of the participants, and the strategy renewal rules of the participants' actions. The factors affecting population change have a certain degree of randomness and a disturbance phenomenon. A network evolutionary game entails a process of studying the constant changes among different strategies in a network structure. Ohtsuki et al. [27] studied three different updating rules for the replication dynamic equations in the network evolutionary game: BD updating, DB updating, and IM updating mechanisms. The BD updating mechanism involves selecting an individual in an appropriate proportion in the network, so that the individual's offspring replaces its random neighbor nodes. The DB updating mechanism involves randomly selecting a dead individual in the network, after which the neighbor nodes of the dead individual compete for the vacant node, replacing the individual according to the appropriate proportion. The IM updating mechanism selected in this paper involves randomly selecting an individual in the network to update its strategy. It can choose to maintain its current strategy or imitate a neighbor's strategy with proportionality, which is in line with the formation process of group behavior in mobile social network advertising. An $n * n$ matrix $B = [b_{ij}]$, Matrix B, can be created for the above three updating mechanisms as follows:

$$BD: b_{ij} = \frac{a_{ii} + a_{ij} - a_{ji} - a_{jj}}{k - 2},$$

$$DB: b_{ij} = \frac{(k+1)a_{ii} + a_{ij} - a_{ji} - (k+1)a_{jj}}{(k+1)(k-2)}, \quad (1)$$

$$IM: b_{ij} = \frac{(k+3)a_{ii} + 3a_{ij} - 3a_{ji} - (k+3)a_{jj}}{(k+3)(k-2)}.$$

Set $g_i = \sum_{j=1}^{n} x_j a_{ij}$ represents the local competition between different strategies, $f_i = \sum_{j=1}^{n} x_j a_{ij}$ represents the

average fitness of strategies i, which is derived from the interaction of all strategies in the whole network, and $\sum_{i=1}^{n} x_i g_i = 0$.

Set $x_i(t)$ as the expected ratio of strategy i at time t and degree k, and the replication dynamic equation in the network is

$$\frac{dx_i}{dt} = x_i(f_i + g_i - \phi), i = 1, 2, \ldots, n. \quad (2)$$

The average fitness in the network is

$$\phi = \sum_{i=1}^{n} x_i(f_i + g_i) = \sum_{i=1}^{n} x_i g_i = \sum_{i,j=1}^{n} a_{ij} x_i x_j. \quad (3)$$

Then, substitute f_i, g_i, ϕ into (2) to obtain

$$\frac{dx_i}{dt} = x_i \left[\sum_{j=1}^{n} x_j(a_{ij} + b_{ij}) - \phi \right], i = 1, 2, \ldots, n, \quad (4)$$

where a_{ij} is the payoff of strategy i versus strategy j. Therefore, the complete graph in evolutionary game dynamics is transformed into a regular graph with degree k, and the corresponding return matrix becomes $[a_{ij}] \longrightarrow [a_{ij} + b_{ij}]$.

2.3. Establishment of the Network Evolutionary Game Model.
Product innovation is a source of enterprise competitiveness, and the promotion of innovative products is an important step to establishing a company's reputation. According to the theory of innovation diffusion, the distribution of a product's diffusion velocity over time when enterprises promote their innovative products on mobile social network platforms is consistent with the normal distribution. At the early stage of diffusion, the diffusion rate is very slow. When the number of adopters expands to between roughly 10% and 25% of the residents, the diffusion rate will accelerate suddenly, and both the diffusion rate and the number of adopters will increase rapidly, a trend that will be maintained in the future. Progress slows as the number of adopters approaches the saturation point. The change process of the number of innovative product adopters over time is similar to an S-shaped curve. According to the diffusion theory of innovation and the Bass model, early adopters act as "lobbyists" to encourage opinion leaders to accept innovative products. The Bass model divides the crowd into the potential consumer group and the actual consumer group, and the purchasing decision of the innovation group is independent of those of other members of the social system. The time at which the imitation group buys new products is affected by the social system [28–32], so the innovation group plays a significant role in enterprise promotion. Therefore, enterprises should fully consider the role of initial adopters when promoting relevant innovative products [33–35]. Thus, the Bass model is added in the establishment of the product promotion model according to the "innovative" characteristics of enterprises' innovative products, which fully considers the diffusion characteristics of innovative products.

When innovative products are advertised via a mobile social network, positive feedback and negative feedback will be

generated from users [36–38]. Because advertising itself is time sensitive and users are constantly changing, the Bass model describes the dynamic proportion of positive-feedback and negative-feedback users. In this paper, the potential consumer group and actual consumer group in the Bass model are regarded as the group that provides positive feedback to the advertisement, and the remaining users are regarded as the group that provides negative feedback to the promotion advertisement. The Bass model entails an innovation effect and an imitation effect. The innovation effect refers to the positive emotions spontaneously generated from mass media, and in this the innovation population generated by the innovation index of the advertisement is made up of the initial adopters following the promotion of innovative products. The imitation effect refers to the positive emotions generated by individuals who are influenced by users that express positive emotions, namely, consumers who are influenced by initial adopters to accept new products after the promotion of innovative products. The basic formula of the Bass model is as follows:

$$\frac{dN(t)}{dt} = p[m - N(t)] + q\frac{N(t)}{m}[m - N(t)]. \quad (5)$$

Here, $N(t) = mF(t)$, where $N(t)$ represents the number of users who have positive feedback on product promotion. $p[m - N(t)]$ in the formula represents users who provide positive feedback on the product promotion; that is, the users who become innovative product adopters. $qN(t)/m[m - N(t)]$ represents users who generate positive feedback under the influence of other users. In the formula, p represents the innovation coefficient, q represents the imitation coefficient, and p, q range from $[0,1]$. $F(t)$ represents the cumulative proportion of users who give positive feedback on the product's promotion, and $f(t)$ is the proportion of users who generate positive feedback on the product's promotion. $F(t)$ and $f(t)$ can be obtained by solving the differential equations as follows:

$$F(t) = \frac{1 - e^{-(p+q)t}}{1 + (q/p)e^{-(p+q)t}},$$

$$f(t) = \frac{(p+q)^2 e^{-(p+q)t}}{p\left[1 + (q/p)e^{-(p+q)t}\right]^2}. \quad (6)$$

Here, $\overline{F} = 1 - F$ is defined as the proportion of users that have a negative impact on product promotion.

In this paper, the proportion of positive feedback generated from variable advertisement communication is briefly denoted as APF, and the proportion of negative feedback generated from advertisement communication is abbreviated as ANPF. Based on the above Bass model, the expressions of APF and ANPF can be obtained as APF = $F(t)$, ANPF = $\overline{F(t)} = 1 - F(t)$.

When users come into contact with advertisements for innovative products on mobile social networks, they usually choose one of three strategies: favoring, disliking, or ignoring the advertisement. When the advertisement is favorable to the user, the user's information behavior may include giving a "thumbs up" to it, or leaving positive comments. When users feel negatively about the advertisement, the user's information behavior may include commenting on the negative content and

Table 1: Variables impacting the effect of innovative product promotions on mobile social networks.

Variable	Meaning
Likes number (LN)	Percentage of users who like an ad
Advertisement positive feedback (APF)	Proportion of positive feedback groups in advertising communication
Advertisement nonpositive feedback (ANPF)	Proportion of nonpositive feedback groups in advertising communication
Ratio of positive reviews (RPR)	Proportion of positive sentiment in online comments
Ratio of negative reviews (RNR)	Proportion of negative sentiment in online comments
Possibility of ignoring the advertisement (PI)	Likelihood that users ignore the ad

giving negative feedback to the advertisement itself. When the user ignores the advertisement, they take no action other than ignoring it entirely. Based on the above reasoning, variables impacting the effect of innovative product promotions on mobile social networks are identified, as shown in Table 1.

The parameters in the income matrix are simplified into three variables as follows:

$$V_P = \text{APF} + \text{LN} + \text{RPR},$$
$$V_R = \text{ANPF} + \text{RNR}, \quad (7)$$
$$V_I = \text{PI}.$$

Then, the payoff matrix of the network evolutionary game model can be obtained as follows:

$$\begin{array}{cc}
 & \begin{array}{ccc} P & R & I \end{array} \\
\begin{array}{c} P \\ R \\ I \end{array} & \begin{pmatrix} 0 & a_{12} & a_{13} \\ a_{21} & 0 & a_{23} \\ 0 & 0 & 0 \end{pmatrix}
\end{array} \quad (8)$$

Therefore,

$$a_{12} = \frac{V_P - V_R}{3},$$

$$a_{21} = \frac{V_R - V_P}{3}$$

$$a_{13} = \frac{V_P - V_I}{3}, \quad (9)$$

$$a_{23} = \frac{V_R - V_I}{3},$$

where a_{ij} represents the probability that the user who chooses strategy i will persuade the user who originally chose strategy j to choose strategy i, which can be identified from the above equation $a_{ij} = -a_{ji}$. Users who generate positive or negative feedback will not be persuaded to adopt the "ignore" attribute, and users who adopt the "ignore" strategy will only be persuaded to adopt a positive or a negative feedback strategy. In addition, users who adopt the same

strategy do not need to convince each other, so the diagonals of the revenue matrix are all 0. Finally, the data in the matrix have been standardized in this paper, and their absolute value is [0, 1].

3. Solution to, and Analysis of, the Network Evolutionary Game Model

3.1. Solving the Evolutionary Game Model. There should be no deleted nodes in the entire network of the mobile social network's advertising users, so the IM model is applied, and the formula is as follows:

$$B = \begin{pmatrix} 0 & \dfrac{6a_{12}}{(k+3)(k-2)} & \dfrac{3a_{13}}{(k+3)(k-2)} \\ \dfrac{6a_{21}}{(k+3)(k-2)} & 0 & \dfrac{3a_{23}}{(k+3)(k-2)} \\ \dfrac{-3a_{13}}{(k+3)(k-2)} & \dfrac{-3a_{23}}{(k+3)(k-2)} & 0 \end{pmatrix}. \quad (10)$$

The average fitness of the whole population is expressed as follows:

$$\phi = x_1 x_3 a_{13} + x_2 x_3 a_{23}. \quad (11)$$

According to the dynamic equation of network replication, the positive feedback, negative feedback, and replication dynamic equation for ignoring three behaviors of the promotion advertisement can be obtained as follows:

$$\begin{cases} \dfrac{dx_1}{dt} = x_1 \left[\dfrac{k^2+k}{(k+3)(k-2)} x_2 a_{12} + \dfrac{k^2+k-3}{(k+3)(k-2)} x_3 a_{13} - x_1 x_3 a_{13} - x_2 x_3 a_{23} \right], \\ \dfrac{dx_2}{dt} = x_2 \left[\dfrac{k^2+k}{(k+3)(k-2)} x_1 a_{21} + \dfrac{k^2+k-3}{(k+3)(k-2)} x_3 a_{23} - x_1 x_3 a_{13} - x_2 x_3 a_{23} \right], \\ \dfrac{dx_3}{dt} = x_3 \left[-\dfrac{3}{(k+3)(k-2)} x_1 a_{13} - \dfrac{3}{(k+3)(k-2)} x_2 a_{23} - x_1 x_3 a_{13} - x_2 x_3 a_{23} \right]. \end{cases} \quad (12)$$

3.2. Stability Analysis of the Game Model. The revenue matrix after transformation is as follows:

$$[a_{ij} + b_{ij}] = \begin{pmatrix} 0 & a_{12} + \dfrac{6a_{12}}{(k+3)(k-2)} & a_{13} + \dfrac{3a_{13}}{(k+3)(k-2)} \\ a_{21} + \dfrac{6a_{21}}{(k+3)(k-2)} & 0 & a_{23} + \dfrac{3a_{23}}{(k+3)(k-2)} \\ \dfrac{-3a_{13}}{(k+3)(k-2)} & \dfrac{-3a_{23}}{(k+3)(k-2)} & 0 \end{pmatrix}, \quad (13)$$

$$P_P = x_2 \left[a_{12} + \dfrac{6a_{12}}{(k+3)(k-2)} \right] + x_3 \left[a_{13} + \dfrac{3a_{13}}{(k+3)(k-2)} \right]$$

$$P_R = x_1 \left[a_{21} + \dfrac{6a_{21}}{(k+3)(k-2)} \right] + x_3 \left[a_{23} + \dfrac{3a_{23}}{(k+3)(k-2)} \right]$$

$$P_I = x_1 \left[\dfrac{-3a_{13}}{(k+3)(k-2)} \right] + x_2 \left[\dfrac{-3a_{23}}{(k+3)(k-2)} \right].$$

To achieve the best effect of advertising promotion, $P_P > P_R, P_P > P_I$ should be satisfied at the same time. The following is the income analysis of the two cases.

Case 1. $P_P > P_R$; that is, when promoting innovative products, the revenue generated by users who give positive

feedback on advertisements is greater than that generated by users who give negative feedback. Moreover, supposing $x_2 = \varepsilon_1, x_3 = \varepsilon_2, x_1 = 1 - \varepsilon_1 - \varepsilon_2$, this formula can be simplified as $\varepsilon_1 = \varepsilon_2 = \varepsilon, x_1 = x_3 = \varepsilon, x_2 = 1 - 2\varepsilon$.

$$\varepsilon\left[a_{12} + \frac{6a_{12}}{(k+3)(k-2)} + a_{13} + \frac{3a_{13}}{(k+3)(k-2)} - a_{23} - \frac{3a_{23}}{(k+3)(k-2)}\right] - (1-2\varepsilon)\left[a_{21} + \frac{6a_{21}}{(k+3)(k-2)}\right] > 0, \varepsilon \longrightarrow 0. \quad (14)$$

If the above formula is true, it is satisfied by $a_{21} + 6a_{21}/(k+3)(k-2) < 0$. If $a_{12} > 0$, then

$$V_P - V_R = \text{APF} + \text{LN} + \text{RPR} - \text{ANPF} - \text{RNR} > 0,$$
$$\text{APF} + \text{LN} + \text{RPR} > \text{ANPF} + \text{RNR}.$$
$$(15)$$

If $a_{21} + 6a_{21}/(k+3)(k-2) = 0$, the following formula shall be satisfied:

$$a_{12} + \frac{6a_{12}}{(k+3)(k-2)} + a_{13} + \frac{3a_{13}}{(k+3)(k-2)} - a_{23} - \frac{3a_{23}}{(k+3)(k-2)} > 0$$
$$\Rightarrow (\text{APF} + \text{LN} + \text{RPR})\left(2k^2 + 2k - 3\right) > (\text{ANPF} + \text{RNR})\left(2k^2 + 2k - 3\right) + \text{PI} \quad (16)$$
$$\Rightarrow \text{PI} < 0.$$

However, $PI \geq 0$, so the above inequality is not true.

Case 2. $P_P > P_I$, that is, when the enterprise promotes innovative products, the revenue generated by satisfying users

who express negative reactions to the advertisement is greater than the revenue generated by satisfying users who ignore the advertisement. We still assume that $x_2 = \varepsilon_1$, $x_3 = \varepsilon_2, x_1 = 1 - \varepsilon_1 - \varepsilon_2$.

$$\varepsilon\left(a_{12} + \frac{6a_{12}}{(k+3)(k-2)} + a_{13} + \frac{3a_{13}}{(k+3)(k-2)} + \frac{3a_{23}}{(k+3)(k-2)}\right) - (1-2\varepsilon)\left(\frac{-3a_{13}}{(k+3)(k-2)}\right) > 0, \varepsilon \longrightarrow 0. \quad (17)$$

If the above formula is true, then $3a_{13}/(k+3)(k-2) > 0, a_{13} > 0$ must be satisfied. Then, the following formula shall be satisfied:

$$V_P - V_I = \text{APF} + \text{LN} + \text{RPR} - \text{PI} > 0,$$
$$\text{APF} + \text{LN} + \text{RPR} > \text{PI}.$$
$$(18)$$

If $3a_{13}/(k+3)(k-2) = 0$, then the following formula must be satisfied:

$$a_{12} + \frac{6a_{12}}{(k+3)(k-2)} + a_{13} + \frac{3a_{13}}{(k+3)(k-2)} + \frac{3a_{23}}{(k+3)(k-2)} > 0. \quad (19)$$

After reduction, the formula is as follows:

$$\left(2k^2 + 2k - 3\right)(\text{APF} + \text{LN} + \text{RPR}) > \left(k^2 + k - 3\right)(ANPF + RNR)$$
$$+ \left(k^2 + k\right)\text{PI}$$
$$\Rightarrow \text{APF} + \text{LN} + \text{RPR} > \text{ANPF} + \text{RNR}.$$
$$(20)$$

Based on the above three situations, we can get the best conditions for promoting and disseminating innovative products when

$$''\text{APF} + \text{LN} + \text{RPR} > \text{ANPF} + \text{RNR}'' \text{ and}$$
$$''\text{AAPF} + \text{LN} + \text{RPR} > PI \text{ or}$$
$$\text{APF} + \text{LN} + \text{RPR} = \text{PI and APF} + \text{LN} + \text{RPR} > \text{ANPF} + \text{RNR}''.$$
$$(21)$$

4. Simulation Results and Analysis

According to the constraint conditions, replication dynamic equation, and Bass model outlined in the previous section, in order to further simulate the influence of user information behavior on the promotion effect of innovative products of enterprises in mobile social networks, as well as to intuitively identify the influence of various parameter changes on the promotion effect, the revenue matrix parameters should be set as $k = 3, p = 0.4, q = 0.8, \mathrm{LN} = 0.3, \mathrm{RPR} = 0.3, \mathrm{RNR} = 0.3, \mathrm{PI} = 0.6$. Additionally, the initial policy proportions of the three kinds of user information behaviors are, respectively, $P = 0.25, R = 0.15, I = 0.6$. According to the replication dynamic model (17), MATLAB tools are used to simulate the changing trends of user information behaviors for giving positive feedback, giving negative feedback, and ignoring the advertisement, as shown in Figure 1.

Through the test, the set initial value satisfies the constraint condition, and the promotion effect achieves the best state. As can be seen in Figure 1, as time goes on, users who give positive feedback on promotion advertisements in mobile social networks continue to increase and reach the optimal state when they are stable. Conversely, the proportion of users who ignore the advertisement or generate negative feedback declines and stabilizes at 0 over time. In order to further study the influence of each parameter of the revenue matrix on the promotion effect of enterprises' innovative products, MATLAB is used to simulate the change assignment of each parameter. Under the condition that the linkage reaction satisfies the constraint conditions without considering parameters, we observe the influence of the simulation results of each group on the promotion effect.

When measuring the advertising promotion effect on mobile social networks, the number of positive feedback comments on advertisements is N_P, the number of negative feedback comments is N_R, and the total number of users is N. The product promotion effect index (PPEI) is introduced as follows:

$$\mathrm{PPEI} = \frac{N_P - N_R}{N}. \tag{22}$$

4.1. Influence of the Initial Diffusion of Enterprises' Innovative Products on the Promotion Effect. We change the values in the Bass model when other parameter values remain unchanged and show the simulation results in Figure 2. The results reveal that the higher the value of the innovation effect coefficient and imitation effect coefficient, the stronger the advertising effect of the innovation product promotion and the sooner it reaches a stable value. However, when p and q reach a certain threshold, they have little positive impact on the promotion effect. When the innovation effect is very low but the imitation effect is high, the positive effect of advertising will reach the optimal state and become stable. Figure 3 shows that the advertisement itself then spreads faster, and when the t value reaches 5, the advertisement spread reaches a stable value. As shown in Figure 2, in the case of setting $p = 0.4$, $q = 0.8$, when the t value reaches 30, the advertising diffusion will reach a stable level. Therefore, the advertising itself plays a significant role in the effect of
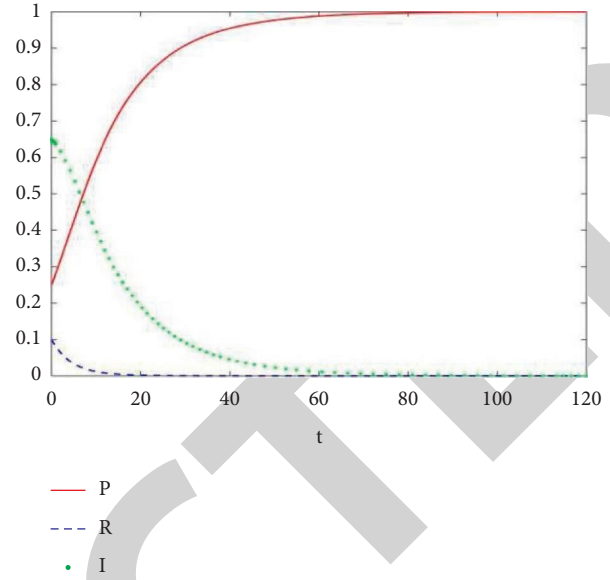

Figure 1: Variation trend of different information strategy selection ratio.

mobile social network advertising in the early stage, whereas it has little effect in the later stage. We find that enterprises must plan advertising effectively in the early stage of product promotion to improve the innovative effect of advertising, as this will expand the scope of the enterprises' innovative products and develop a better reputation for the innovative products. We also find that the initial advertising planning of product promotion plays an important role in the effect of product promotion, as shown in Figures 2 and 3.

4.2. Influence of the Number of Likes on the Promotion Effect. When other parameters remain unchanged, changing the value of the proportion of likes (LN) that users give to mobile social network advertisements will influence the effect of advertisement promotion, as shown in Figure 4. The figure shows that in extreme cases, such as when the proportion of likes is extremely low (for example, LN = 0), keeping other parameters unchanged will cause a short-term decrease in the advertising effect, and the promotion effect will reach the optimal value and become stable. The value of the time will be extended accordingly, but the diffusion effect will ultimately remain optimally stable. Furthermore, by varying the LN values, we find that the higher the number of likes for advertisements on a mobile social network platform, the better the effect of product promotion.

4.3. Influence of the Proportion of Emotional Polarity of Product Promotion Advertising Comments on the Product Promotion Effect. When other parameters remain unchanged, changing the proportion of the emotional polarity of comments on the product advertisement on mobile social networks influences the product promotion effect, as shown in Figure 5. Figure 5(a) shows that the more positively biased the comments, the more beneficial the product promotion effect. Figure 5(b) further shows
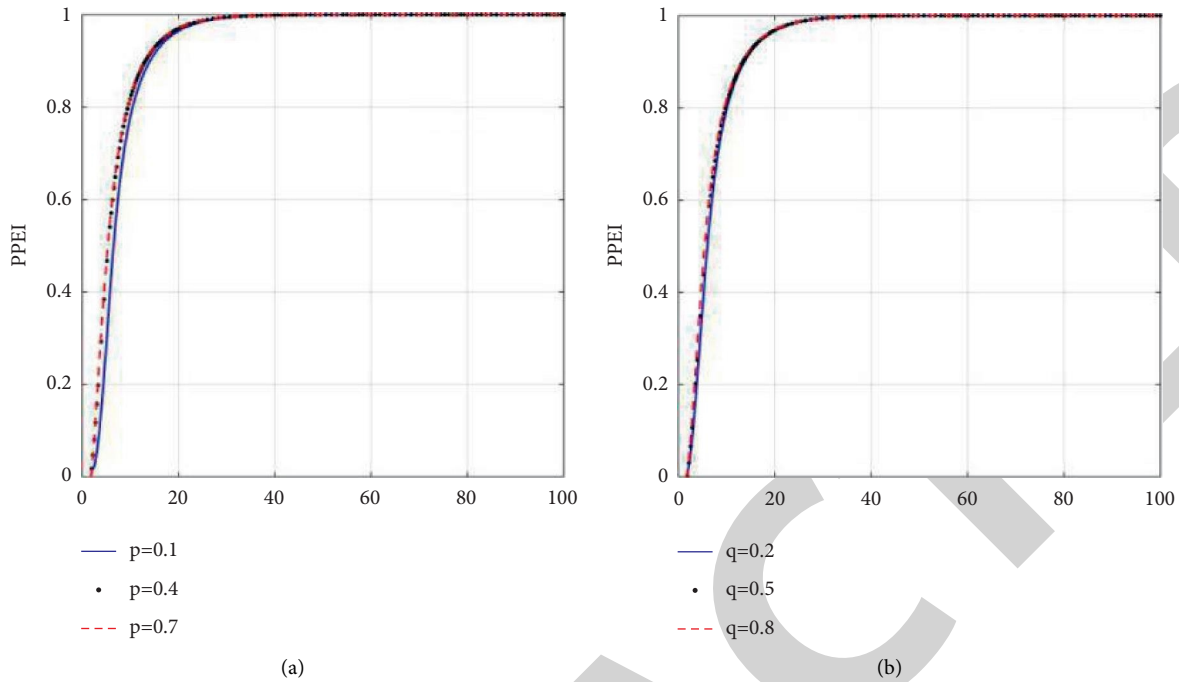
Figure 2: The influence of innovation effect coefficient P (a) and imitation effect coefficient Q (b) on the product promotion effect of product advertising on mobile social networks.
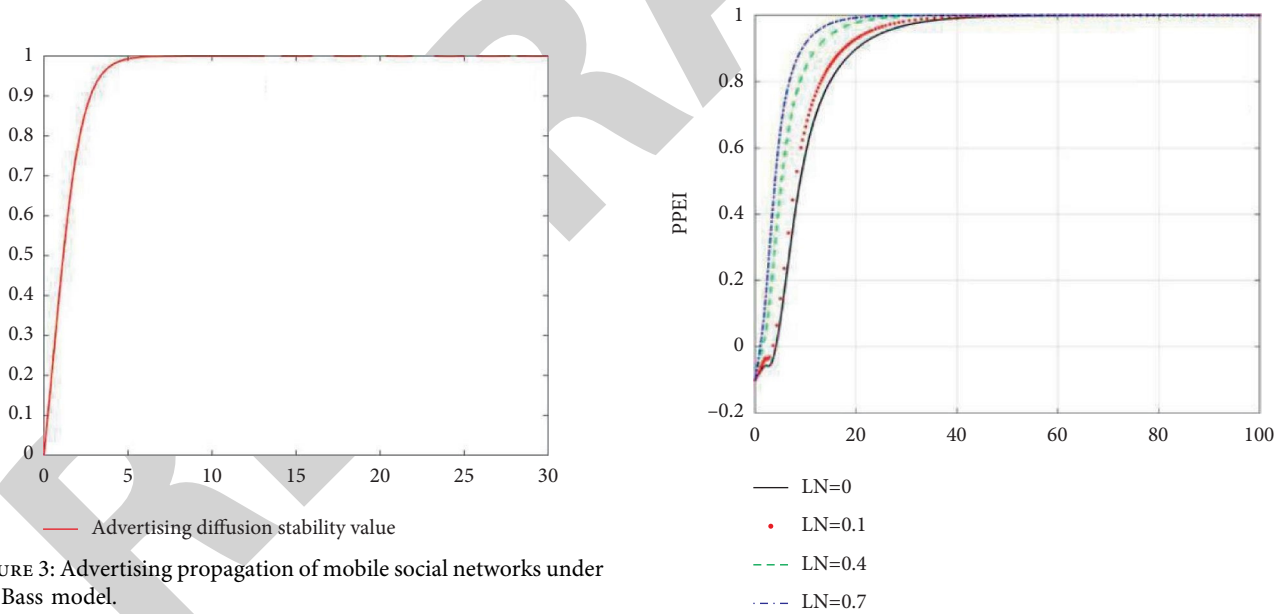

Figure 3: Advertising propagation of mobile social networks under the Bass model.

Figure 4: Influence of proportion of users' likes on the product promotion effect.

that if there are many negative comments, the time it takes for product promotion to reach the optimal effect will slow down. In extreme cases, the effect of product promotion will be negatively affected, so that the proportion of users with negative reactions to product advertisements on mobile social networks will be larger than that of users with positive reactions. When there are more negative comments than positive ones, it becomes vital to implement successful promotion strategies to influence public opinion of the products.

4.4. Influence of the Proportion of Users following the Ignore Strategy on the Product Promotion Effect. Changing the proportion of users who adopt the ignore strategy influences the product promotion effect, as shown in Figure 6 (assuming that other parameters remain unchanged). Figure 6 shows that the higher the proportion of users who adopt the ignore strategy, the longer it will take for the promotion effect to reach the optimal state. Therefore, enterprises
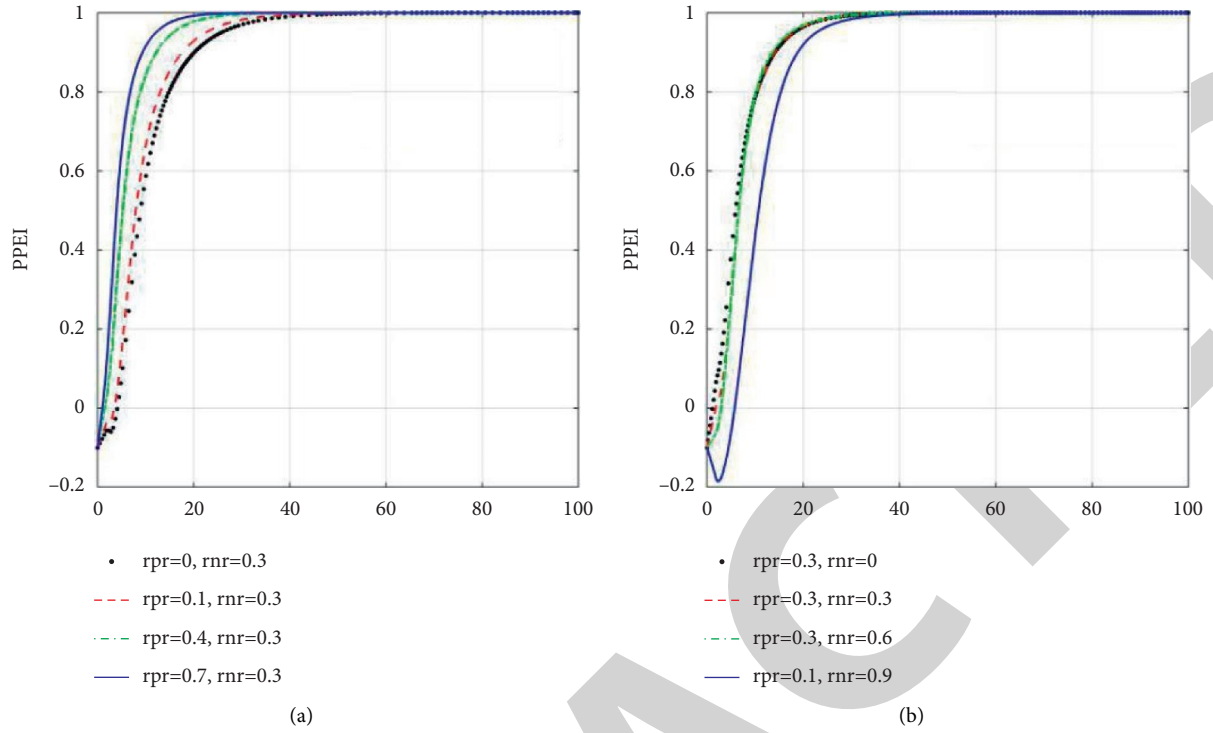
(a)

(b)

Figure 5: Influence of the proportion of positively biased comments (a) and negatively biased comments (b) on mobile social network advertisements on the effect of product promotion.
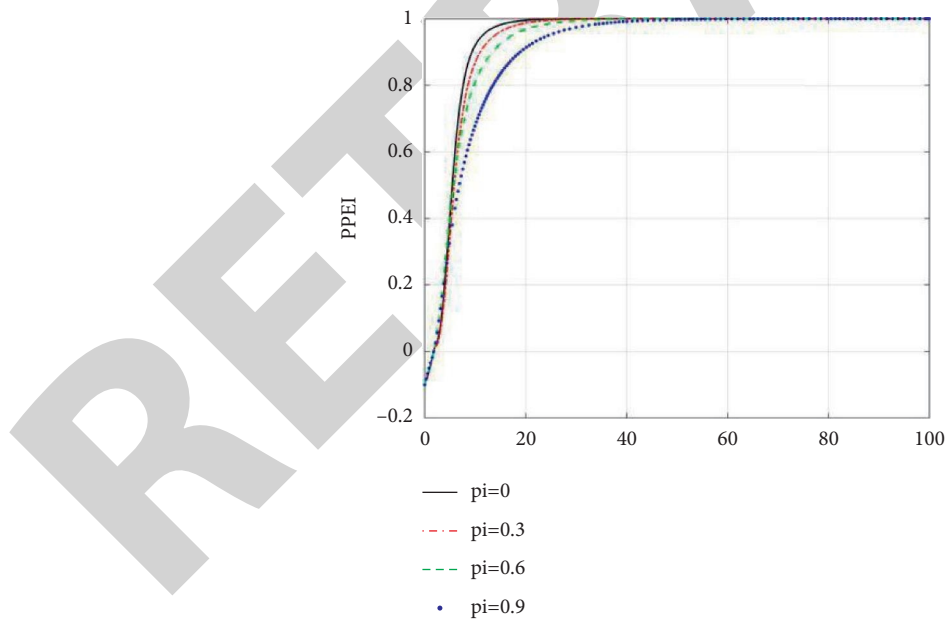

Figure 6: Influence of the proportion of users using the ignore strategy on product promotion effect.

should ensure successful product publicity in the early stage of promotion, so that more target users are exposed to their advertisements and the effect of promotion will reach the best state this morning.

5. Conclusions and Recommendations

According to the model constructed in this paper, and the simulation depicted, mobile social network marketing has a significant impact on the promotion effect of innovative products in the initial stage of product promotion, and user information behavior on mobile social network platforms will impact the promotion effect of innovative products from multiple perspectives. First, the diffusion of enterprises' innovative products in the initial stage of promotion has a significant impact on the promotion effect, while the later stage has little impact. Second, when user feedback is poor, advertisement diffusion has an obvious effect on product promotion. Third, on mobile social networks, the proportion of positive user feedback has a greater impact on the product promotion effect, while the proportion of negative feedback has a smaller impact on the product promotion effect. Fourth, the impact of negative comments is time sensitive. Combined with the above conclusions, and based on mobile social networks, we propose the following suggestions for the promotion of enterprises' innovative products.

(1) When promoting innovative products, enterprises should pay attention to initial adopters of the product following its promotion and should strive to improve the innovation effect so as to drive the imitation effect. Enterprises can effectively plan, compare, and screen out their product use paths by studying consumers' use scenarios, finding consumers' pain points and comfort points, and locking in early adopters of innovative products. Moreover, by establishing an emotional connection with initial adopters of the product, enterprises can improve their positive impact on other potential consumer groups.

(2) Enterprises should reduce the display of negative comments on their innovative product advertisements on mobile social networks and increase the display of "likes." When choosing an innovative product promotion platform, enterprises can choose to reduce the RNR in the model and increase the proportion of LN to accelerate the product promotion effect and reach the optimal value. For example, an advertisement can display not only the number of "likes" but also the number of "favorites," "reposts," and "shares." This will generate positive psychological hints when users watch the advertisements of the company's innovative products, so that the promotion effect will continue to improve.

(3) By promoting innovative products on mobile social network platforms, enterprises can prolong the dividend period of advertising diffusion; that is, increasing LN and RPR in the model can improve the diffusion effect when users perform poorly in promoting mobile social network platforms. The effectiveness of the advertising lasts through the initial stage of advertising dissemination, but by creating an overall positive public opinion on the platform, enterprises can prolong the duration of the positive effect of advertising diffusion. Official media can facilitate interesting interactions on online platform advertisements. When enterprises promote innovative products, they can effectively carry out promotional activities and interactions on the platform, which can prolong the "bonus" period of advertising diffusion, allowing the promotion effect of innovative products to reach an optimal and stable state as soon as possible and thereby improving the effect of product promotion.

(4) Through the online comments function, mobile social network advertisements increase the amount of information that users have access to; however, some users may post unwarranted negative feedback on products to confuse people. When encountering these negative comments, the enterprise should maintain the diffusion speed of advertising and ensure product quality, as well as continuing to encourage positive comments and likes. After a short period of decline, the product promotion effect will naturally recover.

6. Conclusion

Based on the network evolutionary game model, this paper studies the influence of user information behavior on mobile social network platforms on the promotion effect for enterprises' innovative products. Based on bounded rationality, we construct a game model based on the group's choice of strategy in mobile social network marketing communication, obtain the corresponding mean field equation, and solve this equation for the group's choice of strategy under different conditions. We use a MATLAB tool for the numerical simulation of the model, and we provide a visual presentation of how the user's choice of strategy affects the promotion effect of enterprises' innovative products. Finally, we provide relevant suggestions based on our findings. This paper uses quantitative model methods to study the influence of user information behaviors on the promotion effect of enterprises' innovative products, which augments extant qualitative research. In future research, real data could be used to verify this model.

Data Availability

The simulation experiment data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

References

[1] Y. Liu, "Word of mouth for movies: its dynamics and impact on box office revenue," *Journal of Marketing*, vol. 70, no. 3, pp. 74–89, 2006.

[2] T. Chen, L. Peng, J. Yang, and G. Cong, "Analysis of user needs on downloading behavior of English vocabulary APPs based on data mining for online comments," *Mathematics*, vol. 9, no. 12, Article ID 1341, 2021.

[3] D. Chen, "How the service recovery of negative online reviews affect customers' purchase intention-based on the platform of taohao," in *Proceedings of the China Marketing International Conference*, pp. 679–693, Xi'an, China, 2015.

[4] M.-L. Chung, H.-J. Jhan, M.-Y. Liou, J.-S. Li, and Y.-S. Hou, "An investigation of innovation imitation products and consumer purchases situational attribute," *Procedia - Social and Behavioral Sciences*, vol. 40, pp. 689–694, 2012.

[5] Z. Li, F. Li, J. Xiao, and Z. Yang, "Effects of negative customer reviews on sales: evidence based on text data mining," in *Proceedings of the IEEE International Conference on Data Mining Workshops*, pp. 838–847, Singapore, November 2018.

[6] J. Ren, W. Yeoh, M. Shan Ee, and A. Popovič, "Online consumer reviews and sales: examining the chicken-egg relationships," *Journal of the Association for Information Science and Technology*, vol. 69, no. 3, pp. 449–460, 2017.

[7] Z. Zhao, J. Wang, H. Sun, Y. Liu, Z. Fan, and F. Xuan, "What factors influence online product sales? Online reviews, review system curation, online promotional marketing and seller guarantees analysis," *IEEE Access*, vol. 8, pp. 3920–3931, 2020.

[8] Z. Zhou, G. Zhan, and N. Zhou, "How does negative experience sharing influence happiness in online brand community? A dual-path model," *Internet Research*, vol. 30, no. 2, pp. 575–590, 2019.

[9] C. Dellarocas, "The digitization of word of mouth: promise and challenges of online feedback mechanisms," *Management Science*, vol. 49, no. 10, pp. 1407–1424, 2003.

[10] R. R. Mukkamala, J. I. Sørensen, A. Hussain, and R. Vatrapu, "Detecting corporate social media crises on facebook using social set analysis," in *Proceedings of the IEEE International Congress on Big Data*, pp. 745–748, New York, NY, USA, July 2015.

[11] M. U. Nazir, S. Tharanidharan, M. S. Mian et al., "Social media competitive analysis - a case study in the pizza industry of Pakistan," *Communications in Computer and Information Science*, vol. 932, pp. 313–325, 2019.

[12] P. Li, X. Yang, L.-X. Yang, Q. Xiong, Y. Wu, and Y. Y. Tang, "The modeling and analysis of the word-of-mouth marketing," *Physica A: Statistical Mechanics and Its Applications*, vol. 493, pp. 1–16, 2018.

[13] C. Peters, C. H. Amato, and C. R. Hollenbeck, "An exploratory investigation of consumers' perceptions of wireless advertising," *Journal of Advertising*, vol. 36, no. 4, pp. 129–145, 2007.

[14] Q. Shen and J. Miguel Villas-Boas, "Behavior-based advertising," *Management Science*, vol. 64, no. 5, pp. 2047–2064, 2018.

[15] L.-J. Kao and Y.-P. Huang, "An effective social network sentiment mining model for healthcare product sales analysis," in *Proceedings of the 2018 IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, pp. 2152–2157, Miyazaki, Japan, October 2018.

[16] I. C. Juanatas, R. R. Fajardo, E. T. Manansala, A. A. Pasilan, J. R. Tabor, and H. D. A. Balmeo, "Sentiment analysis platform of customer product reviews," in *Proceedings of the International Conference on Computational Intelligence and Knowledge Economy*, pp. 230–234, Dubai, UAE, December 2019.

[17] F. Li and T. C. Du, "The effectiveness of word of mouth in offline and online social networks," *Expert Systems with Applications*, vol. 88, pp. 338–351, 2017.

[18] M. A. A. Dewi, N. N. Annisa, P. Kareen, A. Edwita, and D. I. Sensuse, "Analysing the critical factors influencing consumers' knowledge sharing intention in online communities and its impact on consumer product involvement, product knowledge and purchase intention," in *Proceedings of the 2017 International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, pp. 149–158, Bali, Indonesia, October 2017.

[19] M. Jianjun, "Research on collaborative filtering recommendation algorithm based on user behavior characteristics," in *Proceedings of the International Conference on Big Data & Artifical Intelligence & Software Engineering*, pp. 425–428, Bangkok, Thailand, November 2020.

[20] C. H. Tsai, Z. G. Zhu, T. Ku, and W. F. Chien, "Personal APP behavior analysis based on mobile device networks," in *Proceedings of the 2016 Eleventh International Conference on Computer Science & Education (ICCSE)*, pp. 405–412, Nagoya, Japan, August 2016.

[21] Z. Liu, L. Lang, L. Li, Y. Zhao, and L. Shi, "Evolutionary game analysis on the recycling strategy of household medical device enterprises under government dynamic rewards and punishments," *Mathematical Biosciences and Engineering: MBE*, vol. 18, no. 5, pp. 6434–6451, 2021.

[22] Z. Liu, Q. Qian, B. Hu et al., "Government regulation to promote coordinated emission reduction among enterprises in the green supply chain based on evolutionary game analysis," *Resources, Conservation and Recycling*, vol. 182, Article ID 106290, 2022.

[23] X. Li, L. Cheng, X. Niu, S. Li, C. Liu, and P. Zhu, "Highly cooperative individuals' clustering property in myopic strategy groups," *The European Physical Journal B*, vol. 94, no. 6, p. 126, 2021.

[24] C. Li, H. Xu, and S. Fan, "Synergistic effects of self-optimization and imitation rules on the evolution of cooperation in the investor sharing game," *Applied Mathematics and Computation*, vol. 370, Article ID 124922, 2020.

[25] Y. A. Argyris, A. Muqaddam, and Y. Liang, "The role of flow in dissemination of recommendations for hedonic products in user-generated review websites," *International Journal of Human-Computer Interaction*, vol. 36, no. 3, pp. 271–284, 2020.

[26] T. Klaus and C. Changchit, "Toward an understanding of consumer attitudes on online review usage," *Journal of Computer Information Systems*, vol. 59, no. 3, pp. 277–286, 2019.

[27] H. Ohtsuki and M. A. Nowak, "The replicator equation on graphs," *Journal of Theoretical Biology*, vol. 243, no. 1, pp. 86–97, 2006.

[28] J. D. Bohlmann, R. J. Calantone, and M. Zhao, "The effects of market network heterogeneity on innovation diffusion: an agent-based modeling approach," *Journal of Product Innovation Management*, vol. 27, no. 5, pp. 741–760, 2010.

[29] D. Zhao, S.-F. Ji, H.-P. Wang, and L.-W. Jiang, "How do government subsidies promote new energy vehicle diffusion in the complex network context? A three-stage evolutionary game model," *Energy*, vol. 230, Article ID 120899, 2021.

[30] Y. Zhang and L. Li, "Research on travelers' transportation mode choice between carsharing and private cars based on the logit dynamic evolutionary game model," *Economics of Transportation*, vol. 29, Article ID 100246, 2022.

[31] W. Liu, S. Long, D. Xie, Y. Liang, and J. Wang, "How to govern the big data discriminatory pricing behavior in the platform service supply chain?An examination with a three-party evolutionary game model," *International Journal of Production Economics*, vol. 231, Article ID 107910, 2021.

[32] H. Meng, X. Liu, J. Xing, and E. Zio, "A method for economic evaluation of predictive maintenance technologies by integrating system dynamics and evolutionary game modelling," *Reliability Engineering & System Safety*, vol. 222, 2022.

[33] B. Li, Y. Feng, Z. Xiong, W. Yang, and G. Liu, "Research on AI security enhanced encryption algorithm of autonomous IoT systems," *Information Sciences*, vol. 575, pp. 379–398, 2021.

[34] Y. He, L. Dai, and H. Zhang, "Multi-branch deep residual learning for clustering and beamforming in user-centric network," *IEEE Communications Letters*, vol. 24, no. 10, pp. 2221–2225, 2020.

[35] F. Liu, G. Zhang, and J. Lu, "Heterogeneous domain adaptation: an unsupervised approach," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 31, no. 12, pp. 5588–5602, 2020.

[36] C. Huang, X. Wu, X. Wang, T. He, F. Jiang, and J. Yu, "Exploring the relationships between achievement goals, community identification and online collaborative reflection," *Educational Technology & Society*, vol. 24, no. 3, pp. 210–223, 2021.

[37] W. Zheng, L. Yin, X. Chen, Z. Ma, S. Liu, and B. Yang, "Knowledge base graph embedding module design for Visual question answering model," *Pattern Recognition*, vol. 120, Article ID 108153, 2021.

[38] W. Zheng, X. Liu, X. Ni, L. Yin, and B. Yang, "Improving visual reasoning through semantic representation," *IEEE Access*, vol. 9, Article ID 91476, 2021.