Simulation Research on Marketing Effect of Enterprise in Social Network Based on SIR Model

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Keywords: Social network, Enterprise marketing, SIR model, Netlogo, Marketing strategy.

Abstract. With the emergence and development of social platforms, how to use social networks to spread quickly to achieve the expected marketing effect has become an urgent issue for enterprises to solve. This paper is based on the classic SIR model, divide social network users into five categories: potential users, ordinary spreaders, strengthening spreaders, purchasing users and information immune. Through the modeling of Netlogo, The experiments simulated the propogation process of enterprise marketing information in social network, studied seven factors influencing marketing effect by several groups of simulations. This paper analyze the results of simulations and provide effective suggestions for enterprises to develop marketing strategies.

1. Introduction

In recent years, social new media platforms have experienced rapid development, it carries an increasingly rich and massive amount of data. More and more users buy commodities by sharing information of commodities on social media, and some users post comments on the platform to exchange ideas about commodities. Users and their relationships constitute a social network, enterprises can spread their marketing messages across the social network to achieve the purpose of publicity and profit.

According to "research report on characteristics of Chinese microblog media and user usage", nearly half of the surveyed users actively forward and spread the content they are interested in after browsing it on social platforms, which promote the continuous transmission of marketing information. Users on social platforms build relationships to share information and experiences with others[1],this characteristic provides a new thinking for network marketing, the key of the current research goal is how to use the characteristics of social network to achieve better marketing effect.

Existing researches on social network marketing mainly focus on three aspects. Research on social network marketing model of a single social platform, Peipei Zuo[2] analyzed the current situation and the challenges of WeChat marketing, put forward some suggestions for the development of marketing on WeChat; Hong Cao et al. [3] collected and analyzed sina weibo data, build a model of weibo user portrait to provide basis for accurate marketing of enterprises in weibo. Research on single influencing factors of social network marketing, Yanping Gong et al. [4] proposed specific marketing strategies through analyzed the psychological mechanism and advantages of fan marketing in social networks; Guangyu Mu et al. [5] studied the trust relationship between consumers in social networks and the influence of trust factors in social advertising on consumer behaviors. Research on single influencing factors of a single social platform, Bowen Cao et al. [6] studied the influence of opinion leaders on consumers' decisions through questionnaire survey and other methods; Jun Wang et al. [7] took weibo web celebrity marketing as an example and proposed weibo marketing strategies.

2. Model Architecture

2.1 SIR model

This study is based on SIR epidemic model to simulate the propagation and diffusion process of

enterprise marketing information in complex social networks. The traditional SIR epidemic model assumes that each node goes through three stages of virus transmission: S(susceptible),I(infectious) and R(removed).With a constant population, susceptible people contact with infected people have a certain probability of being infected and then become infectious people, and at the same time, infectious people have a certain probability to enter the removed stage of immunity to the virus.

2.2 Improved model based on SIR model

According to the individual differences of users in social platforms during marketing information propagation process, all network nodes are divided into the following five categories in the improved model: potential users(S), ordinary spreaders(I_1), strengthening spreaders(I_2), purchasing users(R_1) and information immune(R_2).Similar to the traditional SIR model, marketing information in social networks also goes through three stages of communication. But users in the infectious stage are classified as ordinary spreaders(I_1) and strengthening spreaders(I_2), they have the same function of transmission, but different transmission intensity. Users in the removed stage are classified as purchasing users(R_1) and information immune(R_2), both are immune to marketing information. The marketing effect of the enterprise is mainly judged according to the proportion of purchasing users(R_1).The model architecture of marketing information transmission in social networks is shown in figure 1.

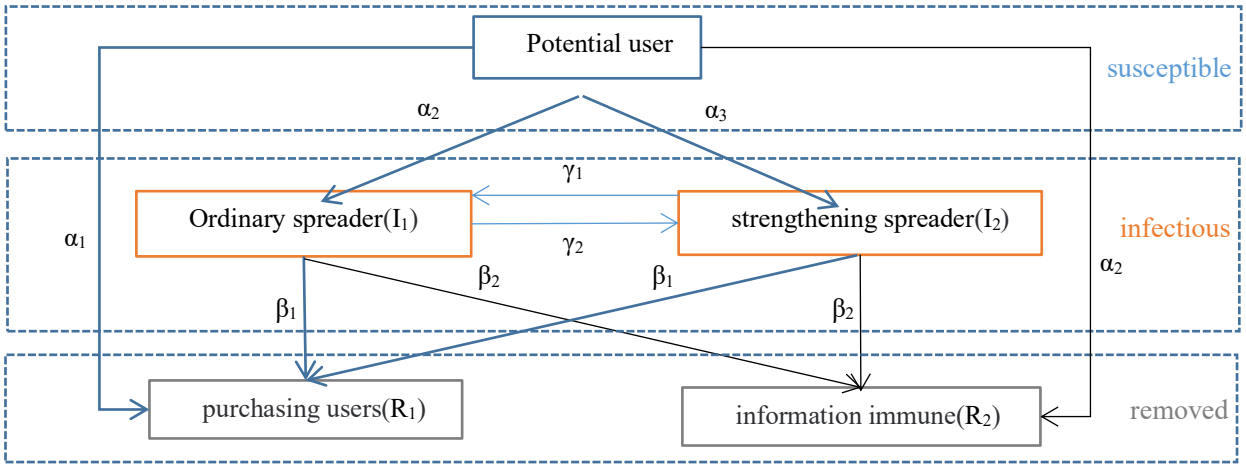

Figure 1. Model architecture

The improved model follows some basic assumptions:

(1) It is assumed that the total number of users in the social network and the strong and weak relationship between users remain unchanged, and the social network is evenly distributed.

(2) Assume that the relationship between all user nodes is bidirectional.

(3) Assume that the total number of all users in the social network is constant, and user status is the five user states set in this model.

(4) Assume that potential users in the social network are only influenced by two types of spreader to change their status.

(5) Assume that strengthening spreader have the multiple of θ as much impact on potential users as ordinary spreader.

The dynamic differential equations of the model can be constructed (1):

$$\begin{cases} \dfrac{ds(t)}{t} = -\alpha_4 s(t)\left(i_1(t)+\theta i_2(t)\right) - \alpha_3 s(t)\left(i_1(t)+\theta i_2(t)\right) - \alpha_2 s(t) - \alpha_1 s(t) \\ \dfrac{di_1(t)}{t} = \alpha_4 s(t)\left(i_1(t)+\theta i_2(t)\right) + \gamma_1 i_2(t) - \gamma_2 i_1(t) - \beta_1 i_1(t) - \beta_2 i_1(t) \\ \dfrac{di_2(t)}{t} = \alpha_3 s(t)\left(i_1(t)+\theta i_2(t)\right) + \gamma_2 i_1(t) - \gamma_1 i_2(t) - \beta_1 i_2(t) - \beta_2 i_2(t) \\ \dfrac{dr_1(t)}{t} = \alpha_1 s(t) + \beta_1\left(i_1(t)+i_2(t)\right) \\ \dfrac{dr_2(t)}{t} = \alpha_2 s(t) + \beta_2\left(i_1(t)+i_2(t)\right) \end{cases} \quad (1)$$

3. Experiment results

This paper adopts version 6.0.4 of NetLogo to conduct the simulation of model, and studies the influence of parameter on the proportion of user states in enterprise network marketing process.

As shown in table 1, the experimental parameters are set within a certain range.

Table 1. Range of experimental parameters

Parameter	α_1	α_2	α_3	α_4	θ	β_1	β_2	γ_1	γ_2
Range	(0,0.2]	(0,0.2]	(0,0.4]	(0,0.4]	(0,1.4]	(0,1)	(0,0.5)	(0,0.5)	(0,0.5)

3.1 Reference experiment

Set initial parameters α1=10%, α2 =10%, α3 =30%, α4 =30%, θ=1.2, β1 =50%, β2=10%, γ1 =20%, γ2 =20%, N=10, average degree of the user node is 10, and the initial number of I_1 and I_2 is 5.

Due to the randomness of the experiment, five groups of simulation were conducted, and the average value of the five groups of simulation results was set as the final results. The group of simulations was set as the reference experiment, the final results were shown in figure 2.

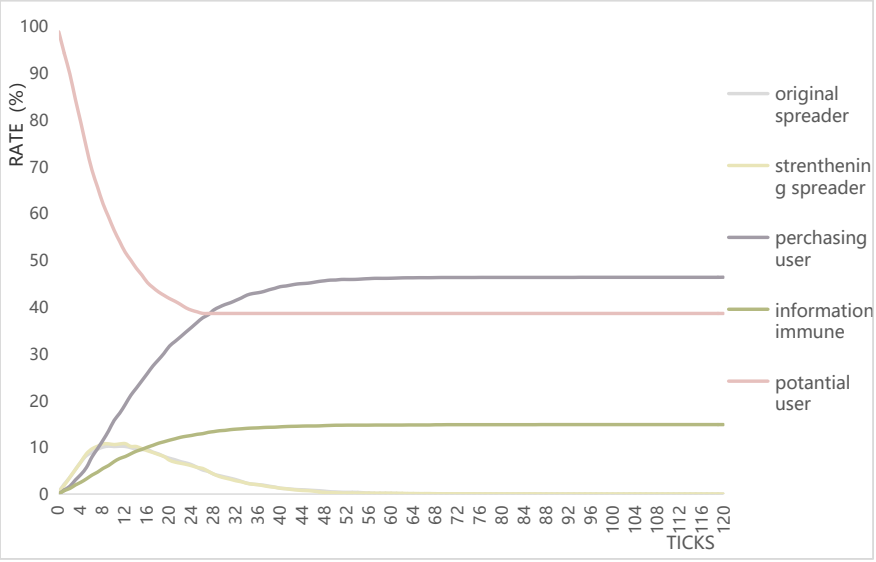

Fig 2. the results of the reference experiment

3.2 Adjustment of parameters

On the basis of other parameters not changing, the experiment was carried out by adjusting the parameters, and after adjusting the parameters once, five times of simulation were carried out to calculate the mean value of the final results to obtain the average maximum value of the proportion of I_1 and I_2 in the marketing transmission, And the average proportion value of R_1, R_2 , S in the end of marketing and the marketing duration T.

(1) Set α_1= (5%,15%,20%), α_2= (5%,15%,20%), α_3= (20%,40%,50%), α_4= (20%,40%,50%), with the results shown in table 2.

Table 2. Adjustment of α

parameter type	Max_{I1}	Max_{I2}	R_1	R_2	S	T
α_1=5%	13.7	15	52.14	18.22	29.64	85.4
α_1=15%	9.74	10.64	42.2	11.67	46.13	79.2
α_1=20%	9.66	9.54	41.3	7.4	51.3	76.8
α_2=5%	12.36	12.88	56.3	18.96	24.74	89.4
α_2=15%	10	9.12	36.86	13.76	49.38	76.2
α_2=20%	8.76	8.48	30.26	12.86	56.88	65.4
α_3=20%	7.62	5.34	23.88	8.88	67.24	78.2
α_3=40%	17.74	22.82	75.86	16.92	9.22	91.4
α_3=50%	15.42	33.44	82.32	16.3	1.22	87.6
α_4=20%	11.56	16.48	65.06	21.08	13.86	77.8
α_4=40%	12.4	9.64	39.14	9.02	51.84	86.6
α_4=50%	13.88	10.32	49.68	9.54	40.78	77.4

(2) Set γ_1= (10%,30%,40%), γ_2= (10%,30%,40%), β_1= (40%,60%,70%), β_2= (5%,15%,20%), the results shown in table 3.

Table 3. Adjustment of γ_1, $\gamma_2$andβ_1, β_2

	Max_{I1}	Max_{I2}	R_1	R_2	S	T
γ_1=10%	10.88	11.32	49.36	15.68	34.96	75.8
γ_1=30%	10.22	10.46	42.3	13.66	44.04	91.4
γ_1=40%	8.5	8.44	31.1	10.14	58.76	71.6
γ_2=10%	10.7	9.8	44.24	14.36	41.4	75.4
γ_2=30%	11.28	12.06	48.78	16.44	34.78	72.2
γ_2=40%	13.24	13.6	54.34	17.04	28.62	88
β_1=40%	11.78	12.1	40.52	15.24	44.24	100.8
β_1=60%	10.84	10.9	46.8	14.62	38.58	66
β_1=70%	9.96	11.2	50.82	14.24	34.94	53.8
β_2=5%	12.16	11.24	46.46	10.06	43.48	112.8
β_2=15%	7.94	8.46	31.62	13.98	54.4	77.4
β_2=20%	8.28	7.8	31.44	17.92	50.64	67.2

(3) Set θ= (0.8,1.0,1.4), the results shown in table 4.

Table 4. Adjustment of θ

	Max_{I1}	Max_{I2}	R_1	R_2	S	T
θ=0.8	7.42	7.68	32.86	12.6	54.54	75.6
θ=1.0	9.98	9.88	41.66	15.7	42.64	73.2
θ=1.4	16.28	16.4	65.68	12.16	22.16	80.8

4. Formulation of Marketing propagation strategies

How to make use of the "small world" feature of social network to spread marketing information more widely and achieve better marketing effect is an important basis for enterprises to formulate marketing strategies. With the analysis of results of experiments in the model, this paper provides the following Suggestions for enterprises to formulate marketing strategies in social networks.

4.1 Select appropriate high-quality social network platform

According to the research results, it can be concluded that such social platform for marketing information has the following advantages to improve marketing effect:

(1) Due to the low repugnance of users to marketing information in high-quality social platforms, it can achieve part of the purpose of controlling the direct conversion rate α_2 and improving purchase rate.

(2) The appropriate social platform has most users who pay attention to the field of the enterprise products, which can also reduce the direct conversion rate of α_2.

(3) In the high quality social platform, the relationship between the majority of users with high intensity, which can makes the user's strengthening coefficient θ higher and improve conversion rate γ_2 of original spreaders to strengthening spreaders.

4.2 Write marketing copy that motivates users to interact actively

Through the control experiment, it can be found that increasing the conversion rate α_3 makes potential users actively become strengthened communicators, which can greatly improve the range of marketing information dissemination and increase the purchase rate. Meanwhile, the content of marketing information can also have a certain impact on other parameters. For marketing information released by enterprises, the author puts forward the following Suggestions:

(1) Marketing information needs to be real-time, combined with the current hot topics to attract users' attention, which can reduce the rate of α_2 and increase the rate of α_3 and α_4.

(2) By increasing the interactive reward mechanism, the conversion rate of α_3 and α_4 can be enhanced at a lower cost.

(3) Set up a selection mechanism, in which the communicator who actively generates high-quality and attractive content gets extra awards. It can make the strengthening coefficient θ and the conversion rate α_3 and α_4 higher.

(4) Increase preferential information to attract users, and pay attention to the intensity, which too high may lead to a large increase of direct purchasing rate α_1 and the reducement of spreaders by the initial. If the efforts are too small, it may not be attractive to increase the rate α_3 and α_4.

4.3 Timely remind users

Increase the frequency of advertising promotion and cooperate with user interaction, which can effectively prevent communicators losing enthusiasm and reduce the rate of β_2.

4.4 Assess and respond to competitor behavior in time

In the middle and later stages of the transmission of marketing information will usually cause competition, enterprises should formulate strategies in advance to deal with such behaviors in a timely manner. Prevent the insreasing of the rate of α_2 and β_2 to make bad effects.

5. Conclusion

The results of each group of experiments in this paper are the mean results, which are representative to a certain extent. However, this paper only carries out the simulation experiment of adjusting the parameters of this group once at a time and draws a research conclusion, and the experimental results may have certain limitations.

In conclusion, the experimental results of this paper provide a reference for the general propagation of enterprise marketing information in social networks, and the research has concluded the factors affecting the marketing effect, providing valuable information for the formulation of

marketing strategies.

References

[1] E Sun, I Rosenn, CA Marlow, TM Lento. Gesundheit! Modeling contagion through Facebook News Feed Mechanics of Facebook Page Diffusion[C]. *California: Proceedings of the 3rd International Conference on Weblogs and Social Media AAAI*, San Jose, CA, 2013.

[2] Peipei Zuo. Analysis of WeChat Marketing Problems[J]. *China Business*,2013(36).

[3] Hong Cao, Suni Wu. User Portrait and Precision Marketing in Big Data Environment Based on Weibo[J]. *Modern Economic Information*,2016(16).

[4] Yanping Gong, Zhongyue Su. Marketing Strategy Analysis of Brand Fans in Social Network Environment [J]. *Journal of Commercial Econemics*,2016(22).

[5] Guangyu Mu, Qing Xu, Xiuli Si. Analysis of Influencing Factors of Social Advertising Information Communication on Trust in Social Network Environment[J]. *Information science*,2018(11).

[6] Bowen Cao, Bo Li. Research on The Influence of Sina Weibo Opinion Leaders on College Students' Consumption Decisions [J]. *E-commerce*,2019(04).

[7] Jun Wang, Wei Dai. Research on Marketing Strategy of "Celebrity Economy" in Weibo Based on 5T Model[J]. *Journal of Hubei University of Technology (Humanities and Social Sciences Edition)*,2018(5).