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Original Research Article

Quantitative Analysis of Diffusion of Public Opinion by the Modified Bass Model for the Dyeing Steamed Bread Incident in China

Lang Liang [1], [2*]

[1]School of Management, Hefei University of Technology, Hefei 230009, China
[2]School of Management, Henan University of Technology, Zhengzhou 450001, China

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***Corresponding author:** Lang Liang **Email:** lianglang_ed@aliyun.com

Abstract

The information diffusion of food safety incident is sometimes more serious than food safety incident itself, because this may lead to severe public opinion and affect purchase intention of individual consumer. Thus, it is very important to study the rule of information diffusion of food safety incident. In this work, a modified Bass diffusion (MBD) model including the role of government is proposed based on the characteristics of food safety information diffusion in China and its analytical solution is derived correspondingly. Such model is tested and validated by a specific case of food safety incident, that is, dyeing steamed bread incident happened in China. The results show that the present MBD model can effectively predict the diffusion of public opinion for food safety information and simultaneously the parameter analysis reveals that the government management to the quality and credibility of information is critical in improving the communication of food safety information.

Keywords: Food safety; Information diffusion; Modified Bass diffusion model; Parameter estimation.

INTRODUCTION

Information diffusion models and theories have been posed very early and many research findings have been achieved. Houser studied the relationship between news reports and people's perception of events from the perspective of communication [9]. On the basis of considering the influence factors of information sender and information receiver, Duggan et al. constructed the diffusion model of crisis information [4]. Genius et al., analyzed the role of information dissemination in the diffusion of agricultural irrigation technology [6]. Bray and Mendelson explained the bullwhip effect in product supply chain [2]. The influencing factors on food safety incidents had been mainly studied in China. Wang et al., analyzed the influencing factors of food safety and divided the influencing factors into four categories [18]. Ma et el., investigated some food safety incidents occurred in China and pointed out the main risk factors and responsibility subjects of food safety [12]. Liang proposed a two-way communication framework and a quantitative analysis of food safety risk factors is implemented based on this framework [11]. Hou put forward some countermeasures and suggestions to promote food quality and safety information transmission [8]. Based on the social impact theory and BASS model, Li et al., constructed the basic model of information diffusion for public dangerous chemicals hazard, which shown that government has driving action for information dissemination [10]. He et al., summarized the problems existing in the construction of food safety information system in China and gave some suggestions on the construction of food safety information system [7].

The information diffusion is mainly studied in the field of communication and information science [15]. There are very few researches on the diffusion of food safety information. The information diffusion of food safety incident is sometimes more serious than food safety accident itself, because the information asymmetry between food enterprise and consumers may lead to severe public opinion and affect purchase

intention of individual consumer. Therefore, it is very important to study the information diffusion of food safety incident. Based on the BASS model, a modified BASS diffusion (MBD) model including the role of government is proposed. Then, the MBD model is tested and validated by simulating the information diffusion of dyeing steamed bread incident happened in China to reveal the role of government in improving the communication of food safety information.

Incident Description

The dyeing steamed bread (DSB) incident was happened at Shanghai City in China in 2011 [3]. The incident was disclosed by the official report of CCTV Financial Channel in April 10, 2011. The report said that Shanghai Shenglu Food Company arbitrarily changed the date of production, used expired raw materials and broke health standards in the producing process of steamed bread. The incident caused a big impact at that time in China and was listed as one of 20 Network hotspot events in 2011 in China [20]. Figure-1 shows the changing trend of the DSB incident gotten by searching the word "dyeing steamed bread" in Baidu, in which the vertical axis denotes the amount of daily increase of public opinion data. It can be seen from Figure-1 that the DSB incident developed rapidly in the first few days, and lasted about 20 days. It was finally subsided through the participation and management of Government.

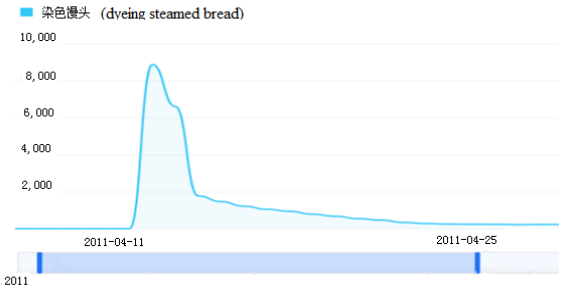

Fig-1: Trend of public opinion data for DSB Incident

Modified BASS model

BASS Model

BASS model was initially built by economists for the forecast of products and technology market. Assuming that the recipient is only affected by mass media, Fourt et al. proposed a forecasting model [5]. Lately, based on the assumption that the recipient is only affected by the oral communication, Manfield established a different forecasting model [13]. Then, based on a comprehensive understand of these studies, Bass believed that the recipients are affected by both mass media and oral communication, and so the following BASS model was proposed in 1969 as [1].

$$\frac{dy(t)}{dt} = p(m - y(t)) + q\frac{y(t)}{m}[m - y(t)] \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Where $y(t)$ stands for the cumulative number of people receiving risk information at time t. $dy(t)/dt$ stands for the rate of people receiving risk information at time t. m stands for the maximum number of potential risk recipients. $y(t)/m$ stands for the proportion of cumulative recipients of risk information versus potential recipients. p stands for external (mass media) impact factor, q stands for internal (oral communication) impact factors.

Modified BASS Model

The influence of government on information diffusion can not be ignored in China. But the BASS model contains only the influence of mass media and oral communication, so a modified BASS (MBD) model includes the influence of government is proposed as follows

$$\frac{dy(t)}{dt} = p(m - y(t)) + q\frac{y(t)}{m}[m - y(t)] - \alpha(m - y(t)) \ldots (2)$$

Eq. (2) can be rewritten in the following form

$$\frac{dy(t)}{(y(t) - m)} - \frac{dy(t)}{y(t) + \frac{m(p-\alpha)}{q}} = -(p + q - \alpha)dt \quad \ldots\ldots (3)$$

Integrating both sides of Eq. (3) yields the general solution of Eq. (2)

$$\frac{y(t) - m}{y(t) + \frac{m(p-\alpha)}{q}} = C \times e^{-(p+q-\alpha)t} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

From the initial condition: $y(t)\big|_{t=0} = 0$, the constant C in Eq. (4) can be determined by

$$C = \frac{q}{p - \alpha} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Then, substituting Eq. (5) into Eq. (4), we have

$$y(t) = m\frac{1 - e^{-(p+q-\alpha)t}}{1 + \frac{q}{p-a}e^{-(p+q-\alpha)t}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Obviously, once the parameters in Eq. (6) are determined, the cumulative number of people receiving risk information at any time can be calculated.

Simulation and Analysis of Public Opinion Diffusion

Data of Public Opinion Diffusion

The data of daily increment (DODI) in public opinion from April 11 to April 30 can be gotten from Figure-1. The data of daily accumulation (DODA) can be calculated out from the DODI. The DODI and DODA are listed in the columns 3 and 4 of Table-1, respectively. Columns 1 and 2 of Table-1 are dates and serial numbers of dates, respectively. The amount of DODA in the column 4 will be used to estimate the parameters in Eq. (6).

Table-1: Data of curves

Date	Serial number	DODI	Actual DODA	Simulated DODA	Case-a	Case-b
11/11	1	236	236	5,520	1,450	1,240
12/11	2	5,622	5,858	14,140	3,830	2,760
13/11	3	13,544	19,400	26,860	7,670	4,600
14/11	4	24,046	43,450	44,160	13,710	6,840
15/11	5	23,035	66,480	65,240	22,840	9,530
16/11	6	21,500	87,980	87,740	35,840	12,750
17/11	7	21,100	109,100	108,620	52,880	16,570
18/11	8	21,112	120,200	125,610	72,930	21,050
19/11	9	8,026	138,200	138,030	93,740	26,240
20/11	10	5,139	143,400	146,400	112,700	32,180
21/11	11	3,920	147,300	151,750	128,030	38,870
22/11	12	2,874	150,200	155,040	139,280	46,270
23/11	13	2,757	152,900	157,030	146,950	54,300
24/11	14	2,345	155,300	158,210	151,930	62,830
25/11	15	2,353	157,500	158,910	155,060	71,690
26/11	16	1,865	159,400	159,320	156,980	80,690
27/11	17	1,924	161,300	159,560	158,150	89,600
28/11	18	1,564	162,900	159,700	158,850	98,230
29/11	19	1,365	164,300	159,790	159,280	106,400
30/11	20	1,721	166,100	159,840	159,530	113,960

Parameter Estimation

In order to simulate the diffusion of public opinion by the present MBD model, the parameters m, p, q and α in Eq (6) need to be estimated. The commonly used parameter estimation methods are ordinary least square (OLS) method [19], nonlinear least squares (NLS) method [17], maximum-likelihood estimation (MLE) method [16] and genetic algorithms (GA) [14], etc. Because the solution of Eq. (6) is a nonlinear function, the NLS method is used to estimate the parameters. The parameters in Eq. (6) are estimated based on the data of the column 4 in Table-1. The estimated results of parameters in Eq. (6) are listed in Table-2. Because $R^2 = 0.995$, it is indicated that the estimated parameters have good fitting degree.

Table-2: The results of parameter estimation

Parameter	Initial value	Estimated value
m	159840	159903
p	0.6	0.541
q	0.6	0.511
a	0.59	0.514
R^2		0.995

Simulation of Public Opinion Diffusion

The simulated DODA, which is listed in the column 5 of Table-1, can be obtained by substituting the estimated parameters in Table-2 into Eq. (6). For the purpose of comparison of the simulated DODA with the actual DODA, Figure-2 displays their curves in terms of time (unit: day), respectively. It can be seen from Figure-2 that: (1) the curve of simulated DODA almost coincides with that of actual MODA, so the modified BASS Model can be used to predict public opinion effectively, and (2) the fastest growing interval for public opinion is days 4-8, which is the key time to control public opinion.

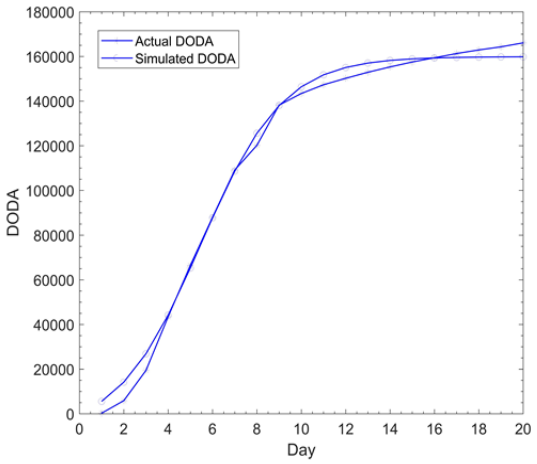

Fig-2: Curves of actual and simulated DODA

The Modified BASS Model can be used to analyze the influence of different parameters and their combinations on public opinion. Here two cases are given. (a) Case-a: letting the parameter $\alpha = 0.534$ and other parameters are kept constant, and (b) Case-b: letting the parameter $\alpha = 0.534,\ q = 0.211$ and other parameters are kept constant. The curves of Case-a and Case-b are plotted in Figure-3. For comparison, the curve of actual DOMA is also drawn in Figure-3. It can be seen from Figure-3 that: (1) the influences of parameters α and q on the public opinion are significant, and (2) the feasible strategies and methods for controlling public opinion can be made by the government in practice to improve the communication

of food safety information based on analyzing and comparing the influence of parameters on public opinion.

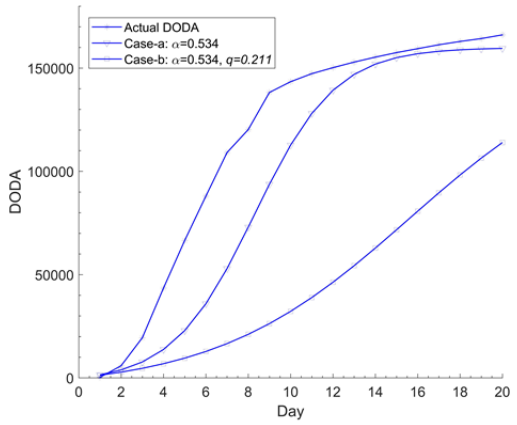

Fig-3: Influence of parameters on public opinion

CONCLUSIONS

Considering the characteristics of food safety information diffusion, a MBD model including the role of government is proposed and the related analytical solution of the model is derived. Then, the parameters of MBD model are estimated by using the function of OLS method for a specific case of dyeing steamed bread incident. For this incident, the variation of public opinion data in terms of time is simulated by substituting the estimated parameters into the analytical solution of the MBD model. The simulated results are of good agreement with the actual variation, which shows that the MBD model proposed in this paper can be used to predict the diffusion of public opinion on food safety events. Further, the parameter analysis indicates it is suggested that the government can make proper strategies and methods to improve the communication to public opinion.

Conflicts of Interest: The author declares no conflict of interest.

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