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# Study on Diffusion Rule of Mobile SNS Based on Modified BASS Model

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**Abstract:** Social Networking Services (SNS) develop rapidly. Aimed at the mobile SNS, the study, on the basis of Rogers's BASS model, breaks the three assumptions of the BASS model that market potential, imitation coefficient and innovation coefficient are constants throughout the diffusion circle, which are modified to a time-related function. In this way, the BASS model modified in accordance with the diffusion rule of mobile SNS is built and the model is also verified. The results show that the curve-fitting result commendably validates the modified model and the model is suitable for predicting the diffusion of mobile SNS. The study also finds that the diffusion of mobile SNS is primarily determined by imitation coefficient, that is, users exchange, social environment and policy environment have a great influence on diffusion of mobile SNS.

**Key words:** BASS model, modified BASS model, mobile SNS, innovation diffusion

## INTRODUCTION

In recent years, mobile SNS has developed at an alarming speed. Mobile internet has the feature of SoLoMo-Social, Local and Mobile. Mobile SNS has become an important service in the virtual society.

E.M. Rogers' model of innovation diffusion has been widely used in many fields. For the study on the innovation diffusion of mobile services, the scholars make a deep analysis from the perspectives of market potential (Michalakelis *et al*., 2008; Lin and Sun, 2008) external factor (Radojicic and Markovic, 2009; Ai, 2010)and internal factor (Wenrong *et al*., 2006; Won *et al*., 2009; Yoon *et al*., 2009). It can be found that BASS model has been widely used in studies on the diffusion of communication services, but the study of SNS is still in the attempt stage. This study modifies the BASS model from perspectives of market potential, external factors and internal factors and also discusses the diffusion mechanism of mobile SNS, which is of great significance both in theory and practice.

## MODEL ESTABLISHMENT

**Setting assumptions:** The study focuses on the diffusion of mobile SNS. It maintains the general assumptions of BASS model:

- **H1:** There is no constraint on the supply of mobile SNS
- **H2:** The mobile SNS users are homogenous and access it by mobile phone terminal
- **H3:** The external and internal influence factors on the diffusion of mobile SNS change with time
- **H4:** The largest market potential for the diffusion of mobile SNS is not constant and it depends on the number of mobile phone users
- **H5:** There is no repetitive purchase in mobile SNS

The study breaks the three assumptions of the BASS model that market potential, imitation coefficient and innovation coefficient are constants throughout the diffusion circle, which are modified to a time-related function.

### Establishment of modified BASS model

**Influences of market potential:** The change of market potential is influenced by two factors. The first is that the largest market potential during the diffusion of mobile SNS is limited by mobile phone users. The second is that the largest market potential is not constant and changes with time.

Therefore, through the analysis of the first factor, we assume that $N_1(t)$ is the cumulative number of added mobile phone users at t; $N_2(t)$ is the cumulative number of added mobile SNS users at t; $F_1(t)$ is the cumulative proportion of added mobile phone users at t; and $F_2(t)$ is the cumulative proportion of added mobile SNS users at t, then:

$$N_1(t) = m_1F_1(t) \quad (1)$$

$$N_2(t) = m_2F_2(t) \quad (2)$$

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$$F_1(t)=\frac{1-e^{-(p_1+q_1)t}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)t}} \quad (3)$$

$$F_2(t)=\frac{1-e^{-(p_2+q_2)t}}{1+\frac{q_2}{p_2}e^{-(p_2+q_2)t}} \quad (4)$$

where, m2 only plays one part and is influenced by N1(t). It can be found from the analysis of the second factor that the ratio of m2 in N1(t) is not a constant and will change with time. The ratio is between 0 and 1 and close unlimitedly to 1. If it is assumed as a time function s(t), then:

$$s(t)=\frac{t}{t+a} \quad (5)$$

where, a is a constant, the influence coefficient of market potential over time, with the range of (0, +8). Then:

$$\frac{m_2}{N_1(t)}=s(t) \quad (6)$$

It can be found from the Eq. 6 that, when a takes a positive number, the ratio will increase with t and be close to 1; when a is within certain limits, it can grow rapidly in the initial stage, which conforms to the feature of practical growth; when a is 0, it will be 1, which indicates mobile phone users all use the mobile SNS.

α is a coefficient that shows the proportion of potential users of mobile SNS, or proportion coefficient for short. If σ takes 3, the ratio will change as shown in Fig. 1.

Through above analysis and equation 1~5, the model of mobile SNS diffusion based on the influence factors can be obtained, shown as below:

$$N_1(t)=m_1[\frac{1-e^{-(p_1+q_1)t}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)t}}] \quad (7)$$

$$N_2(t)=\frac{t}{t+a}m_1[\frac{1-e^{-(p_1+q_1)t}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)t}}][\frac{1-e^{-(p_2+q_2)t}}{1+\frac{q_2}{p_2}e^{-(p_2+q_2)t}}] \quad (8)$$

where, a is a constant, p1 is the external influence factor of diffusion of mobile phone users, p2 is the external influence factor of diffusion of mobile SNS, m1 is the largest market potential of diffusion of mobile phone users, q1 is the internal influence factor of diffusion of mobile phone users, q2 is the internal influence factor of diffusion of mobile SNS, $N_1(t)$ is the cumulative number of mobile phone users at t and $N_2(t)$ is the cumulative number of mobile SNS users at t.

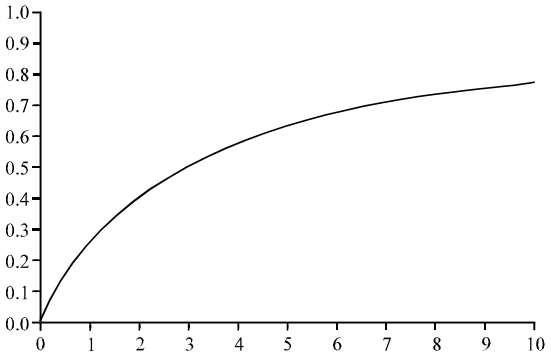


Fig. 1: Change of $m_2/N_1(t)$ with t

**In consideration of external and internal influence factors:** The external influence factor such as mass media *et al.*, is not constant, so the external influence effect can be set as a time function p(t) as follows:

$$p = p(t) \quad (9)$$

Similarly, the internal influence factor such as social environment *et al.*, is not constant, so the internal influence effect can be set as a time function q(t) as follows:

$$q = q(t) \quad (10)$$

The above study has proven that p(t) and q(t) both are decreasing functions; the analysis with Mathematic software shows that if p(t) and q(t) are not in the same functional form, the solutions of their differential formulas are both non-closed-form solutions. Therefore, the study sets both p(t) and q(t) with r[t] as:

$$p(t) = pe\text{-}bt \_ q(t) = qe\text{-}bt \quad (11)$$

where, b is a constant, representing the influence coefficient of the external influence factor and internal influence factor by time, with a range of (0, +8). Hence, in consideration of the variables of external influence factor and internal influence factor, the number of added users n(t) of mobile SNS diffusion at t is:

$$n(t)=[p(t)+\frac{q(t)}{m}N(t)][m-N(t)] \quad (12)$$

Put Eq. 11 into Eq. 12 and obtain:

$$n(t)=[p+\frac{q}{m}N(t)][m-N(t)]e^{-bt} \quad (13)$$

According to Eq. 12, apply Mathematic software to solve differential formula and obtain the process model of mobile SNS diffusion model, as:

$$N(t) = m\frac{1-e^{-(p+q)te^{-bt}}}{1+\frac{q}{p}e^{-(p+q)te^{-bt}}} \quad (14)$$

where, m is the largest market potential of mobile SNS diffusion, p is the external influence factor of mobile SNS diffusion, q is the internal influence factor of mobile SNS diffusion, b is a constant and N(t) is the number of added users of mobile SNS diffusion at t.

**Mobile SNS diffusion model based on modified BASS model:** Put Eq. 5 and 6 into Eq. 2 and obtain:

$$N_2(t) = \frac{t}{t+a}m_1F_1(t)F_2(t) \quad (15)$$

Combine Eq. 14 and obtain:

$$F_1(t) = \frac{1-e^{-(p_1+q_1)te^{-b_1t}}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)te^{-b_1t}}} \quad (16)$$

$$F_2(t) = \frac{1-e^{-(p_2+q_2)te^{-b_2t}}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)te^{-b_2t}}} \quad (17)$$

Put Eq. 16 into Eq. 1 and put Eq. 16 and 17 into Eq. 15 to obtain the modified model of the study, as:

$$N_1(t) = m_1\frac{1-e^{-(p_1+q_1)te^{-b_1t}}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)te^{-b_1t}}} \quad (18)$$

$$N_2(t) = \frac{t}{t+a}m_1\frac{1-e^{-(p_1+q_1)te^{-b_1t}}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)te^{-b_1t}}}\frac{1-e^{-(p_2+q_2)te^{-b_2t}}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)te^{-b_2t}}} \quad (19)$$

where, a and b are constants, p1 is the external influence factor of mobile phone user diffusion, p2 is the external influence factor of mobile SNS diffusion, m1 is the largest market potential of mobile phone user diffusion, q1 is the internal influence factor of mobile phone user diffusion and q2 is the internal influence factor of mobile SNS diffusion.

## DISCUSSION ON THE MODIFIED MODEL

According the expression of mobile SNS diffusion, namely Eq. 18, solve its extremum and obtain:

$$N_1(t)_{max} = \lim_{t\to\infty} m_1\frac{1-e^{-(p_1+q_1)te^{-b_1t}}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)te^{-b_1t}}} = m_1 \quad (20)$$

As is shown, it is consistent with largest market potential of basic BASS model. Similarly, Eq. 21 is obtained; that is, the extremum of N2(t) is m1, as times goes on, the most ideal situation will appear in the market and all mobile phone users will log in and use mobile SNS through mobile phone terminal:

$$N_2(t)_{max} = \lim_{t\to\infty}\frac{t}{t+a}m_1\frac{1-e^{-(p_1+q_1)te^{-b_1t}}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)te^{-b_1t}}}\frac{1-e^{-(p_2+q_2)te^{-b_2t}}}{1+\frac{q_1}{p_1}e^{-(p_1+q_1)te^{-b_2t}}} = m_1 \quad (21)$$

However, take the derivative of N1(t) through formula 13 and obtain:

$$n_1(t) = [p_1 + \frac{q_1}{m_1}N_1(t)][m_1 - N_1(t)] \succ 0 \quad (22)$$

That is, N1(t) and N2(t) are increasing functions; therefore, the largest market potential of the modified model of mobile SNS diffusion is less than m1, which means there are still some mobile phone users not logging in and using mobile SNS through mobile phone terminal in the market.

In the meantime, take the second derivative of Eq. 18 and obtain:

$$\frac{d^2N(t)}{dt^2} = -\frac{1}{m}[-\frac{1}{m}(2qN(t)-qm+pm)(N(t)q+pm)(N(t)-m)e^{-bt} - (N(t)q+pm)(N(t)-m)]e^{-bt} \quad (23)$$

Make Eq. 22 equal 0, so the inflection point of the curve is obtained, as:

$$t^* = \frac{1}{b}\ln[-\frac{1}{m}(2qN(t)-qm+pm)] \quad (24)$$

That is, it is at t* that mobile SNS diffusion reaches the inflection point; before t*, the total number of added users of mobile SNS accelerates to grow; after t*, the total number of added users of mobile SNS presents a downtrend in the rate of rise. And in the end, the best state of market of mobile SNS diffusion will be realized.

## MODEL FITTING EFFECT VERIFICATION

The numbers of China's mobile phone users and SNS users can be obtained, as shown in Table 1 and 2.

The eight parameters to be estimated in the modified model of the study include m1, p1, q1, a, b1, b2, m2 and q2. The study adopts nonlinear least square method, together with Matlab software, to conduct curve fitting.

Table 1: Total number of China's mobile phone users (Unit: Million)

| Time | Value of t | Total number of users | Time | Value of t | Total number of users |
|---|---|---|---|---|---|
| 1997 | 1 | 0.2 | 2005 | 9 | 3.9 |
| 1998 | 2 | 0.3 | 2006 | 10 | 4.7 |
| 1999 | 3 | 0.4 | 2007 | 11 | 5.5 |
| 2000 | 4 | 0.8 | 2008 | 12 | 6.4 |
| 2001 | 5 | 1.4 | 2009 | 13 | 7.4 |
| 2002 | 6 | 2.1 | 2010 | 14 | 8.6 |
| 2003 | 7 | 2.7 | 2011 | 15 | 9.7 |
| 2004 | 8 | 3.3 | | | |

Table 2: Total number of China's mobile SNS users (Unit: Million)

| Time | Value of t | Total number of users |
|---|---|---|
| 2006 | 1 | 0.21 |
| 2007 | 2 | 0.44 |
| 2008 | 3 | 1.05 |
| 2009 | 4 | 1.76 |
| 2010 | 5 | 2.16 |
| 2011 | 6 | 2.65 |

Table 3: Estimation of some parameters of mobile phone users in the modified model

| Parameter | Largest market potential $m_1$ (Unit: Billion) | Innovation coefficient p1 | Imitation coefficient q1 | Time influence coefficient b1 | Coefficient of determination R2 |
|---|---|---|---|---|---|
| Fitting result | 10.8818 | 0.0132 | 0.2255 | 0.0135 | 0.9788 |

Table 4: Estimation of some parameters of SNS users in the modified model

| Parameter | Innovation coefficient p2 | Imitation coefficient q2 | Time influence coefficient b2 | Coefficient of determination R2 |
|---|---|---|---|---|
| Fitting result | 0.0203 | 0.6701 | 0.0805 | 0.9771 |

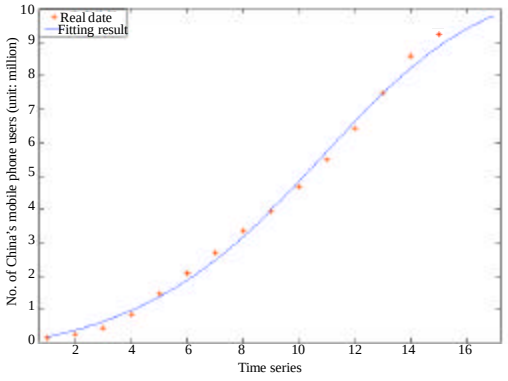


Fig. 2: Comparison of modified model fitting

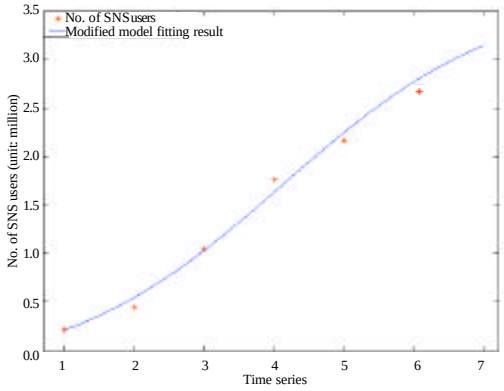


Fig. 3: Comparison of modified model result and the number of mobile phone users fitting result and the number of SNS users

Put the data of Table 1 into Eq. 18, conduct curve fitting on the number of mobile phone users and Table 3 is obtained.

Table 3 shows that the coefficient of determination of parameter fitting result is 0.9788 and the curve fitting result is very good, so the modified model is suitable for predicting the diffusion trend of mobile phone users. In the meantime, the imitation coefficient of 0.2255 is larger than the innovation coefficient of 0.0132, indicating that the influence factor of mobile phone user diffusion is mainly determined by imitation coefficient; that is, users exchange, social environment and policy environment greatly influence mobile phone users. The comparison of fitting curve and the number of mobile phone users is shown in Fig. 2.

According to the above data analysis result of China's mobile phone users, parameter estimation of mobile SNS diffusion is conducted. Put the data of Table 2 into Eq. 19 and Table 4 is obtained.

Table 4 shows that the coefficient of determination of parameter fitting result is 0.9771 and the curve fitting result is very good, so the modified model is suitable for predicting the diffusion trend of mobile SNS. In the meantime, the imitation coefficient of 0.6701 is larger than the innovation coefficient of 0.0805, indicating that the influence factor of mobile SNS diffusion is mainly determined by imitation coefficient; that is, users exchange, social environment and policy environment

greatly influence mobile SNS diffusion. The comparison of fitting curve and the number of mobile SNS users is shown in Fig. 3, with a fine curve fitting result.

Hence, the application of modified BASS model in analyzing mobile SNS diffusion rule can achieve excellent fitting result.

## CONCLUSION

The study combines the definition of innovation diffusion, gives the definition of mobile SNS diffusion and analyzes the main influence factors of mobile SNS diffusion; the study combines literature review and the analysis of mobile SNS diffusion factors, offers the modified model of mobile SNS diffusion in this study on the basis of basic BASS model and verifies that the modified BASS model is more suitable for the actual market change of mobile SNS diffusion than basic BASS model.

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