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# A Case Study on Membership Growth of a Teacher Professional Community Using the Diffusion Model

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## ABSTRACT

This is an exploratory case study to analyze the membership growth of a virtual community named SCTNet by using diffusion model. SCTNet (http://sctnet.edu.tw) is designed to facilitate profession communications among teachers of elementary schools and junior high schools in Taiwan. The diffusion model provides the insight of influential factors for the membership growth on the web site. According to the empirical results, the word-of-mouth has stronger effect than the mass-media advertising. In addition, the diffusion process is slower than those of general innovations or durable goods. The authors propose two possible reasons, one is that teachers belong to different homophilous groups and lack of heterophilous communications, and the other is that the isolation is a general problem surrounding the teachers. Besides, the virtual community is attributed as an interactive media; the more members gather, the more benefits can be generated such as professional advices and emotional supports among members. There should be a so-called "critical mass" in the diffusion curve for such interactive innovation. After the turning point, the membership grows explosively. However, the empirical data of this study does not appear such circumstance. Thus, several aspects that require further researched are suggested in the end of this paper.

Keywords: Virtual community, Membership growth, Diffusion model, Bass model

## INTRODUCTION

Many possibilities appear on the Internet in this decade. Individuals who ramble on the Internet make friends and form their own group or community. The so-called virtual community clusters people who have common interests interacting and communicating through the Internet. They share similar values, personal experiences, professional suggestions or emotional supports [19][21]. However, to build and to maintain a successful virtual community become challenging with more and newer virtual groups booming nowadays. There are many factors involved in the operation. Except sophisticated on-line functions and appealing visual web pages, a good virtual community requires relevant information to support for their business strategies and policies. Among those business essentials, issues about the amount of registered members are especially important because they are related to the survival of a virtual community and its further benefits.

How a virtual community grows in terms of increasing its members can be analyzed through the diffusion model. Bass [3] developed a model to predict the number of users to adopt an innovation. The model well described the sales of televisions, clothes dryers, dishwashers, and other

consumer durables. There are two main effects for people to adopt an innovation or to buy a new product: one is the advertising or mass communication, and the other is the word-of-mouse. In addition, for the diffusion model to work appropriately, two conditions are required. First, people should be able to talk to each other freely. For a non-user to adopt an innovation through the word-of-mouth, users have to talk to non-users and convey that they are users. Second, adopting an innovation is better than not adopting.

The characteristics of virtual community are satisfactory to the Bass model. Practically a virtual community is an innovation for a not-yet-member individual. As the first condition of the diffusion model about free communication, Internet has always been a channel for people to express their opinions or reach any type of information. For the second condition, from the preceding statement about a virtual community, an individual who attends a group associated with similar interests obtains several types of support. Thus, the Bass model can be applied to Internet for predicting and explaining the growth of a virtual community membership.

Analyzing through the diffusion model, this research is to study a non-profit virtual community, named Smart Creative Teachers Network (SCTNet), which has been built to facilitate the professional conversation among junior and elementary school teachers in Taiwan. SCTNet was formed in the middle of 2000, and now serves about 15000 members around Taiwan. The web site provides services such as educational news subscription, email, bulletin boards, teaching resources sharing, chat room, special interest groups, etc. There are certain functions only available for registered members. It is also a forerunner by adopting the novel information technology to enhance the interaction and communication among teachers in Taiwan.

Based on Bass model, the factors that influence a non-user to adopt an innovation are mass communication and word-of-mouth. The purpose of this research is to discover which factor plays the major role in the membership growth of SCTNet according to the assumptions of Bass model. In addition, we will evaluate the performance of the Bass model for describing and interpreting the increase of SCTNet members.

## BASS MODEL

Diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system [20]." Innovation, communication channels, time, and social systems are four essences contained in the diffusion process. Moreover, a diffusion process can either be planed or proceed spontaneously. The result might lead to an evolutionary or revolutionary change in a society.

The adoption during a diffusion process used to be described as an s-shaped form. In the beginning when an innovation is introduced, only a small portion of people who are called innovators adopt the innovation. After a while the innovation has been proved beneficial to those innovators, other people follow so that the diffusion process quickly explodes. Finally, through the abundant of adopters, the risk of adoption is perceived to be low. At this stage, laggards join the adoption; thus, the diffusion process slowly reaches its maximum. Many theoretical models have been derived in order to support the s-shape cumulative distribution; however, most of them are practically meaningless.

Bass [3] developed a diffusion model to describe the spread of an innovation over time. Since then, it has been sufficiently discussed and many revisions or extensions are inspired, especially in the field of marketing. Those models are satisfactorily applied for various innovation diffusions, such as retail service, industrial and agricultural technology, education, consumer durable goods marketing, and software [17][14][7].

Rather than the common interest in how to accelerate diffusion of an innovation, Bass model has its specific concerns in terms of adopters and diffusion time [20]. Let *m* be the number of potential adopters and *t* be the passing time since the innovation has been introduced into the system. The basic assumption of the Bass model is shown in the Equation (1).

$$\frac{dN(t)}{dt} = [g(t)][m - N(t)] \quad (1)$$

where *N(t)* is the cumulative number of adopters at time *t*, and *g(t)* is the probability of adoption at time *t*.

Equation (1) expresses that the increasing adopters during a time unit (from *t*–1 to *t*) equal to the number of non-adopters multiplied by adopting probability. Extended from Equation (1), three diffusion models were derived and briefly introduced.

## External-Influence Model

Let *g(t)* in Equation (1) be simplified as *p* that represents an external influence by the mass-media communication. Now the coefficient of innovation *p* is homogenous through any diffusion time *t*. In addition, it can be assumed that the diffusion process is determined only by the external force and written as the following,

$$\frac{dN(t)}{dt} = p[m - N(t)] \quad (2)$$

## Internal-Influence Model

The adoption probability *g(t)* in Equation (1) can be assumed to be the effect of the interpersonal communication, that is the influence of word-of-mouth. Then Equation (1) can be rewritten as,

$$\frac{dN(t)}{dt} = qN(t)[m - N(t)] \quad (3)$$

where *q* is an coefficient of imitation that is also homogenous through *t*. Note that Equation (3) is under the assumption that the diffusion process is only determined by the external force.

## Mixed-Influence Model

A non-user who intends to adopt an innovation can be affected either by advertising or by word-of-mouth. Thus, it is rational to combine the external effect (Equation (2)) and the internal effect (Equation (3)) for the diffusion process, and the mixed-influence model can be written as Equation (4) [3][16]. Furthermore, its integration is shown as Equation (5). These two equations are the main forms of the Bass model. In addition, the three diagrams in Figure 1 illustrate the theoretical forecasting of the innovation diffusion.

$$\frac{dN(t)}{dt} = [p + qN(t)][m - N(t)] \quad (4)$$

$$N(t) = m\left[\frac{1 - e^{-(p+q)t}}{1 + \frac{q}{p}e^{-(p+q)t}}\right] \quad (5)$$

The graph B of Figure 1 contains two figures which are the pdf $N'(t)$ and cdf *N(t)* of innovation adopters. Time T* indicates the peak of $N'(t)$; meanwhile it is the inflection point for the S-shaped cdf *N(t)*.

Although the Bass model provides abundant implications in practice while it is composed of frugal notations, some constraints summarized by Mahajan and Peerson are required for its application. First, the adoption is only affected by two factors, mass-media communication and word-of-mouth. Second, only one type of innovation involved in the diffusion process without any competitor or substitute. Third, an individual can adopt the innovation only once. Forth, the maximal number of potential adopters is finite and fixed [22]. Finally, prior adopters and potential adopters can freely communicate.

In order to relax those restrictions and better describe various situations, the Bass models has been modified by several researchers [17]. This study is an exploratory case

study that we apply the Bass model to test the membership growth of SCTNet. Through the empirical estimation of the two adoption coefficients *p* and *q* in the Bass model, which factor is more influential is of interest. In addition, how the predicted member growth matches the empirical data is analyzed and discussed.

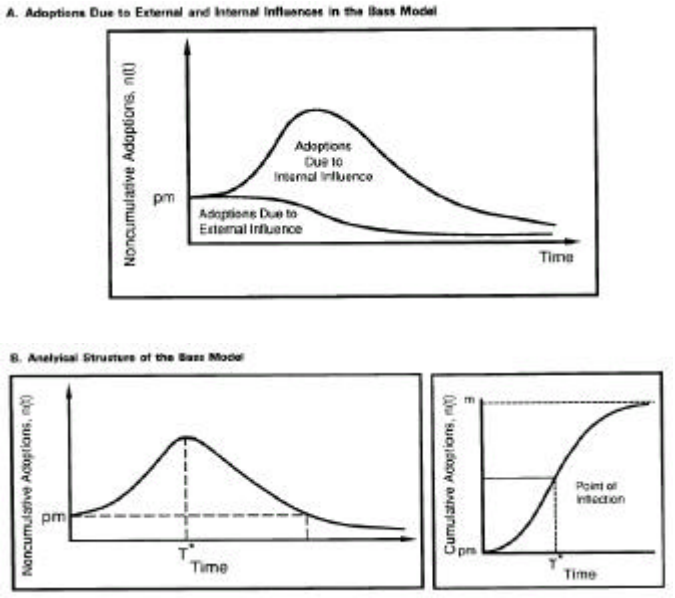


**Figure 1. The Bass model for Forecasting the Rate of Adoption of a New product. Surce: Mahajan, Muller, and Bass (1990).**

## METHOD

### Sample and Empirical Data

The purpose of SCTNet is to facilitate the professional communication among teachers in Taiwan. The potential SCTNet members are teachers in elementary schools and junior high schools. A team located in National Sun, Yat-sen University in Kaohsiung (the second largest city in Taiwan, on the southern part of Taiwan island) takes charge of SCTNet platform development, and the Bureau of education, Kaohsiung city government and many schools and teachers are promoting and managing this community. The promoting activities are mostly held in Kaohsiung, which results in the majority of members from elementary schools of Kaohsiung. Therefore, it is determined to analyze the membership growth of SCTNet based on their members belong to elementary schools of Kaohsiung. The total number of primary school teachers in Kaohsiung is 6344 according to the Ministry of Education, Taiwan. That is set for *m* in the Bass model.

Each SCTNet member can register for only one account. The registration time when an individual applies for the membership is treated as the adoption time in the Bass model. The authors extracted the historical data from the start of SCTNet to June 20, 2001. The duration contains thirty-one weeks. Each week is associated with a number of new members. There are 5457 registration in total. The data is listed in the appendix.

### Bass Model and Parameter Estimation

With the empirical data related to member growing and total potential members, two parameters *p* and *q* in the Bass model can be estimated by different methods. Mahajan et al. [17] provided two perspectives for the parameter estimation, time-varying and time-invariant estimation procedures. "Time-varying estimation procedures are designed to update parameter estimates as new data become available." [17, p.9] These procedures are not used in this study because the empirical data are historical records. On the other hand, the time-invariant estimation procedures include ordinary least square (OLS), maximum likelihood estimation (MLE), and nonlinear least squares (NLS). Among those techniques, NLS usually generates more satisfactory results. In this study, NLS is computed by SPSS 10.0 for the statistic estimation of *p* and *q*.

Moreover, two important requirements have been confirmed. First, the size of adopters should cover the peak of theoretical $n(t^*)$ distribution; otherwise the estimations would not generate stable and robust parameters. Second, the NLS is based on the assumption of continuous variables. For the first condition, the

number of registered members (5457) for this study exceeds the half of the potential members (it is 3172). For the second condition, before estimating diffusion model, the discrete analog to the original continuous differential equation must be formulated. The original differential equation is transformed into the following equation,

$$N(t) = m\left[\frac{1-e^{-(p+q)t}}{1+\frac{q}{p}e^{-(p+q)t}}\right]$$

## EMPIRICAL RESULTS

Table 1 presents the statistic estimation for $p$ and $q$ in the Bass model, where $p$ is estimated as 0.024 and $q$ is 0.071. That R-square is 0.983 which indicates that a good model fit for the empirical data. Figure 2 shows the empirical data and the predicted values for cumulative distribution of registered members.

With results shown in Table 1 and Figure 2, the Bass model is a good model to describe the membership growth of SCTNet. In addition, the fact that the estimated value of $q$ is almost three times of $p$ implies the personal communication is more efficient to recruit new members than the mass-media effect.

**Table 1. The results of NLE estimation procedure.**

Dependent variable is NT

| Source | Sum-of-Squares | df | Mean-Square |
|---|---|---|---|
| Regression | 3.36269E+08 | 2 | 1.68135E+08 |
| Residual | 1421011.039 | 29 | 49000.381 |
| Total | 3.37690E+08 | 31 | |
| Mean corrected | 7.37978E+07 | 30 | |

| | |
|---|---|
| Raw R-square (1-Residual/Total) | 0.996 |
| Mean corrected R-square (1-Residual/Corrected) | 0.981 |
| R(observed vs predicted) square | 0.983 |

| Parameter | Estimate | A.S.E. | Param/ASE | Wald Confidence Interval Lower < 95%> Upper |
|---|---|---|---|---|
| P | 0.024 | 0.002 | 12.416 | 0.020 0.028 |
| Q | 0.071 | 0.008 | 8.721 | 0.054 0.089 |

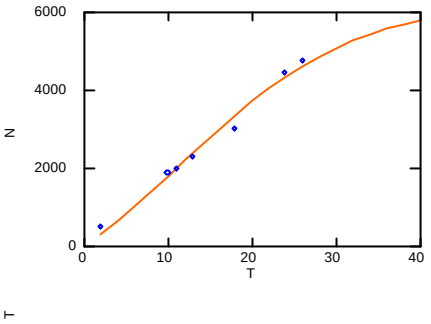


**Figure 2. Cumulative registered members: empirical data versus estimated values**

## DISCUSSIONS

### The Slow Diffusion

For the application of the Bass model to the diffusion process of general innovation, Lawrence and Lawton [11] suggested that $p + q$ ranged from .3 to .7 is appropriate. Sultan et al. [23] suggested the average values for $p$ and $q$ are .03 and .38 respectively where $q$ is often greater than $p$. Table 1 shows the estimation of $p + q$ as 0.095 which is much smaller than the suggested range of Lawrence and Lawton. The low value would result in slow diffusion [23]; that reflects on the real data to let SCTNet membership grow slowly. Nevertheless, the virtual community and traditional marketing for durable goods share very few common properties. Further researches are needed to investigate why the slow diffusion happens. There should be new references for the value of $p + q$ for the Internet.

### Homophily Effect

Rogers [20] explains how homophilous or heterophilous communication can affect the diffusion. "Homophily is the degree to which a pair of individuals who communicate are similar," stated by Rogers, and "Heterophily is the opposite of homophily." Individuals with similar attributes are most likely to have effective communications. Homophily usually accelerates the diffusion process. However, the homophilous diffusion patterns spread horizontally rather than vertically because

the diffusion is limited in a group or system composed by people sharing certain common characteristics. As the opposite to homophily, heterophilous interpersonal links that is close to Granuovetter's theory of weak ties connect two sets of homophilous groups [8]. An efficient diffusion process needs sufficient heterophlous links among different homophilous groups. It turns out that homophily could be an invisible barriers for an innovation diffusion [20].

The target population of SCTNet is teachers of elementary schools and junior high schools in Taiwan. In these schools, a teacher owns at least an undergraduate degree with specific requirement of education credits. Teachers have similar education background and with the same carrer goal as teaching and education. They are homophilous groups. This might be one reason for the slow diffusion rate of SCTNet membership.

## Effect of Isolation

Coleman et al. [6] stated that isolated individual who hardly interacts with others would not learn their experiences about adopting the innovation. A system contains many isolated persons would result in slow diffusion such that the diffusion rate becomes almost a fixed constant. In fact, isolation has turned to be a general problem of teachers [2]. Lortie claimed that both physical and social isolations have long troubled teachers [15]. Harris considered that the architectural structure of school buildings hinders teachers from interacting with each other [9]. In addition, the spirit of autonomy and the respect of privacy diminish communications among teachers [5][13].

The cumulative distribution of registered members shown in Figure 2 looks more close to a straight line than an S-shaped curve. The result implies that isolation might exit among teachers, and thus the chain-reaction snowball does not occur.

## Critical Mass Does Not Appear

Internet has been attributed to the interactive media as well as telephone, fax, electronic messaging systems, etc. For such interactive innovation, the critical mass happens at the time when there is a certain amount of innovation adopters so that each additional adopter would generate extra advantage to a whole system constructed by all the adopters [18]. As discussed by Rogers [20, p.314], an interactive innovation has a steeper S-curve after the diffusion reaching its critical mass.

A virtual community as SCTNet is also an interactive media. The more members gather on the SCTNet, more valuable teaching experiences or resources are shared among the SCTNet members. However, the line shown in Figure 2 suggests that there is none of the critical mass for the SCTNet membership growth. The reason for this empirical result might be the small sample that consists of elementary and junior high school teachers in a city of Taiwan.

## CONCLUSION

There are many unique characteristics for professional virtual community. Understanding the pattern of membership growth can help for the operationed decisions as well as advertising strategies. This paper is an exploratory case study by analyzing the data of SCTNet to observe an innovation diffusion process on the Internet. In the study, the Bass model provides a good model fit to the empirical data, but the diffusion rate appears to be much slower than traditional durable goods used to be discussed in the marketing researches. Several perspectives of the diffusion process are discussed in this paper, possible reasons including homophily, isolation and the small sample size. Nevertheless, the result is not conclusive. Further studies are suggested as the following. Firstly, it has been more than thirty years since the Bass model was proposed in 1969. It has inspired many

different diffusion models for various conditions and applications. Because the virtual community such as SCTNet is an Internet innovation that can be categorized as an interactive innovation, the diffusion model needs to be modified to consider its special characteristics. Alternative models are suggested to be the further research.

Second, whether the target population of SCTNet are all homophilous groups or not should be further investigated so that the influence of social network can be clarified. However, this needs another research design to obtain empirical data from the sample.

Finally, does a life-cycle effect exist in the virtual community as what the traditional marketing researchers found from durable goods or innovations? Although it does not show on the data of SCTNet, life-cycle problem is an important issue for the operational and strategic decisions not only for general business, but also for the Internet.

## Appendix: Source Data

| Week | Number of New registers |
|---|---|
| 1 | 207 |
| 2 | 267 |
| 3 | 253 |
| 4 | 257 |
| 5 | 278 |
| 6 | 161 |
| 7 | 16 |
| 8 | 209 |
| 9 | 151 |
| 10 | 74 |
| 11 | 102 |
| 12 | 192 |
| 13 | 109 |
| 14 | 122 |
| 15 | 119 |
| 16 | 139 |
| 17 | 170 |
| 18 | 181 |
| 19 | 394 |
| 20 | 249 |
| 21 | 201 |
| 22 | 246 |
| 23 | 158 |
| 24 | 185 |
| 25 | 146 |
| 26 | 157 |
| 27 | 135 |
| 28 | 139 |
| 29 | 115 |
| 30 | 150 |
| 31 | 175 |

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