The Third Communication Channel in the Diffusion Process

확산과정에서의 세 번째 의사전달경로

Park, Sang-June(박 상 준)*
Shin, Changhoon(신 창 훈)**

The Bass model assumes two communication channels: mass-media and word-of-mouth. In this paper, we call the mass-media *Type I channel of communications*. The word-of-mouth channel means interaction between non-adopters and adopters. Let us call it *Type II channel of communications*. In the real world, however, the non-adopters who are not aware of the innovation can be affected by communications with other non-adopters who are aware of it. Let us call it *Type III channel of communications* to differentiate with Type II channel. This paper analyzes the impact of Type III channel on diffusion process. The result shows that exponential growth patterns (for example, the adoption patterns of the blockbuster movies) can be observed when non-adopters are influenced by other non-adopters who aware of the innovation.

Key words: diffusion, communication channels, innovation

I. Introduction

Diffusion is process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers 1983, p.6). He also contends that consumers evaluate possible adoption times with the information from communication channels and the uncertainty from newness for adoption time decision of an innovation. After the seminal papers of Mansfield(1961) and Bass(1969), considerable research has been done on modeling the diffusion process.

* Associate Professor of School of Business Administration, Chonbuk National University(psj@chonbuk.ac.kr)
** Corresponding Author and Associate Professor of Department of Logistics System Engineering, Korea Maritime University(chshin@hhu.ac.kr)

While the Mansfield model assumes that there is only one communication channel commonly called as word-of-mouth (W.O.M), the Bass model, which is main impet us underlying diffusion research in marketing, assumes that potential adopters of an innovation are influenced by two means of communications: mass-media and word-of-mouth. It has been found that the Bass model and its various modified forms quite well describe the empirical adoption curve in diverse product/service categories such as retail service, industrial technology, agriculture, and the educational, pharmaceutical and consumer durable markets (Mahajan, Muller and Bass 1990).

Both the Bass model and the Mansfield model assume that the word-of-mouth comes from interpersonal communication with previous adopters. In the real world, however, the potential adopters can be affected by communication with other potential adopters (non-adopters), as well as communications with adopters. This paper tries to analyze the impact of the communications with other non-adopters who are aware of the innovation.

In this article, we develop a general diffusion model and interpret the previous models (Bass model and Mansfield) under the general framework. In addition, we present some findings that have not been addressed in previous studies.

Ⅱ. Model Development

As a theory of communications, the main focus of diffusion theory is on communication channels, which are the means by which information about an innovation is transmitted to or within the social system. These means consist of both the mass media and interpersonal communications (Mahajan, Muller, and Bass 1990).

The Bass model (1969) assumes that a social system consists of two segments: non-adopters and adopters. In the model, the potential adopters (or non-adopters) communicate with adopters and are influenced by the adopters. The potential adopters can also be affected by communication with other potential adopters (non-adopters) who aware of the innovation. Let us assume that a social system can be partitioned into three segments: adopters (Group A), non-adopters who are unaware of the innovation (Group B), non-adopters who are aware of it (Group C). Of course, the adopters are aware of the innovation spreading in a system. We can consider three types of interactions between the three groups: interaction between Group A and Group B, interaction between Group A and Group C, and interaction between Group B and Group C. The aggregated channel of the interaction between Group A and Group B (Group A * Group B) and interaction between Group A and Group C (Group A * Group C) is the identical to the interpersonal communication channel the Bass model (1969) assumes. Let us call this aggregated channel *Type II channel of communications*.

The third type of interaction, which is interaction between Group B and Group C (Group B * Group C), has not considered by previous researchers. In this paper, we will focus on this interpersonal communication cannel. Let us call this channel *Type III channel of communications*, and the mass-media *Type I channel of communications*. In this paper we look at the two broad stages of a consumer's new product adoption process: awareness stage and purchase stage. Previous studies have discussed the behavioral stages of the consumer's new product diffusion process (Mahajan and Muller 1979; Mahajan, Muller and Kerin 1984; Urban, Hauser, and Roberts 1990; Sawhney and Eliashberg 1996; Eliashberg, Jonker, Sawhney, and Wierenga 2000).

To analyze the influence of Type III channel on a diffusion process, let us consider the following mathematical model. <Figure 1> shows the graphical illustration of the proposed model

$$S(t) = p[m - Y(t)] + \frac{q_1}{m} Y(t)[m - Y(t)] + \frac{q_2}{m}[A(t) - Y(t)][m - A(t)] \qquad (1)$$

where the parameters p, q_1, and q_2 represent the impacts of Type I channel, Type II channel, and Type III channel, respectively. $Y(t)$ is the number of previous adopters and m is the total number of potential adopters in a social system, and $A(t)$ is the number of the individuals who are aware of the innovation at time *t*.

The equation (1) is a generalized model of the Bass model. When we assume that the coefficient q_2 is zero, the model reduces to the Bass model. Therefore, the Bass model is a special case of the proposed model. $A(t) - Y(t)$ denotes the number of the individuals who are aware of the innovation but do not adopt the innovation by time t. The proposed model can be written by equation (2) or equation (3).

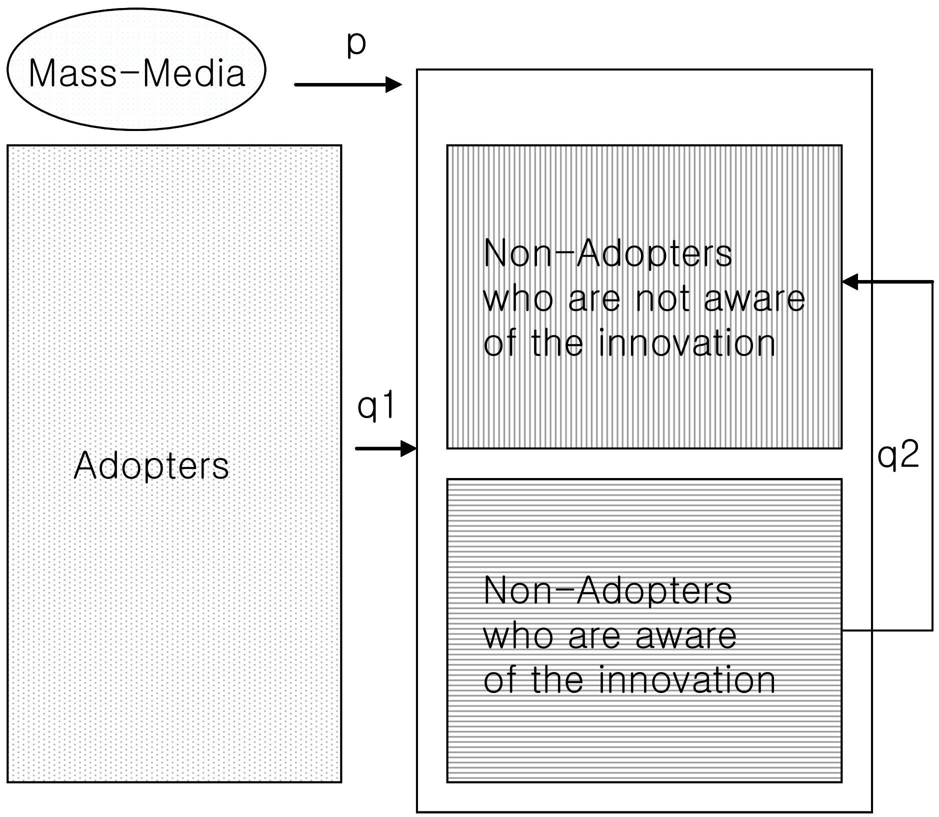
$$\frac{S(t)}{m} = p\left[1 - \frac{Y(t)}{m}\right] + q_1 \frac{Y(t)}{m}\left[1 - \frac{Y(t)}{m}\right] + q_2\left[\frac{A(t)}{m} - \frac{Y(t)}{m}\right]\left[1 - \frac{A(t)}{m}\right]. \qquad (2)$$

$$F'(t) = p[1 - F(t)] + q_1 F(t)[1 - F(t)] + q_2[I(t) - F(t)][1 - I(t)]. \qquad (3)$$

where $F(t) = Y(t)/m$ and $(t) = A(t)/m$.

It is not easy to observe the number of individuals who are aware of the innovation at each period. To escape the data collection hurdle let us compute $I(t)$ with a function of $F(t)$, which is expressed as equation (4), because it is possible to observe the number of adopters at each period.

<Figure 1> Three Types of Communication Channels



$$I(t) = F(t) + (1-\alpha)[1-F(t)]$$

where $0 \le \alpha \le 1$. (4)

As shown in <Figure 2>, we can generate various patterns of $I(t)$ depending on the parameter α in equation (4). The time delay between awareness diffusion and adoption diffusion increases as the α increases.

From equation (3) and equation (4), we get the following hazard function of the proposed model.

$$\frac{F'(t)}{1-F(t)} = p + q_1 F(t) + q_2 \alpha (1-\alpha)[1-F(t)] \ . \quad (5)$$

Because

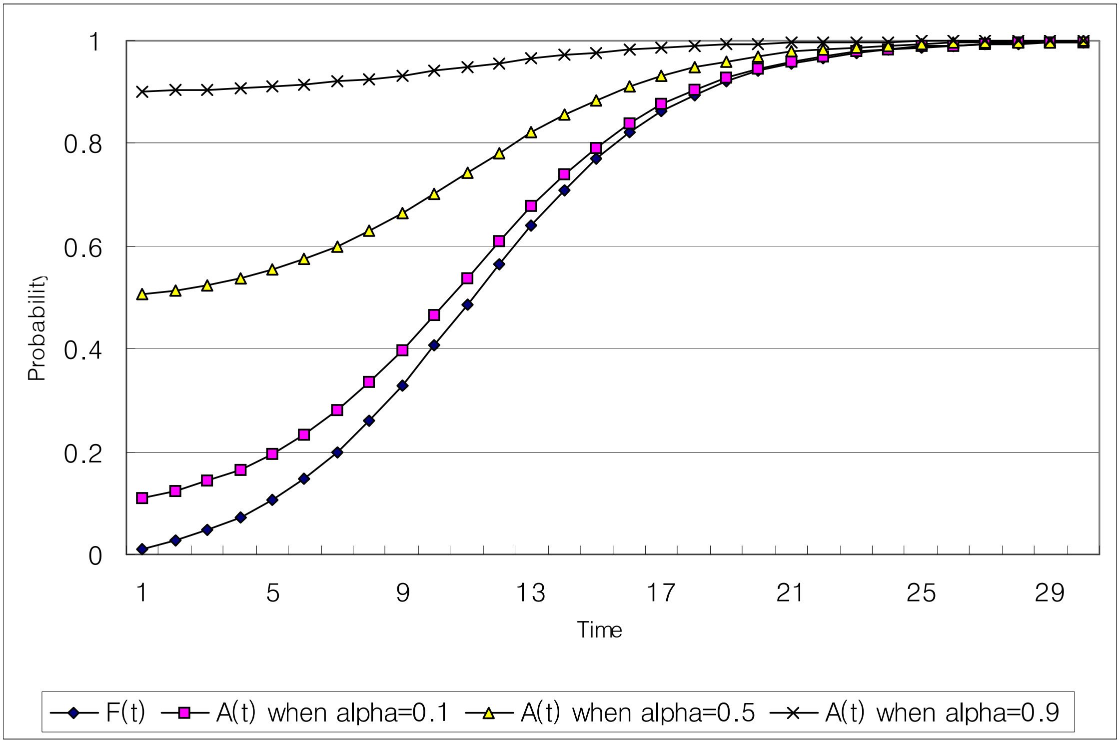
$$I(t) - F(t) = \alpha[1-F(t)] \ge 0 \ , \quad (6)$$

and

$$1 - I(t) = 1 - [\alpha + \alpha\{1-F(t)\}]$$
$$= (1-\alpha)[1-F(t)]. \quad . \quad (7)$$

The final hazard function can be written by equation (8). Interestingly, the proposed model

<Figure 2> Shapes of F(t) and A(t) when p=0.01 and q=0.3



can be written by the hazard form of the Bass model.

$$\frac{F'(t)}{1-F(t)} = \lambda(t) = p^* + q^* F(t) , \tag{8}$$

where $p^* = p + q_2\alpha(1-\alpha)$

and $q^* = q_1 - q_2\alpha(1-\alpha)$.

If we do not consider the third channel (when $q_2 = 0$), the proposed model is exactly the identical to the Bass model. Assuming $F(0) = 0$, we can derive a cumulative adoption probability function.

$$F(t) = \frac{1-\exp(-(p^*+q^*)t)}{1+(q^*/p^*)\exp(-(p^*+q^*)t)} , \tag{9}$$

where $p^* = p + q_2\alpha(1-\alpha)$

and $q^* = q_1 - q_2\alpha(1-\alpha)$.

Ⅲ. Propositions

In equation (9), p^* and q^* are the two parameters of the Bass model and they are functions of 1) the impact of Type I channel, 2) the impact of Type II channel, and 3) the impact of Type III channel, as we see in equation (9). That is why we try to re-interpret the parameters of the Bass model.

From equations (10) and (11), we know that Type I channel and Type II channel has influence on the coefficient of the mass-media and the coefficient of the word-of-mouth in the Bass model, respectively.

$$\frac{\partial p^*}{\partial p} > 0 \text{ and } \frac{\partial q^*}{\partial p} = 0 , \tag{10}$$

$$\frac{\partial p^*}{\partial q_1} = 0 \text{ and } \frac{\partial q^*}{\partial q_1} > 0 . \tag{11}$$

Type III channel positively influences the coefficient of the mass-media in the Bass model, whereas it negatively does the coefficient of the word-of-mouth in the Bass model(see equation (12)).

$$\frac{\partial p^*}{\partial q_2} > 0 \text{ and } \frac{\partial q^*}{\partial q_2} < 0 . \tag{12}$$

The impact of the alpha on the coefficients of the Bass model depends on the interval of the alpha.

$$\frac{\partial p^*}{\partial \alpha} > 0 \text{ where } 0 < \alpha \le 1/2 \text{, and } \frac{\partial p^*}{\partial \alpha} < 0 \text{ where } 1/2 < \alpha \le 1 . \tag{13}$$

$$\frac{\partial q^*}{\partial \alpha} < 0 \text{ where } 0 < \alpha \le 1/2 \text{, and } \frac{\partial q^*}{\partial \alpha} > 0 \text{ where } 1/2 < \alpha \le 1 . \tag{14}$$

Proposition 1: *The greater the influence of Type I channel, the faster the diffusion pace is.*

The greater the hazard rate [equation (8)], the faster the pace of diffusion is. Note that $\frac{\lambda(t)}{p} > 0$.

Proposition 2: *The greater the influence of Type II channel, the faster the diffusion pace is.*

Note that $\frac{\lambda(t)}{q_1} > 0$ in equation (8).

Proposition 3: *The greater the influence of Type III channel, the faster the diffusion pace is.*

Note that $\frac{\lambda(t)}{q_2} > 0$ in equation (8).

Proposition 4: *Potential adopters adopt an innovation earlier when they communicate with non-adopters as well as adopters than when they do only with adopters.*

Note that $\frac{\lambda(t)}{q1} + \frac{\lambda(t)}{q_2} > \frac{\lambda(t)}{q_1}$ and $\frac{\lambda(t)}{q1} + \frac{\lambda(t)}{q_2} > \frac{\lambda(t)}{q_2}$.

Proposition 5: *When the influence of Type III channel is great, exponential growth pattern can be observed.*

We can derive exponential growth pattern when the coefficient p^* is greater than the coefficient q^*: $p^* - q^* = p + 2q_2\alpha(1-\alpha) - q_1 > 0$. See Figure 3. From this condition, we get three conditions.

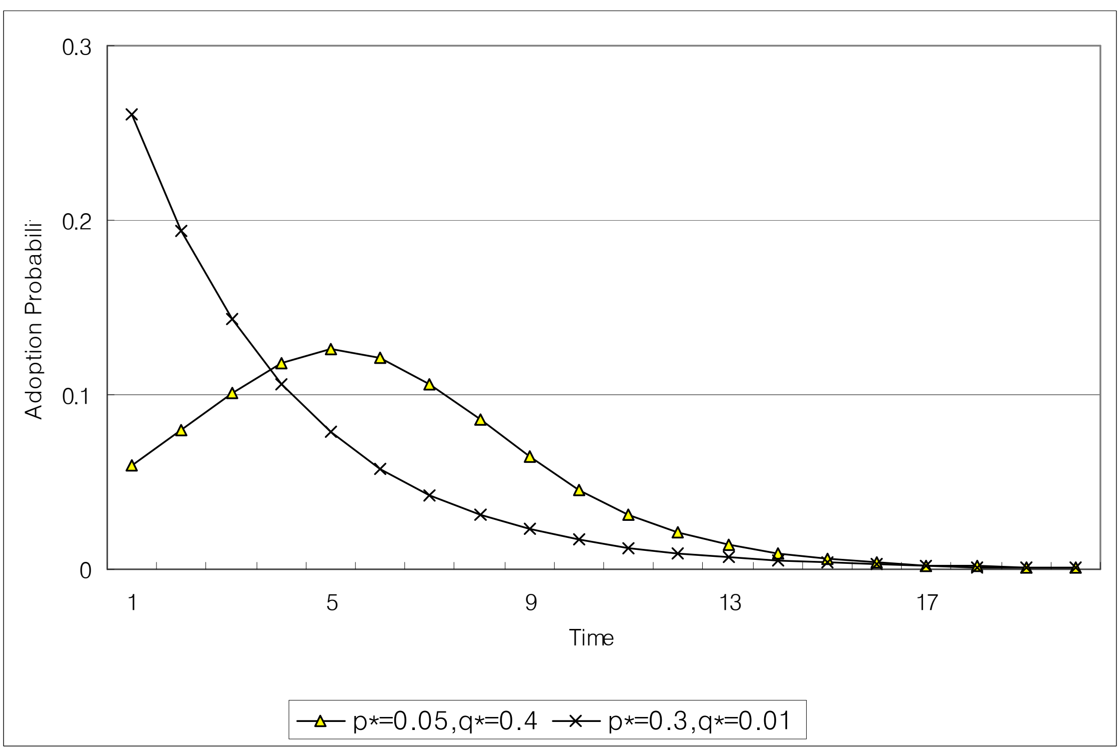
$$\frac{\partial(p^* - q^*)}{\partial p} > 0, \quad \frac{\partial(p^* - q^*)}{\partial q_1} < 0,$$

$$\text{and} \quad \frac{\partial(p^* - q^*)}{\partial q_2} > 0. \qquad (15)$$

Let us look into the third condition among them. The third condition implies that we can observe the exponential sales pattern when the influence of Type III channel is great. Note that Type III channel denotes the interpersonal communications between the non-adopters who are unaware of the innovation and the non-adopters who are aware of it. Figure 4 shows that the exponential growth pattern can be observed depending on the parameter q_2 which denotes the influence from Type III channel.

While growth patterns of 'sleeper movies' such as 'Lorenzo's Oil' and 'The Doctor' show

<Figure 3> Bell-shaped adoption curve vs. exponentially decaying adoption curve



typical bell-shaped curves, growth patterns of 'blockbuster movies' such as 'Terminator 2', 'Robin Hood', and "Die Hard 2" show exponential curves (See Lilien and Rangas-wamy 1998, p.196). Why do the blockbuster movies show us the exponential growth pattern of adoption curve?

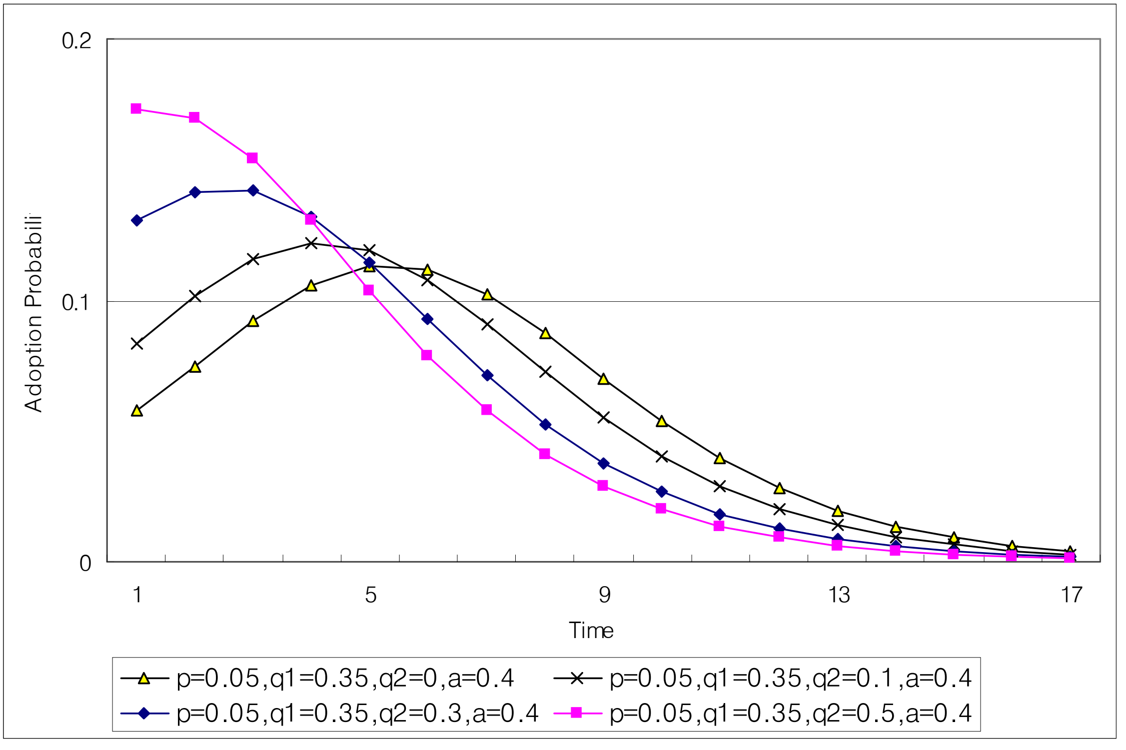
Under the original concept of Bass model, exponential growth is mathematically derived only when the word-of mouth effects coming from adopters is greater than the mass media effects. Most durable goods do not show such patterns although firms have spent much money in mass media.

From proposed model, we can derive such a sales function when q_2 is relatively greater. The blockbuster movies commonly spend much money to mass media before their introduction so that most potential adopters already know their stories. In this case, we can think that the influence of non-adopters can be increased.

Ⅳ. Conclusions

Innovation diffusion models traditionally have been used for in the context of sales

<Figure 4> Various adoption curves depending on the parameter q_2



forecasting. In addition to forecasting, the most useful applications of diffusion models are for descriptive and normative purpose (Mahajan, Muller, and Bass 1990). This paper developed a general diffusion model to use for in the context of the descriptive and normative purpose. Note that the proposed model has some limitations that one can not use it for the sales forecasting purpose.

Unlike the previous models, the proposed model considered the communication channel between non-adopters (between aware and unaware non-adopters). If the influence from the non-adopters does not exist or is negligible, the diffusion exactly follows the path of Bass model under the proposed model.

This paper presented some findings that have not been addressed in previous diffusion literature. Potential adopters adopt new product earlier when they are influenced more strongly by non-adopter group. When the influence from Type III channel (effect of word-of-mouth from non-adopters who are aware of the innovation) is great, exponential growth pattern can be observed. This implies that non-adopters can play a main role in explaining explosive diffusion in the stage of early product life cycle.

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확산과정에서의 세 번째 의사전달경로

박 상 준*
신 창 훈**

국문요약

Bass의 확산모형은 대중매체와 구전(口傳)이라는 두 형태의 의사전달경로를 가정하고 있다. 본 논문은 대중매체 의사전달경로를 첫 번째 의사전달경로 보고 있다. 구전 경로에서는 혁신의 수용자와 비수용자간의 상호작용이 일어난다. 본 논문은 이 구전 경로를 두 번째 의사전달경로로 보고 있다. 그러나 현실에서는 혁신을 알고 있지 못하는 비수용자는 혁신을 알고 있는 비수용자와의 상호작용을 통해 영향을 받을 수 있다. 본 논문에서는 이를 두 번째 의사전달경로와 차별화하기 위하여 세 번째 의사전달경로로 보았다. 본 논문은 세 번째 의사전달경로가 확산과정에 미치는 영향을 분석하였다. 세 번째 의사전달경로가 확산과정에 포함되면 블록버스터영화의 흥행 수입 형태와 같은 지수적 성장 형태도 확산의 한 형태로 유도될 수 있음을 본 논문에서 보이고 있다.

핵심개념: 확산, 의사전달경로, 혁신

* 전북대학교 경영학부 부교수
** 교신저자. 한국해양대학교 물류시스템공학과 부교수