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A study of role of marketing variables in technological innovation diffusion

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Abstract

Diffusion models is an approach to analyse the process of diffusion of innovation. Several diffusion models have been developed to predict the penetration curves while many other models are developed to explain the complexities of the underlying diffusion process .In this paper attempt has been made to explain the process of technological change and diffusion with the help of mathematical model.

Keywords-Bass Model, Generalized Bass Model, external influence, internal influence

Introduction

The diffusion of an innovation has traditionally defined as the process by which on innovation is communicate through certain channels over time among the members of a social system. There are four elements in the diffusion process: the innovation, channels of communication, time and the social system. Technology Diffusion has understood as a process by which new technology or an innovation has propagated through certain channels over time among the units of system. Schumpeter (1939) sees diffusion as the final stage of the technology development. Rogers (1962) describes diffusion of new product as a five-stage process- awareness, interest, evaluation, trial and adoption. Grubler (1998) describes the diffusion as widespread adoption of technologies over time, in space and between social strata. The elements of technology diffusion comprise of innovation, propagation, time, and units of social systems (Narayanan, 2001). Strategies to commercialize technologies is expected to follow a path way set in stages of imagining, incubating, demonstrating, promoting and sustaining technologies (Vedpuriswar, 2003). Diffusion is considering as the stage after invention and innovation of a technology. The diffusion process passes through filtering, tailoring and acceptance of a technology. Many inventions may or may not reach the stage of diffusion. The diffusion processes in general follow an S curve (Figure 1). The curve generally comprises of three distinct phases:

i). an initial slow growth

ii) a rapid take-off period and

iii) a flattening of growth, signifying a near completion of diffusion.

In this study, we discuss how the models structure could be modified to account for some of social dynamics occurring during technological substitution.

Diffusion Model

Bass (1969) model been has been one of the most influential in diffusion modeling. Fourt and Woodlock (1960) assume that the diffusion process is mainly driven by mass-media communication, where as Mansfield's model (1961) assumes that the word of mouth communication as the primary driver of diffusion. Bass was the first to combine the effect of mass-media and word of mouth communication. The adopters are categorizing into two groups- innovators and imitators. Innovators are influence by mass-media communication, or external influence, and imitators are influencing by word of mouth communication, or internal influence.

The differential equation that capture the growth of a new consumer durable is given by

$$n(t) = \frac{dN(t)}{dt} = p\big(m - N(t)\big) + q\frac{N(t)}{m}\big(m - N(t)\big),\ N(0) = 0$$

where $n(t)$ is the number of adopters at time $t, N(t)$ is the cumulative number of adopters up to time t not including t, m is the total market potential and p and q are the coefficients of innovation and imitation respectively. The model is based on the assumptions that the products are purchased infrequently and there are no repeat purchases. Therefore, market potential will be composed of m initial purchases. Secondly, the initial purchases are made by both category of adopters, "innovators" and "imitators". Innovators are venturesome and the number of previous buyers influences daring people who are not influenced by the previous buyers where as imitators.

In the first time period of sales, cumulative adopters are said to be zero and the equations are derived as:

1st year: $N(1) = 0,\ n(1) = pm$

2nd year: $N(2) = N(1) + n(1) = pm$

$$n(2) = p\big(m - N(2)\big) + q\frac{N(2)}{m}\big(m - N(2)\big) = pm(1-p)(1+q)$$

$$N(t) = N(t-1) + n(t-1)$$

$$n(t) = p\big(m - N(t)\big) + q\frac{N(t)}{m}\big(m - N(t)\big) \qquad \ldots(1)$$

where $N(t)$ and $n(t) = dN(t)/dt$ are respectively the cumulative and the noncumulative number of adopters of a new product at time t. The adoption rate $n(t)$ is determined by two additive terms: the first term, $p[m - N(t)]$, represents adoptions due to innovators, where as the second term, $(q/m)N(t)[m - N(t)]$, represents adoptions due to imitators.

To stress the fact that functions $N(t)$ and $n(t)$ depend on parameters m, p and q, we shall write $N(t; m, p, q)$ and $n(t; m, p, q)$

The solution of (1) and the corresponding adoption rate function are given by

$$N(t;m,p,q) = m\frac{1-e^{-(p+q)t}}{1+\frac{q}{p}e^{-(p+q)t}}\ ,\ t \geq 0, \qquad \ldots(2)$$

and
$$n(t;m,p,q) = m\frac{(p+q)^2}{p}\frac{e^{-(p+q)t}}{\left(1+\frac{q}{p}e^{-(p+q)t}\right)^2}\ , t \geq 0 \qquad \ldots(3)$$

The graph of the function N is known as the Bass cumulative adoption curve, and the graph of the function n is known as the Bass (noncumulative) adoption curve.

The graph of the cumulative adoption curve N is an S-shape curve. If $q > p$, for this curve the point of infection occurs at

$$t^* = \frac{1}{p+q} In(q/p)$$

with
$$N(t^*;m,p,q) = m\frac{(q-p)}{2q}$$

(see Fig. 1). For $q \leq p$, the graph is still S-shaped, but the point of inflection occurs at a negative value of t. Furthermore, if $q > p$, it can be easily shown that the adoption rate function n has a maximum value at t^*.

$$n(t^*;m,p,q) = m\frac{(p+q)^2}{4q}$$

and that n is symmetric about the peak t*. In the case when $q > p$, the adoption rate function n is strictly decreasing on [0,∞)Fig.(2).

The Generalized Bass Model

Robinson and Lakhani (1975) external the Bass Model to introduce a price function based on the fact that cost and sales of product depends as the aggregate volumes of sales the model in given by

$$n(t) = \big(m - N(t)\big)\big(p + qN(t)\big)e^{-\lambda P(t)}$$

where $P(t)$ is the price at time t and λ is the price coefficient. This simplistic model does not explain why or when purchase decisions are made.

Dodson and Muller (1971) or gue that the total market is comprised of people who are not aware of the product, people who have already purchased the product. A portion of people who are aware makes the purchase decision and move to the adopters pool. Person who buy the product at time t is given by

$$n(t) = \frac{m[1-e^{-\rho t}]}{[1+\beta m e^{-\rho t/\mu}]}$$

where $\rho = \beta m + \mu$, β is the impact of word of mouth communication and μ is the advertising impact. They extend this model to include repeat purchases.

Horsky and Simon (1983), proposed a diffusion model to takes into account of advertising and its effect on the non adopters. This model is $n(t) = P(t)[m - N(t)]$, $P(t)$ is the conditional probability of adoption given by

$$P(t) = \alpha + \beta \log A(t) + \gamma N(t)$$

where $A(t)$ is the advertising spending at time t, β and γ represents the effectiveness of its sources, α represent information stread through media. The probability of adoption is influence by the advertising budget.

Bass, Krishnan and Jain (1994) proposed the generalised Bass Model to incorporate the effects of price and advertising. They introduce a current marketing component extended Bass Model as follows.

$$n(t) = \frac{dN(t)}{dt} = \left[p\big(m - N(t)\big) + q\frac{N(t)}{m}\big(m - N(t)\big)\right]x(t) \qquad \ldots(4)$$

where $x(t)$ is a function of the marketing mix variable (advertising and price) in time period t

$$\mathrm{x(t)} = 1 + \beta_1 \frac{[P(t) - P(t-1)]}{P(t-1)} + \beta_2 \max\{0, \frac{[a(t) - a(t-1)]}{a(t-1)}\}$$

$\beta_1 =$ coefficient capturing the percentage increases in diffusion speed resulting from a 1% in decreases in price.

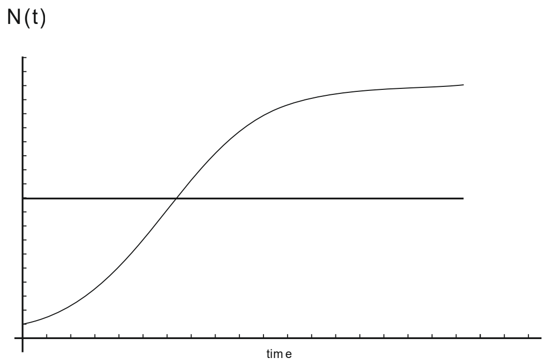
$\beta_2 =$ coefficient capturing the percentage increases in diffusion speed resulting from a 1% increases in advertising.

$P(t) =$ Price in period t, $a(t) =$ advertising in period t

In equation (4), we show that by increasing marketing effort, a firm can increase the likelihood of adoption of the innovation i.e. marketing effort speeds up the rate of diffusion of the innovation in the population. For implementing the model, we can measure marketing effort relative to a base level indexed to 1.0. Then if advertising at time t is double the base level, $x(t)$ will be equal to 2.0.

Conclusion

Bass diffusion model is a popular diffusion model in new product forecasting. This model has the ability to predict number of adoptions timing at peak sales companion of new adopters between actual and forecast values and to predict the long term pattern of diffusion process. The Bass model is used to estimate three parameters innovations, imitations and number of adopters and if these parameters are will estimated, an accurate forecast can be achieved. Such forecasts are not only important for the firm introducing the innovation but also for other companies that make related products that complement, or substitute for, the innovation. This studies help in process of taking decision about the launching of a new product in the market, making right kind of investment in the right technology at right time, pricing the product as it influences the number of potential adopters.



Figure(1)

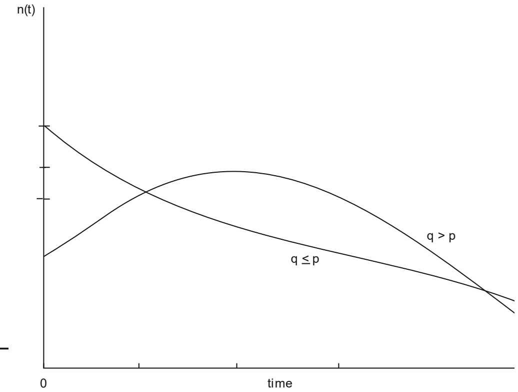


Figure 2.

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