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New Product Diffusion Models in Marketing: An Assessment of Two Approaches

Malcolm Wright and Don Charlett

Rogers's model of new product diffusion, although widely accepted in the marketing literature, has several limitations which are seldom recognised. These limitations are examined, and Rogers's approach is compared to the model of diffusion proposed by Bass. The authors conclude that Rogers's model lacks predictive validity and that its prescriptive guidelines for marketing strategy are untenable. In contrast, the Bass model has considerable predictive power and appears to be well supported by empirical evidence.

Keywords: new product diffusion, innovation, Bass Model, Rogers’ theory

Introduction

One of the most widely held theories of communication in marketing is diffusion theory. Diffusion is a special type of communication in that the messages are concerned with an innovation - something new to the members of the population. The diffusion literature has developed across a number of disciplines to explain the flow of new ideas and practices and the adoption of new products and services throughout a social system (Gatignon & Robertson 1985).

The diffusion process consists of four key elements: an innovation, the social system on which the innovation impacts, the communication channels of that social system, and time (Rogers 1983). Of these elements, diffusion theory's main focus is on the means by which information about an innovation is disseminated to or within the social system, and specifically on mass media and interpersonal communication channels. The influence of interpersonal communication, including nonverbal observations, is seen as a key factor accounting for the speed and shape of the diffusion curve (Rogers 1983; Gatignon & Robertson 1985; Mahajan, Muller & Bass 1990).

Since its introduction to marketing in the early 1960's, diffusion theory has become the subject of considerable research effort. The major impetus behind this research has been the perceived high failure rate of new products and the consequent need to improve the marketing decisions concerned with the launch and diffusion of adoption of such products.

Rogers (1962) developed a model of diffusion which has become widely established in the marketing literature. However, this model has a number of limitations which are seldom recognised, including some severe limitations on its practical application. This paper assesses the traditional approach of Rogers (1962, 1976, 1983) and compares it to a model of new product diffusion proposed by Bass (1969).

Rogers's Classical Normal Distribution Model

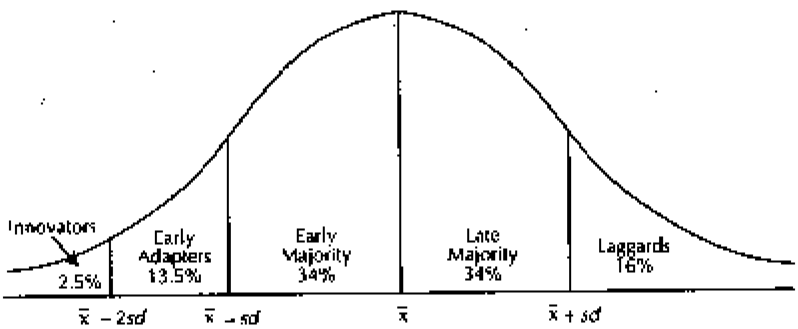
Rogers's (1983) model of diffusion is based on the classical "bell-shaped" normal distribution curve, where the curve represents the frequency of consumers adopting a product over time. If the cumulative number of adopters is plotted, the result is an S-shaped (sigmoid) pattern.

Rogers (1983) contends that the adoption curve is normally distributed because of a learning effect due to personal interaction within social systems. As the number of adopters in the system increases so does the level of interpersonal influence on non-adopters. The result of this influence on adoptions is held to follow a binomial expansion, a mathematical function that follows a normal curve when plotted over a series of successive periods. Rogers (1983) states:

> *Many human traits are normally distributed, whether the trait is a physical characteristic, such as weight or height, or a behavioural trait such as intelligence or the learning of information. Hence, a variable such as innovativeness might be expected to be normally distributed (p.244).*

Rogers (1983) defines innovativeness as *"the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system"* (p.245). On this basis, Rogers has proposed that adopters of an innovation can be classified into five categories. As can be seen from Figure 1, these categories are defined in terms of the number of standard deviations from the mean time of adoption for the population.

Figure 1. Adopter Categorisation on the Basis of Innovativeness



Source: Rogers, Everett M (1983). Diffusion of Innovations (3rd edition). London: The Free Press.

Rogers (1983) has developed a detailed profile of "ideal types" for each of the adopter categories on the basis of demographic, socioeconomic, and personality characteristics. The adopter categories are analogous to the grouping of consumers in a market segmentation study. For example, *innovators* are "venturesome", they are cosmopolitan in outlook, tend to be better educated, willing to take risks, and are more socially mobile than their peers. In a similar manner, each of the five adopter categories have been given a consumer profile (for examples, see Rogers 1962, 1983; Hawkins, Best & Coney 1989).

A considerable amount of research has been conducted to validate the profiles of these adopter categories. The majority of this research is based on major and discontinuous innovations and examines the correlation between variables such as age, education, dogmatism, social participation, and income with time of adoption. From these studies, Rogers (1983) has developed thirty one generalisations of adopter characteristics. For example, *"early adopters have more years of education than later adopters"* (p.251). In marketing, these generalisations have been used as the basis of a prescriptive guideline for speeding up the diffusion process by using *"differential communications programs to reach innovators versus later adopters"* (Gatignon & Robertson 1985).

Hawkins, Best and Coney (1989) describe this as a moving target market approach. According to this approach, once overall target market for the innovation or new product is selected, the firm should specifically target the innovators and early adopters in this target market. As the product gains acceptance, the focus of attention should shift to the early and late majority, who are now more inclined to adopt the innovation because of word of mouth reports from innovators and early adopters. Advertising themes and media vehicles should be progressively tailored to appeal to each new adopter category targeted, and the net effect is to speed up the diffusion process, resulting in increased first time sales and earlier repeat purchases.

Limitations of Rogers's Approach

Although Rogers attempted to identify common traits for each adopter category, the empirical evidence has demonstrated that there is no consistent link between the trait of innovativeness and other personality characteristics. For example, late adopters are characterised as being more dogmatic, but while 17 studies have found a negative correlation between dogmatism and innovativeness, another 19 studies have found no relationship between these two variables (Rogers 1983). Similarly, while 203 studies have found a positive correlation between innovativeness and years of education, a further 72 studies have found no such relationship (Rogers 1983).

The inconsistent nature of adopter groups has serious implications for the model. As Kotler (1991) states:

> *No one has demonstrated the existence of a general personality trait called innovativeness. Individuals tend to be innovators in certain areas and laggards in others (p.343).*

While Rogers (1983, p.248) acknowledges that adopter profiles are product specific, he provides no method for predicting how these profiles will vary across industries. It seems that consumers are innovators not because of some underlying general trait of "innovativeness", but merely because they are one of the first 2.5% of first purchasers, regardless of their demographic, socio-economic, or personality characteristics, and regardless of their adoption behaviour in other circumstances.

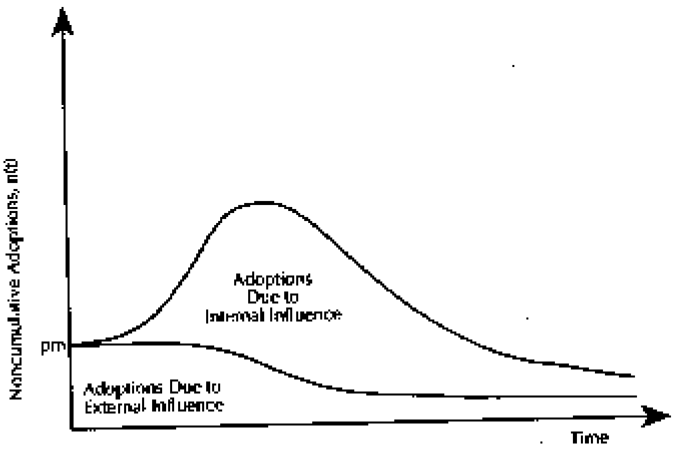
As the model is based on a distribution about the mean time of adoption, calculation of the mean and standard deviation and the identification of adopter categories can not take place until the process of diffusion is complete. Thus, the marketer can not predict who the innovators in a given market are, or what characteristics they are going to have. Yet once the process of diffusion is complete, it is hard to see why the classification of adopters into groups would still be interesting.

The prescriptive guideline of using a "moving target market" approach faces two other potential problems. First, it assumes that targeting "innovators" and "early adopters" will speed the diffusion process due to the personal influence of these segments on the "early majority". In some markets, however, interpersonal communication is limited. For example, many low involvement products receive little word-of-mouth advertising (Gatignon & Robertson 1985). In such markets the personal influence assumption does not hold, and targeting a small group of consumers first is likely to cause the rate of diffusion to be much slower than had the marketer approached the whole market. Second, even in markets where word-of-mouth does have a strong influence, the inconsistent nature of adopter profiles makes it impossible to identify and specifically target the "early adopter" segment. Under such conditions, there is no logical reason that targeting specific segments would produce a better result than targeting the market as a whole (Wright & Esslemont 1994). In fact, mass marketing is likely to lead to a higher rate of diffusion, simply because more potential adopters are being exposed to the new product idea.

The Bass Model

Bass (1969) proposed and tested an epidemiological model for the diffusion of consumer durables and other innovations. Because of the long time intervals between individual purchase occasions for consumer durables, the number of adopters in a time period is virtually identical to the number of sales throughout most of the diffusion process. This enables the number of adoptions in a period to be used as a proxy for sales, and *vice versa*. Figure 2 provides a plot of the conceptual and analytical structure underlying the Bass model.

Figure 2. The Bass New Product Diffusion Model



Source: Mahajan, Muller and Bass (1990). New Product Diffusion Models in Marketing: A Review and Directions for Research. *Journal of Marketing*, 54, 4.

Mathematically, the model can be expressed as:

$$P(t) = p(0) + (q/m)Y(t)$$

Where P(t) is the probability of a purchase at time t, given that the individual has not previously purchased the innovation. In effect, it is a prediction of adoption at the individual level, although Bass also offers equations to determine the aggregate number of adoptions in each time period.

The second term, p(0), is the initial probability of trial. It reflects the tendency to innovate, or to try the product without interpersonal influence, and is referred to as the coefficient of external influence (Mahajan et al. 1990). As shown in Figure 2, the Bass model assumes that innovators, or those who adopt purely because of mass media communication, are present throughout the diffusion process. This differs from Rogers's (1983) model which defines innovators as the first 2.5% to adopt.

The term m is the total number of potential buyers, while q is a parameter measuring the rate of diffusion, also called the imitation effect (Mahajan et al. 1990); q/m is therefore a constant social interaction effect which depends on the total size of the market and the effect of interpersonal influence. This effect of social interaction will be magnified by increases in the total number of people who have ever purchased (represented by Y(t)).

The number of adopters in each period will therefore rise due to the increasing impact of social interaction ((q/m)Y(t)) until such time as this effect is outweighed by the reducing number of people who have not yet adopted (m-Y(t)). The point at which this occurs is the peak of the curve in Figure 2.

Estimating the diffusion curve requires that the values of p(0), q, and m be identified. One method is to analyse historical data once diffusion is complete - but this is no more helpful than Rogers's approach. It is important to be able to identify the values of the parameters before diffusion is well advanced, and this can be done by comparison with historical data for similar products, through market research, by using managerial judgement, or by using secondary data to identify m. When diffusion is partly complete, the data from the early stages can also be used to predict the rest of the diffusion curve, and this is especially useful if the peak of the curve has not yet been reached (Mahajan et al. 1990).

Predictive Validity of the Bass Model

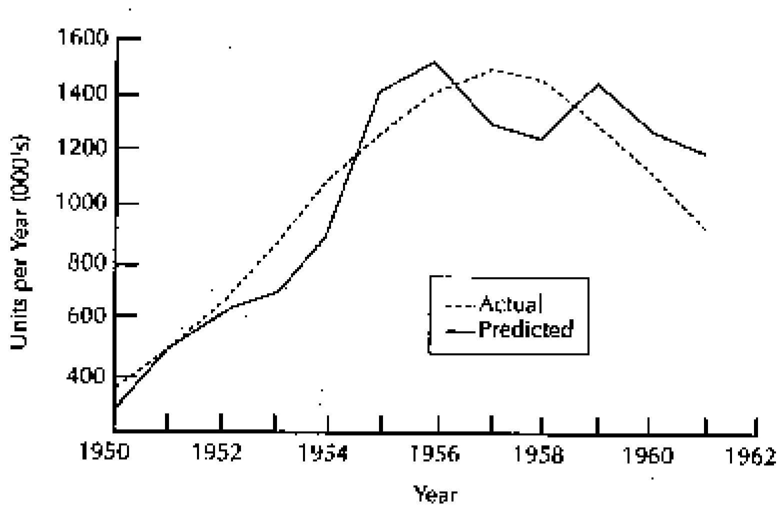
The Bass model and its revised forms have been used for forecasting innovation diffusion in retail service, industrial technology, agricultural, educational, pharmaceutical, and consumer durable goods markets (Bass 1969; Nevers 1972; Dodds 1973; Lawton & Lawton 1979; Tigert & Farivar 1981; Akinola 1986; Kalish & Lillien 1986). Companies that have used the model include Eastman Kodak, RCA, IBM, Sears, and AT&T (Mahajan et al. 1990).

The Bass model has been tested in three main ways. First, the correlation between the predicted and actual number of new adopters for the diffusion period has been examined using historical data. Bass (1969) tested the model on eleven durable goods including refrigerators and black and white televisions with good fits between actual sales and those predicted by the model. An example, for clothes dryers, is given in Figure 3.

Jeuland (1994) compared the performance of the Bass model across 32 data sets, including the 11 durables in the original Bass study, 17 VCR markets in the United States and Europe, and four surveys of hospitals and schools. The diffusion periods varied in these studies from five to fifteen years. They report a very good fit for the model across the data sets, with R-squares of about 0.9.

Similarly, the Bass model performed well in three other studies with R-squared values of 0.96 (diffusion of cocoa-spraying chemicals among Nigerian farmers over a 25 year period), 0.98 (diffusion of an educational innovation in the US over 11 years), and 0.89 (diffusion of photovoltaic home energy system in South-West US over 10 years) (Lawton & Lawton 1979; Akinola 1986; Kalish & Lillien 1986).

Figure 3. Actual and Predicted Sales by the Bass Model for Clothes Dryers



Source: Bass, Frank M (1969). A New Product Growth Model for Consumer Durables, *Management Science*, 15, 224.

Second, the ability of the model to forecast the number of adoptions at the peak of the curve has been tested. Dodds (1973) used the model to forecast the adoption of cable television in the US, he states *"a forecast based on early data would have provided a reasonably good forecast of peak sales four years before the event"* (p.310). Similarly, Lawton and Lawton (1979) used the model to forecast the adoption of a semester system by Ontario High Schools. Projections made in 1973 by the model predicted the innovation to peak during 1976 with 228 schools adopting, indeed, the actual peak occurred in 1976 with 257 schools adopting. Tigert and Farivar (1981) state that the Bass model performs well when appropriate data is available, but warn *"no forecasting model should be a substitute for other elements in the strategic planning process"* (p.90).

Third, the ability of the model to predict the long-term pattern of diffusion has been tested. Three studies using the model have provided good results, with correlations between the predicted and actual number of adopters over time of 0.96 (21 year period), 0.98 (29 year period) and 0.99 (24 year period) (Akinola, 1986; Mahajan & Peterson, 1978).

Although much of the assessment of the Bass model has used historical data, it is not merely a *post hoc* method of analysis. As noted, both predictions based on early data and predictions made before diffusion has peaked have been successful. Furthermore, a significant amount of work has been completed on methods of estimating the parameters of the Bass model during the early stages of an innovation (Mahajan et al. 1990).

Other diffusion patterns have been documented, particularly exponential patterns (Cox 1967; Polli & Cook 1969; Rink & Swan 1979; Robertson 1971). If there was no reason to expect a sigmoid pattern as opposed to an exponential pattern, the predictive validity of the Bass model would be significantly degraded. The sigmoid pattern is primarily due to the process of interpersonal influence; when this is minimal compared to marketing effects an exponential curve of diffusion is predicted (Gatignon & Robertson 1985). Thus, like Rogers's approach, the Bass model relies on the assumption of social interaction between buying units.

Conclusions

Both Rogers's approach and the Bass model combine the effect of innovation from external influences with the effect of interpersonal communication to model a sigmoid cumulative adoption curve. Neither provides a method of modelling diffusion of adoption in markets where interpersonal influence is absent. At this point, however, their similarities cease.

Rogers's approach suffers from empirical evidence that membership of the "innovator" and "early adopter" categories cannot be reliably predicted. The generalisations on which the adopter profiles are based do not hold in different industries, and an individual may be an innovator for one product category but a laggard for another. As it stands, the model can only be valid as a tautological system of *post hoc* classification.

Post hoc classificational systems can provide useful ways to think about the market, improve the managerial understanding, and thus enable better marketing decisions, but attempts to use Rogers's approach in this way suffer from two problems. First, the main prescriptive implication of Rogers's approach is to segment the market into adopter categories and then use a moving target market approach to speed the diffusion process. Unfortunately the inconsistent nature of adopter profiles prevents identification and targeting of the "innovator" and "early adopter" segments, and there is no reason that a moving target market approach should be any better than a standard mass marketing effort. Second, the successful classification of adopter groups by Rogers's approach cannot take place until the diffusion process is complete, by which time it is unlikely to be of interest.

By contrast, the Bass model of diffusion of innovation is able to predict the actual shape of the diffusion curve and the timing and magnitude of its peak. It is well supported by empirical research with high correlations between predictions made by the model and actual data reported across a number of industries. The Bass model is based on estimating three parameters; unlike Rogers's approach, these parameters are not tautological but can be based on measures exogenous to the model, while the relationship between them is clearly defined in terms of the mathematical function of the model.

Even if future research did enable reliable identification of Rogers's innovators in different industries, this would still not allow Rogers's approach to emulate the Bass model by predicting the shape of the adoption curve or the timing and magnitude of its peak. Furthermore, the crucial criterion of predictive success suggests that the role of innovators is far better represented by Bass than by Rogers.

The predictive success of the Bass model and the predictive failure of Rogers's approach are strong reasons for directing further research efforts towards the Bass model. Many interesting and potentially productive research questions easily suggest themselves. For example: how can the Bass model be extended to cover products with smaller inter-purchase times, or to include repeat purchase; what is the most accurate and cost effective method of estimating the parameters of the Bass model; how will the diffusion curve be affected by changes in marketing variables; what equivalent model predicts adoption when interpersonal influence is low?

The predictive ability of the Bass model also provides a powerful reason for practitioners to apply it. Clearly it is a far more successful forecasting tool than Rogers's approach. It could also be developed into a diagnostic tool to determine whether the failure of new products was due to market factors or mistakes by the organisation in an otherwise favourable environment. Further research by academics promises to develop new applications for the Bass model, and Bass himself claims to have recently generalised the model to include the effects of advertising and price changes during the diffusion process (Bass 1994).

Given the superiority of the Bass model over Rogers's approach, and the potential of the Bass model for both academic research and practical application, it seems that the current dominance of Rogers's approach is based on its long history rather than on any theoretical or empirical merit. It seems high time that its place in the marketing textbooks was taken by a model that is not only conceptually elegant, but is also empirically sound.

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Malcolm Wright is a Lecturer, and Don Charlett was a BBS (hons) student, in the Department of Marketing, Massey University.

Footnotes

1. Discontinuous innovations involve major changes in behaviour in an area of importance to the individual or group in order to be adopted (Hawkins, Best and Coney, 1989).

2. These are models used in medicine to predict the spread of communicable diseases. The analogy is quite direct. One person or a small group of people(the innovators) is infected and spreads the disease (the innovation) through personal contact (for example, word of mouth). The epidemic spreads, or diffuses, until all who are susceptible have been infected.