Innovation Diffusion Model for a Product Incorporating Segment-specific Strategy and the Spectrum Effect of Promotion

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Abstract

Promotion is an important component of a firm's marketing mix. It assists in dispersing the product information into minds of the customers and takes them to the final stage of purchase. Various promotional strategies are used by firms to capture maximum potential adopters in the market. Firms adopt segment driven marketing to best utilize its finite marketing resources. Mass market promotion and differentiated market promotion are amongst the two widely used techniques of promotion used in a heterogeneous market, segmented into homogeneous segments. Through mass market promotion, a product is promoted in the

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entire market, using a common promotional strategy, thereby creating a spectrum effect in all the segments of the market. Whereas, differentiated market promotion targets each segment of the market with distinct promotional strategies. In a segmented market, both types of promotional strategies play different and important roles for product adoption in the market. Innovation diffusion models are used to describe the adoption growth of durable technology products over their product life cycle. There is vast literature of innovation diffusion modeling. The existing literature mostly assumes a homogeneous market while formulating the model and effect of mass and differentiated promotion techniques on adoption growth in a segmented market is not yet analyzed. In this paper, we develop an innovation diffusion model for a durable technology consumer product considering the combined effect of mass and differentiated promotion along with the internal influence factors on adoption growth in segmented market. Model validity is tested on a real time data in four segments. Fairly good results have been obtained.

Keywords: *Innovation Diffusion, Mass Market Promotion, Differentiated Market Promotion, Spectrum Effect, Adoption Growth.*

1. Introduction

Promotion plays a dynamic role in the success of a business, product or service. Numerous promotional devices are used by firms to accentuate the value of their products to the customer, differentiate their products from those of the competitors, reach the target markets, increase sales, expand the size of the target market, etc. These may include advertising, sales promotion, personal selling, branding, event participation, etc. Firms adopt different promotional methods with different objectives. A consumer purchase decision can be the result of joint influence from the different promotional strategies; it may be due to some specific promotion that the customer has seen or due to social influence. Mass promotion and differentiated promotion are two major strategies of promotion in a segmented market. Each of these strategies may be conducted by means of different devices of promotion. In this paper, we have formulated an innovation diffusion model to capture the adoption growth over the lifecycle of a durable technology consumer product due to the combined influence of mass promotion and differentiated promotion in a segmented market.

Mass promotion addresses the potential market treating all customers alike and using a single promotional plan for the entire market [Rao (2011); Egan (2007)]. Advertising with TV commercials on national channels, radio, newspaper, etc. are major media of mass promotion. The idea behind such types of promotion is to communicate a message for

the product to large masses. This leads to creation of a spectrum effect in the entire market, spread knowledge and persuade the present and future potential customers to eventually adopt the product. Usually, firms with products having broad appeal, with very large market potential, indulge in mass market promotion. For example, small-size family car manufacturers and marketers such as Maruti, Hyundai, Tata, etc. spend significant portion of their promotional budget on mass promotion. The objective is to reach all possible present and future potential customers.

The impact of mass market promotion varies in different segments of the market. Market segmentation is the division of a market into distinct groups of consumers with common characteristics. These defining characteristics may be geographical (region, state, countries, cities and neighborhoods); demographical (age, gender, income, family size, occupation and education); psychographical (social class, life style, personality and value) or behavioral (user states, usage rate, purchase occasion and attitude towards product). The consumer market is segmented to cater to the differing concerns, interests and preferences of consumers effectively. Mass promotion being visible to audiences in all segments of the market creates an effectiveness spectrum, which is distributed over all the segments [Burrato *et al.* (2006)]. Thus, each segment gets affected by mass market promotion with a fixed proportion of spectrum effect. Mass promotion focuses on the average behavior of the entire population of potential customers. The potential customers in one segment may have some distinguished characteristics which differentiate them from the other segments. The influence of mass promotion on any segment is only partial. In order to target a specific customer, differentiated promotion is carried out by targeting individual segments through distinct promotional strategies. This method of promotion is also called segment-specific or target market promotion in which each segment is tailored separately through unique promotional methods and messages [Berry and Wilson (2001); Rao (2011); Egan (2007)].

In an attempt to capture maximum adopter population, companies carry out both mass and differentiated promotion. In this way, they try to ensure that they can reach out larger audience of potential consumers. Through mass market promotion, companies also reach the average adopter population which may not belong to the supposed target market, but are among the future potential of the product or could build interest in the product. Thus, product acceptance arises due to promotional influence of these two strategies; one, specific to each segment (differentiated/target market promotion) and the other, the spectrum effect arising from mass market promotion.

1.1. *Literature Review*

Innovation diffusion models describe the patterns of adoption, explain the mechanism, and assist in predicting how the product will behave in the market by forecasting its future sales growth. Modeling and forecasting the diffusion of innovations has been a topic of practical and academic interest since the 1960s due to the work of Fourt and Woodlock (1960), Mansfield (1961), Floyd (1968), Rogers (1962), Chow (1967) and Bass (1969). Fourt and Woodlock (1960) assumed that the diffusion process is influenced solely by external factors and proposed the external influence model. This model assumed no interaction between the members of the social system. The internal influence model was proposed which was based on a contagion paradigm that diffusion occurs only through personal contacts. Mansfield (1961) illustrated the applications of internal influence model which was also known as pure imitation diffusion model. Bass (1969) model pioneered to describe the penetration and saturation aspects of the diffusion process over the product life cycle through mixed influence model and it became a widely used first purchase model of new product diffusion in marketing for durable products. It assumes that a potential customer either makes the purchase decision independently or is influenced by a previous purchaser. The first category of consumers is called the innovators, whereas the second category is known as imitators.

Bass model has wide acceptance in the literature, but it works under certain set of assumptions such as constant market size, absence of repeat purchasers, effect of marketing variables etc., which limits its applicability to describe a typical product adoption behavior. Several researchers have worked to develop more generalized models applicable to diverse marketing environments. The study due to Bass (1969) formed basis for the development of many of these models. A dynamic diffusion model was proposed by Mahajan and Peterson (1978), where the market size was permitted to vary over time. Other dynamic diffusion models have been developed by Chow (1967), Lackman (1978), Dodson and Muller (1978), and Sharif and Ramanathan (1981). One of the first to use a heterogeneous population argument was Rogers (1962). He suggests that an adopting unit may pass through a series of stages in the innovation decision process. The multistage nature of the diffusion models was also studied by Midgley (1976), Dodson and Muller (1978), Sharif and Ramanathan (1982) and Mahajan *et al.* (1984). To forecast the use of ethical drugs, repeat purchase models were developed by Lilien *et al.* (1981), and Mahajan and Muller (1982). Models to capture the adoption growth of a new product with respect to time,

advertisement, quality, price, etc. were proposed by Robinson and Lakhani (1975), Horsky *et al.* (1990), Jain *et al.* (1990), Lilien *et al.* (1998). Bass *et al.* (1994) developed a Generalized Bass Model (GBM) (1994) to describe the growth in sales with respect to current marketing efforts. It primarily reflected the current effect of dynamic marketing variables on the conditional probability of adoption. Some studies also focused on analyzing the effect of diffusion channels (Rangaswamy, Gupta 2000), competition [Kauffman and Techatassanasoontorn (2005)], and product bundling (Gupta *et al.* 1999) on adoption growth. Studies carried due Mahajan and Muller (1996), Bass and Bass (2004), Goldenberg and Oreg (2007), explored the new product diffusion caused by technological update. They considered that diffusion of technology updates can increase market potential and reflect the impact of consumer heterogeneity. Based on geographic segmentation Steffens (1998) investigated cross-country heterogeneity in product adoption. Dwyer *et al.* (2005) examined the influence of national culture on the cross national diffusion of innovations. Jha *et al.* (2006) proposed an alternative formulation of GBM [Bass *et al.* (1994)], considering its wide applicability and flexible mathematical form, applicable to describe the two most observed adoption growth curves (s-shaped and exponential) [Lilien (1998)]. The alternative derivation facilitated the development of more generalized innovation diffusion models. They proposed diffusion models considering dynamic product potential and repeat purchase. The adoption growth for these models is also analyzed with respect to promotional effort intensity function.

Chu *et al.* (2008) proposed a diffusion model that reveals the growth pattern of the mobile Internet subscriber in Taiwan utilizing the concepts of the "technical substitution" and the "multi-product competition". Bohlmann *et al.* (2010) examined the effects of various network structures and relational heterogeneity on innovation diffusion within market networks. Chen *et al.* (2011) gave a product diffusion model that investigates the dynamics of single function and fusion product in electronic market. It captures the diffusion transition from two distinct single-function products into one fusion product. Jun *et al.* (2011) proposed an integrated forecasting model that incorporates both first purchase diffusion and replacement component of sales in predicting multi-product diffusion patterns. Qi *et al.* (2012) built the variable contingent diffusion model by introducing Bass model to the diffusion study on customized 3G mobile phone. This model combined the diffusion properties of customized 3G mobile phone and scientifically and effectively predicted the development trend of customized 3G mobile phone.

1.2. *Research Gap and Motivation*

Most of the research conducted in the area of innovation diffusion modeling assumed that the market is homogeneous and developed sales growth models considering the effect of promotion on total adoption. The concept of market segmentation is very popular and important in marketing. Firms develop different marketing mix for different segments to influence them distinctively and create maximum effectiveness of promotion by means of best utilization of its resources from buyers based marketing. From the point of view of practical applications, it is an important consideration for the development of optimization problems for marketing decision making such as promotional resource allocation in a segmented market. Only a few studies consider the impact of segmentation in diffusion modeling [Steffens (1998); Dwyer *et al.* (2005); Viscolani (2009)]. The models developed for homogeneous market to describe total adoption of a product are applied for analysis and decision making for segmented market assuming that adoption in a segmented market can be described simply by differing the parameter of these diffusion models, which is reflected by adding a subscript for each segment on total expected potential, coefficient of innovation, imitation and promotional intensity functions [Jha *et al.* (2007), (2011); Manik *et al.* (2011)]. This may not represent the real-life situations. To avoid unrealistic results and inappropriate estimations, it is very important to develop sales growth model to predict the adoption growth in a segmented market. The adoption of a product in a segmented market is governed by several factors. Mass promotion and differentiated promotion are the most important factors effecting the adoption of product in a segmented market and their effect cannot be ignored. This study addresses this issue by proposing an innovation diffusion model to capture the lifecycle of a durable technology consumer product due to the joint influence of mass market and differentiated market promotion in a segmented market. The proposed model not only addresses the effect of segmentation on adoption growth but also describes it with respect to the promotion intensity function.

In many real-life scenarios, the adoption of a product can be seen to evolve through the combined impact of mass market and differentiated market promotion. For example, consider a multiethnic and multicultural country such as India. Indian market can be segmented geographically into regional segments as the difference in the marketing environments of various regions of the country suggests that each market is different and requires a distinct marketing and promotional programs [Ramaswamy and Namakumari (2009)]. Companies cater to this diversified

customer base of India by promoting product in each region independently in its native regional language as well as with a common national language which reaches several regions with a spectrum effect. In India, national promotion (or mass market promotion) is done in either Hindi or English as these are the most ideally accepted languages all over the country. Regional promotion is done in each region independently keeping in mind their geographic, psychographic and behavioral aspects such as promotional messages are relayed in their native regional language, promoting the product through local events, regional TV channels, etc. Also, the product is promoted using the techniques of mass promotion such as promotion through national TV channels in national language, promotion through national events, etc. which reaches several regions and influences the product awareness as well as product acceptance in each of the geographical segments. Consider for example, various firms in Indian automobile industry such as Maruti Suzuki India Limited (MSIL), Hyundai, Honda, etc. target several platforms and connect them efficiently to produce sales. They use a multitude of national and regional promotional vehicles and media for designing their mass and differentiated promotional strategies. Targeting the potential customers with mass promotion as well as differentiated promotion is not only seen in the durable technology product segment, but also in the consumer good section. For example, Hindustan Unilever Limited (HUL) promotes most of its products through these two strategies viz. Fair & Lovely, a fairness cream is promoted using TV commercials on national TV channels such as Doordarshan, Zee, Star, Sony, etc. These commercials are dubbed in various state-dominant regional languages and are also telecasted in regional TV channels. In this way, higher adoption rates are yielded among different regions.

In this paper, an innovation diffusion model is proposed for a product promoted in a segmented market assuming that the adoption is evolved through external influence due to mass and differentiated promotion along with the internal influence. Keeping in mind the characteristics of the potential population of each segment, differentiated market promotion is done so that the efforts are target-oriented. Also, the product is promoted using mass market promotion with the same promotional strategy in all the segments of the market which affects each segment's population with a fixed spectrum.

The rest of the paper is structured in the following manner. Section 2.1 briefly describes mathematical formulations of innovation diffusion models used as a base for the development of the proposed model. Section 2.2, presents the development of proposed adoption growth

model. In section 3, the proposed model has been validated on a new product adoption data in a segmented market in a real-time situation. The paper is concluded in section 4 with directions for future research.

2. Model Development

Notations

K	:	Total number of segments in the market;
$\bar{N}$ $(\bar{N}_i)$	:	Expected number of potential adopters of the product in the market (i^{th} segment).
$p(p_i)$	:	Coefficient of external influence (i^{th} segment).
$q(q_i)$	:	Coefficient of internal influence (i^{th} segment).
$x(t)(x_i(t))$	:	Instantaneous rate of marketing/promotional effort at time t in the market (i^{th} segment); $X(t) = \int_0^t x(u)\,du$; $X_i(t) = \int_0^t x_i(u)\,du$.
$N(t)(N_i(t))$	:	Expected number of adopters of the product in the market (i^{th} segment) by time t.

2.1. *Mathematical Modeling of Innovation Diffusion Models*

The basic model used in our study is the internal external innovation diffusion model due to Bass (1969). The model can be described with respect to time by the following mathematical equation.

$$\frac{dN(t)}{dt} = \left[p + q\frac{N(t)}{\bar{N}}\right](\bar{N} - N(t)) = p(\bar{N} - N(t)) + \frac{qN}{\bar{N}}(\bar{N} - N(t))$$

Size of cumulative adoption at any time t assuming $N(0) = 0$ can be described as follows

$$N(t) = \bar{N}\frac{1 - \exp^{-(p+q)t}}{1 + (q/p)\exp^{-(p+q)t}} \tag{1}$$

The model has a flexible form as it can reduce to both pure internal or pure external model and also efficiently captures different shapes of the diffusion curve depending on the value of (q/p). Bass model was later

modified by Bass *et al.* (1994) with respect to marketing effort. They proposed GBM under the basic assumption that the rate of purchase with respect to current effect of market variables is proportional to the number of potential adopters remaining to adopt the product at any given time. The mathematical equation describing GBM is given by

$$\frac{\frac{dN(t)}{dt}}{x(t)} = p[\overline{N} - N(t)] + q\frac{N(t)}{\overline{N}}[\overline{N} - N(t)]$$

where $x(t)$ denotes "current marketing effort" to reflect the current effect of dynamic marketing variables on the conditional probability of adoption at time t. Solution for the above equation under the initial conditions $N(t = 0) = 0$ and $X(t = 0) = 0$ is given by

$$N(t) = \bar{N}\frac{1 - e^{-(p+q)(X(t)-X(0))}}{1 + (q/p)e^{-(p+q)(X(t)-X(0))}} \tag{2}$$

where $X(t)$ is the cumulative marketing effort and thus cumulative adoption is a function of cumulative marketing effort.

2.2. *Proposed Model*

Here, we develop an adoption growth model describing the diffusion of a single durable technology consumer product in a segmented market that has a closed form solution in the time domain with respect to promotional intensity function. Since promotion forms the major component of the marketing mix, keeping other factors constant, cumulative adoption is taken as a function of promotional efforts [Jha *et al.* (2006)] to represent the marketing efforts in Bass *et al.* (1994). The promotional effort intensity function represents combined influence due to differentiated market promotion and the spectrum effect of mass market promotion employed in all the segments.

The model is based on the following assumptions.

(1) The market for a new product is divided into K disjoint segments.
(2) Each purchaser buys a single unit of the product.
(3) The consumer decision process is binary (adopt/not adopt).
(4) The potential consumer population for the product in each segment is finite and remains constant during the promotional campaign.

(5) The product in consideration belongs to the category of durable technology consumer products.

(6) Buyers in each segment can be categorized into two groups (i) Innovators and (ii) Imitators.

(7) The external influence is described by the joint influence of mass and targeted promotional strategies.

(8) The consumer behavior within segments is independent of each other.

(9) The parameters of external and internal influences are fixed over the product life cycle.

(10) The rate of purchase with respect to promotional effort intensity is proportional to the number of non-purchasers of the product.

Following the assumptions and notations, the differential equation for the rate of adoption of the product in i^{th} segment with respect to the promotional effort (mass and targeted) is formulated as follows

$$\frac{\frac{d}{dt}N_i(t)}{(x_i(t)+\alpha_i x(t))} = \left(p_i + q_i \frac{N_i(t)}{\overline{N}_i}\right)(\overline{N}_i - N_i(t)),\ i = 1,2,...,K \tag{3}$$

The expected number of adopters in the interval $(0, t]$ in the i^{th} segment is given as follows after solving Eq. (3), under the initial conditions $N_i(t) = 0, X_i(t) = 0, X(t) = 0$ at $t = 0$.

$$N_i(Xi(t),X(t)) = \frac{\overline{N}_i\left(1 - e^{-(p_i+q_i)(X_i(t)+\alpha_i X(t))}\right)}{\left(1+\left(\frac{q_i}{p_i}e^{-(p_i+q_i)(X_i(t)+\alpha_i X(t))}\right)\right)},\ i = 1,2,...,K \tag{4}$$

3. Model Validity and Application

To validate and measure the performance of the proposed model, we performed parameter estimation on a real time adoption and data set of a hatchback car evolved through mass and differentiated promotion. The adoption and promotion data for a period of 24 months have been obtained from an ABC automobile company over four geographic segments. The data has been provided by the firm after suitable transformation to maintain the confidentiality of the data. The firm's identity has not been disclosed for confidentiality reasons.

We have used statistical software SPSS to estimate unknown parameters of the model. Statistical package SPSS, a data management and analysis software provides several statistical data analysis features. The regression module in the package enables the user to validate their non linear regression models. Non-linear regression is a form of the regression analysis in which a nonlinear model is fitted on an observational data consisting of a set of independent variables and the associated dependent variable.

The performance of a model can be judged by its ability to fit the observed data and satisfactorily predict the future behavior of the process. Many established criteria are defined in the literature to validate the goodness of fit of models on any particular data and choose the most appropriate one. Some of these criteria are mean square fitting error (MSE), coefficient of multiple determination (R^2), mean absolute percentage error (MAPE), root mean square prediction error (RMSPE), variation, etc. Here, we use MSE and R^2 to validate the goodness of fit of the proposed model.

3.1. *Data Analysis*

Unknown parameters of the proposed adoption growth model for all four segments are estimated using the given 24-period adoption data against promotion data for mass and differentiated market promotion. The estimated parameter values using nonlinear regression in SPSS are given in Table 1. The MSE and R^2 values are also given in column 6 and 7 of Table 1. Fitting of the models for all the four segments are illustrated graphically in Figures 1– 4 against the actual data. Future forecast for six time periods has been shown in each of these figures for all the segments. It is observed that R^2 values in Table 1 are close to 1, signifying a good fit of

Table 1

Estimation Results

Segments	Parameter Estimates				Fit Statistics	
	$\bar{N}_i$	p_i	q_i	α_i	MSE	R^2
S1	287962	0.000671	0.132113	0.372663	196105.48	0.98513
S2	156601	0.001128	0.470658	0.197823	13832.28	0.99426
S3	106977	0.001344	0.5660355	0.165732	11994.30	0.99825
S4	223291	0.000621	0.3316649	0.263569	173423.74	0.98355

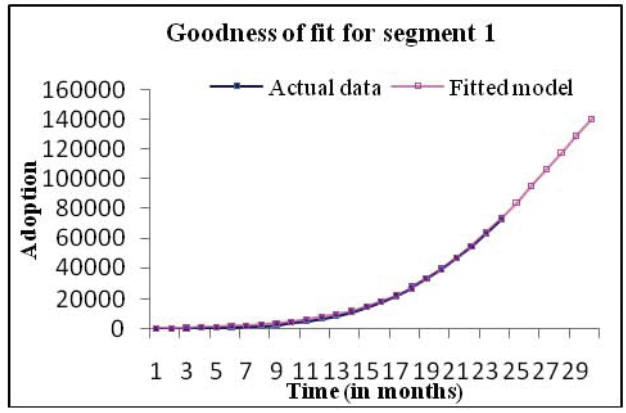

Figure 1

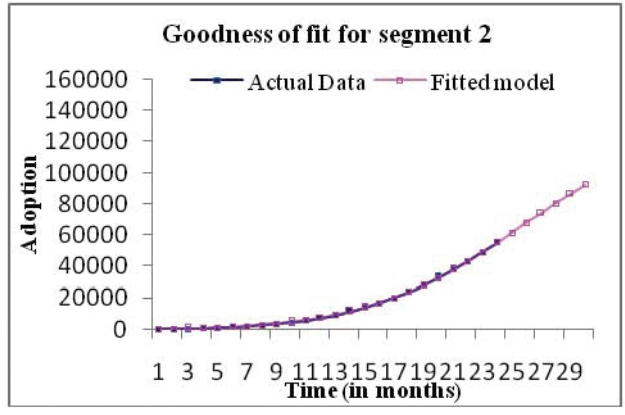

Figure 2

the proposed model. The flexible nature of the mathematical form of the model provides a good fit in all the segments.

The estimation results shows that the influence of mass promotion on adoption is approximately 37.27%, 19.78%, 16.57% and 26.35% in segments S1-S4 respectively. The estimation results also suggest that the product adoption is highly influenced due to social (internal) influence. Note that the results of the model can't be compared with the other models

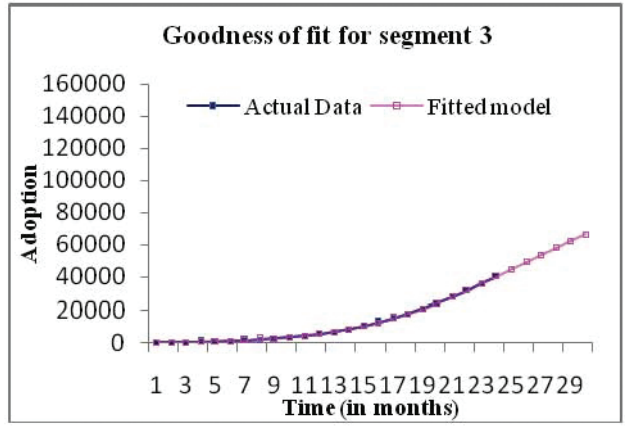

Figure 3

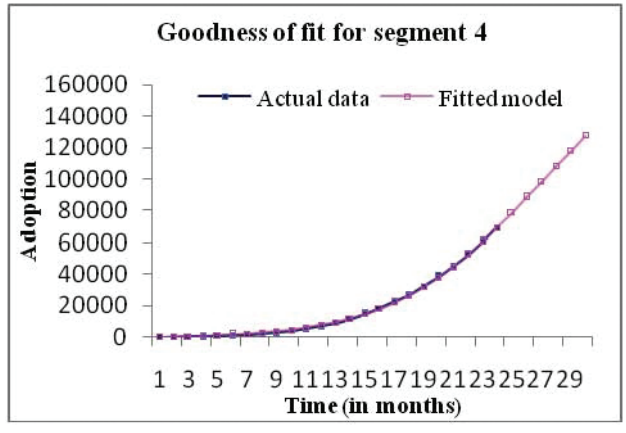

Figure 4

developed in literature as no other existing model considers the marketing environment as considered for the development of the proposed model in this paper to the best of our knowledge. Also note that as the data values in the curves below are in thousands and the curve given here are small in size so the two curves (actual and estimated) seems to be overlapping.

Because of good fitting, small difference in the actual and estimated values and the cumulative value curves, the difference in estimated and actual values in not much visible.

4. Conclusion

In this paper, we have formulated an innovation diffusion model for a durable technology consumer product assuming that the adoption in a segmented market is generated due to the joint effect of mass market and differentiated market promotion along with the internal influence. The effect of mass market promotion reaches each segment proportionally and is referred to as spectrum effect which results in wider exposure of the product. The targeted market promotion influences the potential adopters distinctly in each segment. Although innovation diffusion modeling is widely studied area however the effect of mass and differentiated market promotion on adoption growth in segmented market have been studied for the first time. The model finds lot of applicability in the present marketing scenario as the life cycle for technology products have become shorter, new technology product market have become highly competitive and new product replaces the older ones at very fast rate. Firms adopt buyer driven marketing by means of market segmentation for wider reach of their product and simultaneously uses mass market promotion to create wider spectrum for the firm's current and future products. The model has been validated on a real time adoption data. Lot of scope for further research exists in the area. Various extensions of the model can be worked upon to include more realistic situations such as repeat purchasing, multiple technological generations, dynamic market size, etc. by relaxing the assumptions considered. The model finds much applicability in research and application related to promotional resource allocation in segmented markets.

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