

DIFFUSION ANALYSIS IN MARKETING

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ABSTRACT

The system dynamics technique has been adapted to reflect the dynamics of the diffusion process from both behavioural and marketing strategy perspectives. The diffusion theory has helped in conceptualising and explaining the information process and in evaluating the various market interventions in the spread of new product innovations. The diffusion and adoption process has been studied with particular reference to the personal computer in India.

INTRODUCTION

Diffusion is the process by which an innovation spreads. It is the spread of a new idea from its source of invention or creation to its ultimate users or adopters.

The conceptual foundations (Gastignon, 1985) of diffusion theory are:

- * The concept of innovation
- * The diffusion process over time
- * The personal influence and opinion leadership process
- * The adoption process
- * The role of the innovators and other adopter categories
- * The social system or market segment within which diffusion occurs

To these could be added

- * The role of marketing (change agent) actions
- * The role of competitive actions

A firm that is preparing to introduce for the first time a new consumer durable, would like to make an estimate of

- * the market potential
- * the shape of the likely approach to this potential and
- * the rate of approach to this potential

Two analytical frameworks are available. New product sales can be thought of in terms of

1. Diffusion process
2. Adoption process

The adoption process, focuses on "the mental process through which an individual passes from learning about an innovation to the final adoption". Adoption itself is the act of buying the product in the case of nonrepurchasable products, or the decision to use the product regularly, in the case of repurchasable products (Kotler, 1971).

A major difference between the diffusion process and the adoption process is that diffusion occurs among (groups) persons while adoption is an individual matter.

UNDERLYING THEORY

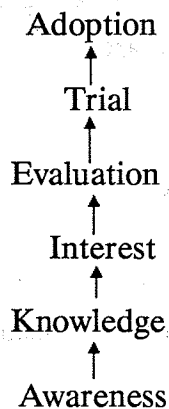
Diffusion research in marketing has placed its major emphasis on the characteristics of consumer innovators. Variables most likely to characterize consumer innovators for technology-based products are higher income, higher education, a favourable attitude towards risk, related knowledge, experience-base for similar technological innovations and so on. Another emphasis has been on the characteristics of innovations that affect the speed of diffusion.

The marketing literature has pursued a further interest. The interest is in the adoption process and the hierarchical stages of adoption through which the decision maker passes.

A high involvement innovation (such as new technology) is a high risk/high information need innovation. For low involvement innovation, however, adopters may skip the information processing and evaluation stages and go directly to trial

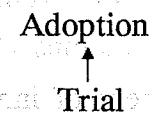
Higher Involvement

Learning Hierarchy



Low Involvement

Hierarchy



Acceptance of an innovation depends very much upon the prospective adopter's culture. Thus closed or traditional systems were found to hinder diffusion while open or modern social systems appear to stimulate it (Baker, 1983).

Following Bernhardt and Mackenzie(1972) the diffusion process for economic goods can be defined as the adoption over time of a specific product, by customers who are linked by channels of communication to a given social structure and by a given system of values or culture. The adoption process is influenced by the product, the potential adopter's characteristics, his linkage to a social structure, change agents and the adopters culture. Different assumptions regarding these may lead to different diffusion models.

If adoption of an innovation is plotted against time from introduction to complete diffusion it will assume the characteristics of a normal distribution, or if plotted cumulatively, assume the familiar S-shaped curve which characterises the product life cycle curve.

The diffusion process can be characterized in terms of three dimensions: the rate of diffusion, the pattern of diffusion and the potential penetration level. The rate of diffusion reflects the speed at which sales occur over time. The potential penetration level is a separate dimension indicating the size of a potential market. That is, the maximum cumulative sales (or adoption) over time (Gastignon, 1985).

OVERVIEW OF MODEL AND FRAMEWORK FOR ANALYSIS

A generic system dynamics model is drawn to study the diffusion process and dynamics of the personal computer market in India (Govindarajan, 1990a). The personal computer market is not described here. However, the generic nature of the complex interactions is depicted in the figure. The analysis was carried out using the following framework (Govindarajan, 1990b).

AWARENESS DIFFUSION:

Awareness diffusion is controlled by advertisement and the rate of growth of the potential adopter population is controlled by price. In the case of durable goods the adoption process is related to observed sales.

The adoption rate $X(t)$ is

$$\dot{X}(t) = [N - X(t)] [a + bX(t)]$$

where

N is the population size

$X(t)$ is the number of adopters by time t .

The implicit assumption in the above equation is that the population is homogeneous. This is a good approximation for diffusion of information. The conditional likelihood of adoption is increasing linearly in the number of existing adopters $a + b x(t)$, where a and b are parameters.

$$X = [N(P) - X] [a + bx]$$

The size of the potential adopter population is a function of price, while the conditional adoption rate still depends linearly on penetration level.

If $a = 0$ in equation (1), the information is spread only by word-of-mouth, where the seed is the initial adopter population. The rate of adoption is then determined by information diffusion and price changes over time.

The degree of awareness is a discrete function. Either the customer is aware or not aware of the product. In general, the awareness of a consumer in time 't' may be described as $DA(t) = f$ (awareness in previous time period, competitors action, word-of-mouth, Retailer efficiency, advertisement and demonstrations).

Diffusion is a reflection of the information propagation or learning process with firms adopting a technology as they come to learn of its existence (epidemic learning models).

The above equations can be rewritten as

$$\frac{dN(t)}{dt} = [a + bN(t)] [\tilde{N} - N(t)]$$

Where a , b and \tilde{N} remain constant over the entire substitution process. That is to say, the diffusion spreads through a static environment. As stated earlier, this assumption is tenuous. Due to changing characteristics of the potential adopter

population, technological changes, product modifications, pricing changes, general economic conditions and other exogenous and endogenous factors, the parameters, a, b and \bar{N} are more likely to change over time.

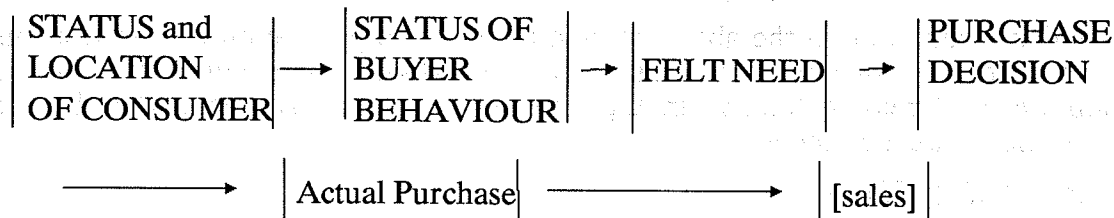
The number of potential adopters \bar{N} is influenced by the product's price and the effectiveness of promotion in establishing multiple uses for the product. The coefficient b , the rate of influence of adopters on non-adopters will be influenced by the product's capacity to stimulate favourable word-of-mouth comments. The rate of influence of advertisement, a , on nonadopters, will be influenced by the size and effectiveness of advertising budget.

BUYER POOL

The number of buyers is influenced by the size of the pool of potential new adopters and repeat buyers. It is also influenced by expected cost. The potential pool of new adopters is increased by effective promotion and favourable word-of-mouth interaction of past satisfied buyers with market place. However, the potential pool of new adopters is also drawn down by the interaction of the likely buyers with the past unsatisfied buyers. The number of buyers are then partitioned and accumulated into satisfied past buyers and unsatisfied past buyers according to the quality of experience index, which has a value between zero and one. The value of quality of experience index implies the percentage of buyers satisfied.

PURCHASES

The purchase process can be shown diagrammatically as follows:



The status of the purchaser includes middle, upper and upper-upper class. The states of buyer behaviour are awareness, knowledge, liking, preference and conviction. The factors which affect the purchase process are of two types: external and internal. The internal effects are due to the interaction of the classic 4 Ps of marketing product, price, promotion and place. The external effects may be general economic conditions, technical developments and so on. The felt need and actual purchase can be described as

Felt Need = F (status and state of the mind of buyer, price of the substitute product, Demonstrations, previous felt need and status)

Actual Purchase = F (Purchase decision and Retailers efficiency)

Purchases are of two types: New and Replacement. New purchases reflect the selection of some fraction of the stream of new purchase decisions in favour of the new technology. Replacement purchases represent purchases to replace products discarded for reasons of wear and tear. For one-time buyer replacement will not be indicated. Given the product availability, the purchaser fraction will be identical to the fraction of potential (acceptor fraction) purchases.

ADOPTION PROCESS

The new product is first adopted by innovators. Any adoption requires the actual purchase of the product. The innovators' social contact (or positive word-of-mouth) induces others (a fraction) to adopt the product (imitators). In both the cases, if the post-adoption behaviour and/or attitude is positive (favourable towards the product), then the consumer remains delighted. Otherwise, the product is abandoned, thereby increasing the non-acceptor level. The company's promotional marketing efforts are aimed at keeping the non-acceptor level to a minimum and if possible, increasing the acceptor level. The acceptance and extent of use of the product are subject to change over time, mainly due to performance-related information. And performance is related to changes in technology or its application (Homer, 1987).

Acceptance is enhanced when information about the product and its performance is favourable. The volume of information includes personal, professional and commercial sources of communication in keeping consumer aware.

PROMOTIONAL EXPENDITURE

A percentage of sales revenue is spent on promotional marketing and product development. Sales have an effect on the promotional budget that, is, the next year's plans depend very much on this year's sales. Thus a company that is growing due to its promotion efforts tends to reinforce its growth by expanding its budget for the next year each time its sales improve. The company's market share is affected by the rate of introducing new products when early introduction gives the firm a leading edge in promotional benefits.

PRODUCT DEVELOPMENT

The durability of a good has two implications. First, it can be stored in inventories. Second, if it provides a stream of services to customers, they may wish to defer purchases to take advantages of price fluctuations (David Rink, 1979).

New product strategy requires a historical base for assessment. Only an understanding of a firm's past product activities can provide the full context by which to evaluate the challenges posed by its next set of new products. The individual product strategic elements can be classified, as falling into four clusters involving the nature of

Products Developed

Markets sought

Technology Employed and the

New Product process

These four elements suggest that measurable comparisons of present to past products may be performed along two basic dimensions. The first dimension is the newness of the technology within the new product relative to technologies already developed by the firm. The second dimension is the newness of the market application for which the new product is targeted compared with the users of past products.

The degree of newness in market application includes levels of newness regarding product packaging, buyers, distribution channels, and support mechanisms. As each new product comes on stream, the cumulative body of the firm's technology and market experience grows accordingly, and becomes much broader for the evaluation of the next new product effort.

A market transition process for consumer durable takes place over time. In general, product differentiation is likely to take place only after demand growth slows due to product saturation. Competitive pressures are also likely to assist the differentiation

process. The introduction and diffusion of new products follow the maturation of older, but related, products within the same market. The process occurs over time and it is crucially important in understanding the differentiation process.

PRICING

Consumers cannot directly verify product quality prior to an initial purchase. Instead, consumers base initial purchases on observed prices, which perfectly signal firm's qualities both in and out of equilibrium. Equilibrium quality is less than efficient, but generally bounded away from the minimum quality. With free entry, observable product variety exceeds what would prevail with perfect information. As repeat purchases become large relative to initial purchases, or as firms become small relative to the size of the market, equilibrium product quality rises, and the market converges to the full information equilibrium.

BEHAVIOURAL FACTORS

The inclusion of qualitative factors becomes necessary in an industry which is in the process of consolidation on the one hand, while witnessing rapid changes on the other, as new markets open and new technology appears with increasing regularity. The image and credibility of the company, its marketing clout, reputation have all to be included in the model. The model may attempt to include the various dimensions of an innovation also.

MODEL DESCRIPTION

A generic system dynamics model is attempted to reflect the diffusion pattern and the dynamics of the India micro market. Details and data have entirely been culled out from various Indian computer magazines and business newspapers. Wherever needed, the data have been assumed in consistence with the prevailing situation in the Indian market. The model is shown in Figure in the form of causal loop diagram. The model is based on the philosophy of Morecroft's (1986) and Homer's (1987) models. As the proposed model is still under progress and view, only the salient features are described.

The model starts with an awareness diffusion model. With a slight modification to the Tourism model of Jambekar and Brokaw (1989), the potential buyer pool can be thought of as

$$L \text{ PBPOOL.K} = \text{PBPOOL.J} + (\text{DT}) (\text{NRADVT.JK} + \text{NRSFCT.JK} + \text{POSINT.JK} - \text{NEGINT.JK} - \text{AADOPT.JK})$$

PBPOOL = Potential buyer pool (Buyer)

NRADVT = Number reached through advertising (Buyers/year)

NRSFCT = Number reached through sales force contact (")

POSINT = Positive interaction between adopters and potential buyers (")

FORGET = Number forgetting (")

NEGINT = Negative interaction between unhappy adopters and potential buyers (")

AADOPT = Actual adopters who have purchased the product (")

The product diffusion spreads through a combinations of several communication processes - advertising, peer group discussions and sales force contact. NRADVT is a function of target audience and advertising expenditure. NRSFCT is a function of the number of sales-person allocated to promotion and their contact rates. The satisfied users and the potential buyers positively interact in an additive way while

the unsatisfied users and potential buyers negatively interact in a multiplicative way and the respective coefficients of interaction have been assumed. A fraction of the people who are aware of the product become actual adopters.

The New product development section takes care of the product developments, which are the outgrowth of projects costing thousands of rupees in R and D activity and require years to complete.

$$L \text{ PRODEV.K} = \text{PRODEV.J} + (\text{DT}) (\text{PRODSR.JK} - \text{PRODCR.JK})$$

$$R \text{ PRODSR.KL} = \text{MAX}(\text{O}, \text{PRODCR.JK} + (\text{IPRODE.K} - \text{PRODEV.K}) / \text{PRODAT})$$

$$R \text{ PRODCR.KL} = \text{PRODEV.K} / \text{PRODT.K}$$

$$A \text{ IPRODE.K} = (\text{IFSRPD.K}) (\text{AVGREV.K}) / \text{SPRODT}$$

$$A \text{ PRRTPD.K} = \text{PECUR.K} / \text{RINCPD.K}$$

$$A \text{ PFCUR.K} = \text{SMOOTH} (\text{CHFUR.JK} / \text{URATE}, \text{TPUCUR})$$

$$A \text{ RINCPD.K} = \text{SMOOTH} (\text{INCPD.K} \text{ INCST}) \text{ PRODEV product development projects (Projects)}$$

PRODSR = Product development start rate (projects/year)

PRODCR = Product development completion (")

IPRODE = Indicated product development (Projects)

IFSRPD = Indicated fraction of sales revenue to product development (0-1)

PRRTPD = Perceived return to product development (1/Project)

PFCUR = Perceived fraction of change to usage rate (0-1)

RINCPD = Recent incorporation of product developments (Projects/year)

CHGUR = Change in usage rate (Usage index)

URATE = Usage rate (")

The functional capability is modeled as

$$A \text{ FUNCAP.K} = (\text{PROCAP.K}) (\text{EEXPEC.K})$$

Where the product capability (PROCAP) is a level variable and the effect of experience on functional capability (EEXPEC) depends on the relative skill of the average user (REAUSR).

The sales lost to new competition and the growth of competition are modeled in the competition sector.

$$R \text{ SLOSNC.KL} = \text{SALES.K} / \text{NORTIM} * \text{FMKJNC.K}$$

$$A \text{ FMKTNC.K} = \text{TABHL} (\text{FMTKN}, \text{MKSTNC.K}, 1, 1)$$

$$A \text{ MKSTNC.K} = (\text{NCOMPC.K} / (\text{MNCOMP.K} + \text{NCOMPC.K})) * \text{SWNCOM}$$

$$L \text{ NCOMPC.K} = \text{NCOMPC.J} + (\text{DT}) (\text{INCOM.JK} - \text{FNCOMP.JK} - \text{MNCOMP.JK})$$

SLOSNC = Sales lost to new competition (Units)

FMKTNC = Fraction of market lost to new competition (Dimensionless)

MKTSNC = Marketing strength of new competition (")

NCOMPC = New competition capacity (Projects/year)

INCOMP = Increase in new competition (")

FNCOMP = Failure of new competition (")

MNCOMP = Maturing of competition (")

In its entirety the model will consist of the following sectors:

Buyer pool, company, promotional marketing, new product, product development, competition, customer, corporate, user perception and summary statistics.

CONCLUSION

A system dynamics framework is suggested for modeling the innovation diffusion and adoption process of a hightech product. Normally, using customer needs as the foundation for marketing in hightech products is problematic, because potential customers often cannot articulate what they need. Marketing efforts should therefore, represent not only promotional but detailing activities also to overcome the marketing and technological constraints faced by such products. Sales, though a significant factor is seldom enough of a determinant about a company's intrinsic value standing in the market. Hence the behavioral aspects are emphasized. In spite of ambiguities and paradigmatic problems, a workable model has been evolved. The parameter fixations and the unknown values of TABLE functions are fraught with such problems. However, the model responds, rather reasonably well and is able to reproduce the state history.

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