"SPECIFYING COMPETITIVE EFFECTS IN DIFFUSION MODELS: AN EMPIRICAL ANALYSIS"

by

Philip PARKER*
and
Hubert GATIGNON**

N° 91/62/MKT

* Assistant Professor of Marketing, INSEAD, Boulevard de Constance, Fontainebleau 77305 Cedex, France.
** Associate Professor of Marketing, The Wharton School, University of Pennsylvania, U.S.A.

Printed at INSEAD,
Fontainebleau, France

SPECIFYING COMPETITIVE EFFECTS IN DIFFUSION MODELS: AN EMPIRICAL ANALYSIS

Philip Parker

and

Hubert Gatignon*

November, 1991

* Philip M. Parker is Assistant Professor of Marketing, INSEAD, Fontainebleau, France and Hubert Gatignon is Associate Professor of Marketing, The Wharton School, University of Pennsylvania. Thanks are extended to Information Resources Inc., Broadcast Advertising Reports and Leading National Advertisers for making the data available and to Leonard Lodish, Katrina Maxwell, David Reibstein, Howard Kunreuther and F. Gerard Adams for their comments on this research. Part of this research was conducted while Hubert Gatignon was a visiting Professor at the European Institute for Advanced Studies in Management, Brussels (Belgium) and at the Facultés Universitaires Catholiques de Mons (Belgium).

SPECIFYING COMPETITIVE EFFECTS IN DIFFUSION MODELS: AN EMPIRICAL ANALYSIS

ABSTRACT

The objectives of this research are to provide a systematic analysis of alternative specifications of brand-level first purchase diffusion models, and to empirically assess within a product category the relative success of these models to explain trial dynamics. In particular, this analysis addresses the following issues for a new and growing category: (1) the role of brand-specific versus category-level (competitive) effects across brands, (2) the role of both price and advertising on brand-level trial dynamics, (3) the existence of static versus dynamic price and advertising elasticities, (4) the response of brand trials to absolute versus relative measures of marketing mix activity, (5) the relative ability of various functional forms (e.g. separable versus nonseparable) in explaining brand-level trial dynamics in a new category, and (6) whether a common functional form, or hypothesized diffusion process can be imposed on all new brands entering into a new category. While such issues have received substantial attention in the literature for existing or newly launched brands in mature categories (e.g., in the area of market share models), these areas are relatively under-researched for new products in new categories which are undergoing a diffusion process.

SPECIFYING COMPETITIVE EFFECTS IN DIFFUSION MODELS: AN EMPIRICAL ANALYSIS

New product diffusion models have been developed to help marketing managers (1) forecast market potentials and sales growth patterns, (2) test hypotheses concerning the nature of the underlying diffusion process, and (3) derive normative rules for optimal marketing mix allocation over the product life cycle (Mahajan, Muller and Bass 1990).

Since the 1960s, models have increased in complexity from growth curves such as the modified exponential curve (Fourt and Woodlock 1960), the Gompertz curve (Chow 1967), the logistic function (Mansfield 1961) and the mixed influence diffusion model of Bass (1969) to diffusion models with varying potentials due to exogenous factors (Mahajan and Peterson 1978, Mahajan, Peterson, Jain and Malhotra 1979) and to models incorporating marketing mix variables.[1] Models with marketing mix variables have typically incorporated one marketing mix variable at a time such as price (Robinson and Lakhani 1975, Dolan and Jeuland 1981, Bass 1980, Kalish 1983), advertising (Horsky and Simon 1983, Simon and Sebastian 1987, Dockner and Jorgensen 1988, Ozga 1960), sales force (Lilien, Rao and Kalish 1981) and distribution (Jones and Ritz 1991). Noteworthy exceptions regarding monopolistic models are Jeuland (1981), who incorporates information propagation due to communication programs and price, and Kalish (1985) who models advertising and price effects on the diffusion process.

Recently, brand-level diffusion models have become of greater interest because the normative recommendations derived from monopolistic markets are feared to be unapplicable to marketing situations when multiple brands enter into a new category (see, for example, Eliashberg and Jeuland 1986). While progress has been made from a normative perspective, empirical models of brand-level diffusion have been under-represented in the literature. In fact, model structures often assumed in normative research have yet to be empirically validated at the brand level. Normative models have used a variety of theoretically plausible specifications to capture marketing mix effects at the brand level (see Mahajan, Muller and Bass 1990, and Hanssens, Parsons and Schultz, Chapter 8, 1990 for reviews of normative diffusion models). For example, Dockner and Jorgensen (1988) develop special cases represented by a number of competitive model specifications, while Eliashberg and Jeuland (1986) assume a unique model and elasticity structure across competitors. Normative analyses also differ in their use of absolute versus relative measures of marketing mix activities. This lack of empirical research noted by Gatignon and Robertson (1985) is not specific to marketing, as Rogers (1983) reports a similar lack of work on decentralized, or competitive processes, partially due to difficulties in observing individual behavior at the brand or firm (change agent) level. In doing so, one must necessarily consider brand-level activities, including, for example, pricing and advertising.

In this paper we propose to study brand-level diffusion models by focusing on four objectives: (1) to formally test various specifications diffusion models of competition, (2) to test relevant theories with respect to the impact of marketing mix activities on the diffusion process for brands in competition, (3) to develop an efficient methodology to empirically compare various nested and non-nested models of the diffusion process, (4) to demonstrate the use of diffusion models to explain the trial diffusion of frequently purchased products. The issues raised in this paper have received substantial attention in the literature for existing or newly launched brands in mature categories (e.g. in the area of market share models). However, these areas are relatively under-researched for new products in new categories undergoing a diffusion process. While diffusion models in marketing have developed considerably (Mahajan, Muller and Bass 1990), empirical evidence has been confined mostly to product category diffusion processes. Instead, we investigate the diffusion at the brand level, i.e., in the context of products or firms which compete in a new market.

Our research approach is similar in spirit to the work of Simon and Sebastian (1987) whose objectives were to assess the influence of advertising on diffusion in monopolistic markets. Here, alternative brand-level diffusion processes are modeled so as to capture the dynamics of competition via brand-specific interpersonal influences, price elasticity dynamics and advertising elasticity dynamics.

We propose a methodology that expands on the work of Jain and Rao (1990) who compare three models using three time series, and Kamakura and Balasubramanian (1988) who compare twelve models using six time series. Rather than using only nested tests of alternative specifications, we consider both nested and nonnested tests of twenty models across five brands in competition. In doing so, we address the following issues for a new and growing category: (1) the role of brand-specific versus category-level effects across brands, (2) the role of both price and advertising on brand-level adoptions (trials), (3) the existence of static versus dynamic marketing mix elasticities, (4) the response of brand adoptions (trials) to absolute versus relative measures of marketing mix activity, (5) the relative ability of various functional forms (e.g. separable versus nonseparable) in explaining brand-level diffusion, and (6) whether a common functional form, or hypothesized diffusion process can be imposed on all new competitors entering into a new category, as certain normative analyses assume.

To estimate the alternative model specifications, a broad search across durable and non-durable categories revealed that one category was suitable for analysis--"hair styling mousses"-- which was a completely new category with multiple entrants. The use of this category provides an opportunity to examine the use of diffusion models on the trial process of frequently packaged goods. Though our investigation is limited to a single product category, clarification of the issues summarized above stand to improve the applicability of normative prescriptions and provide a basis upon which to capture brand-level processes.

In the first section, the question of how brand-level effects can be specified in diffusion models, and the "behavioral" meaning of the various alternatives are discussed. In the second section, an empirical analysis of brand-level first purchases (trials), including time series of multiple brands which entered the market sequentially is presented.

MODELING BRAND-LEVEL DIFFUSION

The diffusion literature recognizes that all categories evolve from a centralized diffusion process, initially dominated by a monopolist, into a decentralized process having many competitors (Rogers 1983). When the first brand of a new product category (innovation) is launched, the firm acts as a monopolist (Eliashberg and Jeuland 1986). Potential and actual first adopters of the new product communicate with their peers and receive information from the firm, via marketing activities. These two forces influence the brand-level diffusion process for decentralized competitive markets. Cross-brand or competitive interpersonal influence was first suggested in the marketing literature by Peterson and Mahajan (1978) and the negative impact of new entrants on the potential market of a single brand (or entrant) is recognized in Horsky and Mate (1988), Erickson (1985), Thompson and Teng (1984), Norton and Bass (1986), and Eliashberg and Jeuland (1986). Marketing mix variables, either measured at the category or brand level, have been an integral part of most models of brand-level or competitive market behavior, including price (Rao and Bass 1985, Dockner and Jorgensen 1988), advertising (Mate 1982, Teng and Thompson 1983, Horsky and Mate 1988), and both price and advertising (Thompson and Teng 1984).

In this section, models that have been used in the literature are considered by presenting a general framework that leads to a systematic analysis of alternative expanded models. We use the general formulation of Dockner and Jorgensen (1988) which we modify to incorporate multiple marketing mix variables. Then, we will discuss in turn the role of interpersonal communications and the influence of marketing mix decisions of brands competing in the market.

The first purchase diffusion process can be generally expressed by the differential equation (1):

$$s_i = \dot{x}_i = f_i\ (x_1, \ . \ . \ . \ x_N;\ P_1, \ . \ . \ . \ . \ , P_N;\ A_1, \ . \ . \ . \ A_N) \qquad (1)$$

where

s = instantaneous number of adopters (new buyers),
x = cumulative number of adopters,
i = firm/product/brand index,
P = price,
A = advertising expenses,
N = number of firms competing in market.

Research investigating optimal advertising and price behavior over time in the most general form has been undertaken while assuming the multiplicative separable form for mathematical tractability (Kalish 1983, Dockner and Jorgensen 1988):

$$s_i = \dot{x}_i = d_i\ (x_1, \ . \ . \ . \ x_N)\ r_i(P_1, \ . \ . \ . \ P_N;\ A_1, \ . \ . \ . \ A_N) \qquad (2)$$

where

$d_i(\cdot)$ = diffusion process equation,

$r_i(\cdot)$ = response function to marketing mix variables.

We will first discuss the two components of equation (2), i.e., the diffusion process *per se* ($d_i(\cdot)$) and the marketing mix effects ($r_i(\cdot)$). Then, we will consider non-separable effects. A significant issue addressed in this research is the functional form since, at least for the non-separable case, the optimal pricing and advertising policies over time can only be derived after first selecting a specific functional form.

Interpersonal Influences and Brand-Level Competition

A brand in competition with other substitutes can diffuse according to a number of different processes, as shown in Figure 1. Figure 1 illustrates the interpersonal influences affecting a given brand in a new category. Adopters of a brand, i, can be influenced by previous adoptions of that brand only (X_i), or all previous brand-level adoptions combined (X), or of competitive brand adoptions only (X_j). In the case of frequently purchased products, the first adoptions (trials) of a brand can come from households who have adopted (tried) other brands — implying multiple brand adoptions. While multiple-brand adopters may exert a particular interpersonal influence, influences from these adopters are captured by total category adoptions, and by competitive adoptions. We will now consider diffusion processes based on the three influences shown in Figure 1.

First, diffusion can be specific to each product/brand; the diffusion process is not influenced by the diffusion of competitive product offerings. This process (for now excluding marketing mix effects) can be represented as in equation (3)[2]:

$$d_i(\cdot) = \left[a_i + b_i \ (x_i/M_i) \right] (M_i - x_i) \tag{3}$$

where

a_i = external influence coefficient of brand i,
b_i = internal influence coefficient of brand i,
M_i = potential number of adoptions of brand i.

In this case, some individuals decide to purchase or try the brand independently of others, i.e., as they are informed from sources external to the social system (Gatignon and Robertson 1985). Other individuals use information from previous adopters; this information is obtained from interpersonal communication, from visual inspection of adcpters, or simply because of the information conveyed by having a sizeable number of adopters. This is the case when the products are substantially differentiated and the information provided by adopters is specific to each product/brand. Equation (3) represents the monopolistic case as each firm is sufficiently differentiated so as to appear as a monopolist of an innovation. Equation 3, therefore, corresponds to the Bass model applied at the brand level. The substitute diffusion models of Peterson and Mahajan (1978) without competitive word-of-mouth reduce to this specification.

In the second process, the diffusion is not specific to the product/brand, but is general to each brand in the product category. This is the case when adopters give general information about the nature of the product and when the product offerings are undifferentiated. Then, each product's first purchases may follow a product category diffusion process i.e.,

$$d_i(\cdot) = \left[\; a_i + b_i \; (x/M) \; \right] (M - x) \tag{4}$$

where

a_i = external influence coefficient of brand i,
b_i = internal influence coefficient of category trials on brand i,
M = potential number of adoptions (trials) in the category,
x = total category adoptions (trials).

In this case, the market potential is not specific to the brand, but is the total market potential from which each brand will draw its share of first purchases. The market potential is depleted whenever any brand is bought for the first time. Horsky and Mate (1988), Eliashberg and Jeuland (1986) and Dockner and Jorgensen (1988), among others, use a similar specification without interpersonal influence diffusion. In the case of frequently purchased products, M should reflect the fact that consumers can adopt (try) multiple brands within the same category; the number of multiple adoptions (trials) per household will generally be limited to some level less than the total number of competing brands (i.e. consumers are not likely to try all competing brands). If an individual tries multiple brands, this should be reflected in this market potential estimate.

Finally, we consider influences from particular brands. Communication between adopters at the brand level typically reflects two types of interpersonal influence: (1) brand-specific influence, and (2) competitive influence (Peterson and Mahajan 1978). Past adopters bought a specific brand. Consequently, they can provide information about that brand. In general, given that they have tried a brand, one may expect that they are satisfied with their choice, because of confirmation of expectations or through the process of cognitive dissonance reduction. In general, they may be, therefore, likely to provide positive information about that brand. There are, however, cases of dissatisfaction which create the diffusion of negative information (Richins 1983). For frequently purchased products, negative trial experience from one brand can lead to trials of another brand by the same individual. The net impact of negative and positive information depends on the degree of persuasion of these sources. Negative information can attenuate positive information, in some cases, to such an extent that it may dominate. This is quite plausible because negative information tends to be more influential than positive information (Leonard-Barton 1985). In most cases, however, the diffusion process that results from the information provided by previous triers of a brand should be positive. The same is not true of the information provided by triers of a competitive brand. Indeed, the evaluation provided by the adopter of brand i about brand j is more likely to be negative. For high involvement decision processes, individuals who have made a first purchase have deliberated and evaluated a number of alternatives; given that they did not choose brand j, they must have found brand j inferior (assuming that both are on the market). Consequently, the fact of having chosen brand i corresponds to a negative evaluation of brand j in relation to brand i. The larger the group of adopters of brand i, the more positive the information about brand i relative to brand j. Therefore, the larger the group of adopters of brand i, the slower the diffusion of brand j. This suggests the following model:

$$d_i(\cdot) = \left[a_i + b_i\ (x_i/M_i) + c_i\ (x - x_i)/(M - x_i)\ \right]\ (M_i - x_i) \qquad (5)$$

where

c_i = competitive internal influence coefficient of brand i.[3]

This specification corresponds to the substitute model of Peterson and Mahajan (1978). Note that a fourth case is possible, when the diffusion process is as discussed above but when the market potential for a brand is general to all the brands, which leads to equation (6):

$$d_i(\cdot) = \left[a_i + b_i\ (x_i/M_i) + c_i\ (x - x_i)/(M - x_i)\ \right] (M - x) \qquad (6)$$

In summary, interpersonal influence which characterizes diffusion processes are represented by parameters b_i and c_i. The brand specific interpersonal effect b_i is expected to be positive, while the influence from the adopters of competitive products (c_i) is expected to be negative.

The Marketing Mix

In addition to the dynamic effects of interpersonal influence on the diffusion of new products, external influences can affect a brand's first purchase diffusion or trial rate. In a decentralized/competitive diffusion process, the suppliers of the innovation use marketing mix activities to speed up the diffusion of their product/brand.

Price. The effect of pricing on the diffusion process can be represented in the response function by the price elasticity of demand over the product life cycle. Mickwitz (1959) was the first to consider the possibility of dynamic price elasticities over the product life cycle. Based on theoretical considerations, Mickwitz contended that price elasticities rise in the first three stages of the life cycle, and fall during the decline, or final stage. The same belief is held by Kotler (1966) and Lambin (1970). Diffusion theory, as expanded into the marketing field by Robertson (1971), suggests that innovators or early adopters of new products have relatively high incomes and are therefore less sensitive to price changes than later adopters. Economic theory similarly argues that elasticities are directly related to the number of alternatives available to the consumers. The greater the number of alternatives or close substitutes, the more brand-specific price sensitivity increases.

An early empirical study by General Motors found results supporting this contention (Dean 1950). Liu and Hanssens (1981), investigating inexpensive gift items, and Tellis (1988), based on a meta analysis of branded products, find that elasticities increase over the product life cycle. Simon (1979) empirically examines the dynamics of price elasticities on 43 brands of frequently purchased products (pharmaceutical, detergents, and household cleansers), and finds that the price elasticity of growth brands decreases over time and the price elasticity of decline brands increases over time. Lilien and Yoon (1988) find that elasticities are stable in introduction and decline stages and decrease during the growth-to-maturity stage of the life cycle when examining the sales of thirty-five industrial chemicals. One possible explanation for the lack of consistency across studies might be due to differences in the level of analysis, some using aggregate industry sales and others performing the analysis at the brand level. More importantly, however, is the question of the theoretical rationale which might explain why these parameters vary over time. Parsons (1975) and Tellis (1988) consider changes in the competitive structure of the market. This is consistent with the traditional approach to modeling competition in econometrics using relative prices as explanatory variables ($\bar{P}_i$). Even though the relative price sensitivity (the response function coefficient) may not change over time, the change in sales due to a constant change in price depends on the changes in competitors' prices. In particular, when a new competitor enters the market with a lower price than the existing competitors (Eliashberg and Jeuland 1986) the incumbent's price appears higher and sales fall; therefore, one approach to modeling brand-level activities is to specify the response function $r(\cdot)$ as a function of relative price, similarly to the price specification in market share models (Brodie and de Kluyer 1984, Lambin 1976). An alternative is to specify the price elasticity to vary explicitly as a function of the number of competitors. In the first case, the impact of competition follows directly from the relative price variable definition. With the prices of the competitors entering in the denominator of the predictor variable, the competitive effects are inversely related to the dependent variable. For example, a new entry with the price lower than the current average, everything else being held constant, makes the relative price of the analyzed brand higher and, therefore, the current (for the introduction period) numbers of first purchases will decrease (assuming a negative significant impact of relative price on purchases). In the second case, it would be hypothesized, according to the literature discussed above, that a brand's price sensitivity to adoption (first purchase) increases as the number of entrants (close substitutes) in the product category increases.

Advertising. The effects of marketing mix (advertising) activities have recently been studied in diffusion theory research. Kotler (1971) reports that advertising elasticities decline over time for packaged goods. The same result is found by Parsons (1975) when examining the advertising elasticity over the life cycle of a household cleanser. Arora (1979) expands this effort by looking at the dynamic elasticities of journal advertising for new pharmaceuticals. As found by Parsons, advertising elasticities approach zero over time. However, there are two different sources of variation of advertising elasticities of a product category. Brands have specific characteristics and, therefore, the changing nature of the market offerings over the product life cycle can alter the product class elasticities. In this paper, we are not concerned with explaining brand differences which are stable over time. Instead, we are interested in explanations due to the changing nature of competitiveness in the market over time, which results in a dollar spent in advertising a brand at a given point in time not generating the same level of response in purchases than another dollar when facing a different competitive environment.

Two factors can explain why the advertising effectiveness of a brand can be expected to decrease over its life. The first explanation comes from the fact that as more competitors enter the market, more competitive advertising reaches consumers and escalation in expenditures are necessary to preserve a constant effect. In addition, as more products enter the market, product redundancies will occur ("me too" products). These explanations for decreasing brand advertising effectiveness can be modeled with two complementary specifications.[4]

If an advertising share predictor is specified to represent competitive effects, the impact of competition follows directly from the share specification ($\bar{A}_i$), i.e., as the marketing actions of competitors enter into the denominator of the predictor variable, the competitive effects are inversely related to the dependent variable. Therefore, in this case, a new entrant which advertises, everything else being held constant, would reduce the share of advertising of the analyzed brand and, therefore, the current (for the introduction period) numbers of purchases would decrease (assuming a positive significant impact of advertising on purchases).

In addition, to represent the greater task difficulty as more brands enter the market, the brand advertising sensitivity can be represented as a function of the number of competitors. It is expected that the larger the number of competitors, the smaller the advertising elasticity coefficient. Both aspects discussed above correspond to the hypothesis that the impact of advertising decreases as competition increases, in addition to effects due to market saturation.

Therefore, the marketing mix variables can be modeled according to either of the two equations (7) and (8)[5]:

$$r_i(\cdot) = [P_i(t)]^{f_{0i} + f_{1i} N(t)} \, [A_i(t)]^{g_{0i} + g_{1i} N(t)} \tag{7}$$

$$r_i(\cdot) = [\bar{P}_i(t)]^{f_{0i} + f_{1i} N(t)} \, [\bar{A}_i(t)]^{g_{0i} + g_{1i} N(t)} \tag{8}$$

Where

$P_i(t)$ = price of brand i at time t
$A_i(t)$ = advertising expenditure for brand i at time t
f_{0i} = intercept of price elasticity for brand i
f_{1i} = coefficient of price elasticity dynamics for brand i
$N(t)$ = number of brands in the product category at time t
g_{0i} = intercept of the elasticity of advertising for brand i
g_{1i} = coefficient of advertising elasticity dynamics for brand i

$$\bar{P}_i(t) = P_i(t) \Big/ \left[\frac{1}{N(t)} \sum_{j=1}^{N(t)} P_j(t) \right]$$

$$\bar{A}_i(t) = A_i(t) \Big/ \sum_{j=1}^{N(t)} A_j(t)$$

Equations (7) and (8) express the impact of marketing-mix variables on the diffusion process. When appled to equation (2), the marketing mix effects and the diffusion process have a separable form. In fact, as discussed earlier, equation (1) might not be separable.

Non Separable Diffusion Functions

The separability question concerns whether price and advertising levels affect one's decision making in interaction with cumulative sales experience or not. It seems plausible that if a product is priced low, for example, then people are more likely to talk about it as being a "great deal". In other words, pricing or advertising can stimulate the communication processes between adopters and non-adopters. Theoretically, advertising can give credibility to interpersonal information or induce an "imitator" to seek information from previous adopters (Simon and Sebastian 1987).

Rogers (1983) suggests that mass media communication is more important during the early stages of an innovation's growth than for later sales. This would imply that short-term communication elasticities decline over time. The separable marketing mix response function allows for this phenomenon implicitly because of the saturation effects of the market and explicitly with equations (7) and (8). However, the same dynamics as specified by these equations apply to both the external influence process and to interpersonal communication. In fact, according to the argument discussed above, the external influence coefficient is given greater importance in the beginning of the life cycle while the internal influence coefficient dominates later.

To represent this phenomenon, both the external and internal influence coefficients can be expressed as functions of advertising (Horsky and Simon 1983, Simon and Sebastian 1987, Teng and Thompson, 1983).[6] In theory, one could develop individual response functions associated with each coefficient. The latter approach is difficult due to estimation problems of multicollinearity (Simon and Sebastian 1987). It is nevertheless instructive to test alternative non-separable formulations which correspond to specifications previously analyzed in the literature. A non separable specification is proposed by Simon and Sebastian (1987)[7] where the response function is multiplied by the coefficient of brand-spe ific internal influence, b_i:

$$s_i = [a_i + b_i (x_i/M_i) r_i(\cdot)] (M_i - x_i) \qquad (9)$$

This specification does not increase the number of parameters but does allow one to evaluate how sensitive the parameters are to alternative formulations. In equation (9), advertising and price are viewed as marketing tools which stimulate positive word of mouth.

The second alternative formulation multiplies the response function to the coefficient of innovation and not to the other diffusion parameters, similar to the model estimated by Horsky and Simon (1983):

$$s_i = [a_i \ r_i (\cdot) + b_i (x_i/M_i)] (M_i - x_i) \qquad (10)$$

In this case, advertising and price directly affect the likelihood of a potential adopter to purchase at that period without being influenced by an early adopter's information. Although the role of marketing is substantially different depending on these specifications, the hypotheses concerning the moderating role of competition remain unchanged.

In equations (9) and (10), the diffusion process is brand specific whereas the corresponding alternatives with a product class process are represented by equations (11) and (12):

$$s_i = [a_i + b_i (x/M) r_i (\cdot)] (M - x) \qquad (11)$$

$$s_i = [a_i \ r_i (\cdot) + b_i (x/M)] (M - x) \qquad (12)$$

EMPIRICAL ANALYSIS OF COMPETITIVE MODELS

Data

In order to compare the alternative specifications, the data set must have a reasonably large number of entrants (in order to assess competitive effects) and include (from the first day of the category's existence) the trials (first purchases), price, and advertising expenditures of all existing brands. The product category defined as "hair styling mousses" was the only category which met these criteria (with no seasonality) among hundreds of categories screened (consumer electronics and frequently purchased products). This category began with the first entrant in February 1984. By March 1985 there were 9 different (yet similar) brands offered on the market. The date of entry of the brands are as follows:

Brand (order of entry)	Date
1	02/19/84
2	03/11/84
3	05/06/84
4	05/06/84
5	07/01/84
6	08/12/84
7	10/28/84
8	11/18/84
9	02/10/85

The brands studied include the pioneer brand, L'Oreal, and eight other "me too" products whose only differentiation consisted of their individual umbrella brand names. All entrants studied are national brands and were launched nationally; only trials in mass channels are considered (supermarkets and drug stores). After the first nine brands (or two and a half years), category segmentation led to an additional forty brand entrants by 1988; these later brands differentiated themselves on various attributes, including fragrances, flavors (e.g. lemon, cherry), colors (e.g. blue, purple), metallic/glitter content, alcohol content, and hair treatment abilities (e.g. strong hold, weak hold). Across the nine brands considered, Brand 6 (Suave) is known as a follower or an umbrella "me too" brand for other hair care products. Data sources relied on include (1) Information Resources, Inc. (IRI) for first purchase/trial and price data, (2) Broadcast Advertising Report (BAR) for broadcast advertising, and (3) Leading National Advertisers (LNA) for print media advertising.

Trial and Price Data

In 1984/1985 (the period of the product category introduction), IRI collected purchasing data from over 20,000 households across eight markets. Only first purchases of a given brand of the product class were used from a static sample of approximately 6,000 households who continually participated during the diffusion of the hair mousse products. IRI data are aggregated to cover periods of four weeks each (i.e., months). A maximum of 26 data points could be retrieved for each brand, so that the data cover at most 26 months for each of the brands studied. Average prices are given for those first purchases (trials) recorded over each observation period.[8] Figures 2 and 3 provide graphic illustrations of the number of trials, and prices for each of the brands in the product category over the periods following their market introduction. The last two brands that entered the market as well as brand 5 were excluded from the analysis due to lack of observations. Neither of these brands achieved any significant penetration in the market, as shown in Figure 2. Brand 7 was also excluded because of its lack of diffusion process.

Trials of Brand 7 follow a purely random process which could not be fit by any model of diffusion.

Advertising Data

Broadcast Advertising Reports (BAR) collects monthly advertising data covering a number of broadcast media: local spot television, national network television, cable television, and radio. For each of these media, BAR calculates estimates of brand specific expenditures based on the time of day an advertisement is aired, its duration (in seconds), audience covered (e.g., local versus national), and the broadcast station (e.g., NBC, CBS, etc.). These estimates are aggregated on a monthly basis for each brand advertised.

Similar to BAR, Leading National Advertisers (LNA) collects brand-specific monthly advertising data covering print media, including magazines, newspapers and newspaper inserts. All major and most minor magazines and newspapers are scanned for advertisements. Based on advertising rate cards supplied by the publishers, the size of the advertisement (e.g., full-page, half-page, etc.) and the format (black-and-white, or color), monthly expenditures are estimated for each brand.

In order to derive total advertising expenditures, the broadcast and print media expenditures (from BAR and LNA sources) are aggregated into total advertising expenditures by brand (in thousands of dollars).[9] Figure 4 shows the advertising expenditures for the nine brands introduced to the market during the period of investigation following the entry.

Estimation

In order to test the existence of the competitive effects discussed above and compare the performance of the various model specifications, econometric models are specified and estimated at the brand-level. The alternatives tested correspond to various combinations of the four diffusion equations (equations (3), (4), (5), (6)) with the two alternative specifications of the marketing response functions (equations (7) and (8)). In addition, the non separable models represented by equations (9), (10), (11) and (12) are also estimated, leading to 16 models to be evaluated. These models are reported in Table 1 (where the time index t has been deleted for greater clarity).

When the marketing mix variables have no effect, these models reduce to simpler models which are also estimated. Models 1, 2, 9, 10, 11 or 12 reduce to model 17, models 3, 4, 13, 14, 15 and 16 reduce to model 18, model 5 and 6 reduce to model 19 and models 7 and 8 reduce to model 20 as specified in Table 1. It should also be noted that with the restriction that $c_i = 0$ models 19 and 20 reduce to model 17.

The market potentials (M_i) were first estimated by applying the original Bass model individually to each brand.[10] The aggregate market potential (M) was then estimated to be the sum of the individual brands' potential as the competitors entered the market; the aggregate potential reflects, therefore, multiple adoptions (trials) across brands.[11] Then, the diffusion parameters were estimated using the estimated market potential specific to each model specification as an externally evaluated parameter as in Gatignon, Eliashberg and Robertson (1989).

Comparison of Models

Instead of reporting all of the parameter estimates for each model, tests were performed to compare each specification and only the retained models for each brand are presented and discussed.

When models are nested, such as model 17 which is a restricted version of model 1, a likelihood ratio test can be performed. The restricted model is defined as the null hypothesis and the alternative hypothesis represents the unrestricted model specification. Therefore, it is possible to select the best model specification within nested specifications. However, tests of non-nested, non-linear models are not commonly performed in the marketing literature. In our case, these tests are critical. Multiple tests exist for non-nested models. However, different criteria can be used. Because we are testing a theory in this study (the existence of certain types of effects) rather than building models purely for predictive and/or for decision making purposes, parsimony should not be a factor in the selection of the test to apply (Rust and Schmittlein 1985). Therefore, there is no need to use criteria that correct for the number of parameters. Such a test is proposed by Cox (1961, 1962) and modified by Pesaran and Deaton (1978). The test used is described in the Appendix. Due to the inherent nonlinearity of the proposed models, the diffusion parameters are estimated using the Marquardt nonlinear estimation technique. These estimates approach the Gauss maximum likelihood estimates.

For each brand, tests for nested models are first performed and the Cox test is applied to select the best of the non-nested models among the retained nested models. The fit statistics of each model are provided in Table 2 and the model test results are presented in Tables 3 and 4. Because of collinearity, models 5, 6, 7, and 8, which involve competitive effects of diffusion through the parameter c_i and competitive marketing mix effects could not be estimated. Consequently, the only models with competitive interpersonal diffusion are models 19 and 20. Table 2 reports for each brand and each model the residual sum of squares as well as the correlation between the predicted and actual monthly trials. This correlation is a typical measure of fit for non-linear models (Judge et al. 1985). A static version of the marketing mix coefficients is also estimated for each brand. Because these static models are restricted ($f_{1i} = g_{1i} = 0$) versions of the models presented in Table 1, nested model tests apply. These chi-square tests are reported in Table 3. The model number corresponds to the numbers shown in Table 1 to which the letter S is assigned to indicate the static (restricted) version of each model. The statistically "best" nested models are then compared using the Cox test for non-nested models (Table 4). As can be seen in Table 4, the asymmetry of the Cox test does not define a single best alternative. Cox tests are performed separately for models where the diffusion is brand specific (models 1, 2, 9, 10, 11, 12) and for models where the diffusion is product class-wide (models 3, 4, 12, 14, 15, 16). When the Cox test is inconclusive, the more parsimonious model is retained. For each brand, the final model reported in Table 5 is the "best" according to the Cox test performed among the best brand specific versus product class diffusion models; if two models are statistically equivallent, both are reported.

The tests of nested models are shown in Table 3 for each brand, where the product class diffusion models (using M as the market potential of all brands) are shown separately from the brand specific diffusion models (which use a brand specific market potential M_i). The most complete (dynamic marketing mix effects) specification of each model form is first tested against its least restricted version, which is the static marketing mix effect model. For example, for brand 1, the static restricted version is not statistically different from the dynamic specification of model 1. For model

2, however, the more complete dynamic specification has statistically a better fit. The retained model is then tested against the next restriction, i.e., a model with no marketing mix variables. The models with no marketing variables are the basic Bass models specified either with a brand specific diffusion (model 17) or with a product class diffusion (model 18). If one of the non-basic models is retained, the corresponding basic model is rejected. These nested tests lead to the selection of a subset of the original conceptually feasible models. However, since the models retained so far are non-nested, the Cox test must be used to select final models.

Table 4 presents these results in the form of matrices of scores for each brand. Cox tests are performed among the retained brand specific diffusion models and among the retained product class diffusion models resulting in two matrices depending on the diffusion level specification. The rows correspond to the test when the model on the row is the null hypothesis and the model in the column is the alternative hypothesis. For example, for brand 1, among the retained brand specific diffusion models, the static version of model 11 is retained and among the product class diffusion models, the static version of model 15 is selected.

A third matrix for each brand is necessary to select between the best of the brand specific diffusion models and the best of the product class diffusion models. Again using brand 1 as an example, model 15S is rejected when the null is model 11S while we fail to reject model 11S when 15S is the null hypothesis. We therefore select model 11S to represent the diffusion of brand 1. In a few instances, such as for brands 3 and 4, selection could not be made due to inconclusive Cox tests and the same number of parameters prevented us from using the primary criterion. This primary criterion is used, for example, for brand 5 to decide between models 2 and 12S in favor of model 12S. These options were then retained for the final Cox tests. In the case of brand 4, for example, models 1 and 9 are clearly rejected in favor of model 13, leading to an unambiguous conclusion. However, two models are reported for brand 3 as the criteria could not distinguish between models 10 and 4. The estimated models are shown in Table 5 with a summary of the characteristics of the retained models across the brands. This fit is graphically compared to the actual data and to the basic Bass model in Figure 2. This figure shows clearly that the lack of smoothness in the data is explained well by the retained models.

The correlation between the predicted trials and the actual data are shown for each brand in Table 5. The range from 0.71 to 0.91 indicates a good fit of the retained models. The final models retained can be classified by the type of diffusion process (brand specific versus product class), by the marketing mix effects being dynamic or static, by whether marketing effects are competitive due to a relative or not relative specification (static), and by whether the marketing variable affects the coefficient of external influence, the coefficient of internal influence or both.

Analysis of Retained Models

Based on the tests described above, this analysis addresses the following issues:

(1) the role of brand-specific versus category level diffusion across competitive entrants,
(2) the role of marketing mix elements on brand-level diffusion processes,
(3) the existence of static versus dynamic elastic responses over the brand life cycle,
(4) the response of brand trials to absolute versus relative measures of marketing mix activity, and
(5) the appropriate use of separable versus non-separable functional forms incorporating brand-level marketing mix elements.

More generally, this research empirically tests whether a common functional form, or hypothesized diffusion process can be imposed on or characterizes all new brands entering into a new category, as certain normative analyses assume. The answer to this general question is "no". Each brand diffusion's is best represented by a different model specification. This is particularly critical because it creates asymmetries across brand trials which imply different recommendations for optimal marketing activities of each brand, rather than the same strategy for all brands.

Concerning the first issue of whether diffusion is brand or product class specific, the first brand to enter the market is characterized by its own brand-specific diffusion, which could correspond to the fact that, for the period during which the brand is in a monopoly situation, the product class is made up of that single brand. The finding that brand specific diffusion represents best the diffusion of the first brand suggests a strong brand identification, which insulates that brand from competitors. This finding is particularly significant given that, in the product class studied, the second brand entered the market only three weeks after the first entrant. This is reinforced by the fact that absolute marketing activities (as opposed to relative with respect to competitors) impact its diffusion and that sensitivity to marketing mix is not affected by the number of competitors. Therefore, the first brand seems to diffuse in the market independently of competitive developments. This quasi-monopolistic behavior might be seen as a pioneer's advantage.

Except for the sixth brand, the first generic-type brand which also develops according to its own diffusion, the early followers are characterized by a product class-wide diffusion. Therefore, the followers do not seem to be able to develop their own market niche. This could be the reason for the difficulty of late entrants, such as brands 7, 8, and 9, and possibly brand 5, to be successful in this market. The sixth brand, Suave, achieves a brand specific diffusion, possibly benefiting from an established brand name since this brand is marketed under an umbrella brand strategy. Although the brand was undifferentiated apart from its name, it was introduced following a corporate policy of very low prices with no advertising (which is not needed because the brand relies on the overall umbrella brand awareness). In fact, as can be seen from Figure 3 (and which was confirmed in a conversation with the brand manager), brand 6 was originally priced too low for generating satisfactory profits and the price was subsequently raised progressively. This explains the positive price sensitivity parameter of that brand.

With respect to the second and third issue, for all of the brands investigated, the diffusion process is not independent of marketing activities which clearly play a significant role. Sensitivity to marketing mix variables is dynamic, i.e., varying when new competitors enter the market, except for brands 1 and 6. Regarding price, however, the only brand sensitive to that factor is the second entrant. This brand's trials become more sensitive to price as more brands entered into competition. Apart from brand 2, price coefficients are static as the parameters for the impact of the number of competitors are not significant. With respect to price, therefore, our analysis supports the findings of Tellis (1988), and Nagel (1987), among others, that if price sensitivities are dynamic, they would tend to increase over the product life cycle as brand competition increases.

The dynamic nature of the marketing effects come mostly, however, from advertising. Advertising sensitivities can decline, increase, or be insignificant, depending on the brand, and, in particular, the number of competitors. The pioneer's advertising response parameters are not statistically different from zero, while the second and third entrant's sensitivities to advertising increased as the category matured. This increasing sensitivity may reflect the fact that brand-level advertising is only effective after a category's general awareness is high (created by the pioneer, L'Oreal). This free-rider benefit may be short-lived, however, as the next entrants eventually have declining elasticities as the number of competitors increase. The dynamics found for these entrants may explain why later entrants chose not to advertise. This finding, therefore, generally does not support the idea that advertising elasticities decline over the product life cycle, or are constant across competitive entries into a new category. Clearly the optimal timing (pioneer versus follower) and the level of marketing activity will be affected by such dynamics if they are considered prior to launch.

Regarding the fourth issue of whether marketing variables are specific (absolute) or relative to competitors's actions (relative price and share of voice), the results indicate that this depends on the brand. Likewise, regarding the fifth issue, this analysis provides little support (only possibly for brand 3) of the separable form. A number of brands' external influence coefficient is affected by marketing variables, although the analysis suggests that in some instances, marketing variables affect the coefficient of internal influence (brands 3 and 4). As Simon and Sebastian (1987) indicate, these differences across brands may be due to the different nature of the content of advertising for each brand. This is a product category where it is very feasible to emphasize the social benefits of using the product. This could have an influence on the impact of consumer response to marketing activities and/or interpersonal communications (either in its visual or verbal form). The lack of clear support for the separable functional form is consistent with empirical studies of consumer durables at the category level (Kamakura and Balasubramanian 1988, Jain and Rao 1989).

SUMMARY

In this study, we empirically estimated and compared a number of brand-level model specifications typically found in the marketing literature which derives optimal marketing mix strategies over the brand's life cycle. This empirical investigation is limited to a single product category, which prevents general substantive inferences about the diffusion of innovations facing competition in general. The product category analyzed is a frequently purchased item. Consequently, the trial dynamics, in particular in terms of word-of-mouth, may be different for durable goods. For example, it is possible that the degree of dissatisfaction and consequently switching to a different brand leads to a stronger interpersonal influence than for durable goods.

The results of this study nevertheless point out a number of conclusions critical for modeling the diffusion of competing brands and with important managerial implications. First, the results indicate that each brand can follow a brand specific or a product class diffusion process and that marketing's impact varies for each brand's trials: sometimes it is a dynamic competitive force or, in other cases, the brand is strong enough to stand on its own as a quasi-monopoly.

Marketing mix variables are also shown to be critical in the diffusion of brands, and their impact is not identical across brands. The sensitivity of trials to price increases over the product life cycle or is constant, while advertising sensitivity appears to be insignificant, increase or decrease over the product life cycle, depending on the order of entry.

Similar to findings for consumer durables, the separable functional form does not seem to be supported, and, even though more tractable mathematically for optimization purposes, would not be relevant for the brands analyzed in this paper. This is particularly critical because a functional form must be adopted for the optimization of the non-separable forms; only one separable functional form fits the data in this study well.

Generally, this study illustrates that asymmetries in the diffusion process exists across brands. This implies that optimal marketing mix strategies should recognize the various cases which derive from the various brand diffusion models. For example, while the first brand has a brand specific diffusion, the second entrant could follow a product class diffusion. These asymmetries should lead to different optimal strategies over time for each brand.

FOOTNOTES

1. A number of non-symmetric growth curves have also been proposed and fitted, e.g., Sharif and Kabir (1976), Jeuland (1981), Easingwood, Mahajan and Muller (1983), or Von Bertalanffy (1957). For a complete review, see Mahajan, Muller and Bass (1990).

2. The external influence model of Fourt and Woodlock (1960) and the internal influence model of Mansfield (1961) are not discussed further as conceptually they correspond to special cases of the mixed influence model of Bass (1969). Asymmetric growth curves in which the parameters' "behavioral" interpretation has not been assessed are not discussed in this paper.

3. Although in theory each brand could have a different impact on the diffusion of their competitors, for practical purposes due to estimation which would become unfeasible, all competitors can be assumed to have an homogeneous impact on the diffusion of brand i.

4. It should be noted that a third explanation comes from the saturation level being achieved in the market which reduces indirectly the impact that advertising can possibly have. This phenomenon is implicitly represented by the saturation of the market in the diffusion model specification.

5. Though similar in spirit to the response function above, market share model specifications such as the multiplicative competitive interaction model (Cooper and Nakanishi 1988) are not considered here due to the category dynamics studied (i.e., new entrants' trials in a new category).

6. The separable marketing mix response function can be interpreted in this manner, with the restriction of equal effects of marketing variables on both the diffusion model's external and internal influence coefficients.

7. Although Simon and Sebastian (1987) consider the monopolistic case for the analysis of competitive brands, we consider a similar model where the potential market is either brand specific or general to the category.

8. When there is no trial recorded during a period, price for the period is set equal to the average price for the prior period when purchases occurred.

9. Advertising data was (collected on a calendar basis) disaggregated to a daily basis assuming a uniform daily distribution and re-aggregated to correspond to the IRI four-week periods. A value of one was used for periods without advertising.

10. Because this analysis investigates an inexpensive frequently purchased product, it does not seem necessary to formulate M_i as a function of price, as in Kalish (1983); furthermore, Kamakura and Blasubramanian (1988) and Jain and Rao (1989) find that price affects the coefficients of internal and external influence, rather than the market potential for high and low priced consumer durables.

11. Although alternatives such as estimating the Bass model at the category level are feasible, our approach recognizes that the product category potential changes when new brands are introduced. This is especially relevant in the case of first purchases of frequently purchased items when an individual who is in the potential market of one brand may also be in the potential market for a competitive brand.

TABLE 1. Alternative Model Specifications

Combination of Equations	Formulation	Model Number
Separable Models:		
3,7	$s_i = \left[a_i + b_i\ (x_i/M_i) \right] (M_i - x_i) \left[P_i^{f_{oi}+f_{1i}N(t)}\ A_i^{g_{oi}+g_{1i}N(t)} \right]$	1
3,8	$s_i = \left[a_i + b_i\ (x_i/M_i) \right] (M_i - x_i) \left[\bar{P}_i^{f_{oi}+f_{1i}N(t)}\ \bar{A}_i^{g_{oi}+g_{1i}N(t)} \right]$	2
4,7	$s_i = \left[a_i + b_i\ (x/M) \right] (M - x) \left[P_i^{f_{oi}+f_{1i}N(t)}\ A_i^{g_{oi}+g_{1i}N(t)} \right]$	3
4,8	$s_i = \left[a_i + b_i\ (x/M) \right] (M - x) \left[\bar{P}_i^{f_{oi}+f_{1i}N(t)}\ \bar{A}_i^{g_{oi}+g_{1i}N(t)} \right]$	4
5,7	$s_i = \left[a_i + b_i\ (x_i/M_i) + c_i(x-x_i)/(M-x_i) \right] (M_i - x_i) \left[P_i^{f_{oi}+f_{1i}N(t)}\ A_i^{g_{oi}+g_{1i}N(t)} \right]$	5
5,8	$s_i = \left[a_i + b_i\ (x_i/M_i) + c_i(x-x_i)/(M-x_i) \right] (M_i - x_i) \left[\bar{P}_i^{f_{oi}+f_{1i}N(t)}\ \bar{A}_i^{g_{oi}+g_{1i}N(t)} \right]$	6
6,7	$s_i = \left[a_i + b_i\ (x_i/M_i) + c_i(x-x_i)/(M-x_i) \right] (M - x) \left[P_i^{f_{oi}+f_{1i}N(t)}\ A_i^{g_{oi}+g_{1i}N(t)} \right]$	7
6,8	$s_i = \left[a_i + b_i\ (x_i/M_i) + c_i(x-x_i)/(M-x_i) \right] (M - x) \left[\bar{P}_i^{f_{oi}+f_{1i}N(t)}\ \bar{A}_i^{g_{oi}+g_{1i}N(t)} \right]$	8

TABLE 1. (Continued)

Combination of Equations	Formulation	Model Number
Non-Separable Models:		
9,7	$s_i = \left[a_i+b_i\ (x_i/M_i)\ P_i^{f_{oi}+f_{1i}N(t)}\ A_i^{g_{oi}+g_{1i}N(t)} \right] (M_i - x_i)$	9
9,8	$s_i = \left[a_i+b_i\ (x_i/M_i)\ \overline{P}_i^{f_{oi}+f_{1i}N(t)}\ \overline{A}_i^{g_{oi}+g_{1i}N(t)} \right] (M_i - x_i)$	10
10,7	$s_i = \left[a_i\ P_i^{f_{oi}+f_{1i}N(t)}\ A_i^{g_{oi}+g_{1i}N(t)} + b_i\ (x_i/M_i) \right] (M_i - x_i)$	11
10,8	$s_i = \left[a_i\ \overline{P}_i^{f_{oi}+f_{1i}N(t)}\ \overline{A}_i^{g_{oi}+g_{1i}N(t)} + b_i\ (x_i/M_i) \right] (M_i - x_i)$	12
11,7	$s_i = \left[a_i+b_i\ (x/M)\ P_i^{f_{oi}+f_{1i}N(t)}\ A_i^{g_{oi}+g_{1i}N(t)} \right] (M - x)$	13
11,8	$s_i = \left[a_i+b_i\ (x/M)\ \overline{P}_i^{f_{oi}+f_{1i}N(t)}\ \overline{A}_i^{g_{oi}+g_{1i}N(t)} \right] (M - x)$	14
12,7	$s_i = \left[a_i\ P_i^{f_{oi}+f_{1i}N(t)}\ A_i^{g_{oi}+g_{1i}N(t)} + b_i\ (x/M) \right] (M - x)$	15
12,8	$s_i = \left[a_i\ \overline{P}_i^{f_{oi}+f_{1i}N(t)}\ \overline{A}_i^{g_{oi}+g_{1i}N(t)} + b_i\ (x/M) \right] (M - x)$	16
Restricted Models ($f_{oi} = f_{1i} = g_{oi} = g_{1i} = 0$):		
	$s_i = \left[a_i + b_i\ (x_i/M_i) \right] (M_i - x_i)$	17
	$s_i = \left[a_i + b_i\ (x/M) \right] (M - x)$	18
	$s_i = \left[a_i + b_i\ (x_i/M_i) + c_i\ (x-x_i)/(M - x_i) \right] (M_i - x_i)$	19

TABLE 1. (Continued)

Combination of Equations	Formulation	Model Number
Restricted Models (continued):		
	$s_i = \left[a_i + b_i\ (x_i/M_i) + c_i\ (x-x_i)/(M - x_i)\right] (M - x)$	20

Where

s_i = first purchases of brand i at time t,

a_i = external influence coefficient of brand i,

b_i = internal influence coefficient of brand i,

c_i = competitive internal influence coefficient of brand i,

M_i = potential number of adopters of brand i,

P_i = price of brand i at time t,

$\overline{P}_i$ = price of brand i relative to the average price of competition at time t,

A_i = advertising expenditure for brand i at time t,

$\overline{A}_i$ = advertising share of brand i relative to the competition at time t,

f_{0i} = intercept of price elasticity of demand for brand i,

f_{1i} = coefficient of price elasticity dynamics for brand i,

$N(t)$ = number of products in the product category at time t,

g_{0i} = intercept of the elasticity of advertising for brand i

g_{1i} = coefficient of advertising elasticity dynamics for brand i.

TABLE 2. Fit Statistics of Estimated Models

Model	Brand 1 RSS	Brand 1 r	Brand 2 RSS	Brand 2 r	Brand 3 RSS	Brand 3 r	Brand 4 RSS	Brand 4 r	Brand 6 RSS	Brand 6 r
1	1524.95	.69	97.48	.89	135.66	.71	148.53	.82	2427.00	.69
1S	1714.18	.65	127.93	.85	161.63	.63	219.31	.71	2431.35	.69
2	1929.69	.57	149.02	.82	113.76	.77	219.94	.71	1112.13	.88
2S	1960.75	.57	153.47	.81	150.57	.71	237.31	.68	1922.69	.76
3	2221.02	.64	112.16	.88	130.00	.73	134.00	.83	2282.66	.71
3S	2248.85	.63	161.03	.83	156.69	.64	208.64	.73	2404.18	.69
4	2566.21	.56	185.88	.79	106.67	.79	193.56	.75	1395.18	.83
4S	2643.05	.55	186.53	.78	151.42	.65	232.24	.69	2070.92	.74
9	1642.68	.66	106.42	.87	117.34	.74	143.54	.82	1328.75	.88
9S	1941.58	.32	134.07	.84	215.43	.43	253.25	.65	2052.67	.74
10	1891.61	.58	153.57	.81	95.37	.80	214.39	.72	2155.86	.78
10S	1977.31	.57	159.20	.80	235.12	.33	232.61	.69	2426.46	.69
11	1208.90	.76	88.70	.90	142.83	.68	163.46	.80	2415.51	.70
11S	1430.86	.71	159.62	.64	180.77	.56	178.39	.77	2510.92	.67
12	1952.85	.57	162.34	.80	124.75	.75	181.80	.77	1159.31	.87
12S	2248.97	.47	200.76	.74	162.89	.62	217.23	.72	1301.42	.85
13	2215.63	.65	110.02	.87	130.01	.73	120.40	.85	2301.30	.71
13S	2581.03	.54	174.46	.82	167.73	.60	164.10	.79	2317.43	.71
14	2643.31	.55	158.46	.80	90.62	.82	147.31	.81	2417.34	.69
14S	2792.41	.54	171.11	.79	112.04	.76	153.89	.81	2440.74	.69
15	1869.48	.69	78.80	.91	145.92	.67	172.01	.78	2374.07	.70
15S	2199.71	.64	173.24	.81	157.06	.63	208.18	.73	2374.34	.70
16	2567.44	.55	190.95	.78	115.61	.78	222.44	.70	2114.53	.74
16S	2655.11	.55	198.48	.76	151.07	.66	228.24	.69	2243.87	.72
17	2249.62	.46	283.20	.60	240.50	.30	334.42	.49	2515.35	.67
18	3153.12	.44	308.51	.60	201.82	.48	328.63	.54	2440.82	.69
19	2229.96	.48	279.28	.61	218.93	.41	298.76	.59	2387.06	.71
20	2647.04	.48	259.98	.64	200.94	.48	319.91	.63	2390.32	.70
N	26		24		26		26		19	

TABLE 3. Tests of Nested Models[a]

	Dynamic vs. Static	vs.	No Marketing Mix
BRAND 1:			
Brand Specific Diffusion			
	{ 1 vs. 1S → 1S (3.04)}	vs.	17 → 1S (7.07)**
	{ 2 vs. 2S → 2S (0.42)}	vs.	17 → 17 (3.57)
	{ 9 vs. 9S → 9S (4.35)}	vs.	17 → 17 (3.83)
	{10 vs. 10S → 10S (1.15)}	vs.	17 → 17 (3.35)
	{11 vs. 11S → 11S (4.38)}	vs.	17 → 11S (11.76)**
	{12 vs. 12S → 12S (3.67)}	vs.	17 → 17 (0.01)
	→ Retained non-nested models:		1S, 11S
Product Class Diffusion:			
	{ 3 vs. 3S → 3S (0.32)}	vs.	18 → 3S (8.79)**
	{ 4 vs. 4S → 4S (0.77)}	vs.	18 → 18 (4.59)
	{13 vs. 13S → 13S (3.97)}	vs.	18 → 18 (5.21)
	{14 vs. 14S → 14S (1.43)}	vs.	18 → 18 (3.16)
	{15 vs. 15S → 15S (4.23)}	vs.	18 → 15S (9.36)*
	{16 vs. 16S → 16S (0.87)}	vs.	18 → 18 (4.47)
	→ Retained non-nested models:		3S, 15S
BRAND 2:			
Brand Specific Diffusion			
	{ 1 vs. 1S → 1 (6.52)**}	vs.	17 → 1 (25.60)*
	{ 2 vs. 2S → 2S (0.71)}	vs.	17 → 2S (14.70)*
	{ 9 vs. 9S → 9S (5.54)}	vs.	17 → 9S (17.95)*
	{10 vs. 10S → 10S (0.86)}	vs.	17 → 10S (13.82)*
	{11 vs. 11S → 11 (14.10)*}	vs.	17 → 11 (27.86)*
	{12 vs. 12S → 12S (5.10)}	vs.	17 → 12S (8.26)**
	→ Retained non-nested models:		1, 2S, 9S, 10S, 11, 12S
Product Class Diffusion:			
	{ 3 vs. 3S → 3 (8.68)**}	vs.	18 → 3 (24.28)*
	{ 4 vs. 4S → 4S (0.08)}	vs.	18 → 4S (12.08)*
	{13 vs. 13S → 13 (11.06)*}	vs.	18 → 13 (24.75)*
	{14 vs. 14S → 14S (1.84)}	vs.	18 → 14S (14.15)*
	{15 vs. 15S → 15 (18.91)**}	vs.	18 → 15 (32.76)*
	{16 vs. 16S → 16S (0.93)}	vs.	18 → 16S (10.59)*
	→ Retained non-nested models:		3, 4S, 13, 14S, 15, 16S

[a] Chi squared statistics are in parentheses
* Significant at .01 level
** Significant at .05 level

TABLE 3. Tests of Nested Models[a] (Continued)

Dynamic vs. Static	vs.	No Marketing Mix
BRAND 3:		
Brand Specific Diffusion		
{1 vs. 1S → 1S (4.55)}	vs.	17 → 1S (10.33)*
{2 vs. 2S → 2 (7.29)**}	vs.	17 → 2 (19.46)*
{9 vs. 9S → 9 (15.80)*}	vs.	17 → 9 (18.66)*
{10 vs. 10S → 10 (23.46)*}	vs.	17 → 10 (24.05)*
{11 vs. 11S → 11 (6.12)**}	vs.	17 → 11 (13.55)*
{12 vs. 12S → 12 (6.94)**}	vs.	17 → 12 (17.07)*
→ Retained non-nested models:		1S, 2, 9, 10, 11, 12
Product Class Diffusion:		
{3 vs. 3S → 3S (4.86)}	vs.	18 → 3S (6.58)**
{4 vs. 4S → 4 (9.11)**}	vs.	18 → 4 (16.58)*
{13 vs. 13S → 13 (6.62)**	vs.	18 → 13 (11.43)**
{14 vs. 14S → 14S (5.52)}	vs.	18 → 14S (15.30)*
{15 vs. 15S → 15S (1.91)}	vs.	18 → 15S (6.52)**
{16 vs. 16S → 16 (6.96)}	vs.	18 → 16 (14.49)*
→ Retained non-nested models:		3S, 4, 13, 14S, 15S, 16
BRAND 4:		
Brand Specific Diffusion		
{1 vs. 1S → 1 (10.13)*}	vs.	17 → 1 (21.10)*
{2 vs. 2S → 2S (1.98)}	vs.	17 → 2S (8.92)**
{9 vs. 9S → 9 (14.76)*}	vs.	17 → 9 (21.99)*
{10 vs. 10S → 10S (2.12)}	vs.	17 → 10S (9.44)*
{11 vs. 11S → 11S (2.27)}	vs.	17 → 11s (16.34)*
{12 vs. 12S → 12S (4.63)}	vs.	17 → 12S (11.22)*
→ Retained non-nested models:		1, 2S, 9, 10S, 11S, 12S
Product Class Diffusion:		
{3 vs. 3S → 3 (11.51)*}	vs.	18 → 3 (23.32)*
{4 vs. 4S → 4S (4.74)}	vs.	18 → 4S (9.03)**
{13 vs. 13S → 13 (8.05)**}	vs.	18 → 13 (26.11)*
{14 vs. 14S → 14S (1.14)}	vs.	18 → 14S (19.73)*
{15 vs. 15S → 15S (4.96)}	vs.	18 → 15S (11.87)*
{16 vs. 16S → 16S (0.67)}	vs.	18 → 16S (9.48)*
→ Retained non-nested models:		3, 4S, 13, 14S, 15S, 16S

TABLE 3. Tests of Nested Models[a] (Continued)

Dynamic vs. Static						vs.	No Marketing Mix			
BRAND 6:										
Brand Specific Diffusion										
{1	vs.	1S	→	1S	(0.03)}	vs.	17	→	17	(0.65)
{2	vs.	2S	→	2	(10.40)*}	vs.	17	→	2	(15.51)*
{9	vs.	9S	→	9	(8.26)*}	vs.	17	→	9	(12.13)*
{10	vs.	10S	→	10S	(2.25)}	vs.	17	→	17	(0.68)
{11	vs.	11S	→	11S	(0.74)}	vs.	17	→	17	(0.03)
{12	vs.	12S	→	12S	(2.20)}	vs.	17	→	12S	(12.52)*
		→ Retained non-nested models:					2, 9, 12S			
Product Class Diffusion:										
{3	vs.	3S	→	3S	(0.99)}	vs.	18	→	18	(0.29)
{4	vs.	4S	→	4	(7.50)*}	vs.	18	→	4	(10.63)*
{13	vs.	13S	→	13S	(0.13)}	vs.	18	→	18	(0.99)
{14	vs.	14S	→	14S	(0.18)}	vs.	18	→	18	(0.01)
{15	vs.	15S	→	15S	(0.01)}	vs.	18	→	18	(0.52)
{16	vs.	16S	→	16S	(1.13)}	vs.	18	→	18	(1.60)
		→ Retained non-nested models:					4			

TABLE 4: Tests of Non-Nested Models

BRAND 1:

Brand-Specific Diffusion

Models: Nul \ Alt.	1S	11S
1S	—	-4.72
11S	1.65	—

Product-Class Differentiation

Models: Nul \ Alt.	3S	15S
3S	—	-9.02
15S	3.45	—

→ 11S vs. 15S

Models: Nul \ Alt.	11S	15S
11S	—	-0.03
15S	-2.14	—

→ Retained model: 11S

BRAND 2:

Brand-Specific Diffusion

Models: Nul \ Alt.	1	2S	9S	10S	11	12S
1	—	-2.83	- 0.82	-1.96	-1.66	-3.44
2S	- 4.20	—	- 3.07	-0.49	-4.90	0.33
9S	-12.58	-1.93	—	-1.23	-5.03	-3.30
10S	- 3.50	-0.99	- 2.74	—	-4.77	-1.07
11	0.82	-1.83	1.12	-0.74	—	-3.33
12S	-11.77	-3.86	-18.89	-5.42	-8.23	—

Product-Class Differentiation

Models: Nul \ Alt	3	4S	13S	14S	15	16S
3	—	-1.46	-1.38	-1.90	-6354.1	-2.40
4S	-4.75	—	-6.45	-1.98	- 6.54	0.93
13S	-3.58	-3.09	—	-2.14	- 2.88	-3.15
14S	-4.47	-1.90	-3.44	—	-10.97	-1.58
15	3.34	-3.37	-0.38	-1.44	—	-4.43
16S	-5.63	-2.66	-8.90	-2.47	-6.84	—

→ 11 vs. 15

Models: Nul \ Alt.	11	15
11	—	-5.06
15	-0.72	—

→ Retained model: 15

TABLE 4: Tests of Non-Nested Models (Continued)

BRAND 3:

Brand-Specific Diffusion

Models: Nul \ Alt.	1S	2	9	10	11	12S
1S	—	- 3.61	- 2.36	- 4.30	- 2.57	- 3.10
2	- 0.55	—	- 0.54	-13.96	- 0.25	- 4.73
9	- 0.32	- 1.33	—	-15.90	-0.001	- 2.83
10	0.16	- 0.68	2.10	—	0.70	0.72
11	0.31	- 3.55	- 1.87	- 5.06	—	- 4.37
12	0.66	-10.25	- 1.82	- 2.23	0.46	—

Product-Class Differentiation

Models: Nul \ Alt	3S	4	13	14S	15S	16
3S	—	- 6.62	- 5.17	1.34	0.06	- 5.02
4	0.66	—	1.58	8.81	0.71	- 4.74
13	- 0.14	- 5.91	—	1.11	0.08	- 5.97
14S	-99.03	-192.41	-61.91	—	-98.46	-160.07
15S	- 1.95	- 6.18	- 3.29	1.12	—	- 4.99
16	- 0.49	- 5.79	- 0.86	- 1.84	- 0.39	—

→ 10 vs. 4 or 16

Models: Nul \ Alt.	10	4	16
10	—	-3.77	0.03
4	-1.86	—	-4.74
16	-7.52	-5.79	—

→ Retained model: 10 or 4

BRAND 4:

Brand-Specific Diffusion

Models: Nul \ Alt.	1	2S	9	10S	11S	12S
1	—	0.13	-1.06	-0.51	-0.82	-0.39
2S	-4.06	—	-4.15	-0.96	-2.41	-1.53
9	-0.53	-0.10	—	-0.13	0.86	-0.71
10S	-3.86	0.61	-13.00	—	-1.87	-1.79
11S	-2.59	0.51	-9.79	0	—	-0.19
12S	-2.80	-0.76	-7.63	-1.37	-1.77	—

Product-Class Differentiation

Models: Nul \ Alt	3	4S	13	14S	15S	16S
3	—	-0.06	- 5.29	-6.11	-1.56	-0.13
4S	- 4.31	—	- 7.57	-5.32	-1.58	-7.09
13	0.32	0.64	—	-2.22	-0.40	0.56
14S	- 2.68	-0.61	-294.77	—	-1.93	-0.73
15S	-4038.1	-0.25	- 4.79	-2.57	—	-0.40
16S	- 3.96	2.48	-113.39	-3.65	-1.38	—

→ 1 or 9 vs. 13

Models: Nul \ Alt.	9	1	13
9	—	-0.53	-2.29
1	-1.06	—	-3.70
13	0.93	0.71	—

→ Retained model: 13

TABLE 4: Tests of Non-Nested Models (Continued)

BRAND 6:

Brand-Specific Diffusion | Product-Class Differentiation

Models: Nul \ Alt.	2	9	12S
2	—	- 0.79	-2.27
9	-3.17	—	-5.11
12S	-1.93	-12.98	—

Model 4

→ 12S vs. 4

Models: Nul \ Alt.	12S	4
12S	—	-0.62
4	-2.60	—

→ Retained model: 12S

TABLE 5. Estimated Parameters for Retained Models*

BRAND 1:

$$S_i = \left[0.8424 P_i^{-4.361} A_i^{0.0346} + 0.0993 \left(\frac{x_i}{M_i} \right) \right] (M_i - x_i) \qquad r = 0.71$$

(0.254) (0.0269) (0.5632) (0.0001)

BRAND 2:

$$S_i = \left[0.018 P_i^{-0.4776 - 0.0622N(t)} A_i^{-0.071 + 0.0104N(t)} - 0.0132 \left(\frac{X}{M} \right) \right] (M-X) \qquad r = 0.91$$

(0.0813) (0.3162) (0.075) (0.234) (0.0008) (0.0099)

BRAND 3:

$$S_i = \left[0.0017 + 0.0605 \left(\frac{X}{M} \right) \bar{P}^{-4.08 + 0.0735N(t)} \bar{A}^{-0.0135 + 0.0094N(t)} \right] (M-X) \qquad r = 0.79$$

(0.5204) (0.1382) (0.0526) (0.6476) (0.8219) (0.023)

$$S_i = \left[0.0169 + 0.0822 \left(\frac{x_i}{M_i} \right) \bar{P}^{-12.84 + 0.3789N(t)} \bar{A}^{-0.4157 + 0.0295N(t)} \right] (M_i - x_i) \qquad r = 0.80$$

(0.0014) (0.6972) (0.2326) (0.5771) (0.335) (0.1742)

Brand 4:

$$S_i = \left[0.0019 + 0.3375 \left(\frac{X}{M} \right) P_i^{-6.205 + 0.0868N(t)} A_i^{0.3973 - 0.0176N(t)} \right] (M-X) \qquad r = 0.85$$

(0.0513) (0.5045) (0.02) (0.278) (0.0287) (0.0196)

Brand 6:

$$S_i = \left[0.4723 P^{8.365} + 0.1597 \left(\frac{x_i}{M_i} \right) \right] (M_i - x_i) \qquad r = 0.85$$

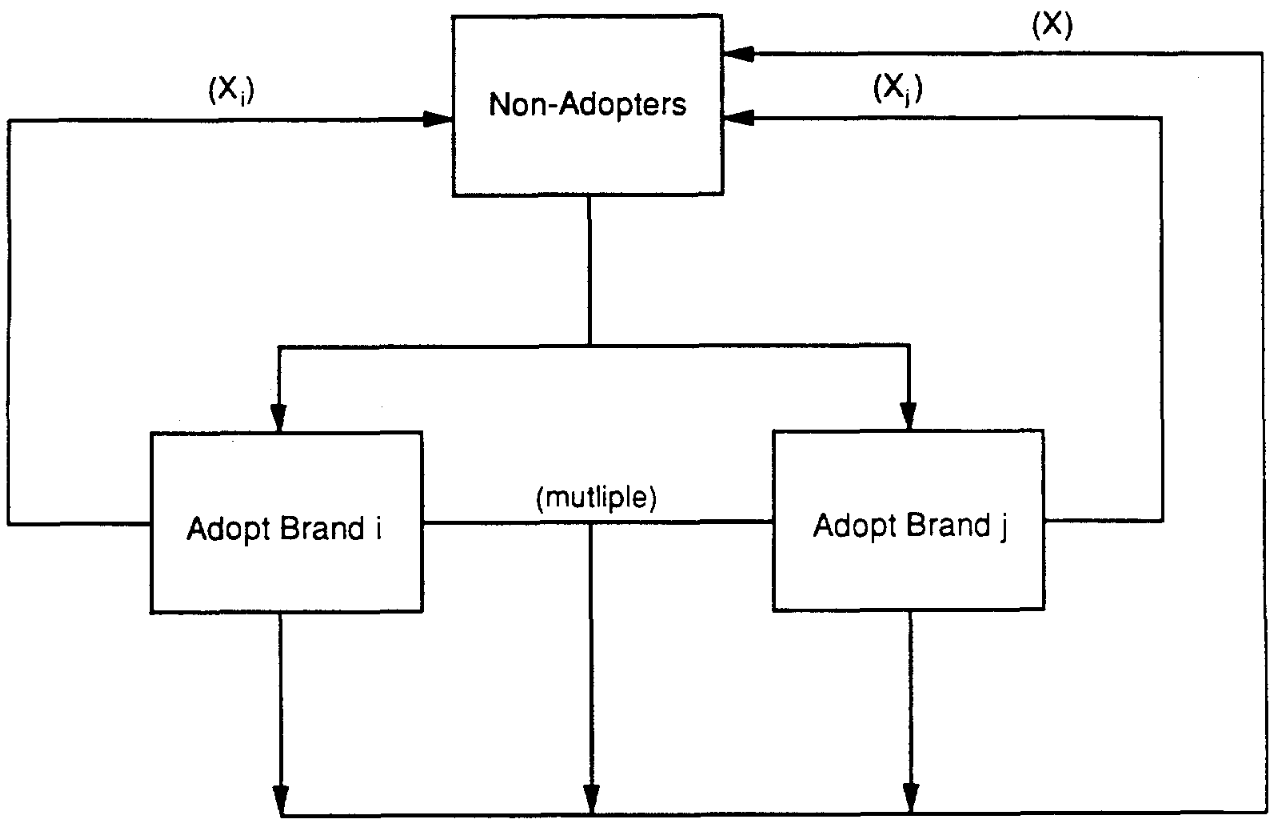
(0.0305) (0.0019) (0.0001)

SUMMARY OF ESTIMATED MODEL SPECIFICATION

Brand	Model	Brand (B) vs. Product (P) Diffusion	Static (S) vs. Dynamic (D) Marketing Effects	Absolute (A) vs. Relative (R) Marketing Impacts	External (E) vs. Internal (I) vs. Both (B) Confluence Coefficient
1	11S	B	S	A	E
2	15	P	D	A	E
3	4/10	P/B	D	R	B/I
4	13	P	D	A	I
6	12S	B	S	R	E

*Numbers in parenthesis indicate the significance level

Figure 1. Brand-Level Adoption Influences
(2 Brand Case)



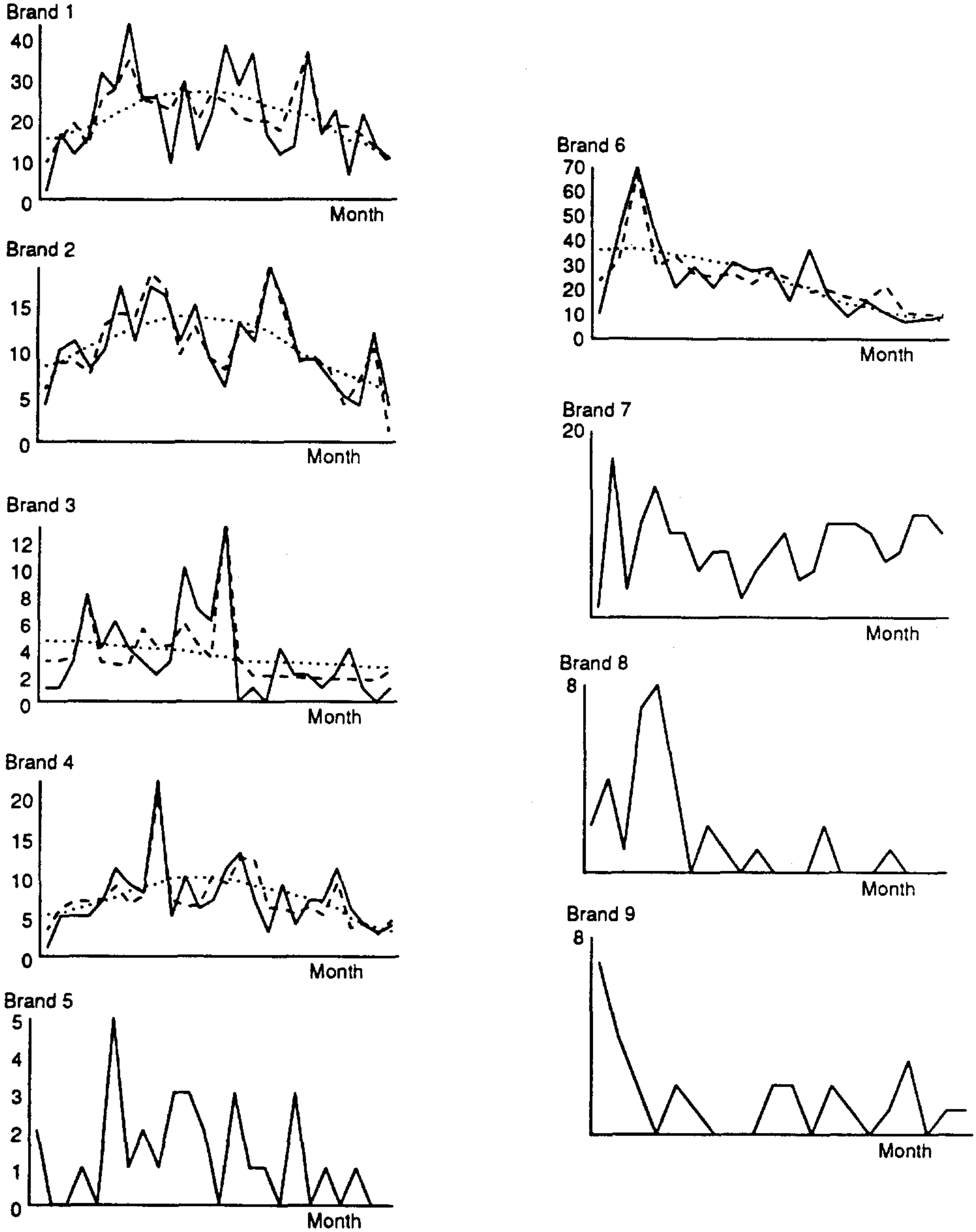
Note: X_i signifies influence associated with adopters of brand i.

X_j signifies influence associated with adopters of brand j.

X signifies influence associated with adoptions of all brands.

Multiple signifies the adoption of more than one brand within the category for for a given household; otherwise, influences are based on single brand adoptions.

Figure 2. Trial Curves by Brand (Number of First Purchases on Vertical Axes Per Month)*



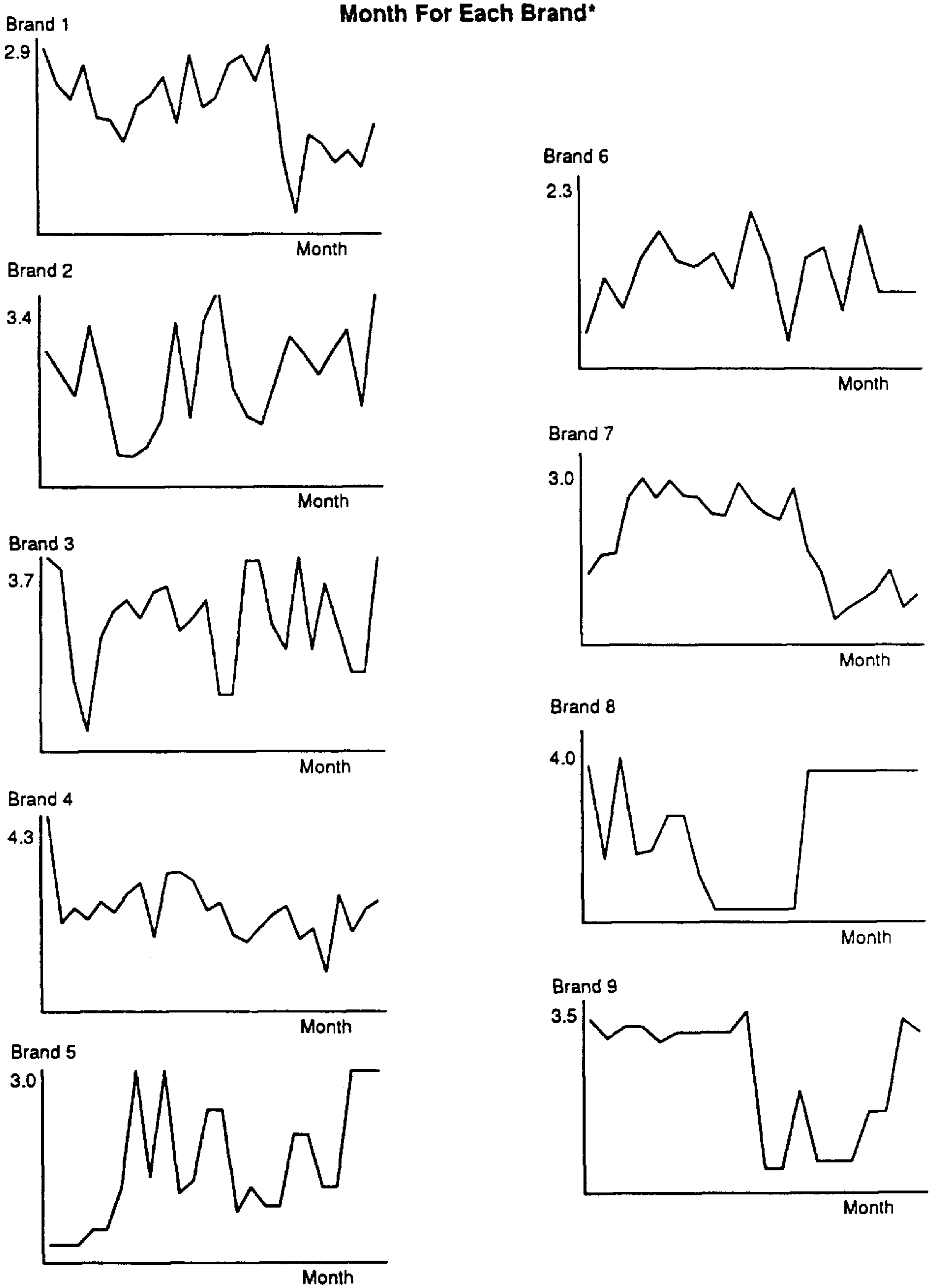
***The first observation corresponds to the brand introduction month**

··· Fitted Data According to Bass Model

— Actual Data

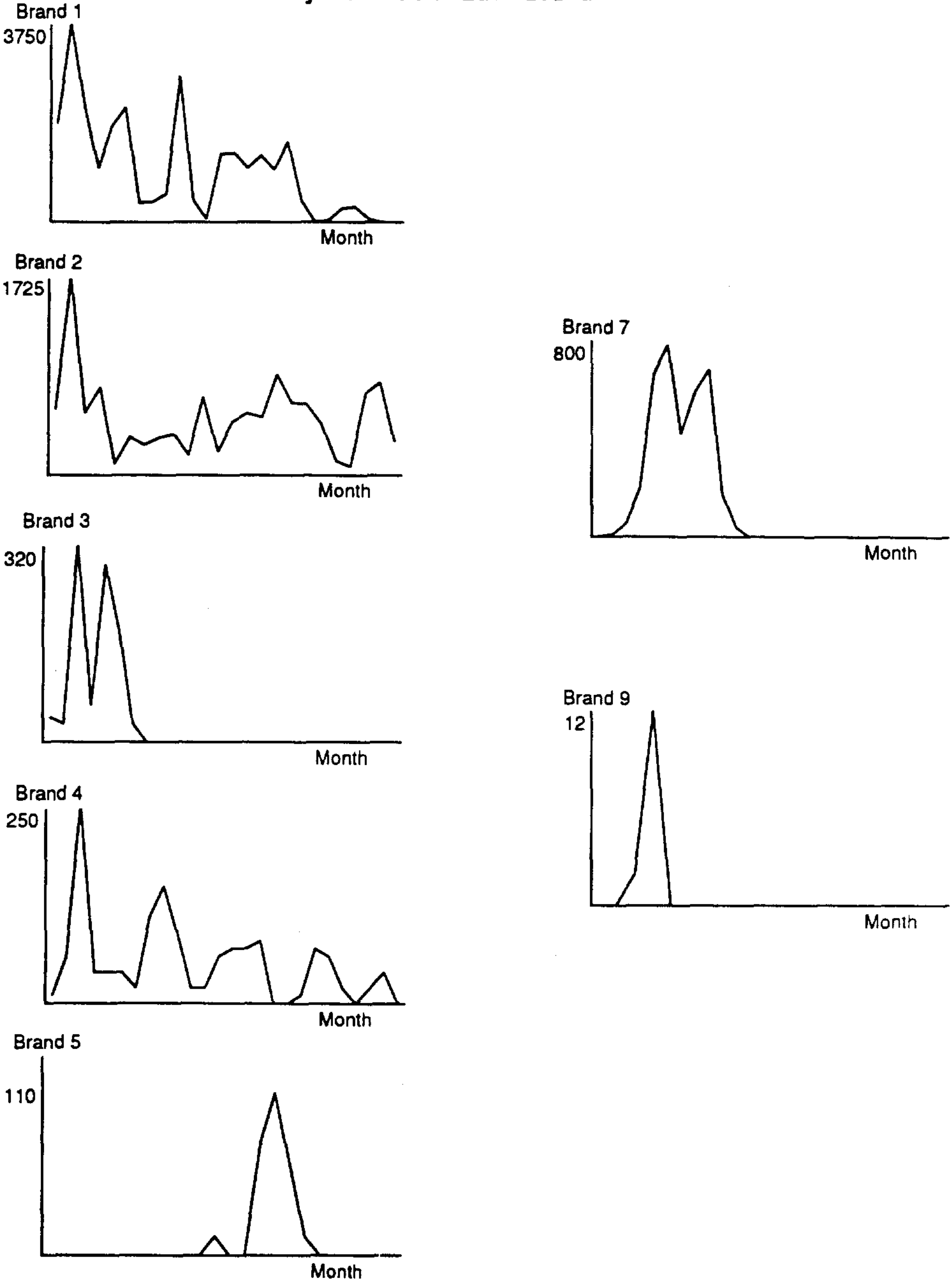
-- Fitted Data According to Retained Model

Figure 3. Average Price Charged In A Month For Each Brand*



*** The first observation corresponds to the brand introduction month specific to each brand. Therefore, the months do not match across brands.**

Figure 4. Advertising Expenditure Curves By Months For Each Brand*



*** The first observation corresponds to the brand introduction month specific to each brand. Therefore, the months do not match across brands. Advertising Expenditures are in thousand dollars. Brands 6 and 8 did not advertise.**

REFERENCES

Arora, Rahindas (1979), "How Promotion Elasticities Change," Journal of Advertising Research, 19 (June), 57-62.

Bass, Frank M. (1969), "A New Product Growth Model for Consumer Durables," Management Science, 15, 5, 215-227.

________ (1980), "The Relationship Between Diffusion Rates, Experience Curves, and Demand Elasticities for Consumer Durable Technological Innovations," Journal of Business, 53, 3 (July), Part 2, 51-67.

Bettman, James R. (1970), An Information Processing Theory of Consumer Choice, Reading, MA: Addison-Wesley.

Brodie, Roderick and Cornelis A. de Kluyver (1984), "A Comparison of Market Models and Estimation Procedures, "Journal of Marketing Research, 21, 2, 194-201.

Chow, G. (1967), "Technological Change and the Demand for Computers," 57: 1117-3.

Cooper, Lee G. and Masao Nakanishi (1988), Market Share Analysis: Evaluating Competitive Marketing Effectiveness, Boston, MA: Kluwer Academic Publishers.

Cox, D. R. (1961), "Test of Separate Families of Hypothesis, "Proceedings of the fourth Berkeley Symposium on Mathematical Statistics and Probability, Vol. 1, Berkeley, CA: University of California Press.

________ (1962), "Further Results on Tests of Separate Families of Hypothesis, "Journal of the Royal Statistical Society, Series B, 24, 406-424.

Dean, Joel (1950), "Pricing Policies for New Products," 26,45-53.

Dockner, Engelbert and Steffen Jorgensen (1988), "Optimal Pricing Strategies for New Products in Dynamic Oligopolies," Marketing Science, 7 (Fall), 315-334.

Dolan, Robert J. and Abel P. Jeuland (1981), "Experience Curves and Dynamic Demand Models: Implications for Optimal Pricing Strategies," Journal of Marketing, 45, 1 (Winter), 52-62.

Easingwood, Christopher, Vijay Mahajan and Eitan Muller (1983), "A Non-Uniform Influence Innovation Diffusion Model of New Product Acceptance," Marketing Science, 2 (Summer), 273-296.

Eliashberg, Jehoshua and Abel P. Jeuland (1986), "The Impact of Competitive Entry in a Developing Market Upon Dynamic Pricing Strategies," Marketing Science, 5, 20-36.

Erickson, Gary M. (1985), "A Model of Advertising Competition," Journal of Marketing Research, 22 (August), 297-304.

Fourt, Louis A. and Joseph W. Woodlock (1960), "Early Prediction of Market Success for New Grocery Products," Journal of Marketing, 25 (October), 31-38.

Gatignon, Hubert and Thomas S. Robertson (1985), "A Propositional Inventory for New Diffusion Research," Journal of Consumer Research, 11 (March), 849-867.

________, Jehoshua Eliashberg and Thomas S. Robertson (1989), "Modeling Multinational Diffusion Patterns: An Efficient Methodology," Marketing Science, 8, 3, 231-247.

________ and Thomas S. Robertson (1986), "An Exchange Theory Model of Interpersonal Communications," in Richard J. Lutz, ed., Advances in Consumer Research, 13, 629-632.

________, Barton A. Weitz and Pradeep Bansal (1990), "Brand Introduction Strategies and Competitive Environments," Journal of Marketing Research, forthcoming.

Horsky, Dan and Karl Mate (1988), "Dynamic Advertising Strategies of Competing Durable Good Producers," Marketing Science, 7, 4 (Fall), 356-367.

________ and Leonard S. Simon (1983), "Advertising and the Diffusion of New Products," Marketing Science, 2, (Winter), 1-17.

Jain, Dipak C. and Ram C. Rao (1989), "Effect of Price on the Demand for Durables: Modeling, Estimation and Findings," Journal of Business and Economic Statistics.

Jeuland, Abel P. (1981), "Parsimonious Models of Diffusion of Innovations, Part B: Incorporating the Variable of Price," Working Paper, University of Chicago, July.

Jones, J. Morgan and Christopher J. Ritz (1991), "Incorporating Distribution Into New Product Diffusion Models," International Journal of Research in Marketing, 8, 2, 91-112.

Judge, George G., W. E. Griffiths, R. Carter Hill, Helmet Lutkepohl and Tsoung-Chao Lee (1985), The Theory and Practice of Econometrics, New York, NY: John Wiley and Sons.

Kalish, Shlomo (1983), "Monopolist Pricing with Dynamic Demand and Production Cost," Marketing Science, 2, (Spring), 135-159.

________ (1985), "A New Product Adoption Model with Price, Advertising and Uncertainty," Management Science, 31, 12 (December), 1569-1585.

Kamakura, Wagner A. and Siva K. Balasubramanian (1988), "Long-term View of the Diffusion of Durables," International Journal of Research in Marketing, 5, 1-13.

Kotler, Philip (1965), "Competitive Strategies for New Product Marketing Over the Life Cycle," Management Science, 12, B 104-B 119.

Lambin, Jean-Jacques (1970), "Advertising and Competitive Behavior: A Case Study," Applied Economics, 2, 231-251.

________, (1976), Advertising, Competition and Market Conduct in Oligopoly Overtime, Amsterdam: Holland Publishing Company.

Lilien, Gary L., Ambar G. Rao and Shlomo Kalish (1981), "Bayesian Estimation and Control of Detailing Effort in a Repeat Purchase Diffusion Environment," Management Science, 27 (May), 493-506.

________ and Eunsang Yoon, "An Exploratory Analysis of the Dynamic Behavior of Price Elasticity over the Product Life Cycle: An Empirical Analysis of Industrial Chemical Products," in Issues in Pricing, Timothy M. Devinney ed., Lexington Books, Lexington 1988, 261-287.

Liu, L., and Dominique Hanssens (1981), "A Bayesian Approach to Time-Varying Cross-Sectional Regression Models," Journal of Econometrics, 15, 341-56.

Leonard-Barton, Dorothy (1985), "Expert as Negative Opinion Leaders in the Diffusion of a Technological Innovation," Journal of Consumer Research, 11, 4 914-926.

Mahajan, Vijay, Eitan Muller and Frank M. Bass (1990), "New Product Diffusion Models in Marketing: A Review and Directions for Research," Journal of Marketing, 54, 1, 1-26.

________ and Robert A. Peterson (1978), "Innovation Diffusion in a Dynamic Potential Adopter Population," Management Science, 24 (15), 1569-1597.

________, Robert A. Peterson, Arun K. Jain and Naresh Malhotra (1979), "A New Product Growth Model with a Dynamic Market Potential," Long Range Planning, 12 (4), 62-69.

Mansfield, Edwin (1961), "Technological Change and the Rate of Imitation," Econometrica, 29, 741-766.

Mickwitz, Gosta (1959), Marketing and Competition, Helsingfors: Central Trykerict.

Nagel, Thomas T. (1987), "The Strategy and Tactics of Pricing," Englewood Cliffs, NJ: Prentice Hall.

Norton, John A. and Frank M. Bass (1987), "A Diffusion Theory Model of Adoption and Substitution for Successive Generations of High Technology Products," Management Science, 3 (September) 1063-1086.

Ozga, S. (1960), "Imperfect Markets Through Lack of Knowledge," Quarterly Journal of Economics, Parsons, Leonard J. (1975), "The Product Life Cycle and Time Varying Advertising Elasticities," Journal of Marketing Research, 12, 3 (November), 476-480.

Pesaran, M. H., and A. S. Deaton (1978), "Testing Nonrested Nonlinear Regression Models," Econometrica, 46, 677-694.

Peterson, Robert A. and Vijay Mahajan (1978), "Multi-Product Growth Models," in Jagdish Sheth, ed., Research in Marketing, Vol. 1, Greenwich, CT: JAI Press, 201-231.

Rao, Ram C. and Frank M. Bass (1985), "Competition, Strategy, and Price Dynamics: A Theoretical and Empirical Investigation," Journal of Marketing Research, 22 (August), 283-296.

Richins, Marsha L. (1983), "Negative Word-of-Mouth by Dissatisfied Consumers: A Pilot Study," Journal of Marketing, 47 (Winter) 68-78.

Robertson, Thomas S. (1971), Innovation Behavior and Communication, New York: Holt, Rinehart and Winston.

________, and Hubert Gatignon (1986), "Competitive Effects on Technology Diffusion," Journal of Marketing, 50, 3, 1-12.

Robinson, Bruce and Chet Lakhani (1975), "Dynamic Price Models for New-Product Planing," Management Science, 21, 10 (June), 1113-1122.

Rogers, Everett M. (1983), Diffusion of Innovations, New York, NY: The Free Press.

Rust, Roland T. and David C. Schmittlein (1985), "A Bayesian Cross-Validated Likelihood Method for Comparing Alternative Specifications of Quantitative Models," Marketing Science, 4, 1, 20-40.

Sharif, M. Nawaz and C. Kabir (1976), "A Generalized Model for Forecasting Technological Substitution," Technological Forecasting and Social Change, 8, 353-364.

Simon, Hermann (1979), "Dynamics of Price Elasticity and Brand Life Cycles: An Empirical Study," Journal of Marketing Research, 16 4 (November), 439-452.

________ and Karl-Heinz Sebastian (1987), "Diffusion and Advertising: The German Telephone Campaign," Management Science, 33, 4 (April), 451-466.

Tellis, Gerard J. (1988), "The Price Elasticity of Selective Demand: A Meta-Analysis of Econometric Models of Sales," Journal of Marketing Research, 25 (November), 331-41.

Teng, Jinn-Tsair and Gerald L. Thompson (1983), "Oligopoly Models for Optimal Advertising When Production Costs Obey A Learning Curve," Management Science, 29 9, 1067-1101.

Thompson, Gerald L. and Jinn-Tsair Teng (1984), "Optimal Pricing and Advertising Policies for New Product Oligopoly Models," Management Science, 3, 2 (Spring), 148-168.

Tigert, Douglas and Behrooz Farivar (1981), "The Bass New Product Growth Model: A Sensitivity Analysis for a High Technology Product," Journal of Marketing, 45 (Fall), 61-90.

Von Bertalanffy, L. (1957), "Quantitative Laws in Metabolism and Growth," Quarterly Review of Biology, 32, 217-231.

APPENDIX
Description of Tests for Comparing Non-Nested Models

Assume two non-linear models (Pesaran and Deaton 1978),

Model 1: $y = f\ (X,\beta) + e \qquad e \sim N\ (0,\ \sigma^2 I)$

Model 2: $y = g\ (W,\omega) + u \qquad u \sim N\ (0,\ \mu^2 I)$

In model 1, y is predicted by X and in model 2, y is predicted by W. The number of parameters (or elements) of β and ω can be different. Let set first model 1 as the null hypothesis (H_0) and model 2 as the alternate hypothesis (H_1). The maximum likelihood estimators of β and σ^2 are $\hat{\beta}$ and $\hat{\sigma}^2$. Similarly, the maximum likelihood estimators of ω and μ^2 are $\hat{\omega}$ and $\hat{\mu}^2$. The Cox test is based on the test statistic $\hat{C}_1 = \frac{T}{2}\ (\mathrm{Ln}\ \hat{\mu}_2 - \mathrm{Ln}\ \mu^{*2})$, where T is the number of observations and μ^{*2} is obtained as follows:

(1) Predict y using the maximum likelihood estimator of β under model 1, i.e., $\hat{\beta}$:

$\hat{y}_1 = f\ (X,\hat{\beta})$

(2) Regress $\hat{y}_1$ on the W's

$\hat{y}_1 = g\ (W,\ \omega) + u_1.$

Minimizing the sum of squared residuals (least squares), this leads to an estimate of $\omega, \hat{\omega}_1$ and mean squared residuals

$\frac{1}{T}\ (\hat{u}_1{}'\hat{u}_1)$

(3) Compute μ^{*2} using

$\mu^{*2} = \hat{\sigma}^2 + \frac{1}{T}\ (\hat{u}_1'\ \hat{u}_1)$

(4) Compute $\hat{C}_1$ using

$\hat{C}_1 = \frac{T}{2}\ (\mathrm{Ln}\ \hat{\mu}^2 - \mathrm{Ln}\ \mu^{*2})$

(5) Compute the variance of C_1 using

$V(\hat{C}_1) = (\hat{\sigma}^2/\mu^{*4})\ [\hat{u}_1'\ \psi_1\ \hat{u}_1]$

where

$\psi_1 = I_T - Z\ (\hat{\beta})\ [Z(\hat{\beta})'\ Z\ (\hat{\beta})]^{-1}\ Z\ (\hat{\beta})'$

$Z\ (\beta)$ is the matrix of first order derivatives of model 1 evaluated at the maximum likelihood $\hat{\beta}$ for each observation. C_1 is normally distributed with variance $V(\hat{C}_1)$. If $\hat{C}_1$ is significantly different from zero, model 1 (H_0) is rejected. If not, we fail to reject model 1.

Because this is not a symmetric test, we need to perform the parallel test where model 2 becomes H_0 and model 1 become H_1. The computations are similar except for switching the models:

$$H_0 : \quad \text{(Model 2) } y = g\ (W,\ \omega) + u \qquad u \sim N(o,\mu^2 I)$$

$$H_1 : \quad \text{(Model 1) } y = f\ (X,\ \beta) + e \qquad e \sim N(o,\sigma^2 I)$$

The maximum likelihood estimates of ω and μ_2 are $\hat{\omega}$ and $\hat{\mu}^2$ as before and similarly for Model 1 $\hat{\beta}$ and $\hat{\sigma}^2$ are maximum likelihood estimators of β and σ. The test now is based on the test statistic

$$C_2 = \frac{T}{2}\ (\text{Ln}\ \hat{\sigma}^2 - \text{Ln}\ \sigma^{*2})$$

The computation of C_2 is analogous to the computation of C_1.

Combining the two tests, the four cases shown in Figure A can occur. If the test based on C_1 (where model 1 is the null hypothesis) fails to reject model 1, and model 2 is rejected based on C_2 (where model 2 is the null hypothesis), model 1 is selected. Similarly, model 2 is retained if model 1 is rejected when it is set as the null hypothesis and model 2 cannot be rejected when it corresponds to the null hypothesis. For the other two combinations, the test is inconclusive. In such cases, where no conclusion can be reached, model selection must be based on other criteria. Parsimony and/or plausibility of parameter estimates might be appropriate criteria in such cases.

In summary, for a pair of models, four estimations are needed

1. Maximum likelihood estimators of model 1 parameters
2. Maximum likelihood estimators of model 2 parameters
3. Estimates of model 2 parameters predicting $\hat{y}_1$'s
4. Estimates of model 1 parameters predicting $\hat{y}_2$'s

		Test 2 (based on C_2)	
		Model 2 Rejected	Model 2 Not Rejected
Test 1 (based on C_1)	Model 1 Rejected	Inconclusive	Retain Model 2
	Model 1 Not Rejected	Retain Model 1	Inconclusive

FIGURE A. Possible Outcomes of Cox Test

INSEAD WORKING PAPERS SERIES

1988

88/01	Michael LAWRENCE and Spyros MAKRIDAKIS	**"Factors affecting judgemental forecasts and confidence intervals"**, January 1988.
88/02	Spyros MAKRIDAKIS	**"Predicting recessions and other turning points"**, January 1988.
88/03	James TEBOUL	**"De-industrialize service for quality"**, January 1988.
88/04	Susan SCHNEIDER	**"National vs. corporate culture: implications for human resource management"**, January 1988.
88/05	Charles WYPLOSZ	**"The swinging dollar: is Europe out of step?"**, January 1988.
88/06	Reinhard ANGELMAR	**"Les conflits dans les canaux de distribution"**, January 1988.
88/07	Ingemar DIERICKX and Karel COOL	**"Competitive advantage: a resource based perspective"**, January 1988.
88/08	Reinhard ANGELMAR and Susan SCHNEIDER	**"Issues in the study of organizational cognition"**, February 1988.
88/09	Bernard SINCLAIR-DESGAGNÉ	**"Price formation and product design through bidding"**, February 1988.
88/10	Bernard SINCLAIR-DESGAGNÉ	**"The robustness of some standard auction game forms"**, February 1988.
88/11	Bernard SINCLAIR-DESGAGNÉ	**"When stationary strategies are equilibrium bidding strategy: The single-crossing property"**, February 1988.
88/12	Spyros MAKRIDAKIS	**"Business firms and managers in the 21st century"**, February 1988
88/13	Manfred KETS DE VRIES	**"Alexithymia in organizational life: the organization man revisited"**, February 1988.
88/14	Alain NOEL	**"The interpretation of strategies: a study of the impact of CEOs on the corporation"**, March 1988.
88/15	Anil DEOLALIKAR and Lars-Hendrik RÖLLER	**"The production of and returns from industrial innovation: an econometric analysis for a developing country"**, December 1987.
88/16	Gabriel HAWAWINI	**"Market efficiency and equity pricing: international evidence and implications for global investing"**, March 1988.
88/17	Michael BURDA	**"Monopolistic competition, costs of adjustment and the behavior of European employment"**, September 1987.
88/18	Michael BURDA	**"Reflections on "Wait Unemployment" in Europe"**, November 1987, revised February 1988.
88/19	M.J. LAWRENCE and Spyros MAKRIDAKIS	**"Individual bias in judgements of confidence"**, March 1988.
88/20	Jean DERMINE, Damien NEVEN and J.F. THISSE	**"Portfolio selection by mutual funds, an equilibrium model"**, March 1988.
88/21	James TEBOUL	**"De-industrialize service for quality"**, March 1988 (88/03 Revised).
88/22	Lars-Hendrik RÖLLER	**"Proper Quadratic Functions with an Application to AT&T"**, May 1987 (Revised March 1988).

88/23	Sjur Didrik FLAM and Georges ZACCOUR	**"Equilibres de Nash-Cournot dans le marché européen du gaz: un cas où les solutions en boucle ouverte et en feedback coïncident"**, Mars 1988.
88/24	B. Espen ECKBO and Herwig LANGOHR	**"Information disclosure, means of payment, and takeover premia. Public and Private tender offers in France"**, July 1985, Sixth revision, April 1988.
88/25	Everette S. GARDNER and Spyros MAKRIDAKIS	**"The future of forecasting"**, April 1988.
88/26	Sjur Didrik FLAM and Georges ZACCOUR	**"Semi-competitive Cournot equilibrium in multistage oligopolies"**, April 1988.
88/27	Murugappa KRISHNAN Lars-Hendrik RÖLLER	**"Entry game with resalable capacity"**, April 1988.
88/28	Sumantra GHOSHAL and C. A. BARTLETT	**"The multinational corporation as a network: perspectives from interorganizational theory"**, May 1988.
88/29	Naresh K. MALHOTRA, Christian PINSON and Arun K. JAIN	**"Consumer cognitive complexity and the dimensionality of multidimensional scaling configurations"**, May 1988.
88/30	Catherine C. ECKEL and Theo VERMAELEN	**"The financial fallout from Chernobyl: risk perceptions and regulatory response"**, May 1988.
88/31	Sumantra GHOSHAL and Christopher BARTLETT	**"Creation, adoption, and diffusion of innovations by subsidiaries of multinational corporations"**, June 1988.
88/32	Kasra FERDOWS and David SACKRIDER	**"International manufacturing: positioning plants for success"**, June 1988.
88/33	Mihkel M. TOMBAK	**"The importance of flexibility in manufacturing"**, June 1988.
88/34	Mihkel M. TOMBAK	**"Flexibility: an important dimension in manufacturing"**, June 1988.
88/35	Mihkel M. TOMBAK	**"A strategic analysis of investment in flexible manufacturing systems"**, July 1988.
88/36	Vikas TIBREWALA and Bruce BUCHANAN	**"A Predictive Test of the NBD Model that Controls for Non-stationarity"**, June 1988.
88/37	Murugappa KRISHNAN Lars-Hendrik RÖLLER	**"Regulating Price-Liability Competition To Improve Welfare"**, July 1988.
88/38	Manfred KETS DE VRIES	**"The Motivating Role of Envy : A Forgotten Factor in Management"**, April 88.
88/39	Manfred KETS DE VRIES	**"The Leader as Mirror : Clinical Reflections"**, July 1988.
88/40	Josef LAKONISHOK and Theo VERMAELEN	**"Anomalous price behavior around repurchase tender offers"**, August 1988.
88/41	Charles WYPLOSZ	**"Assymetry in the EMS: intentional or systemic?"**, August 1988.
88/42	Paul EVANS	**"Organizational development in the transnational enterprise"**, June 1988.
88/43	B. SINCLAIR-DESGAGNÉ	**"Group decision support systems implement Bayesian rationality"**, September 1988.
88/44	Essam MAHMOUD and Spyros MAKRIDAKIS	**"The state of the art and future directions in combining forecasts"**, September 1988.
88/45	Robert KORAJCZYK and Claude VIALLET	**"An empirical investigation of international asset pricing"**, November 1986, revised August 1988.
88/46	Yves DOZ and Amy SHUEN	**"From intent to outcome: a process framework for partnerships"**, August 1988.
88/47	Alain BULTEZ, Els GIJSBRECHTS,	**"Asymmetric cannibalism between substitute items listed by retailers"**, September 1988.

	Philippe NAERT and Piet VANDEN ABEELE	
88/48	Michael BURDA	"Reflections on 'Wait unemployment' in Europe, II", April 1988 revised September 1988.
88/49	Nathalie DIERKENS	"Information asymmetry and equity issues", September 1988.
88/50	Rob WEITZ and Arnoud DE MEYER	"Managing expert systems: from inception through updating", October 1987.
88/51	Rob WEITZ	"Technology, work, and the organization: the impact of expert systems", July 1988.
88/52	Susan SCHNEIDER and Reinhard ANGELMAR	"Cognition and organizational analysis: who's minding the store?", September 1988.
88/53	Manfred KETS DE VRIES	"Whatever happened to the philosopher-king: the leader's addiction to power, September 1988.
88/54	Lars-Hendrik RÖLLER and Mihkel M. TOMBAK	"Strategic choice of flexible production technologies and welfare implications", October 1988
88/55	Peter BOSSAERTS and Pierre HILLION	"Method of moments tests of contingent claims asset pricing models", October 1988.
88/56	Pierre HILLION	"Size-sorted portfolios and the violation of the random walk hypothesis: Additional empirical evidence and implication for tests of asset pricing models", June 1988.
88/57	Wilfried VANHONACKER and Lydia PRICE	"Data transferability: estimating the response effect of future events based on historical analogy", October 1988.
88/58	B. SINCLAIR-DESGAGNÉ and Mihkel M. TOMBAK	"Assessing economic inequality", November 1988.

88/59	Martin KILDUFF	"The interpersonal structure of decision making: a social comparison approach to organizational choice", November 1988.
88/60	Michael BURDA	"Is mismatch really the problem? Some estimates of the Chelwood Gate II model with US data", September 1988.
88/61	Lars-Hendrik RÖLLER	"Modelling cost structure: the Bell System revisited", November 1988.
88/62	Cynthia VAN HULLE, Theo VERMAELEN and Paul DE WOUTERS	"Regulation, taxes and the market for corporate control in Belgium", September 1988.
88/63	Fernando NASCIMENTO and Wilfried R. VANHONACKER	"Strategic pricing of differentiated consumer durables in a dynamic duopoly: a numerical analysis", October 1988.
88/64	Kasra FERDOWS	"Charting strategic roles for international factories", December 1988.
88/65	Arnoud DE MEYER and Kasra FERDOWS	"Quality up, technology down", October 1988
88/66	Nathalie DIERKENS	"A discussion of exact measures of information assymetry: the example of Myers and Majluf model or the importance of the asset structure of the firm", December 1988.
88/67	Paul S. ADLER and Kasra FERDOWS	"The chief technology officer", December 1988.

1989

89/01	Joyce K. BYRER and Tawfik JELASSI	"The impact of language theories on DSS dialog", January 1989.
89/02	Louis A. LE BLANC and Tawfik JELASSI	"DSS software selection: a multiple criteria decision methodology", January 1989.

89/03	Beth H. JONES and Tawfik JELASSI	**"Negotiation support: the effects of computer intervention and conflict level on bargaining outcome"**, January 1989.
89/04	Kasra FERDOWS and Arnoud DE MEYER	**"Lasting improvement in manufacturing performance: In search of a new theory"**, January 1989.
89/05	Martin KILDUFF and Reinhard ANGELMAR	**"Shared history or shared culture? The effects of time, culture, and performance on institutionalization in simulated organizations"**, January 1989.
89/06	Mihkel M. TOMBAK and B. SINCLAIR-DESGAGNÉ	**"Coordinating manufacturing and business strategies: I"**, February 1989.
89/07	Damien J. NEVEN	**"Structural adjustment in European retail banking. Some view from industrial organisation"**, January 1989.
89/08	Arnoud DE MEYER and Hellmut SCHÜTTE	**"Trends in the development of technology and their effects on the production structure in the European Community"**, January 1989.
89/09	Damien NEVEN Carmen MATUTES and Marcel CORSTJENS	**"Brand proliferation and entry deterrence"**, February 1989.
89/10	Nathalie DIERKENS, Bruno GERARD and Pierre HILLION	**"A market based approach to the valuation of the assets in place and the growth opportunities of the firm"**, December 1988.
89/11	Manfred KETS DE VRIES and Alain NOEL	**"Understanding the leader-strategy interface: application of the strategic relationship interview method"**, February 1989.
89/12	Wilfried VANHONACKER	**"Estimating dynamic response models when the data are subject to different temporal aggregation"**, January 1989.
89/13	Manfred KETS DE VRIES	**"The impostor syndrome: a disquieting phenomenon in organizational life"**, February 1989.
89/14	Reinhard ANGELMAR	**"Product innovation: a tool for competitive advantage"**, March 1989.
89/15	Reinhard ANGELMAR	**"Evaluating a firm's product innovation performance"**, March 1989.
89/16	Wilfried VANHONACKER, Donald LEHMANN and Fareena SULTAN	**"Combining related and sparse data in linear regression models"**, February 1989.
89/17	Gilles AMADO, Claude FAUCHEUX and André LAURENT	**"Changement organisationnel et réalités culturelles: contrastes franco-américains"**, March 1989.
89/18	Srinivasan BALAK-RISHNAN and Mitchell KOZA	**"Information asymmetry, market failure and joint-ventures: theory and evidence"**, March 1989.
89/19	Wilfried VANHONACKER, Donald LEHMANN and Fareena SULTAN	**"Combining related and sparse data in linear regression models"**, Revised March 1989.
89/20	Wilfried VANHONACKER and Russell WINER	**"A rational random behavior model of choice"**, Revised March 1989.
89/21	Arnoud de MEYER and Kasra FERDOWS	**"Influence of manufacturing improvement programmes on performance"**, April 1989.
89/22	Manfred KETS DE VRIES and Sydney PERZOW	**"What is the role of character in psychoanalysis?"** April 1989.
89/23	Robert KORAJCZYK and Claude VIALLET	**"Equity risk premia and the pricing of foreign exchange risk"** April 1989.
89/24	Martin KILDUFF and Mitchel ABOLAFIA	**"The social destruction of reality: Organisational conflict as social drama"** zApril 1989.

89/25	Roger BETANCOURT and David GAUTSCHI	**"Two essential characteristics of retail markets and their economic consequences"** March 1989.
89/26	Charles BEAN, Edmond MALINVAUD, Peter BERNHOLZ, Francesco GIAVAZZI and Charles WYPLOSZ	**"Macroeconomic policies for 1992: the transition and after"**, April 1989.
89/27	David KRACKHARDT and Martin KILDUFF	**"Friendship patterns and cultural attributions: the control of organizational diversity"**, April 1989.
89/28	Martin KILDUFF	**"The interpersonal structure of decision making: a social comparison approach to organizational choice"**, Revised April 1989.
89/29	Robert GOGEL and Jean-Claude LARRECHE	**"The battlefield for 1992: product strength and geographic coverage"**, May 1989.
89/30	Lars-Hendrik ROLLER and Mihkel M. TOMBAK	**"Competition and Investment in Flexible Technologies"**, May 1989.
89/31	Michael C. BURDA and Stefan GERLACH	**"Intertemporal prices and the US trade balance in durable goods"**, July 1989.
89/32	Peter HAUG and Tawfik JELASSI	**"Application and evaluation of a multi-criteria decision support system for the dynamic selection of U.S. manufacturing locations"**, May 1989.
89/33	Bernard SINCLAIR-DESGAGNÉ	**"Design flexibility in monopsonistic industries"**, May 1989.
89/34	Sumantra GHOSHAL and Nittin NOHRIA	**"Requisite variety versus shared values: managing corporate-division relationships in the M-Form organisation"**, May 1989.
89/35	Jean DERMINE and Pierre HILLION	**"Deposit rate ceilings and the market value of banks: The case of France 1971-1981"**, May 1989.
89/36	Martin KILDUFF	**"A dispositional approach to social networks: the case of organizational choice"**, May 1989.
89/37	Manfred KETS DE VRIES	**"The organisational fool: balancing a leader's hubris"**, May 1989.
89/38	Manfred KETS DE VRIES	**"The CEO blues"**, June 1989.
89/39	Robert KORAJCZYK and Claude VIALLET	**"An empirical investigation of international asset pricing"**, (Revised June 1989).
89/40	Balaji CHAKRAVARTHY	**"Management systems for innovation and productivity"**, June 1989.
89/41	B. SINCLAIR-DESGAGNE and Nathalie DIERKENS	**"The strategic supply of precisions"**, June 1989.
89/42	Robert ANSON and Tawfik JELASSI	**"A development framework for computer-supported conflict resolution"**, July 1989.
89/43	Michael BURDA	**"A note on firing costs and severance benefits in equilibrium unemployment"**, June 1989.
89/44	Balaji CHAKRAVARTHY and Peter LORANGE	**"Strategic adaptation in multi-business firms"**, June 1989.
89/45	Rob WEITZ and Arnoud DE MEYER	**"Managing expert systems: a framework and case study"**, June 1989.
89/46	Marcel CORSTJENS, Carmen MATUTES and Damien NEVEN	**"Entry Encouragement"**, July 1989.
89/47	Manfred KETS DE VRIES and Christine MEAD	**"The global dimension in leadership and organization: issues and controversies"**, April 1989.
89/48	Damien NEVEN and Lars-Hendrik RÖLLER	**"European integration and trade flows"**, August 1989.

89/49	Jean DERMINE	**"Home country control and mutual recognition"**, July 1989.
89/50	Jean DERMINE	**"The specialization of financial institutions, the EEC model"**, August 1989.
89/51	Spyros MAKRIDAKIS	**"Sliding simulation: a new approach to time series forecasting"**, July 1989.
89/52	Arnoud DE MEYER	**"Shortening development cycle times: a manufacturer's perspective"**, August 1989.
89/53	Spyros MAKRIDAKIS	**"Why combining works?"**, July 1989.
89/54	S. BALAKRISHNAN and Mitchell KOZA	**"Organisation costs and a theory of joint ventures"**, September 1989.
89/55	H. SCHUTTE	**"Euro-Japanese cooperation in information technology"**, September 1989.
89/56	Wilfried VANHONACKER and Lydia PRICE	**"On the practical usefulness of meta-analysis results"**, September 1989.
89/57	Taekwon KIM, Lars-Hendrik RÖLLER and Mihkel TOMBAK	**"Market growth and the diffusion of multiproduct technologies"**, September 1989.
89/58 (EP,TM)	Lars-Hendrik RÖLLER and Mihkel TOMBAK	**"Strategic aspects of flexible production technologies"**, October 1989.
89/59 (OB)	Manfred KETS DE VRIES, Daphna ZEVADI, Alain NOEL and Mihkel TOMBAK	**"Locus of control and entrepreneurship: a three-country comparative study"**, October 1989.
89/60 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Simulation graphs for design and analysis of discrete event simulation models"**, October 1989.
89/61 (All)	Susan SCHNEIDER and Arnoud DE MEYER	**"Interpreting and responding to strategic issues: The impact of national culture"**, October 1989.
89/62 (TM)	Arnoud DE MEYER	**"Technology strategy and international R&D operations"**, October 1989.
89/63 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Equivalence of simulations: A graph approach"**, November 1989.
89/64 (TM)	Enver YUCESAN and Lee SCHRUBEN	**"Complexity of simulation models: A graph theoretic approach"**, November 1989.
89/65 (TM, AC, FIN)	Soumitra DUTTA and Piero BONISSONE	**"MARS: A mergers and acquisitions reasoning system"**, November 1989.
89/66 (TM,EP)	B. SINCLAIR-DESGAGNÉ	**"On the regulation of procurement bids"**, November 1989.
89/67 (FIN)	Peter BOSSAERTS and Pierre HILLION	**"Market microstructure effects of government intervention in the foreign exchange market"**, December 1989.

<u>1990</u>

90/01 TM/EP/AC	B. SINCLAIR-DESGAGNÉ	**"Unavoidable Mechanisms"**, January 1990.
90/02 EP	Michael BURDA	**"Monopolistic Competition, Costs of Adjustment, and the Behaviour of European Manufacturing Employment"**, January 1990.
90/03 TM	Arnoud DE MEYER	**"Management of Communication in International Research and Development"**, January 1990.
90/04 FIN/EP	Gabriel HAWAWINI and Eric RAJENDRA	**"The Transformation of the European Financial Services Industry: From Fragmentation to Integration"**, January 1990.
90/05 FIN/EP	Gabriel HAWAWINI and Bertrand JACQUILLAT	**"European Equity Markets: Toward 1992 and Beyond"**, January 1990.

90/06 FIN/EP	Gabriel HAWAWINI and Eric RAJENDRA	**"Integration of European Equity Markets: Implications of Structural Change for Key Market Participants to and Beyond 1992"**, January 1990.
90/07 FIN/EP	Gabriel HAWAWINI	**"Stock Market Anomalies and the Pricing of Equity on the Tokyo Stock Exchange"**, January 1990.
90/08 TM/EP	Tawfik JELASSI and B. SINCLAIR-DESGAGNÉ	**"Modelling with MCDSS: What about Ethics?"**, January 1990.
90/09 EP/FIN	Alberto GIOVANNINI and Jae WON PARK	**"Capital Controls and International Trade Finance"**, January 1990.
90/10 TM	Joyce BRYER and Tawfik JELASSI	**"The Impact of Language Theories on DSS Dialog"**, January 1990.
90/11 TM	Enver YUCESAN	**"An Overview of Frequency Domain Methodology for Simulation Sensitivity Analysis"**, January 1990.
90/12 EP	Michael BURDA	**"Structural Change, Unemployment Benefits and High Unemployment: A U.S.-European Comparison"**, January 1990.
90/13 TM	Soumitra DUTTA and Shashi SHEKHAR	**"Approximate Reasoning about Temporal Constraints in Real Time Planning and Search"**, January 1990.
90/14 TM	Albert ANGEHRN and Hans-Jakob LÜTHI	**"Visual Interactive Modelling and Intelligent DSS: Putting Theory Into Practice"**, January 1990.
90/15 TM	Arnoud DE MEYER, Dirk DESCHOOLMEESTER, Rudy MOENAERT and Jan BARBE	**"The Internal Technological Renewal of a Business Unit with a Mature Technology"**, January 1990.
90/16 FIN	Richard LEVICH and Ingo WALTER	**"Tax-Driven Regulatory Drag: European Financial Centers in the 1990's"**, January 1990.
90/17 FIN	Nathalie DIERKENS	**"Information Asymmetry and Equity Issues"**, Revised January 1990.
90/18 MKT	Wilfried VANHONACKER	**"Managerial Decision Rules and the Estimation of Dynamic Sales Response Models"**, Revised January 1990.
90/19 TM	Beth JONES and Tawfik JELASSI	**"The Effect of Computer Intervention and Task Structure on Bargaining Outcome"**, February 1990.
90/20 TM	Tawfik JELASSI, Gregory KERSTEN and Stanley ZIONTS	**"An Introduction to Group Decision and Negotiation Support"**, February 1990.
90/21 FIN	Roy SMITH and Ingo WALTER	**"Reconfiguration of the Global Securities Industry in the 1990's"**, February 1990.
90/22 FIN	Ingo WALTER	**"European Financial Integration and Its Implications for the United States"**, February 1990.
90/23 EP/SM	Damien NEVEN	**"EEC Integration towards 1992: Some Distributional Aspects"**, Revised December 1989
90/24 FIN/EP	Lars Tyge NIELSEN	**"Positive Prices in CAPM"**, January 1990.
90/25 FIN/EP	Lars Tyge NIELSEN	**"Existence of Equilibrium in CAPM"**, January 1990.
90/26 OB/BP	Charles KADUSHIN and Michael BRIMM	**"Why networking Fails: Double Binds and the Limitations of Shadow Networks"**, February 1990.
90/27 TM	Abbas FOROUGHI and Tawfik JELASSI	**"NSS Solutions to Major Negotiation Stumbling Blocks"**, February 1990.
90/28 TM	Arnoud DE MEYER	**"The Manufacturing Contribution to Innovation"**, February 1990.

90/29 FIN/AC	Nathalie DIERKENS	**"A Discussion of Correct Measures of Information Asymmetry"**, January 1990.
90/30 FIN/EP	Lars Tyge NIELSEN	**"The Expected Utility of Portfolios of Assets"**, March 1990.
90/31 MKT/EP	David GAUTSCHI and Roger BETANCOURT	**"What Determines U.S. Retail Margins?"**, February 1990.
90/32 SM	Srinivasan BALAK- RISHNAN and Mitchell KOZA	**"Information Asymmetry, Adverse Selection and Joint-Ventures: Theory and Evidence"**, Revised, January 1990.
90/33 OB	Caren SIEHL, David BOWEN and Christine PEARSON	**"The Role of Rites of Integration in Service Delivery"**, March 1990.
90/34 FIN/EP	Jean DERMINE	**"The Gains from European Banking Integration, a Call for a Pro-Active Competition Policy"**, April 1990.
90/35 EP	Jae Won PARK	**"Changing Uncertainty and the Time-Varying Risk Premia in the Term Structure of Nominal Interest Rates"**, December 1988, Revised March 1990.
90/36 TM	Arnoud DE MEYER	**"An Empirical Investigation of Manufacturing Strategies in European Industry"**, April 1990.
90/37 TM/OB/SM	William CATS-BARIL	**"Executive Information Systems: Developing an Approach to Open the Possibles"**, April 1990.
90/38 MKT	Wilfried VANHONACKER	**"Managerial Decision Behaviour and the Estimation of Dynamic Sales Response Models"**, (Revised February 1990).
90/39 TM	Louis LE BLANC and Tawfik JELASSI	**"An Evaluation and Selection Methodology for Expert System Shells"**, May 1990.
90/40 OB	Manfred KETS DE VRIES	**"Leaders on the Couch: The case of Roberto Calvi"**, April 1990.
90/41 FIN/EP	Gabriel HAWAWINI, Itzhak SWARY and Ik HWAN JANG	**"Capital Market Reaction to the Announcement of Interstate Banking Legislation"**, March 1990.
90/42 MKT	Joel STECKEL and Wilfried VANHONACKER	**"Cross-Validating Regression Models in Marketing Research"**, (Revised April 1990).
90/43 FIN	Robert KORAJCZYK and Claude VIALLET	**"Equity Risk Premia and the Pricing of Foreign Exchange Risk"**, May 1990.
90/44 OB	Gilles AMADO, Claude FAUCHEUX and André LAURENT	**"Organisational Change and Cultural Realities: Franco-American Contrasts"**, April 1990.
90/45 TM	Soumitra DUTTA and Piero BONISSONE	**"Integrating Case Based and Rule Based Reasoning: The Possibilistic Connection"**, May 1990.
90/46 TM	Spyros MAKRIDAKIS and Michèle HIBON	**"Exponential Smoothing: The Effect of Initial Values and Loss Functions on Post-Sample Forecasting Accuracy"**.
90/47 MKT	Lydia PRICE and Wilfried VANHONACKER	**"Improper Sampling in Natural Experiments: Limitations on the Use of Meta-Analysis Results in Bayesian Updating"**, Revised May 1990.
90/48 EP	Jae WON PARK	**"The Information in the Term Structure of Interest Rates: Out-of-Sample Forecasting Performance"**, June 1990.
90/49 TM	Soumitra DUTTA	**"Approximate Reasoning by Analogy to Answer Null Queries"**, June 1990.
90/50 EP	Daniel COHEN and Charles WYPLOSZ	**"Price and Trade Effects of Exchange Rates Fluctuations and the Design of Policy Coordination"**, April 1990.

90/51 EP	Michael BURDA and Charles WYPLOSZ	"Gross Labour Market Flows in Europe: Some Stylized Facts", June 1990.
90/52 FIN	Lars Tyge NIELSEN	"The Utility of Infinite Menus", June 1990.
90/53 EP	Michael Burda	"The Consequences of German Economic and Monetary Union", June 1990.
90/54 EP	Damien NEVEN and Colin MEYER	"European Financial Regulation: A Framework for Policy Analysis", (Revised May 1990).
90/55 EP	Michael BURDA and Stefan GERLACH	"Intertemporal Prices and the US Trade Balance", (Revised July 1990).
90/56 EP	Damien NEVEN and Lars-Hendrik RÖLLER	"The Structure and Determinants of East-West Trade: A Preliminary Analysis of the Manufacturing Sector", July 1990
90/57 FIN/EP/ TM	Lars Tyge NIELSEN	Common Knowledge of a Multivariate Aggregate Statistic", July 1990
90/58 FIN/EP/TM	Lars Tyge NIELSEN	"Common Knowledge of Price and Expected Cost in an Oligopolistic Market", August 1990
90/59 FIN	Jean DERMINE and Lars-Hendrik RÖLLER	"Economies of Scale and Scope in the French Mutual Funds (SICAV) Industry", August 1990
90/60 TM	Peri IZ and Tawfik JELASSI	"An Interactive Group Decision Aid for Multiobjective Problems: An Empirical Assessment", September 1990
90/61 TM	Pankaj CHANDRA and Mihkel TOMBAK	"Models for the Evlauation of Manufacturing Flexibility", August 1990
90/62 EP	Damien NEVEN and Menno VAN DIJK	"Public Policy Towards TV Broadcasting in the Netherlands", August 1990
90/63 SM	Sumantra GHOSHAL and Eleanor WESTNEY	"Organising Competitor Analysis Systems", August 1990
90/64 SM	Sumantra GHOSHAL	"Internal Differentiation and Corporate Performance: Case of the Multinational Corporation", August 1990
90/65 EP	Charles WYPLOSZ	"A Note on the Real Exchange Rate Effect of German Unification", August 1990
90/66 TM/SE/FIN	Soumitra DUTTA and Piero BONISSONE	"Computer Support for Strategic and Tactical Planning in Mergers and Acquisitions", September 1990
90/67 TM/SE/FIN	Soumitra DUTTA and Piero BONISSONE	"Integrating Prior Cases and Expert Knowledge In a Mergers and Acquisitions Reasoning System", September 1990
90/68 TM/SE	Soumitra DUTTA	"A Framework and Methodology for Enhancing the Business Impact of Artificial Intelligence Applications", September 1990
90/69 TM	Soumitra DUTTA	"A Model for Temporal Reasoning in Medical Expert Systems", September 1990
90/70 TM	Albert ANGEHRN	"'Triple C': A Visual Interactive MCDSS", September 1990
90/71 MKT	Philip PARKER and Hubert GATIGNON	"Competitive Effects in Diffusion Models: An Empirical Analysis", September 1990
90/72 TM	Enver YÜCESAN	"Analysis of Markov Chains Using Simulation Graph Models", October 1990
90/73 TM	Arnoud DE MEYER and Kasra FERDOWS	"Removing the Barriers in Manufacturing", October 1990
90/74 SM	Sumantra GHOSHAL and Nitin NOHRIA	"Requisite Complexity: Organising Headquarters-Subsidiary Relations in MNCs", October 1990

90/75 MKT	Roger BETANCOURT and David GAUTSCHI	"The Outputs of Retail Activities: Concepts, Measurement and Evidence", October 1990
90/76 MKT	Wilfried VANHONACKER	"Managerial Decision Behaviour and the Estimation of Dynamic Sales Response Models", Revised October 1990
90/77 MKT	Wilfried VANHONACKER	"Testing the Koyck Scheme of Sales Response to Advertising: An Aggregation-Independent Autocorrelation Test", October 1990
90/78 EP	Michael BURDA and Stefan GERLACH	"Exchange Rate Dynamics and Currency Unification: The Ostmark - DM Rate", October 1990
90/79 TM	Anil GABA	"Inferences with an Unknown Noise Level in a Bernoulli Process", October 1990
90/80 TM	Anil GABA and Robert WINKLER	"Using Survey Data in Inferences about Purchase Behaviour", October 1990
90/81 TM	Tawfik JELASSI	"Du Présent au Futur: Bilan et Orientations des Systèmes Interactifs d'Aide à la Décision," October 1990
90/82 EP	Charles WYPLOSZ	"Monetary Union and Fiscal Policy Discipline," November 1990
90/83 FIN/TM	Nathalie DIERKENS and Bernard SINCLAIR-DESGAGNE	"Information Asymmetry and Corporate Communication: Results of a Pilot Study", November 1990
90/84 MKT	Philip M. PARKER	"The Effect of Advertising on Price and Quality: The Optometric Industry Revisited," December 1990
90/85 MKT	Avijit GHOSH and Vikas TIBREWALA	"Optimal Timing and Location in Competitive Markets," November 1990
90/86 EP/TM	Olivier CADOT and Bernard SINCLAIR-DESGAGNE	"Prudence and Success in Politics," November 1990
90/87 FIN/EP	Lars Tyge NIELSEN	"Existence of Equilibrium in CAPM: Further Results", December 1990
90/88 OB/MKT	Susan C. SCHNEIDER and Reinhard ANGELMAR	"Cognition in Organisational Analysis: Who's Minding the Store?" Revised, December 1990
90/89 OB	Manfred F.R. KETS DE VRIES	"The CEO Who Couldn't Talk Straight and Other Tales from the Board Room," December 1990
90/90 MKT	Philip PARKER	"Price Elasticity Dynamics over the Adoption Lifecycle: An Empirical Study," December 1990

<u>1991</u>

91/01 TM/SM	Luk VAN WASSENHOVE, Leonard FORTUIN and Paul VAN BEEK	"Operational Research Can Do More for Managers Than They Think!," January 1991
91/02 TM/SM	Luk VAN WASSENHOVE, Leonard FORTUIN and Paul VAN BEEK	"Operational Research and Environment," January 1991
91/03 FIN	Pekka HIETALA and Timo LÖYTTYNIEMI	"An Implicit Dividend Increase in Rights Issues: Theory and Evidence," January 1991
91/04 FIN	Lars Tyge NIELSEN	"Two-Fund Separation, Factor Structure and Robustness," January 1991
91/05 OB	Susan SCHNEIDER	"Managing Boundaries in Organisations," January 1991
91/06 OB	Manfred KETS DE VRIES, Danny MILLER and Alain NOEL	"Understanding the Leader-Strategy Interface: Application of the Strategic Relationship Interview Method," January 1990 (89/11, revised April 1990)

91/07 EP	Olivier CADOT	"Lending to Insolvent Countries: A Paradoxical Story," January 1991
91/08 EP	Charles WYPLOSZ	"Post-Reform East and West: Capital Accumulation and the Labour Mobility Constraint," January 1991
91/09 TM	Spyros MAKRIDAKIS	"What can we Learn from Failure?", February 1991
91/10 TM	Luc Van WASSENHOVE and C. N. POTTS	"Integrating Scheduling with Batching and Lot-Sizing: A Review of Algorithms and Complexity", February 1991
91/11 TM	Luc VAN WASSENHOVE et al.	"Multi-Item Lotsizing in Capacitated Multi-Stage Serial Systems", February 1991
91/12 TM	Albert ANGEHRN	"Interpretative Computer Intelligence: A Link between Users, Models and Methods in DSS", February 1991
91/13 EP	Michael BURDA	"Labor and Product Markets in Czechoslovakia and the Ex-GDR: A Twin Study", February 1991
91/14 MKT	Roger BETANCOURT and David GAUTSCHI	"The Output of Retail Activities: French Evidence", February 1991
91/15 OB	Manfred F.R. KETS DE VRIES	"Exploding the Myth about Rational Organisations and Executives", March 1991
91/16 TM	Arnoud DE MEYER and Kasra FERDOWS et.al.	"Factories of the Future: Executive Summary of the 1990 International Manufacturing Futures Survey", March 1991
91/17 TM	Dirk CATTRYSSE, Roelof KUIK, Marc SALOMON and Luk VAN WASSENHOVE	"Heuristics for the Discrete Lotsizing and Scheduling Problem with Setup Times", March 1991
91/18 TM	C.N. POTTS and Luk VAN WASSENHOVE	"Approximation Algorithms for Scheduling a Single Machine to Minimize Total Late Work", March 1991
91/19 MKT	Vikas TIBREWALA and Bruce BUCHANAN	"An Aggregate Test of Purchase Regularity", March 1991
91/20 MKT	Darius SABAVALA and Vikas TIBREWALA	"Monitoring Short-Run Changes in Purchasing Behaviour", March 1991
91/21 SM	Sumantra GHOSHAL, Harry KORINE and Gabriel SZULANSKI	"Interunit Communication within MNCs: The Influence of Formal Structure Versus Integrative Processes", April 1991
91/22 EP	David GOOD, Lars-Hendrik RÖLLER and Robin SICKLES	"EC Integration and the Structure of the Franco-American Airline Industries: Implications for Efficiency and Welfare", April 1991
91/23 TM	Spyros MAKRIDAKIS and Michèle HIBON	"Exponential Smoothing: The Effect of Initial Values and Loss Functions on Post-Sample Forecasting Accuracy", April 1991 (Revision of 90/46)
91/24 TM	Louis LE BLANC and Tawfik JELASSI	"An Empirical Assessment of Choice Models for Software Evaluation and Selection", May 1991
91/25 SM/TM	Luk N. VAN WASSENHOVE and Charles J. CORBETT	"Trade-Offs? What Trade-Offs?" April 1991
91/26 TM	Luk N. VAN WASSENHOVE and C.N. POTTS	"Single Machine Scheduling to Minimize Total Late Work", April 1991
91/27 FIN	Nathalie DIERKENS	"A Discussion of Correct Measures of Information Asymmetry: The Example of Myers and Majluf's Model or the Importance of the Asset Structure of the Firm", May 1991
91/28 MKT	Philip M. PARKER	"A Note on: 'Advertising and the Price and Quality of Optometric Services', June 1991
91/29 TM	Tawfik JELASSI and Abbas FOROUGHI	"An Empirical Study of an Interactive, Session-Oriented Computerised Negotiation Support System (NSS)", June 1991

91/30 MKT	Wilfried R. VANHONACKER and Lydia J. PRICE	"Using Meta-Analysis Results in Bayesian Updating: The Empty Cell Problem", June 1991
91/31 FIN	Rezaul KABIR and Theo VERMAELEN	"Insider Trading Restrictions and the Stock Market", June 1991
91/32 OB	Susan C. SCHNEIDER	"Organisational Sensemaking: 1992", June 1991
91/33 EP	Michael C. BURDA and Michael FUNKE	"German Trade Unions after Unification - Third Degree Wage Discriminating Monopolists?", June 1991
91/34 FIN	Jean DERMINE	"The BIS Proposal for the Measurement of Interest Rate Risk, Some Pitfalls", June 1991
91/35 FIN	Jean DERMINE	"The Regulation of Financial Services in the EC, Centralization or National Autonomy?" June 1991
91/36 TM	Albert ANGEHRN	"Supporting Multicriteria Decision Making: New Perspectives and New Systems", August 1991
91/37 EP	Ingo WALTER and Hugh THOMAS	"The Introduction of Universal Banking in Canada: An Event Study", August 1991
91/38 EP	Ingo WALTER and Anthony SAUNDERS	"National and Global Competitiveness of New York City as a Financial Center", August 1991
91/39 EP	Ingo WALTER and Anthony SAUNDERS	"Reconfiguration of Banking and Capital Markets in Eastern Europe", August 1991
91/40 TM	Luk VAN WASSENHOVE, Dirk CATTRYSSE and Marc SALOMON	"A Set Partitioning Heuristic for the Generalized Assignment Problem", August 1991
91/41 TM	Luk VAN WASSENHOVE, M.Y. KOVALYOU and C.N. POTTS	"A Fully Polynomial Approximation Scheme for Scheduling a Single Machine to Minimize Total Weighted Late Work", August 1991
91/42 TM	Rob R. WEITZ and Tawfik JELASSI	"Solving A Multi-Criteria Allocation Problem: A Decision Support System Approach", August 1991
91/43 SM	Sumantra GHOSHAL and Christopher BARTLETT	"Building Transnational Capabilities: The Management Challenge", September 1991
91/44 SM	Sumantra GHOSHAL and Nitin NOHRIA	"Distributed Innovation in the 'Differentiated Network' Multinational", September 1991
91/45 MKT	Philip M. PARKER	"The Effect of Advertising on Price and Quality: An Empirical Study of Eye Examinations, Sweet Lemons and Self-Deceivers", September 1991
91/46 MKT	Philip M. PARKER	"Pricing Strategies in Markets with Dynamic Elasticities", October 1991
91/47 MKT	Philip M. PARKER	"A Study of Price Elasticity Dynamics Using Parsimonious Replacement/Multiple Purchase Diffusion Models", October 1991
91/48 EP/TM	H. Landis GABEL and Bernard SINCLAIR-DESGAGNE	"Managerial Incentives and Environmental Compliance", October 1991
91/49 TM	Bernard SINCLAIR-DESGAGNE	"The First-Order Approach to Multi-Task Principal-Agent Problems", October 1991
91/50 SM/TM	Luk VAN WASSENHOVE and Charles CORBETT	"How Green is Your Manufacturing Strategy?" October 1991
91/51 MKT	Philip M. PARKER	"Choosing Among Diffusion Models: Some Empirical Guidelines", October 1991
91/52 EP	Michael BURDA and Charles WYPLOSZ	"Human Capital, Investment and Migration in an Integrated Europe", October 1991
91/53 EP	Michael BURDA and Charles WYPLOSZ	"Labour Mobility and German Integration: Some Vignettes", October 1991
91/54 TM	Albert ANGEHRN	"Stimulus Agents: An Alternative Framework for Computer-Aided Decision Making", October 1991

91/55 EP/SM	Robin HOGARTH, Claude MICHAUD, Yves DOZ and Ludo VAN DER HEYDEN	**"Longevity of Business Firms: A Four-Stage Framework for Analysis"**, November 1991
91/56 TM/EP	Bernard SINCLAIR-DESGAGNE	**"Aspirations and Economic Development"**, November 1991
91/57 MKT	Lydia J. PRICE	**"The Indirect Effects of Negative Information on Attitude Change"**, November 1991
91/58 OB	Manfred F. R. KETS DE VRIES	**"Leaders Who Go Crazy"**, November 1991
91/59 OB	Paul A. L. EVANS	**"Management Development as Glue Technology"**, November 1991
91/60 TM	Xavier DE GROOTE	**"Flexibility and Marketing/Manufacturing Coordination"**, November 1991 (revised)
91/61 TM	Arnoud DE MEYER	**"Product Development in the Textile Machinery Industry"**, November 1991