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Lag Structures in Commodity Advertising Research

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Abstract

This paper examines basic assumptions about the lag structure of advertising. Evidence suggests for frequently consumed commodities, the lag structure is probably a monotonic decreasing function. Confusion may exist over what advertising variables to analyze and what shape the lag structure should take. Cumulative structure need to be differentiated from decay structures.

Key words: advertising, decay effect, cumulated effect.

Lag Structures in Commodity Advertising Research

The passing of the Dairy and Tobacco Adjustment Act in 1983 generated interest in the economic impact of commodity advertising. Regional advertising research committees and conferences were organized to foster communication between agricultural economists and other interested people. Different approaches to evaluate commodity advertising have recently been discussed at the NEC-63 research conference on commodity advertising and promotion held in February 1989. Both demand system approaches (Brown and Lee; Green and Chang; Goddard; Cox; and Chang and Kinnucan) and single equation approaches with different advertising decay structures (Jones and Choi) were discussed at the conference. One of the important topics discussed was the advertising decay structure. The center of the discussion on advertising decay was whether decay structures take different forms, i.e., monotonic decreasing, bell-shaped, and other shapes.

The purpose of this study is to further examine advertising decay structure shapes. In the next section, decay structures used in previous commodity advertising research will be reviewed. Then advertising and marketing studies will be used to theorize the general shape of the advertising decay structure, and a discussion will be provided to point out where confusion over the decay structure appears to be.

Review of Past Research

Depending on research objectives and nature of the data used, lag structure assumptions made in past advertising research on agricultural commodities can be classified into at least four categories: (1) zero lag effect; (2) monotonic decreasing lag structures; (3) bell-shaped lag structures; and (4) monotonic increasing structures.

In the first category, the emphasis of the research was placed on the functional form of the advertising variables used. For example, in the Thompson and Eiler, the Hockman et al, and the Ward (1975) studies, the inverse of advertising expenditures was used with the authors assuming the impact of advertising effort on demand was increasing at a decreasing rate. Similarly, logarithmic advertising expenditure was used by Hockman et al and by Kinnucan and Forker for the same reason.

In the second category, selection of advertising variables and determination of length and shape of lagged advertising effects were determined by how well alternative models fit the data. Researchers have estimated the impact of advertising using distributed lags, current and lagged advertising expenditure variables without any transformation or simply the Houthakker and Taylor habit persistence model with the advertising lag effects captured through the lagged dependent variable. Examples include the polynomial lag structure used by Ward (1976); the lagged dependent variable approach used by Lee and Fairchild; Goddard and Amuah; and Liu and Forker; the simple decreasing lag structures used by Lee (1981); the decreasing lag structure used by Ward (1989) for live weight and box beef; and the lag structure used by Jones and Ward.

In the third category, the data were again used to determine the shapes of the lag structures. Different distributed lag techniques have been explored, such as the polynomial lag used by Ward (1976); and the Pascal lag used by Kinnucan and Forker. In general, no explanation was given for assuming a bell-shaped lag structure; when an explanation was given, the common argument was that it takes time for advertising to reach its full impact as well for the impact to dissipate. Other reasons (Jastram) are (1) printed materials may not be read immediately after they are delivered and (2) frequency of shopping may not coincide with frequency of advertising.

In the fourth category, the current advertising effect was found to be insignificant; however, the lagged advertising effects were significant (Lee and Tilley; Liu and Forker; Ward, 1989). The arguments for the insignificant current advertising effect is that it takes time for consumers to react to advertising efforts.

In addition to the use of distributed lags and current and lagged advertising expenditures, some researchers have used cumulated advertising expenditures. In general there are two types of variables used in regressions to estimate advertising effects. The first type includes current and lagged advertising expenditures for selected periods of time; e.g., the advertising variables used in Ward (1976), Lee (1981), and Kinnucan and Forker. The second type includes weighted cumulative advertising expenditures for selected periods of time. For example, Aviphant et al used the sum of three monthly advertising expenditures with the same weight, unity, for each monthly expenditure; while Ward and Dixon used the sum of twelve-monthly advertising expenditures with an increasing and then decreasing weighing scheme to calculate the weighted cumulative advertising expenditure.

Different functional forms such as square roots (Ward and Myers), cubic roots (Ward and Dixon), and logarithmic forms (Ward and McDonald; Ward and Dixon) have also been incorporated into lag structures in other studies. In addition, two types of advertising effects, the carryover effect and the cumulated effect were important in these studies.

Advertising Response

Advertising response in this paper refers to the functional relationship between some advertising input and some output or effect of presumed value for the advertiser. For simplicity, the input measure is assumed to be the monetary expenditure on advertising and output measures include sales as well as the abstract concept of "psychological stock of knowledge and attitudes." The advertising response may refer to the reaction of a given individual or to the aggregate reaction of members of a target group.

The literature shows that almost all writers who consider the effects of advertising subscribe to one or the other following shapes of the response function: (1) the concave-downward function and (2) the S-shaped logistic function. The concave function implying monotonically diminishing returns to advertising expenditure is shown in Figure 1a. Figure 1b shows the S-shaped advertising response function, which first has increasing returns and then, after an inflection point, diminishing returns. The latter are the advertising response functions for a single time period, the horizontal axis is the amount of advertising expenditures.

Two major types of advertising impacts have been discussed in the literature when more than one time period is involved. The first one indicates that current advertising expenditures do not have their full impact on sales in the current accounting period, but continue to impact sales over an extended period of time; this is called the decay or carryover effect. The second type of advertising impact indicates that several exposures may be required before an individual decides to buy; this is called the cumulative effect of advertising. Related to both types of impacts is the idea that if advertising ceases, sales will not decrease immediately to a level that would exist without advertising. The usual assumption is that the total effect of a dollar's worth of advertising is spread out over several time periods.

Decay effect

A number of studies have been made regarding the decay effect of sales when advertising is stopped. For example, Vidale and Wolfe discussed different cases where the decay was found to occur at a constant rate per unit time. Benjamin et al report somewhat similar findings. Zielske demonstrates that advertising will be quickly forgotten if the consumer is not continuously exposed to it; and, without repeated exposures to advertising, the number of recalls decreases over time.

In analyzing the demand impact of advertising, a basic assumption usually made is a consumer's demand for the product (q_t) in question depends on his/her psychological stock (s_t) of knowledge and attitudes which, in turn, depends on advertising. A positive relationship between demand and the stock is usually assumed, i.e.,

(1) $\partial q_t/\partial s_t > 0$,

where t indicates time. The psychological stock can further be written as a function of current advertising effort (a_t) and the past psychological stock (s_{t-1}), i.e.,

(2) $s_t = s(a_t, s_{t-1})$.

If one substitutes s_{t-j}, $j=1,\ldots,n$ repeatedly in (2) one has

(2') $s_t = s(a_t, a_{t-1}, \ldots\ldots, a_0)$,

where a_t is the level of advertising in time t and a_0 is the level of advertising in the first period in which the product was advertised. An increase in advertising is also assumed to positively affect the stock of knowledge and thus demand, i.e.,

(3) $\partial s_t/\partial a_{t-j} > 0$, and

$\partial q_t/\partial a_{t-j} = (\partial q_t/\partial s_t)(\partial s_t/\partial a_{t-j}) > 0$, for all j.

Given that consumer's do not have perfect memory, one can conclude

(4) $\partial q_t/\partial a_{t-i} < \partial q_t/\partial a_{t-j}$ for all $i > j$.

assuming $\partial s_t/\partial a_{t-i} < \partial s_t/\partial a_{t-j}$, if $i > j$. The latter assumption is directly based on the idea that less of an event is remembered as time goes by. Of course, exceptions to equation (4) are possible as previously alluded to (Jastram). For example, due to habit or perhaps frequency of payday, consumers may only shop for the goods in question on a weekly, biweekly, or monthly basis. The consumer response to advertising in a given period may be delayed simply because the next shopping trip is more than a period away. Another example involves possible delay between when advertising occurs and when the consumer is exposed to it. For instance, printed advertising in a magazine may not be read for several weeks after the advertisement first appears. Even if the consumer responded immediately after the exposure, a lag between when the advertisement first appeared and when the consumer responded would exist.

Could Jastram's arguments be used to explain the bell-shaped lag structure in food advertising research? The answer is "probably not." First, expenditures on printed materials account for a very small fraction of total advertising expenditures for most types of food; it would be difficult to argue printed materials dominated the advertising impact and result in a bell-shaped response curve. In addition, printed material is often discarded shortly after received. Normally, consumers are unlikely to save newspapers for more than one week or magazines for an extended period, and read old advertisements. The other argument regarding shopping frequency versus advertising frequency probably does not apply to most food items, either. For example, for daily consumed commodities, such as orange juice, milk, and beef, consumer purchase frequencies may be once a week or once every other week. When monthly or quarterly data are used in the analysis, it becomes difficult to argue that people need more than a month or three months to get around to purchasing the product. With these observations the bell-shaped lag structure is unlikely to depict the advertising of many daily consumed food commodities.

Most advertising research conducted by agricultural economists until recently tried to measure the carryover (or decay or delay) effects of advertising effort using current and lagged advertising expenditures. These effects refer to "one-shot" or impulse advertising changes; they answer the question "if advertising is increased by one unit (the measure of advertising could be dollars, recall levels, etc.) in a period and then stopped, what will happen to the current and future demand for the product of interest?" Based on previous discussion, the carryover effect structure can have only one functional form, i.e., a monotonic decreasing functional form ($0 < \partial q_t/\partial a_{t-i} < \partial q_t/\partial a_{t-j}$, for all $i > j$). In mathematical terms, one tries to estimate $\partial q_t/\partial a_{t-i}$, $i=0,1,...,n$, where n is the length of the lag beyond which the advertising effect disappears or is approximately zero.

The decay structure discussed above also obviously implies that the consumer's psychological stock of knowledge is positively related to the consumer's psychological stock of knowledge at time t-1, i.e.,

(5) $\partial s_t/\partial s_{t-1} > 0$.

Appel found that advertising changes in effectiveness with the passage of time. There was a slight increase in recall (which was attributed to learning) followed by a fairly regular decline, which was attributed to wear-out of the advertising message. In addition, Greenberg and Suttoni found that commercials for infrequently purchased products (e.g., an automobile, a camera, etc.) may wear out slower than those for everyday products (e.g., milk, beef, orange juice, etc.). These empirical findings indicate that the decay effect of advertising varies depending on the way the product is advertised and the nature of the product.

Insight into the learning effect and the wear-out effect of advertising can be obtained by differentiating (5) with respect to a_t. Note that $\partial(\partial s_t/\partial s_{t-1})/\partial a_t$ could be positive, negative, or zero. When it is positive (negative or zero), the interaction between current advertising and the lagged stock of knowledge is positive (negative or zero), which suggests a learning process (a wear-out effect or no effect at all). Again, the advertising effect coming from the interaction between s_{t-1} and a_t will only depreciate over time.

With a bell-shaped lag structure for advertising effect, one would require $\partial s_t/\partial a_{t-i} < \partial s_t/\partial a_{t-j}$; for some $j > i$; in other words, the researcher assumes the consumer's stock of knowledge about the product could increase over time without additional advertising effort. The inconsistency between monotonic decay effects and bell-shape lag structures found by many researchers is, perhaps, caused by confusion about the carryover effect and cumulated effect, which results in misspecified models.

Cumulated Advertising Effect

The cumulated effect of advertising can be considered as the sum of current and lagged advertising effects. For example, following the above argument that the lagged advertising effect is a decreasing function of time, consider Figure 2a where the vertical axis represents the consumer's psychological stock of knowledge, the horizontal axis represents time, and curve aa represents levels of psychological stock of knowledge over time. In this particular case, the total stock of knowledge

(s_{t+i}) and the current stock of knowledge are identical. Note that it is unlikely that a producer would advertise his/her product for one and only one time as suggested by Figure 2a. Usually a producer will advertise his/her product continuously; therefore, the current stock of knowledge is the sum of currently gained knowledge plus left-over past knowledge. For example, in Figure 2b, under the assumptions that the advertising effect on the stock of knowledge lasts for three time periods (t-1 through t+1) and the advertising impacts on the stock of knowledge are the same for each of these periods, the current stock of knowledge (ad) at time t-1 is oo' which increases to ad, the sum of ab and ac in time period t, and again increases to a'e, the sum of a'b', a'c', and a'd', in time period t+1. If the advertising is stopped after time t+2, the current stock of knowledge would decrease, and eventually disappear after time t+5. The result is a hump-shaped curve o'defo". If the advertising effort is sustained at this level, then the cumulated stock of knowledge will approach level L as time goes to infinity. In addition, if learning and wear-out effects are considered, the s_t curve could be S-shaped as depicted in Figure 1b. Other shapes for the s_t curve, such as double-bell shaped or irregular shaped s_t curves, can also be constructed using different levels of advertising expenditures over time.

The bell-shaped s_t curve may have been confused by some researchers as the advertising decay function. In order to estimate the current stock of knowledge, one needs information on the lag structure of advertising impacts so that a weighing scheme can be developed for calculation of a weighted cumulated advertising expenditure variable. Ward and Dixon's approach is very close to the estimation of cumulated advertising impact; however, they used a bell-shaped weighing scheme for their calculation of cumulated advertising expenditures and their interpretation of advertising results is not clear.

Another possible source of confusion over the bell-shaped advertising decay function arises from the analyses conducted by Rao and Miller. In their studies, the authors assumed a S-shaped advertising response curve (a single period model). If one is interested in changes in sales due to advertising effort, one can differentiate the response curve with respect to advertising expenditure, which results in a bell-shaped curve. In Rao and Miller's study the dependent variable is the change in sales.

Threshold in Advertising Response

The argument used to interpret the lack of a current advertising effect but significant lagged advertising effects (for example "the production of consumer information takes ν **periods...** (Liu and Forker, p. 230)) requires discussion of advertising thresholds (Krugman). The threshold concept of advertising has two dimensions: a certain amount of advertising during any time period is required to produce an impact on sales and several time periods may be required to realize the impact of advertising on sales.

In Figure 2b, the horizontal line kk represents the threshold that advertising has to reach before it has any impact on sales. To reach this threshold, one could advertise heavily during a period or advertise continuously so that consumer's psychological stock will reach this level at some later time. With this assumption, the demand relationship in (1) can be rewritten as

$$(1') \quad \partial q_t/\partial s_t > 0 \qquad \text{if } s_t > k$$
$$\partial q_t/\partial s_t = 0 \qquad \text{otherwise,}$$

where k is the threshold level for advertising. In Figure 2b, the threshold is reached at time t+1.

Again, if it is argued that it takes several time periods of advertising for consumers to build up their psychological stock of knowledge and start buying the product, as is the case shown in Figure 2b, then the weighted sum of current and lagged advertising expenditures should be used in the analysis. Unfortunately, the advertising variables used in cited studies involving the threshold concept are current and lagged advertising expenditures (Lee and Tilley; Liu and Forker). If the stock of knowledge exceeds the threshold, there is not a problem. However, the modelling techniques used to estimate the relations (1) and (1') should be different.

Concluding Remarks

In this paper, basic assumptions about advertising lag structures were investigated. In general, the evidence suggests that for frequently consumed commodities, the lag structure of advertising should take the shape of a monotonic decreasing function. With this basic structure, the cumulated advertising effect can be evaluated. The discussion presented in this paper suggests that there may be confusion among researchers about what advertising variables should be used in regression analysis and what the lag structure should look like; the result may be a misspecified model. In general, problems arise when researchers use the cumulated advertising effect concept to estimate advertising decay structures.

A review of past advertising research results reveals that there is a lack of interpretation about functional forms for advertising decay structures in the agricultural economics profession and too much emphasis on statistical goodness-of-fit and statistical tests.

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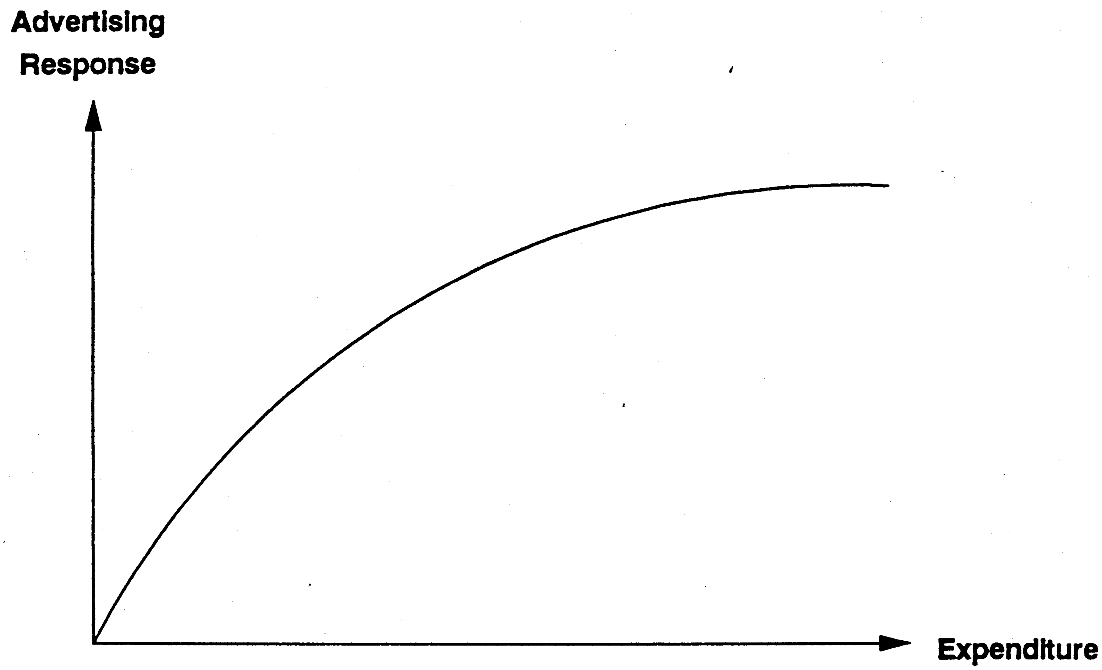

Figure 1a A Concave Response Curve

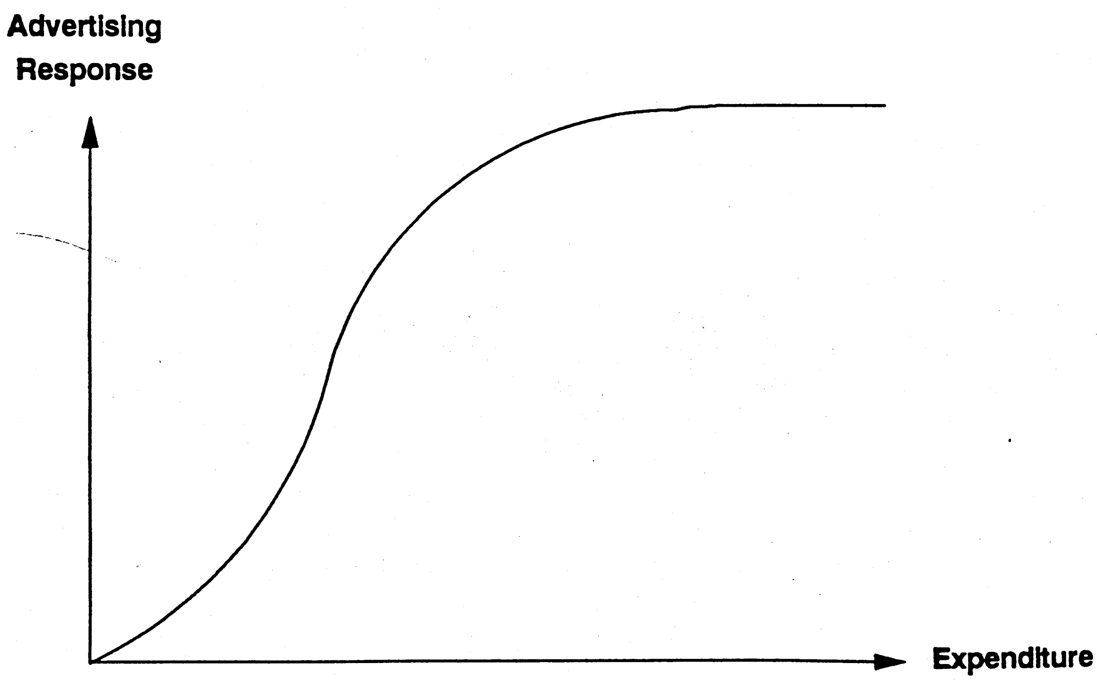

Figure 1b A S-shaped Response Curve

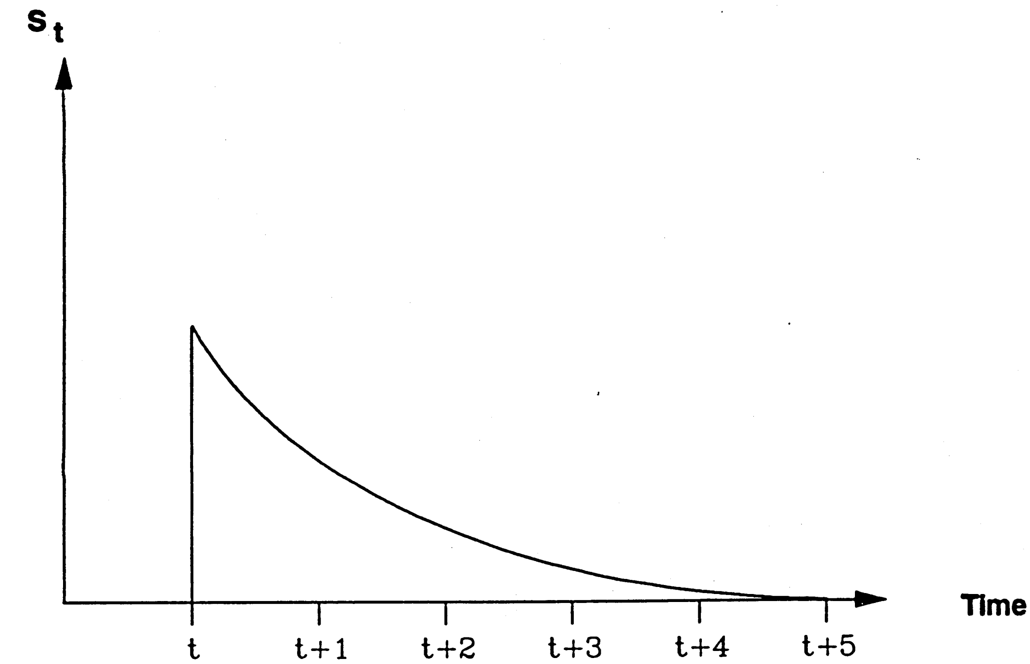

Figure 2a A Typical Advertising Decay Function

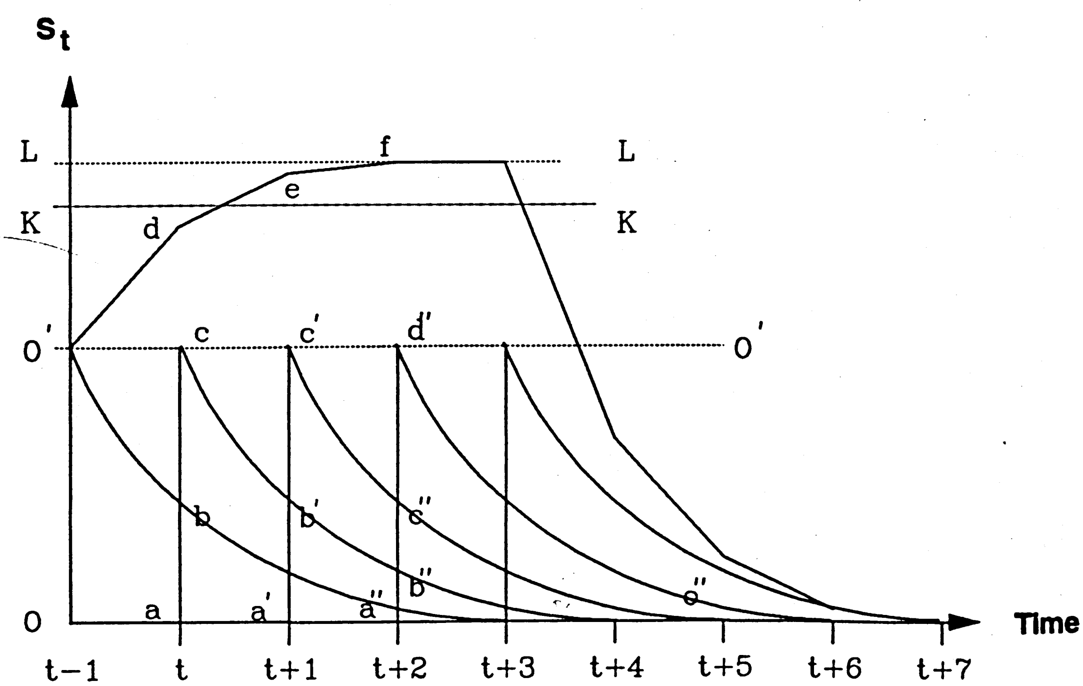

Figure 2b A Cumulated Advertising Response Function