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MEASUREMENT OF SALES RESPONSE TO
GENERIC PROMOTION OF FOOD PRODUCTS:
SEMINAR PROCEEDINGS

October 1973

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These papers were drawn from a seminar sponsored by the Southern Regional Workgroup on Market Dynamics. The coordinating committee consisted of Olan Forker, Cornell; Peter Henderson, ERS, USDA; W. Bernard Lester, Economic Research Director, Florida Department of Citrus, University of Florida; and John Nichols, Texas A&M University. Robert Branson of Texas A&M is the current Chairman of the Workgroup and Dr. Jarvis Miller, Director, The Texas Agricultural Experiment Station is Administrative Advisor. The seminar participants are listed below:

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The workgroup sponsors occasional seminars on agricultural marketing and market development. This is the first time the proceedings have been published. The workgroup welcomes the interest of persons involved in research on market development problems of agricultural and food products.

FOREWORD

Many agricultural commodity groups have long had an interest in developing promotion programs of a generic nature to expand markets for their products. Indications are that this concept is being considered by more and more groups who are organized at state and national levels to take advantage of such programs. This trend will be reinforced to the extent that governmental policy moves toward a more "market oriented" stance for agriculture.

In this environment, economists concerned with agricultural and food marketing problems are being drawn into the evaluative process inherent in the establishment and operation of such a program. The papers included here were presented at a seminar held May 31 - June 1, 1973 in New Orleans. The purpose of this seminar was to examine both traditional and new methods of evaluating sales response to generic promotion programs.

The organization adopted here reflects the intent of the program and hopefully capitalizes on the complementary features of the papers presented. In the first paper, Peter Henderson (ERS, USDA) sets the stage by reviewing traditional procedures of market tests and controlled experiments. He also discusses the advantages and limitations of various experimental designs. In the second paper, Seymour Banks (Leo Burnett, Inc.) discusses the validity of market research models both in terms of the market and the organization employing them, and indicates some classical solutions to the validity questions raised.

The next set of papers discusses some techniques and theoretical considerations which provide alternatives or improvements in selected analytical approaches to promotion evaluation. Lester Myers (University of Florida) discusses in the third paper the use of random coefficients regression as a technique for estimating advertising response functions. Such a procedure permits random variation of the coefficients and provides knowledge of the variance function which could be of value to decision makers. The allocation of resources to "demand creation" by the monopolistic firm is discussed by Eithan Hochman and Oded Hochman (Berkeley and Tel-Aviv Universities) in the fourth paper. A theoretical analysis is developed which indicates the nature of the investment process for "demand creation" capital relative to productive capital.

In the last set of papers the emphasis is placed on applications and issues raised in evaluating the impact of generic promotion efforts. Ronald Ward (Florida Department of Citrus) reviews the recent application of econometric techniques to the measurement of advertising effectiveness

in the Florida citrus industry. Doyle Eiler and Olan Forker (Cornell University) examine the compromises in research procedure resulting from the competing demands of timeliness, executability and quality of results. In the last paper Robert Branson (Texas A&M University) turns to the question of integrating promotion evaluation research into a more comprehensive concept of market development research.

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Additional copies of the Proceedings may be obtained by requesting MRC 73-6 from the Texas Agricultural Market Research and Development Center, Texas A&M University, College Station, Texas 77843. There is a charge of \$2.00 each.

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QUANTITATIVE METHODS OF EVALUATING SALES RESPONSE TO ADVERTISING AND RELATED PROMOTIONAL ACTIVITIES

Peter Henderson*

Sales volume of a specific product or a number of designated products depend upon the direct effect and the interaction of a number of variables. To name a few, the number of consumers or potential consumers, per capita disposable income, distribution of income, number of uses of a product, product quality, price of product, price of competing products, product distribution, consumer knowledge, relative selling efforts, and relative advertising and promotional support--both quantitative and qualitative. Moreover, the values and influence of specific variables as well as relationships are constantly changing over time. Thus, to separate out the sales influence of specific variables is a complex and challenging endeavor.

Evaluating the sales response to advertising and sales promotional activities probably offers a greater challenge than other sales influencing variables for several reasons. Normally, advertising and sales promotion are competitive marketing tools that are closely interrelated with other facets of production and marketing, such as comparative quality and quality control, pricing strategies, product improvement, distribution, personal selling effort, and retaliatory efforts of competitors as well as the composition and quality of the promotional mix itself.

Moreover, historical data series for variables known or suspected to influence sales is seldom available in the form needed by researchers for economic and statistical analysis to make precise estimates. For example, most of our aggregate data for agricultural products are on an annual or quarterly basis. Yet for many products, sales and consumption patterns vary by months, weeks or even days. Estimates for the elasticity of demand with respect to prices and income for such products, and similar estimates for sales relationships of other variables, calculated on basis of annual or quarterly data is useless to management of marketing firms, as well as misleading to others. Illustrative of such products with highly seasonal demand fluctuation for which estimates based on annual and quarterly data are inappropriate include: turkeys, broiler-fryers, peaches and other soft fruits, steaks and chops, and roast and stew meats.

Faced with such complex problems, it is small wonder that research designed to establish quantitative and economic relationships for advertising and sales promotional activities, as well as other facets of marketing

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is still in its infancy compared to that of biological and physical sciences related to production. The late start of economic research in this area does offer advantages; however, we are able to take advantage of developmental work in research methodology and techniques by other researchers. Many of these techniques can be adapted and refined to quantify sales and economic relationships to promotional activities including econometric models, operational research techniques, and mathematical and statistical models developed by biological, physical scientist and behavioral researchers.

In this respect I will discuss some research techniques the U.S. Department of Agriculture has utilized in evaluating short and intermediate term sales response to merchandising and promotional activities.

SUB-DIVIDED TIME SERIES, OR BEFORE, DURING AND AFTER SALES TEST

This is the least sophisticated technique we have employed. Sales comparisons are made during and after a promotion campaign to sales before the promotion or during some base period in one or more markets--replication in several markets is preferable. If total sales is the criteria of measurement, the basic assumption is made that all other variables affecting sales remain constant except advertising and promotional inputs. This is a major weakness of the techniques since, in general, other things (variables) affecting sales seldom remain constant. However, if shares of market is the measurement criteria, then we have a "horse of a different color" as changes in other variables affecting sales of the product would also affect sales of competing products; thus, changes in market share would be a reliable estimate of the effectiveness of the promotional campaign. The technique is simple to use, all that is required is monitoring sales and application of a simple "t" test, or X^2 test to determine whether the change in sales is significant. Where share of market data are available or easily obtained I would not hesitate to use this technique. It would be recommended to test the promotional campaign in a number of markets rather than a single isolated market to eliminate the problem of basing a decision on a sample of one.

MATCHED MARKETS OR TEST AND CONTROL MARKETS

In this technique pairs of markets are carefully matched on basis of sales and other variables affecting sales. Then through random selection one market is assigned to the test group of markets with the remaining market in each pair assigned to a control group of markets. It is assumed that other variables affecting sales except the one or ones undergoing test will change in same direction and same magnitude in control markets as in the test markets. Considerable back data and homogeneity analysis are required

to select markets used in the experiment, also the degrees of freedom for statistical test of significant differences of sales change is limited. Due to the limitation of degrees of freedom in statistical test of significant sales changes, it is generally advantageous to set up experiment as complete randomized blocks since stores or markets must be grouped into homogeneous groups and would provide a greater number of degrees of freedom for statistical tests.

While this research method is superior to the sub-divided time series method if total sales is the criteria of measurement, it has no material advantage if market share is the criteria of measurement and the same number of markets are used. Moreover, the added cost is disproportionate to the increase in precision of estimates.

CONTROLLED EXPERIMENTS UTILIZING BIOMETRIC DESIGNS TO ASSIGN TEST ITEMS TO MARKETS AND SPECIFIED TIME PERIODS

These experimental designs were originated by biological and physical scientist as a means of increasing precision in research findings in conducting field plot experiments, animal feeding trials, etc. The logic underlying the development of these designs included such considerations as: the inherent fertility, water holding capacity, sunlight and other factors affecting yields varied from one side of a field plot to the other. Thus, if plots could be divided into more homogeneous subplots for replication, estimates of yields, etc. derived from such experiments would be superior to completely random experimentation. Similarly rates of weight gains or milk productions were affected by such variables as age, breed, position in feedlot, birth weight, period of lactation. Thus, livestock researchers found that they could improve their research by developing and using similar techniques as researchers engaged in field experimentation. Out of these efforts of biological and physical scientists aided by statisticians, the field of biometric statistics has evolved encompassing research designs ranging from randomized complete blocks and latin squares to be balanced and unbalanced lattice squares and factorial designs.

The statistical model and assumption underlying the use of biometric designs in conducting market experiments is the same as for analysis of variance:

$Y_{ij} = U + C_i + T_j + e_{ij}$ where: U = overall means; C_i and T_j are constants which are additive with zero means and common variance; individual Y_{ij} have common variance e_{ij} which is randomly distributed, and there is no interaction or covariance between the constants C_i and T_j . The assumptions are covered in most statistical texts and will not be discussed in technical detail. However, practical application will be emphasized.

It was not until the late 1940's and early 1950's that economic and market researchers discovered that these designs and/or modifications could be utilized to improve research results relating to sales influences of such variables as prices, merchandising techniques, and advertising and promotional campaigns.

The influence of variables inherently associated with stores or cities and time could be equalized on the experimental materials (item or items being investigated) by using stores, cities and time periods as plant scientist use row and columns (blocks or plots and subplots) in field experiments. That is, on basis of previous sales, group stores, markets and time periods into homogeneous groups and subject variables being investigated to same conditions. Moreover, by systematically subjecting test variables to specified conditions the researcher is in a position to estimate overall sales response, as well as for the specific conditions over which tests were replicated. For example, replicating sales test of a new product in high, middle and low income areas; or to test sales response of two or more levels of advertising at two or more levels of another promotional activity would allow the researcher to appraise the overall response of test, as well as the response for subunits.

Careful grouping of test stores or cities with respect to sales during specified time periods is a key element on the successful utilization of biometric designs in conducting sales test. A basic assumption is that each city, store or time period has a constant effect on sales of the test item. If this assumption is violated then the non-constant effect is confounded with the effect of the test item and experimental errors are magnified. In such cases the magnitude of residual or unexplained variation (experimental error) may in fact be greater than it would be in a completely randomized experiment. Thus, the proper use of these research techniques requires considerable knowledge of sales variations associated with units to be stratified in the designs. Most often this requires securing and analyzing prior sales data to properly group sampling units (stores or cities by specific time periods) and select the most appropriate design for assessing the test variable(s). For example if on the basis of prior sales data, cities or stores within a city could be grouped with homogeneous sales levels for selected time periods, then a randomized complete block design could be effectively utilized for each such grouping with time period representing blocks (Figure 1). However, if the sales level varied among cities or stores as well as time periods, a latin square design would be more appropriate (Figure 2). In general, analysis of prior sales data can be most easily accomplished through graphic analysis or plotting sales against time as shown in Figures 3 and 4.

A randomized complete block design as shown in Figure 1 would be appropriate for stores with homogeneous sales levels over different time periods as depicted in Figure 3.

Analysis of variance for this design is as follows:

Source	df	ss	M.S.	F
Total	23	$\sum d_{yij}^2$	---	
Between				
Blocks	3	$\sum d_{Bi}^2$	SSB/3	M.S. Blocks/M.S. Error
Treatment	5	$\sum d_{Tj}^2$	SST/5	M.S. Treat./M.S. Error
Error	15	by sub	SSE/15	

In contrast to the above analysis of variance, if the same six stores had been used in a matched store or test and control store experiment, the stores would have been divided into two groups of three each. Only one item can be tested at a time. Regardless of whether one item is tested over the four time periods or a different item tested during each period, each test is a separate experiment.

The analysis of variance for each test is as follows:

Source	df	ss	M.S.	F
Total	5	$\sum d_{yij}^2$	---	
Between Groups	1	$\sum d_{Gi}^2$	SS/1	MSG/MSE
Within Groups	4	by sub	SS/4	

Moreover, if four separate tests were conducted, the experimental errors for test items cannot be pooled.

In the randomized complete block design, test items designated by letters (A, B, C, etc.) are randomly assigned to stores within each block or time period; thus, it is possible that one or more stores would receive the same treatment in two or more consecutive time periods as shown in Figure 1.

In the event there is variation in sales level associated with both stores or cities and time periods, as illustrated in Figure 4, the latin square design or a modification thereof, is appropriate for assigning test treatments to stores and time periods as shown in Figure 2. It will be noted that this design is balanced.

Matched Stores	Blocks or Time Periods			
	1	2	3	4
1	F	A	A	A
2	B	E	D	C
3	A	F	F	F
4	C	D	B	B
5	D	B	C	D
6	E	C	E	E

Figure 1. Randomized complete blocks design for assigning treatments to stores during specified time periods.

Time Periods	Stores or Cities			
	1	2	3	4
I	A	B	C	D
II	B	C	D	A
III	C	D	A	B
IV	D	A	B	C

Figure 2. Latin square design for assigning treatments to stores and time periods.

That is, the number of columns, rows and treatments are equal and each treatment appears once and only once in each row and column. The letters representing treatments in the design, Figure 4, have been imposed on the chart of sales by stores and time periods (Figure 3) to illustrate how this assignment of treatment equalizes the sales influence of variables associated with stores and time when such influences are constant. However, if the influence of treatments and variables associated with time are compounded favoring some treatments at the expense of others.

The analysis of variance for a 4 x 4 latin square design is as follows:

Source	df	SS	MS	F
Total	15	$\sum d_{yijk}^2$		
Cols. (stores)	3	$\sum d_{ci}^2$	SS/3	MSC/MSE
Rows (Time)	3	$\sum d_{Rj}^2$	SS/3	MSR/MSE
Treatments	3	$\sum d_{TKS}^2$	SS/3	MST/MSE
Error	6	by sub.	SS/6	

It can be noted that the degrees of freedom (df) for error is reduced by three as compared to a comparable randomized complete blocks design; thus, the latin square design would not be used in preference to the randomized complete blocks design unless the variation associated with time periods was significant as the estimates derived from the latter design would be more precise.

The double change over design is a modification of the latin square design. The added feature is that this modification provides for balance in treatment sequences. That is each treatment preceeds and follows other treatments included in the experiment (Figure 6). A further feature is the addition of an extra time period to the basic design. This feature enables the estimation of both the direct and residual or carry-over effect of each treatment which cannot be done with the simple latin square and randomized complete blocks design.

Time Periods	Stores or Cities			
	1	2	3	4
I	A	B	C	D
II	Ba	Db	Ac	Cd
III	Cb	Ad	Da	Bc
IV	Dc	Ca	Bd	Ab
V	Dd	Cc	Bd	Aa

Figure 6. Extra period latin square change order design (lower case letters denote residual or carry-over effect of previous treatment).

This feature makes the design very useful in advertising and promotion research since management as well as the researcher is most interested in the combined effect (direct and residual) of advertising and promotion on sales. The analysis of variance for this design (illustrated in Figure 6) is as follows:

Source	df	SS	MS
Total	19	$\sum d_{yijk}^2$	
Columns	3	$\sum d_{ci}^2$	SS/3
Rows	4	$\sum d_{Rj}^2$	SS/4
Treatment			
Direct	3	$\sum d_{DTK}^2$	SS/2
Residual	3	$\sum d_{RTK}^2$	SS/2
Error	6	by sub.	SS/8

The degrees of freedom in error term is the same as for the 4 x 4 latin square, the precision of the experiment and estimate of coefficients are increased, however, if carry-over effects are present, since these effects tend to increase the magnitude of the SS for errors.

The balanced lattice designs are similar in some respects to the latin square design. In this design, some treatment effects are confounded and are separated through mathematical procedures. The advantages of this design, like factorial designs, using basic randomized complete blocks or latin squares, is that estimates can be gained of the combined response to two or more variables. The lattice designs and factorial design are not frequently used in sales evaluations test because of the number of homogeneous test units (stores or cities; and time periods) required to replicate the various treatment combinations.

Covariance analysis can be utilized with all of these designs. This involves regressing sales data for a concomitant variable for which data are obtained concurrent with sales. For example, the number of customers patronizing stores or total store sales which reflects both number of customers and purchasing power could be used in covariance analysis to correct for any unforeseen disruption of sales for a particular store and time period. Sum of squares for all components of variation are corrected as well as treatment means in these computations. The degrees of freedom for error is reduced by one for regression.

We have also used multiple regression analysis with covariance corrections for variations in sales associated with months and annual shifts in sales levels. The computational procedures are straight forward and follow the usual procedure for multiple regression analysis. The only modification is that the data for dependent and independent variables are put in a two-way table so that covariance with months and years can be computed. We have found that this improves the precision of estimates for sales relationship where a decided seasonal pattern of consumption or purchase patterns exist. The sales response to advertising and promotional inputs is estimated by comparing observed sales during advertising and promotional campaigns to predicted or expected sales with advertising and promotion. This technique is efficient in use of resources where adequate historical data series are available to identify and quantify the influence of independent variables affecting sales. This, however, is the chief disadvantage to using the technique as adequate data are seldom available.

I have presented the ideal approach for use of selected biometric designs. In actual practice one seldom has data available to match and group stores as depicted in the charts. However, practical application should reasonably approach the ideal. The degree of precision required in developing estimates will vary by situation faced by the researchers; moreover, the researcher frequently must provide the best answer possible within a short time period. Thus, he must select a technique which will provide better answers and bases for making decision than currently used.

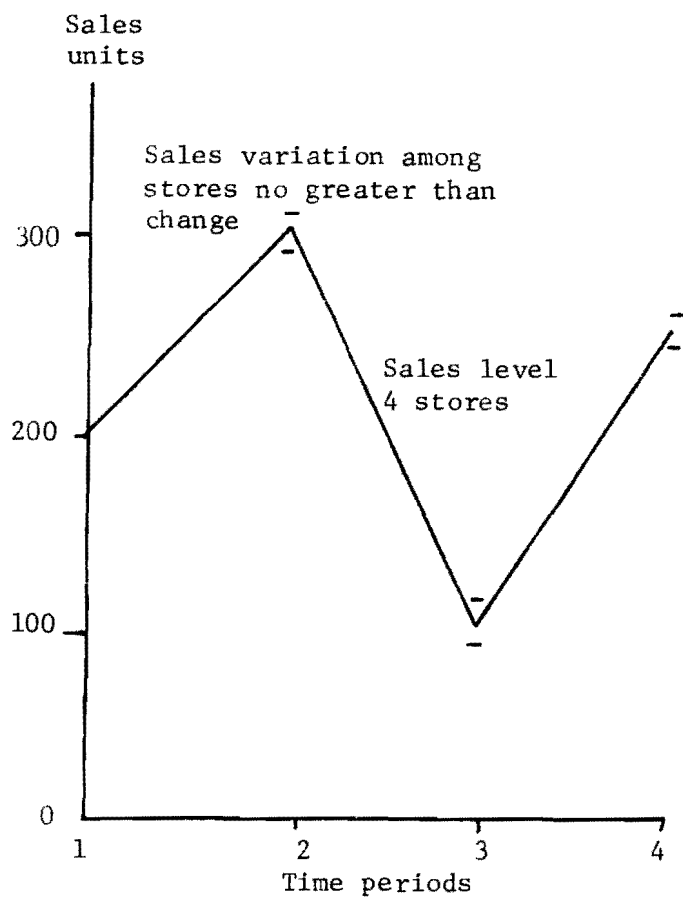


Figure 3. Constant sales variation between stores

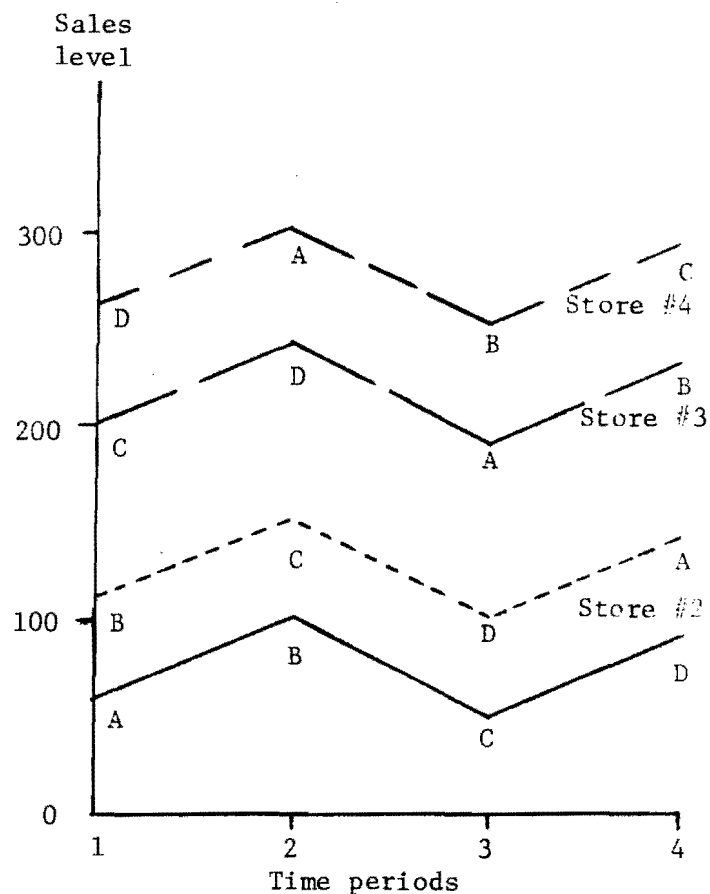


Figure 4. Constant sales variation between stores and time periods

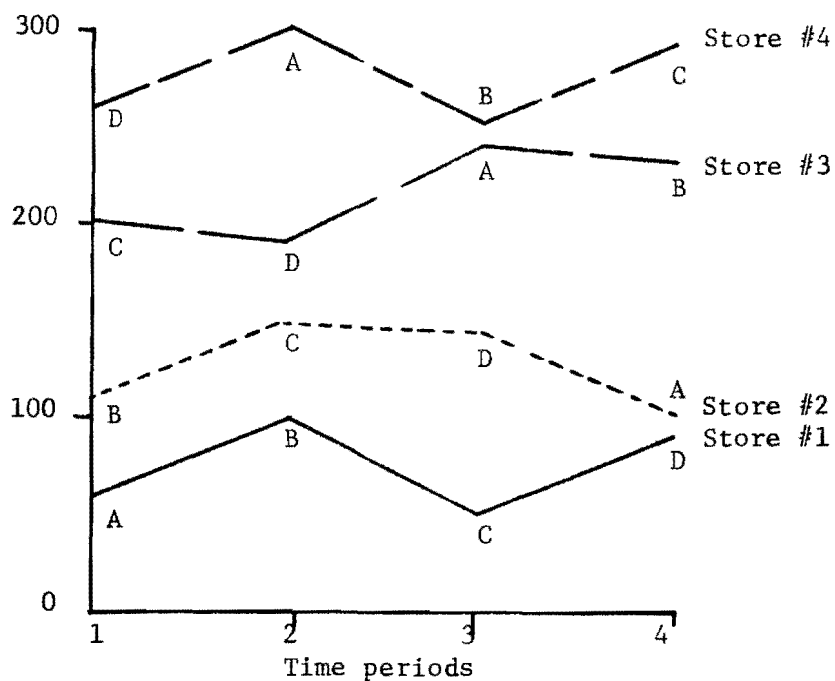


Figure 5. Average sales variation between stores constant but not constant between time periods

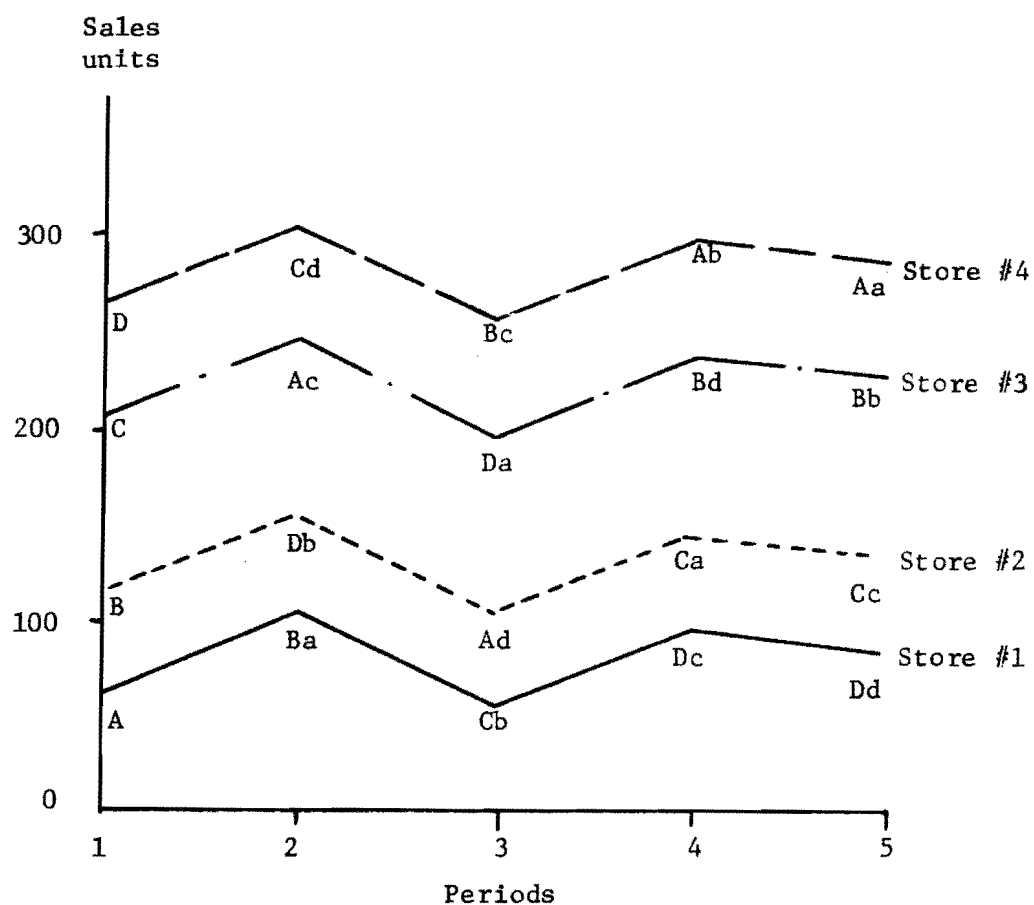


Figure 6a. Constant sales variation between stores and time periods with extra period latin square treatment sequences superimposed upper case letters treatments lower case signified carry-over or residual effect of previous treatment

WHAT'S THE HANG-UP FOR MARKETING EXPERIMENTS?

Seymour Banks*

INTRODUCTION

I think it's useful to start with some comments by Professor John Little which, I believe, provide an appropriate background for my remarks: "The big problem with management science models is that managers practically never use them. There have been a few applications, of course, but the practice is a pallid picture of the promise." 1/

The same kind of remark applies also to the utilization of experimental design to the development of marketing strategies or parameters, particularly those involving advertising in mass media. Recently, I came across a scheme that is helpful in indicating the reasons for this hang-up.

In worrying about the implementation of marketing decision models, Schultz and Slevin have developed an approach to implementation called behavior market building. This theory states that the probability of success of a marketing decision model depends upon how well the model represents a real market and also upon how compatible the model is with the organization using it. A decision model's "fit" with the market is called its market validity; its "fit" with the organization is called its organizational validity. 2/

QUESTIONS OF MARKET VALIDITY

As I see it, one of the principal issues of market validity involved in experimentation is the fit between the media used in the test and the media used subsequently. It may seem trivial but if one

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1/ Little, John D. C., "Models and Managers: The Concept of a Decision Calculus," Management Science, Vol. 16, No. 8 (1970) pp. B466-485.

2/ Schultz, Randall and Dennis Slevin, "Behavioral Considerations in the Implementation of Marketing Decision Models," Combined Proceedings, Spring and Fall 1972 Conferences, Series No. 34, American Marketing Association, Boris W. Becker and Helmut Becker, eds.

wishes to test the effect of television advertising on the consumption rate of a product, he should use television, not the combination of radio and newspaper advertising.

There are a whole host of problems of this type. For example, a proposed national media strategy may envision the use of 4-color magazine advertisements to stress appetite appeal or to enhance the attractiveness of various uses of the product. However, typically, one cannot find magazines able to insert special test advertisements in the markets or areas used as test units; hence he will use newspapers as the carriers of this type of effort. If he does, he is up against a dilemma. Typically, one simulates a national campaign in terms of impressions or dollars per household or per capita in test areas. However, a newspaper will tend to reach 70-80% or even 90% of the households within its coverage area, while magazines more typically will reach 10-20% of households. Thus simulating magazines with newspaper insertions will generate a different pattern of relative penetration per insertion than magazines do with subsequent effects on timing between subsequent insertions and repetition of exposure to the campaign.

Nor is one out of the woods by using direct mail to carry the desired test ads to the desired proportion and type of households because these ads are out of the normal editorial context in which they would be used in practice.

Another aspect of market validity is the match of physical coverage of different media. I became sensitized to this issue when I was once asked to evaluate a study comparing the use of newspapers and of television for a product. The person who designed the study attempted to evaluate the results for television on the basis of the newspaper coverage area--and in this case the television coverage area was substantially larger.

Incidentally, the principal medium of choice for national advertisers is television and the bigger they are, the more their effort is concentrated in television. The peak is hit among the top 10 food companies--75% of whose advertising goes into television.

The important issue of market validity raised by the use of television is the definition of the market covered by a given test campaign. It has become customary to subdivide the country into local TV market coverage areas--one major TV rating service calls theirs Areas of Dominant Influence; the other refers to them as Designated Market Areas. In either case, counties are assigned to a market's coverage area on the basis of its plurality position on the combined share of audience given to the stations in that market relative to each of the other markets obtaining audience in that county.

For example, the Oklahoma City SMSA consists of 3 counties with a combined population of 231,000 households but its DMA covers 27 counties with a population of 426,000 households.

The assignment of counties to television coverage areas may differ slightly from organization to organization but they usually wind up with approximately 200 such markets and, I suppose, 3/4ths of county assignments to areas being identical; differences are marginal.

QUESTIONS OF ORGANIZATIONAL VALIDITY

Recourse to television coverage areas as the basis of test unit definition solves problems of market validity but it exacerbates the problem of organizational validity. There are two major and inter-related criteria effective here: one arising from the nature of the geographical units which an advertiser is accustomed to use as the basis for planning and evaluating his own selling and promotional strategies; and one dealing with the operational units used to carry out research plans.

Now, for the first aspect. Let's take a case in the dairy field of Federal Milk Marketing Order Areas. If one is accustomed to plan and execute strategy on that geographical basis, he will build up an array of population data, wholesale and retail information, etc., on those bases. Hence, when it comes time to plan experiments, he will almost instinctively attempt to plan those marketing experiments around such Areas as test units. However, if he does so, he may find himself led into a large number of compromises in order to find media vehicles that match his accustomed market areas.

If he switches to natural media units, he raises another challenge to operational validity: cost. These television market coverage areas are natural rather than political units and one must often develop all desired data from scratch. It drives marketing managers right up the wall to spend \$25,000 in research costs to evaluate a \$10,000 media experiment, even if the \$10,000 media costs represent a simulation of a national budget of \$1,000,000.

SOME CLASSICAL SOLUTIONS

Private enterprise, in its classical profit-seeking role, has attempted to solve the problems of both market and organizational validity by coming up with a new type of market research procedure. Selling Areas-Marketing, Inc.--pronounced SAMI, a subsidiary of Time,

Inc.--is basically a market-by-market research organization with markets defined upon the basis of TV coverage patterns. SAMI works exclusively in the food field and works on the basis of warehouse withdrawals or shipments to retail stores. Chains, wholesalers, Health and Beauty Aid rack jobbers and frozen food warehouses deliver their entire set of movement figures in machine-readable form for the products handled by SAMI. SAMI then reformats this material, combining it with the SAMI product master codes and then processes it.

Depending upon processing systems, either the food operator or SAMI identifies those shipments going to stores inside or outside the given market area. Only the data from stores within the market are reported as such; the data for stores outside of a given area are used in developing national projections.

Let me summarize the advantages of a service like SAMI:

1. Its data are generated on a market-by-market basis and are not subdivisions of national totals; hence are ideal for experimentation.
2. Its data are aggregates of all shipments made by key chain and independent wholesalers accounting for 60% or more of the sales in an area.
3. Back data are often available.
4. SAMI covers almost 70 product groups, broken into about 400 categories.
5. However, fresh meat, perishables and such types of store-delivered items such as milk, bread and soft drinks do not appear in the SAMI reports.

Whether one is asked to select among SAMI markets as test units for market experimentation or deals with other types of geographically defined units, he is always concerned about pre-selecting markets in order to reduce variability among test areas. Paul Green et al have suggested the use of a numerical procedure--cluster analysis--to match prospective test markets on the basis of a large variety of characteristics which might affect test marketing results. ^{3/} However, they suggest that these characteristics be subject to factor analysis first, using the principal components procedure rather than using the characteristics as independent classification variables. Typically, one finds that, because of correlation among characteristics, he will wind up with a substantially smaller list of factors than he started with. Next, cluster analysis of one type or another is applied to the markets on the basis of their scores on the selected factors.

^{3/}Green, Paul E., Ronald E. Frank and Patrick J. Robinson, "Cluster Analysis in Test Market Selection," Management Science, Vol 13, No. 8, April 1967, pp. B387-400.

Appended to this paper are three tables illustrating the effect of clustering 88 SMSAs before and after factor analysis of 14 city characteristics. Two factors were identified: one was called "size" and the other "demographic." It is interesting to note that cluster 5 on Table 3 was closest to the origin of the factor axes--hence, these areas can be viewed as most representative of the 88. Note also that the groupings in Table 3 are somewhat different than those in Table 2 because of the implicit weighting of the 14 characteristics arising from their pattern of non-zero and varying intercorrelations.

Perhaps the most interesting of the classical innovations derives from CATV--the use of a special dual cable installation, set up primarily for television advertising research. ^{4/} By participating in the original wiring of a market, AdTel was able to hook up subscribers to either of the dual cables on an alternate checkerboard basis throughout the area--each A and B square represents a cluster of 80 to 90 homes. Let us first discuss the input side of this facility. Manipulation of messages is done at a special head-end installation where trained technicians view 3 consoles, one for each network. The top screen of the console shows the off-the-air picture; a second row has two screens, one for the A cable and one for the B cable; and the lower one is for previewing special videotaped commercials to be cut-in on either channel as desired. Working with a program schedule supplied by a participating advertiser, it is possible to add, delete, or change commercials--all appearing naturally in their original network or local program context. AdTel claims a 97% cut-in (or -out) completion rate--with the bulk of the failures coming from last minute changes on the part of networks or stations.

The research output of this facility derives from two matched panels of about 1,200 operative families on each of the two cables, 2400 in all, plus an oversupply of 15-20 percent in order to deliver a static sample of 1,000 per cable for tests running a year or more. The members of these panel families record all appropriate food, drug and household purchases in a weekly diary. Each major product has its own recording section within the diary. In addition, the diary contains a symptom section that is used to measure low-incidence health care products based upon reasons for their usage.

Initially, the two panels were matched on the basis of 62 different demographic, media, brand and buying characteristics. Two key matching criteria are the amount of time spent by the housewife watching television and the stores where panel members buy groceries and drugs. Demographics of panel members are updated once a year at the start of the fall television season.

^{4/} Adler, John and Alfred A. Kuehn, "How Advertising Works in Market Experiments," Proceedings, 15th Annual Conference, Advertising Research Foundation, (October 14, 1969) pp. 63-70.

In addition to the weekly panel reports, AdTel conducts three attitude and awareness studies--fall, winter and spring--among families who are not in the diary panel but whose location on the cable is known. Questions include top-of-mind awareness or salience, advertising recall, product usage and brand ratings.

McGuire points out that such dual or split cable television procedures avoid the "noisiness" of aggregate data and the logical difficulties of interpreting panel data from non-experimental or naturalistic exposures. ^{5/}

In my opinion, he makes a major contribution to experimentation by pointing out the need to treat advertising as operating on a different pattern of timing than other market variables such as price reductions, deals, coupons, store displays, etc. Normally, if one is interested in the cumulative effect of advertising, he provides for such a circumstance through the use of several months-long periods or through the use of carryover designs. However, in analyzing panel data, it is customary to analyze the data on a weekly or monthly basis. McGuire points out that weekly or monthly comparisons between the panel halves are designed to test for single shifts in relative purchasing behavior at time t_i against the null hypothesis of no effect.

He analyzed data consisting of purchases of a canned product by over two thousand families over a 64-week period, of which the last thirty-nine comprised the test period. All families which filed reports at least once in both the control and test periods were included, giving 1,085 families in the test panel and 1,227 families in the control panel; on the average, each family filed reports in 56 of the 63 periods measured. He found that use of a modified logistics response function increased the size of the advertising coefficient almost fourfold over that of the weekly average advertising impact measured by linear regression. The F statistic for testing the null hypothesis of no effect was converted from a number not quite significant at the 0.1 level to one significant at the .0001 level.

^{5/} McGuire, Timothy, "Measuring and Testing Advertising Effectiveness with Split-Cable TV Panel Data," Presented at the Annual Meeting of the American Statistical Association, Montreal, August 14-17, 1972.

A P P E N D I X

TABLE 1

City* Characteristics Used in the Cluster Analysis

Character- istic Number	Description of Characteristics	Measurement Units	Data Source
1	Population	Thousands of Persons	Sales Management
2	Number of Households	Thousands of Households	Sales Management
3	Retail Sales	Thousands of Dollars	Sales Management
4	Effective Buying Income	Thousands of Dollars	Sales Management
5	Median Age	Number of Years	U. S. Census
6	Proportion Male	Per Cent	U. S. Census
7	Proportion Non-White	Per Cent	U. S. Census
8	Median School Years Completed for Persons 25 Years and Over	Number of Years	U. S. Census
9	Proportion of Labor Force Unemployed	Per Cent	U. S. Census
10	Retail Outlets	Thousands of Outlets	U. S. Census
11	Wholesale Outlets	Thousands of Outlets	U. S. Census
12	Newspaper Circulation of Daily and Sunday Papers	Thousands of Papers	Printers' Ink
13	Television Coverage	Thousands of Homes Reached	American Research Bureau
14	Monthly Circulation of Transit Ads	Thousands of Exposures	Printers' Ink

18

*All cities are defined in terms of standard metropolitan areas. The nation's three largest cities--New York, Chicago and Los Angeles--were excluded due to disparate size.

Source:

Green, Paul E., Ronald E. Frank and Patrick J. Robinson, Management Science, Vol 13, April 1967 (B-352).

Results of Cluster Analysis (Original Data)

Cluster No.	City	Cluster No.	City	Cluster No.	City
1	Omaha Oklahoma City Dayton Columbus Fort Worth	7	Sacramento San Bernardino San Jose Phoenix Tucson	13	Allentown Providence Jersey City York Louisville
2	Peoria Davenport Binghamton Harrisburg Worcester	8	Gary Nashville Jacksonville San Antonio Knoxville	14	Paterson Milwaukee Cincinnati Miami Seattle
3	Canton Youngstown Toledo Springfield Albany	9	Indianapolis Kansas City Dallas Atlanta Houston	15	San Diego Tacoma Norfolk Charleston Ft. Lauderdale
4	Bridgeport Rochester Hartford New Haven Syracuse	10	Mobile Shreveport Birmingham Memphis Chattanooga	16	New Orleans Richmond Tampa Lancaster Minneapolis
5	Wilmington Orlando Tulsa Wichita Grand Rapids	11	Newark Cleveland Pittsburgh Buffalo Baltimore	17	San Francisco Detroit Boston Philadelphia
6	Bakersfield Fresno Flint El Paso Beaumont	12	Albuquerque Salt Lake City Denver Charlotte Portland	18	Washington St. Louis

Points not in a cluster: Honolulu
Wilkes-Barre

Source:

Green, Paul E., Ronald E. Frank and Patrick J. Robinson, Management Science,
Vol 13, April 1967 (B-393).

TABLE 3

Results of Cluster Analysis (Factored Data)					
Cluster No.	City	Cluster No.	City	Cluster No.	City
1	Charlotte Nashville Omaha Oklahoma City Memphis	7	Birmingham Syracuse Tulsa Grand Rapids Youngstown	13	Peoria Davenport Richmond Fort Lauderdale Hartford
2	Bridgeport Louisville New Haven Rochester Toledo	8	Birmingham Knoxville Chattanooga Harrisburg Canton	14	Paterson Cincinnati Miami Portland New Orleans
3	Orlando Flint Shreveport Beaumont Mobile	9	St. Louis Newark Pittsburgh Cleveland Buffalo	15	Tampa Providence Jersey City York Wilkes-Barre
4	Jacksonville Wichita San Antonio Tucson Bakersfield	10	Springfield Worcester Albany Allentown Lancaster	16	Indianapolis Kansas City Baltimore Houston Washington
5	Dayton Fort Worth Columbus San Bernardino Denver	11	Dallas Seattle Atlanta Minneapolis Milwaukee	17	San Francisco Detroit Boston Philadelphia
6	Albuquerque El Paso Tacoma Salt Lake City Sacramento	12	Phoenix San Jose Gary Fresno Wilmington	18	San Diego Norfolk Charleston Honolulu

Source:

Green, Paul E., Ronald E. Frank and Patrick J. Robinson, Management Science, Vol 13, April 1967 (B-396).

ADVERTISING RESPONSE FUNCTIONS WITH RANDOM COEFFICIENTS

Lester H. Myers*

INTRODUCTION

Methodological issues related to advertising research can be delineated into three problem areas. First, and possibly the most difficult, is the problem of securing relevant observations (data). Work in this area can be divided into the controlled experiment approach, as exemplified by the work of Clement et al. [2] and the time series approach as exemplified by Nerlove and Waugh [7] and more recently by McClelland et al. [6]. A second problem area deals with the statistical analysis once the data have been secured. While the methods used here depend somewhat on the nature of the available data, some recent emphasis has been placed on regression analysis to obtain estimates of the advertising response functions (see McClelland et al. [6] and Ward and Richardson [12]). The third problem area involves the development of decision models for determining optimum allocations of advertising budgets. These models appear to be fairly well developed in the literature.¹

Although these three problem areas are interdependent, this paper is primarily devoted to estimation models. Specifically, I would like to suggest a type of regression model, called random coefficients regression (RCR), as a technique for estimating advertising response functions. The technique follows from the logic of the response model and provides (1) an estimation technique which is more consistent with the way in which the real world response function is generated and (2) additional information about the variance of the demand function which may be used by decision makers in allocating advertising budgets.

THE ECONOMIC MODEL

Random Coefficients

It is assumed, for the purposes of this paper, that the relationship of interest is the consumer demand function. That is, we are primarily interested

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¹See Bass, et al. [1] for several allocation models. Also, McClelland et al. [6] represents the empirical application of an allocation model to citrus advertising expenditures.

in measuring how various levels of advertising expenditures affect the demand for a given commodity. Furthermore, let us assume that the measurement of this demand function is based upon a time series of cross section observations. Time series of MRCA consumer panel or of A.C. Neilson foodstore audit data are consistent with this assumption.

Given these assumptions let the industry-wide demand function for the commodity of interest be expressed in linear form as follows:²

$$(1) \quad Q_t = b_0 + b_1 P_t + b_2 A_t + b_3 I_t + \mu_t$$

where:

Q_t is the per capita consumption of the commodity during period t ;

P_t is the average price for the commodity during period t ;

A_t is the advertising expenditure for the commodity during period t ;

I_t is the per capita income during period t ;

μ_t is the random error term; and

b_k ($k = 0, \dots, 3$) are unknown parameters.

Equation (1) represents an aggregate demand function and is based upon the theory of individual consumer behavior. In order to arrive at a "nice" aggregate function, we usually make two very important assumptions regarding the nature of demand functions across individuals. First, we assume that all consumers in the market face a uniform price. Second, we assume that the parameters of the individual demand functions are constant among individuals. That is, individual A responds to price changes in the same way as individual B. These, of course, are fairly unrealistic assumptions.

Suppose we reformulate (1) as follows:

$$(2) \quad Q_{it} = b_{0i} + b_{1i} P_{it} + b_{2i} A_{it} + b_{3i} I_{it} + \mu_{it} \\ (i = 1, 2, \dots, n; t = 1, 2, \dots, T).$$

The subscript i refers to an observation on an individual and the subscript t refers to a time series observation period. This model allows coefficients to vary from individual to individual and at the same time does not assume that, for a given observation period, all units face equal independent variable values. Several people including Zellner [13], Swamy [8 and 9] and Theil and Mennes [10] have considered the statistical implications of equation (2).

The conclusions differ somewhat depending upon the assumptions made regarding the sample. If we assume that there is a random selection of individuals from a population of individuals whose behavior is described by

²In order to simplify the presentation, it is assumed that the total advertising response occurs during the period of the expenditure and that no close substitutes for the commodity exist.

(2), then the result is a random coefficients regression (RCR) model of the following formulation:

$$(3) \quad Q_{it} = (\bar{b}_1 + \mu_{1it})P_{it} + (\bar{b}_2 + \mu_{2it})A_{it} + (\bar{b}_3 + \mu_{3it})I_{it} + (\bar{b}_0 + \mu_{0it})$$

where:

Q_{it} is the quantity sales to unit i during observation period t ;

P_{it} is the average price paid by unit i during observation period t ;

A_{it} is the amount of advertising expenditures spent on advertising message available to unit i during observation period t ;

I_{it} is the income of unit i during period t ; and

the \bar{b}_k 's ($k = 0, \dots, 3$) are unknown means of the coefficients and the μ_{kit} 's are the additive random elements in the coefficients.

It is assumed that for $i, j = 1, 2, \dots, n$; $t, t' = 1, 2, \dots, T$; and

$k, k' = 0, 1, \dots, 3$:

$$(4) \quad E(\mu_{kit}) = 0$$

$$E(\mu_{kit}\mu_{k'jt'}) = \begin{cases} \sigma_{kk'} & \text{if } i = j, t = t' \text{ and } k = k' \\ 0 & \text{otherwise} \end{cases}$$

where i, j refer to individual units; t, t' refer to observation periods; and k, k' refer to individual coefficients.

The interpretation of model (3) under assumption (4) is that if an independent variable increases by one unit, all other independent variables remaining constant, the dependent variable responds with a random change with a finite mean and a positive variance. The randomness of the coefficients is attributed to the random selection of individuals from a population of individuals whose behavior is described by equation (2).³

³The randomness in the coefficient for advertising expenditures may be generated in an additional manner. The advertising expenditure variable in most cases will be expressed in dollars expended. Actual dollars are spent for various media, copy, publication outlets, etc. If we do not assume, for example, that a dollar spent on T.V. advertising is equivalent to a dollar spent on newspaper advertising, then we again introduce a random response to advertising expenditures.

COEFFICIENTS AS STOCHASTIC FUNCTIONS OF INDEPENDENT VARIABLES

Income Levels and Advertising Response

In the development thus far, we have argued that the consumer demand response to advertising changes is random with a finite mean and positive variance. In this section I would like to go a step further and suggest that the response is a stochastic function of a systematic variable. There is some appeal to the idea that how one reacts to a given amount and quality of advertising pressure is dependent upon the socio-economic characteristics possessed by the individual. As an extreme example, one could argue that a nationwide television commercial for Lincoln Continental automobiles will elicit substantially lower sales response among welfare recipients than among executives of large corporations.

Perhaps a more realistic example is the experience of the Florida citrus industry. Since about 1967-68, the generic advertising program has been designed to give equal message weight to all three major forms of processed orange juice (frozen, chilled and canned). The reaction in terms of sales changes since 1967 has been quite different among different economic groupings. For example, from 1967 to 1971, consumption of canned orange juice per household decreased 32 percent for upper income levels and increased 13 percent for lower middle income levels. Presumably, both economic segments were subjected to the same quality and intensity of advertising message. Also, this difference is difficult to explain by income levels alone since the relative prices of frozen and canned orange juice are such that lower income people would be better off financially by buying frozen as opposed to canned orange juice.

Let us assume then that the response to advertising expenditures is a stochastic function of income levels.⁴ For equation (2), the advertising component might be reformulated as:

$$(5) \quad b_{2it} A_{it} = (\beta_3 + \beta_4 I_{it} + \mu_{2it}) A_{it}$$

where assumptions (4) still hold.

Advertising Levels and Price Response

Another look at equation (2) with respect to the effects of advertising expenditures on the price-quantity relationship is in order. This model assumes that alternative levels of advertising expenditures will shift the price-quantity relationship but that these shifts are parallel shifts. Figure 1 illustrates the situation for two levels of advertising expenditures (A_{i1} and A_{i2}).

⁴ See Langham and Mara [5] for a description of the situation where the coefficient is believed to be a stochastic function of time.

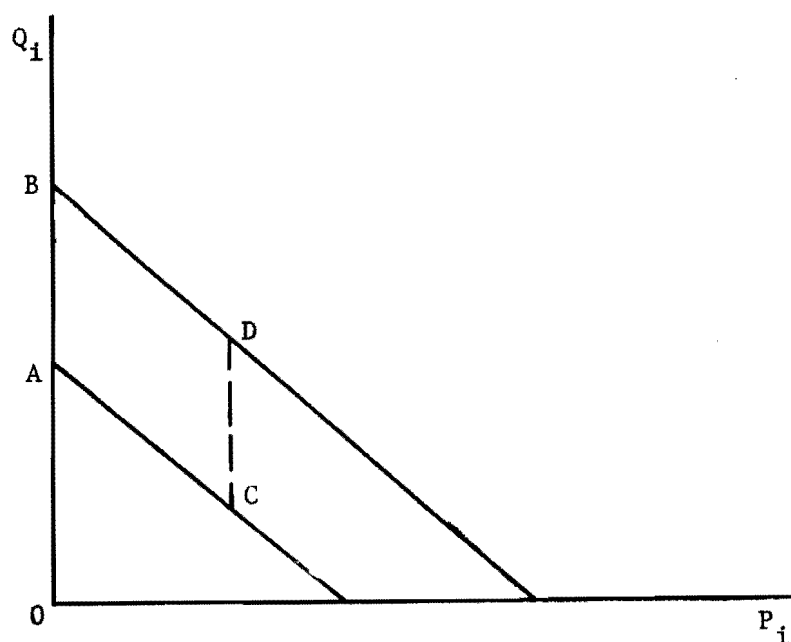


Figure 1.

In Figure 1, point A represents the price-quantity intercept when advertising levels are at A_{i1} ; i.e., from equation (2), $A = b_0 + b_{21}A_{i1}$.

Point B represents the price-quantity intercept when advertising levels are increased to A_{i2} ; i.e., from equation (2), $B = b_0 + b_{21}A_{i2}$. Then the vertical distance between the two price-quantity lines is $D - C$, or $b_{21}(A_{i2} - A_{i1})$.

That is, the price-quantity relationship for an individual unit will shift by the amount of the advertising expenditure change times the respective advertising coefficient. The price-quantity slope remains constant, which suggests that advertising really doesn't influence product loyalty with respect to price adjustments.

It would appear that a much more realistic model would allow for price-quantity slope changes as advertising levels change. That is, our model should permit advertising changes to affect the price-quantity slope as well as the level of the relationship. For equation (2), the price component might be reformulated as:

$$(6) \quad b_{1i}P_{it} = (\beta_1 + \beta_2 A_{it} + \mu_{1it})P_{it}$$

where assumptions (4) still hold. Suppose we let:

$$(7) \quad \bar{b}_0 = \beta_0 \text{ and } \bar{b}_3 = \beta_5.$$

Then substituting (5), (6) and (7) into (3) gives:

$$(8) \quad Q_{it} = \beta_0 + \beta_1 P_{it} + \beta_2 P_{it} A_{it} + \beta_3 A_{it} + \beta_4 A_{it} I_{it} + \beta_5 I_{it} + w_{it}$$

$$\text{where } w_{it} = \mu_{0it} + \mu_{1it} P_{it} + \mu_{2it} A_{it} + \mu_{3it} I_{it}.$$

Given assumptions (4) and letting the observations run from 1 to m,

where $m = n$ times T , then:

$$(9) \quad E(WW') = \Theta = \begin{bmatrix} \theta_{11} & \dots & \theta_{1m} \\ \vdots & \ddots & \vdots \\ 0 & \dots & \theta_{mm} \end{bmatrix}$$

Assuming the independent variables to be fixed:

$$(10) \quad \theta_{jj} = \sigma_{00} + \sigma_{11} P_j^2 + \sigma_{22} A_j^2 + \sigma_{33} I_j^2 \quad (j = 1, 2, \dots, m).$$

The classical linear regression model is a special case of the RCR model when $\mu_{kit} = 0$ for $k = 1, 2, 3$. That is, the classical linear regression model allows for random variation in the intercept only. Intuitively it seems inconsistent to allow for random variation of the intercept coefficient and to assume fixed parameters for the slope coefficients. Thus, the RCR model appears much more realistic than the OLS model.

IMPLICATIONS OF MODEL

In summary form, the model of advertising response thus far developed leads to the following implications.

- (a) Primarily because of aggregation across sample units, random variation in the slope coefficients should be permitted.
- (b) Consumer reaction to certain independent variable values is systematically related to certain other independent variable values suggesting that cross-products of selected variable pairs be included as additional explanatory variables in the model.
- (c) Because of random variation in the slope coefficients, the variance of w_{it} is a function of the independent variable values; i.e., w_{it} is heteroscedastic and ordinary least squares will yield unbiased but inefficient estimators.

- (d) Since the variance of w_{it} is a function of the independent variable values and if a decision maker has control over at least some of the independent variable values, his actions will affect not only the average value of Q_{it} (in our model) but the variance of Q_{it} as well. It is realistic to assume that commodity organizations have control of advertising budgets and may derive some utility from the manipulation of the variance of demand as well as the average level of demand.

AN ESTIMATION PROCEDURE

Several researchers have suggested estimation methods for obtaining consistent estimators for equation (8). These methods center around the Aitken's generalized least squares estimator:

$$(11) \hat{\beta} = (X'\Theta^{-1}X)^{-1} X'\Theta^{-1}Y$$

where:

- $\hat{\beta}$ is the vector of estimates for the β coefficients of equation (8);
- X is the matrix of independent variable values;
- Θ is as described in (9) and (10); and
- Y is the vector of dependent variable values.

A major problem with (11) is that Θ is unknown. Alternatives to (11) involve the use of an estimate of Θ to derive a generalized feasible Aitken's estimator that is consistent and asymptotically efficient.

The stepwise procedure suggested here is developed primarily by Hildreth and Houck [3] and Theil [11]. The first step toward obtaining consistent and asymptotically efficient estimates for (8) is to estimate the coefficients of equation (8) using ordinary least squares. Obtain from this regression a vector of residuals, E , where E represents the least squares estimates of W from (9). Then following Hildreth and Houck [3, p. 586] it can be shown that:

$$(12) \dot{E} = G\sigma + z$$

where:

- \dot{E} is a vector of squared residual terms; i.e., $\dot{e}_{it} = e_{it}^2$;
- G is a known function of the independent variables in matrix form;
- σ is the vector of unknown variances; and
- z is a vector of residuals where each element is defined as the difference between e_{it}^2 and the expected value of e_{it}^2 .

One possibility is to use OLS to estimate σ from equation (12). Theil [11, p. 624] shows that if OLS is used to estimate (12), the error term is also heteroscedastic and suggests using a generalized feasible Aitken's estimator to estimate the elements of σ . Thus, the second step is to apply weighted least squares to (12) to obtain estimates of σ , σ^* .

The third step is to use the estimates of σ_{kk}^* ($k = 0, \dots, 3$) to replace the σ_{kk} in equation (10) in order to obtain an estimate of θ, θ^* . Then, the estimated matrix θ^* is used in turn to derive consistent estimators for (11); i.e.,

$$\beta^* = (X' \theta^{*-1} X)^{-1} X' \theta^{*-1} Y$$

While this appears to be a complicated process it can be programmed so that to the applied researcher it is no more difficult than many other techniques currently being used.

One very important problem with estimating the σ_{kk} with OLS is that there are no sign restrictions on the estimates and it is very likely that some of the estimates will be negative. Hildreth and Houck suggest two alternative ways around this problem. The first is defined as:

$$\tilde{\sigma}_{kk} = \max(\sigma_{kk}^*, 0)$$

That is, if the weighted least squares estimate of σ_{kk} turns out to be negative, set it equal to zero.

The second procedure suggested is to minimize the sum of squares of (12) subject to the constraint that all σ_{kk}^* are greater than or equal to zero. This turns out to be a quadratic programming problem and a solution algorithm is given by Judge and Takayama [4].

USE OF VARIANCE INFORMATION FOR DECISION MAKING

Economists normally assume as an objective function for a firm or industry the maximization of profits. Certain resource constraints are, of course, incorporated into the model. It would seem reasonable to assume further that industry decision makers would have some interest in the variability of sales and/or profits as well as the average level of each.

Suppose that the firm or industry produces a product (Q) for which the demand is a function of price (P), advertising expenditures (A) and consumer incomes (I) as follows:

$$Q = f(P, A, I)$$

with a variance function

$$\sigma_q^2 = g(P, A, I).$$

Assuming a linear total cost function and fixed prices for Q, the profit function would be derived as follows:

$$\begin{aligned} TR &= P_q Q = P_q f(P, A, I) \\ TC &= kQ = kf(P, A, I) \\ \pi &= TR - TC = (P_q - k) f(P, A, I) \end{aligned}$$

The firm or industry might be expected to maximize expected profit subject to an acceptable variance constraint and possibly some other resource or production constraints. Assuming the firm or industry has control over advertising expenditures but not prices or consumer incomes, then an appropriate model might be:

$$\begin{aligned} \text{max: } & (P_q - k) f(P, A, I) \\ \text{s.t. } & \bar{g}(\bar{P}, A, \bar{I}) \leq \tilde{\sigma}_q^2 \\ & \bar{P}, A, \bar{I} \geq 0 \end{aligned}$$

The first inequality assures that the variance would be smaller than some acceptable level, $\tilde{\sigma}_q^2$, to the decision maker. The left side of this constraint simply states the variance function when P and I levels are determined exogenous to the firm or industry and A is the critical decision variable.

The RCR model proposed here for measuring advertising response functions provides a way for measuring the variance function as well as the profit function and represents a statistical model that is consistent with the economic model under the assumption that the utility of a producer, or group of producers, is a function of expected profits and the variance of profits.

SUMMARY

The RCR model for estimating advertising response functions is appealing first because it permits random variation of the coefficients and second because it provides knowledge of the variance function which could be of value to decision makers.

The main implications of the model development as presented in this paper are:

- (1) Cross-products between a price variable and the advertising expenditure variable should enter the model to permit price-quantity slope changes as well as level changes due to advertising pressure.
- (2) Cross-products between an advertising expenditure variable and consumer incomes should enter the model to permit a systematic variation in advertising response according to income groupings.
- (3) The error terms are heteroscedastic and a generalized feasible Aitken's estimator should be used to estimate the coefficients.

The basic demand function presented for illustrative purposes throughout this paper is not intended to be a complete advertising response function. When formulating such a function one would want to consider advertising lag effects, prices of substitutes, etc. The intent here is primarily to present the RCR concept. The application of RCR models to distributed lag models is discussed by Swamy [9], and the practitioner is referred to that article for the model specification when lagged responses to advertising expenditures are suspected.

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ON THE RELATIONS BETWEEN DEMAND CREATION AND GROWTH IN A MONOPOLISTIC FIRM*

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INTRODUCTION

A monopolistic firm makes decisions over time about the allocation of its resources between investments in the production process and investments in the selling process. Within a static framework, there is extensive literature on the subject; references can be found in Hahn [7], Hieser and Soper [8], and Ball [2]. Nerlov and Arrow [13] formulated and analyzed a dynamic model for a monopolistic firm facing a demand law influenced by advertising. In their model they assume that there is a stock of goodwill measured in units having a price of \$1.00, so that a dollar of advertising expenditure increases the stock of goodwill by a like amount. Even though they initially formulated the problem as a functional one in advertising and price, they then reduced it to a functional one in advertising alone. Dhrymes [3] extended the same model to include investment in productive capital as well.

Thompson and Proctor [16] analyzed the behavior of a monopolistic firm encompassing investments, output prices, informative advertising, and brand advertising; their model is basically linear in its structure with a linear demand function and a fixed-coefficient production function.

A number of economists (Gould [5], Treadway [17], and Lucas [10,11], for example) recently contributed analyses using the "cost of adjustment" argument to obtain an investment demand function for the competitive firm. Gould [6] applied this approach to optimal advertising policy but retained the assumption of competitive conditions in the product market; he did not take into consideration investment in productive capital.

In our present model we use an approach similar to the one adopted by Hochman et al. [9] in analyzing the demand for investment in productive and financial capital and apply it to the relations between demand creation and the growth of a monopolistic firm.

As the demand-creation relations follow an S-shaped curve, different phases in the behavior of the growing firm are conceived.

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In the early stages of growth, all resources are invested in the expansion of the firm's production capacity; there is no activity in demand creation. This phase is followed by a second one in which all investments are channeled to demand-creation capital. In this phase the firm takes advantage of the increasing marginal returns to demand-creation capital by diverting into demand creation some of the existing productive resources acquired during the first phase. In the last phase the firm chooses to invest in both types of capital. The steady state is reached in the last phase in regions of decreasing marginal returns to both types of capital.

Regarding the optimal dynamic path, it is shown that operation in a region where the schedule of demand creation follows an S-shaped curve will result in an investment cycle in productive capital: Positive investment in the first interval is followed by disinvestment in the second interval; then there is a renewal of investment in productive capital in the last interval. The cycle in demand-creation capital, on the other hand, is characterized by zero investments at the first interval followed by positive investment at an increasing rate through the following intervals although, during the last interval, the rate of investment starts to decrease. Investment in demand creation after it starts is always continuous, contrary to investment in productive capital.

When there are investment or disinvestment activities in both types of capital (phases II and III), it is shown that the Dorfman-Steiner theorem [4] is replaced by the following: A firm which can influence the demand for its product through direct allocation to demand-creation capital will allocate its resources between this type of capital and productive capital in such a way that the ratio of the rate of growth of demand price (with respect to demand-creation capital) and the rate of growth of output (with respect to productive capital) will be equal to one plus the reciprocal of the elasticity of demand and will, therefore, be bounded between zero and one.

THE MODEL

Let K denote the stock of resources utilized in producing the quantity sold q . The production function $q = q(K)$ is twice continuously differentiable where $q_K > 0$ and $q_{KK} < 0$. The assumption that production is a function of only one resource, which may be interpreted as a production function with fixed proportion between capital and labor, is adopted here since it simplifies the exposition considerably and allows us to concentrate on the main problem of allocation between production and demand creation.

The firm may divert part of its resources (human and nonhuman) such as skillful labor, research personnel, and equipment and buildings to departments that either involve themselves directly with the promotion of sales (see Hieser and Soper [8]) or are involved in research and development (R & D)

of the product, i.e., changes in the quality of the product holding the output constant. Let A denote this type of capital which is devoted directly to demand creation, and let the demand relations be defined by $p = p(q, A)$. The price function is twice continuously differentiable with $p_q < 0$, $p_{qq} < 0$, and $p_A > 0$. The second partial differential p_{AA} behaves as described in Figure 1; it is first positive and then changes to negative at inflection point (A) .

The assumption of S-shaped relations of demand creation has both theoretical and empirical bases (see the discussions in Rao [15] and Hieser and Soper [8]). The state of the firm is described by the two variables K and A whose rates of change over time are given by

$$\dot{K} = I - \sigma K \quad (1)$$

$$\dot{A} = a - \sigma A \quad (2)$$

where I denotes gross investment in productive capital; and a denotes current outlays in advertising, R & D, and any other expenditures that directly influence the price of the product at a given output. We assume equal rates of depreciation of both stocks. 1/

The cash flow during each period of the firm is thus 2/

$$R = pq - w(c) \quad (3)$$

where $c = a + I$, the total gross investment at period t . The "adjustment cost" function $w(c)$ includes the price of capital as well as the cost of adjustments and is defined by $w(c) \geq 0$ for $c \geq 0$, where $w_c > 0$ and $w_{cc} > 0$.

1/ The assumption of equal rates of depreciation may be justified by considering the total stock of resources available for the firm as pooled together under the heading of "capital" while, on the optimal path, decisions are made as to what portion will be diverted into production and what portion into demand creation.

2/ The independent variable t will be omitted whenever possible.

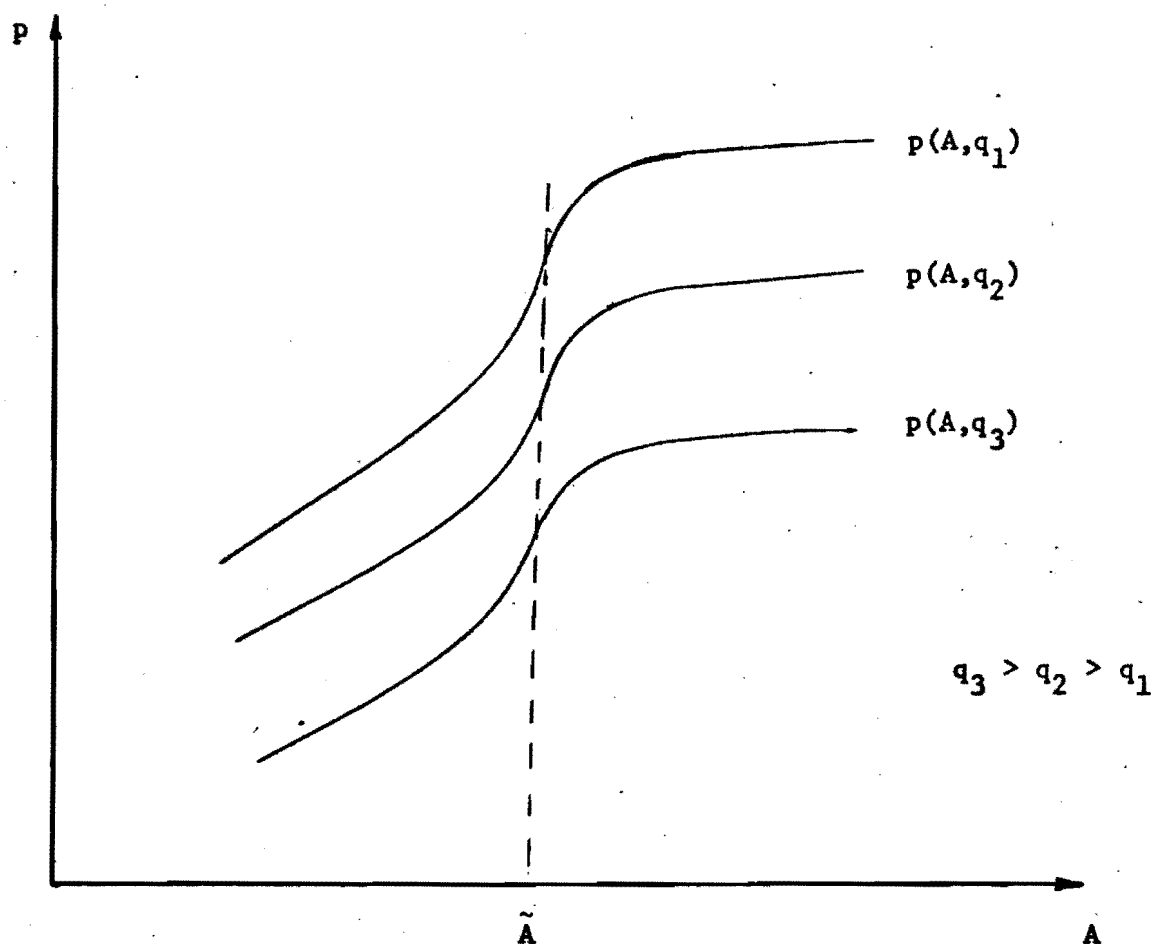
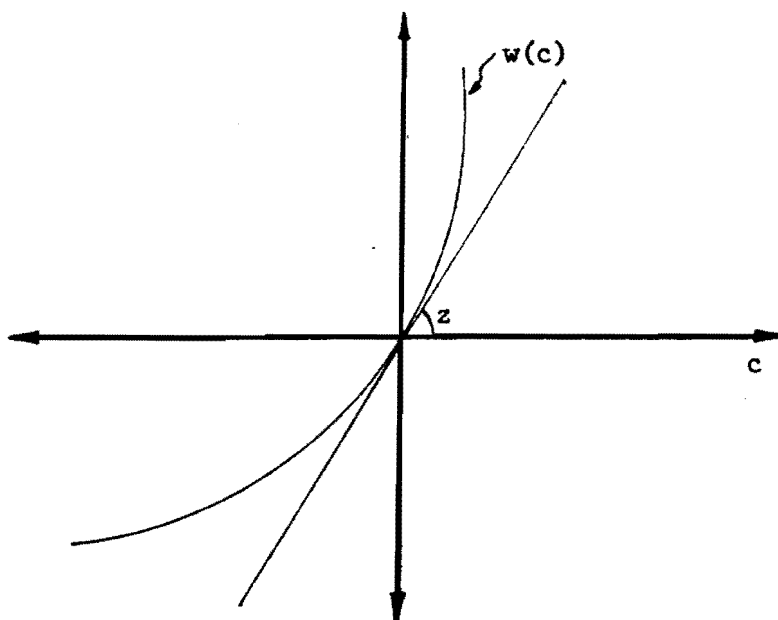


Figure 1

for all values of c . ^{3,4/} Thus, the maximization problem of such a firm can be stated as follows:

$$\max \int_0^{\infty} R e^{-rt} dt = \int_0^{\infty} [pq - w(c)] e^{-rt} dt \quad (4)$$

^{3/} This can be made more explicit by assuming the cost component in the function to be equal to $z \cdot c$, where z is the price of capital in the market. If the capital market is competitive and z has a fixed value, the function $w(c)$ has the following shape:



At the point $c = 0$ $w = z$, but the adjustment costs divert the function $w(c)$ from its tangent at $c^c = 0$ as C increases or decreases. If the capital market is imperfect, the deviation from the tangent is increased.

^{4/} The same model may describe alternatively a firm which allocates its skilled labor between production and demand creation, other resources being fixed. Note that, if this approach is adopted, even though labor is hired, it is considered as a stock of human capital. This may be the case in a firm which supplies services only and its employees are not fired as a matter of policy, e.g., the IBM Corporation. The prospective employee needs special training which is taken into account in the adjustment costs, and his "price" is measured by the discounted value of his future salaries. In case of budget cutting, the firm gains the discounted value of all future salaries which the fired employees would have received after deduction of costs of adjustment caused by compensation payments and other frictional costs. We assume that the adjustment costs of recruiting new employees are the dominant factor so that the adjustment costs of reallocating them between the different departments may be ignored.

subject to

$$\begin{aligned}\dot{K} &= I - \sigma K \\ \dot{A} &= I - \sigma A \\ K + I &\geq 0, K(0) = K_0 \\ A + a &\geq 0, A(0) = A_0.\end{aligned}$$

This is a problem of calculus of variations where the state variables are K and A and the controls are I and a . ^{5/}

DESCRIPTION OF RESOURCE ALLOCATION BETWEEN DEMAND CREATION AND GROWTH OF THE FIRM

Applying the Maximum Principle [1] and [14] by using the current value Lagrangian

$$\begin{aligned}L(A, K, \lambda_1, \lambda_2, a, I, \mu_1, \mu_2) e^{rt} &= pq - w(c) + \lambda_1(a + \sigma A) + \lambda_2(I + \sigma K) \\ &+ \mu_1(A + a) + \mu_2(K + I)\end{aligned}\quad (5)$$

we obtain the necessary conditions for maximization as follows:

$$\begin{aligned}(a) \quad w_c &\leq \lambda_1 & (w_c - \lambda_1)(A + a) &= 0 \\ (b) \quad w_c &\leq \lambda_2 & (w_c - \lambda_2)(K + I) &= 0 \\ (c) \quad \dot{\lambda}_1 &\leq \lambda_1(r + \sigma) - P_A q & [\dot{\lambda}_1 - \lambda_1(r + \sigma) + P_A q] (A + a) &= 0 \\ (d) \quad \dot{\lambda}_2 &\leq \lambda_2(r + \sigma) - q_K^{MRq} & [\dot{\lambda}_2 - \lambda_2(r + \sigma) + q_K^{MRq}] (K + I) &= 0\end{aligned}\quad (6)$$

where $MRq = \frac{d}{dq} (pq)$.

^{5/}See Arrow and Kurz [1] and Pontryagin et al. [14].

Note that, if there is any production and sale activity by the firm, equality always holds in (6b) and (6d); the only alternative is exit from the industry. ^{6/} Assuming the conventional negative-sloped marginal revenue curve (MRq), there is a level of output, say q_0 , such that

$$MRq[q, p(q, 0)] \geq 0 \text{ for } q \leq q_0$$

and

$$MRq[q, p(q, 0)] \leq 0 \text{ for } q \geq q_0.$$

There also exists a value of productive capital \hat{K} such that

$$q_K(\hat{K})MRq[q(\hat{K}), p(q(\hat{K}), 0)] = p_A[q(\hat{K}), 0] \cdot q(\hat{K})$$

where $q(\hat{K}) < q_0$.

If the initial state is such that $K_0 < \hat{K}$ and $A_0 = 0$, the following system of equations holds:

$$\begin{aligned} (a) \quad & A = 0, \quad a = 0 \\ (b) \quad & \lambda = W_c(I) \\ (c) \quad & \dot{\lambda} = \lambda(r + \sigma) - q_K(K)MRq[q(K), 0]. \end{aligned} \tag{7}$$

Conditions (7b) and (7c) have the usual interpretation: (7b) states that the shadow price $\lambda(t)$ must be equated to the marginal cost of investment in productive capital at time t ; and (7c)--in integral form--states that $\lambda(t)$ is the discounted value at time t of later values of marginal products of productive capital, which in turn equals--by (7b)--the immediate marginal cost of adjustment (see Treadway [17]).

At $K = \hat{K}$ (6a) and (6c) become equalities, and the firm starts to invest in demand creation as well. The following system of equations will replace (7).

$$\begin{aligned} (a) \quad & A + a > 0, \quad K + I > 0 \\ (b) \quad & \lambda = w_c(c) \\ (c) \quad & \dot{\lambda} = \lambda(r + \sigma) - q_K(K)MRq[q(K), A] = \lambda(r + \sigma) - p_A[q(K), A]q(K) \\ (d) \quad & q_K(K)MRq[q(K), A] = p_A[q(K), A]q(K). \end{aligned} \tag{8}$$

Condition (8c)--in integral form--states that $\lambda(t)$ is at the same time the discounted value of later values of marginal products of demand creation capital. Condition (8d) describes the well-known equality of the values

^{6/} See discussion of the behavior in phase I at page 15 and also in Treadway [17].

of the marginal products of the two types of capital. If we denote $\eta_{yx} = (\partial y / \partial x) (x/y)$, then (8d) can be rewritten

$$\frac{1}{K} \eta_{qK} (1 + \eta_{pq}) = \frac{1}{A} \eta_{pA}. \quad (9)$$

From (9), we can verify that the ratio between the rate of growth in demand price resulting from investment in A and the rate of growth in output resulting from investment in K equals $1 + \eta_{pq}$. From the fact that $\eta_{pq} < 0$ and the rational behavior of the monopolist in choosing such outputs that $MR_q \geq 0$, we have on the optimal path:

$$0 \leq \frac{\text{rate of growth in demand price with respect to A}}{\text{rate of growth in output with respect to K}} \leq 1.$$

We now assume weak separability in the demand relations which imply: 7/

$$\begin{aligned} (a) \quad \frac{\partial}{\partial q} (\eta_{pA}) &= 0 \\ (b) \quad \frac{\partial}{\partial A} (\eta_{pq}) &= 0 \end{aligned} \quad (10)$$

Thus, under (10), the left-hand side of (9) is a function $f(K)$ of K alone; and the right-hand side is a function $g(A)$ of A alone.

In Figure 2 we draw $f(K)$ as a function of K under the assumption of diminishing marginal products of productive capital; and $g(A)$, as a function of A under the assumption that $p(A, q)$ for any given q , behaves as described in Figure 1. The relations between K and A on the optimal path can be derived directly from Figure 2 and are described in the (K, A) plane by the

segmented curve (Q-curve) in Figure 3. Let $Q(K, A) = \frac{1}{K} \eta_{qK} (1 + \eta_{pq}) - \frac{1}{A} \eta_{pA}$.

Then, the segmented Q-curve can be divided into three segments:

$$\begin{aligned} S_1 &= \{(K, A) : Q(K, A) > 0, 0 \leq K \leq \hat{K}, A = 0\} \\ S_2 &= \{(K, A) : Q(K, A) = 0, \tilde{K} \leq K \leq \hat{K}, 0 \leq A \leq A_m\} \\ S_3 &= \{(K, A) : Q(K, A) = 0, \tilde{K} \leq K \leq \bar{K}, A_m \leq A < \infty\} \end{aligned}$$

7/ The meaning of the assumptions of weak separability is that, in the plane (p, q) , the tangents to the demand curves for different A 's but the same q intersect at the same point; it is the same in the (p, A) plane for different q 's but the same A .

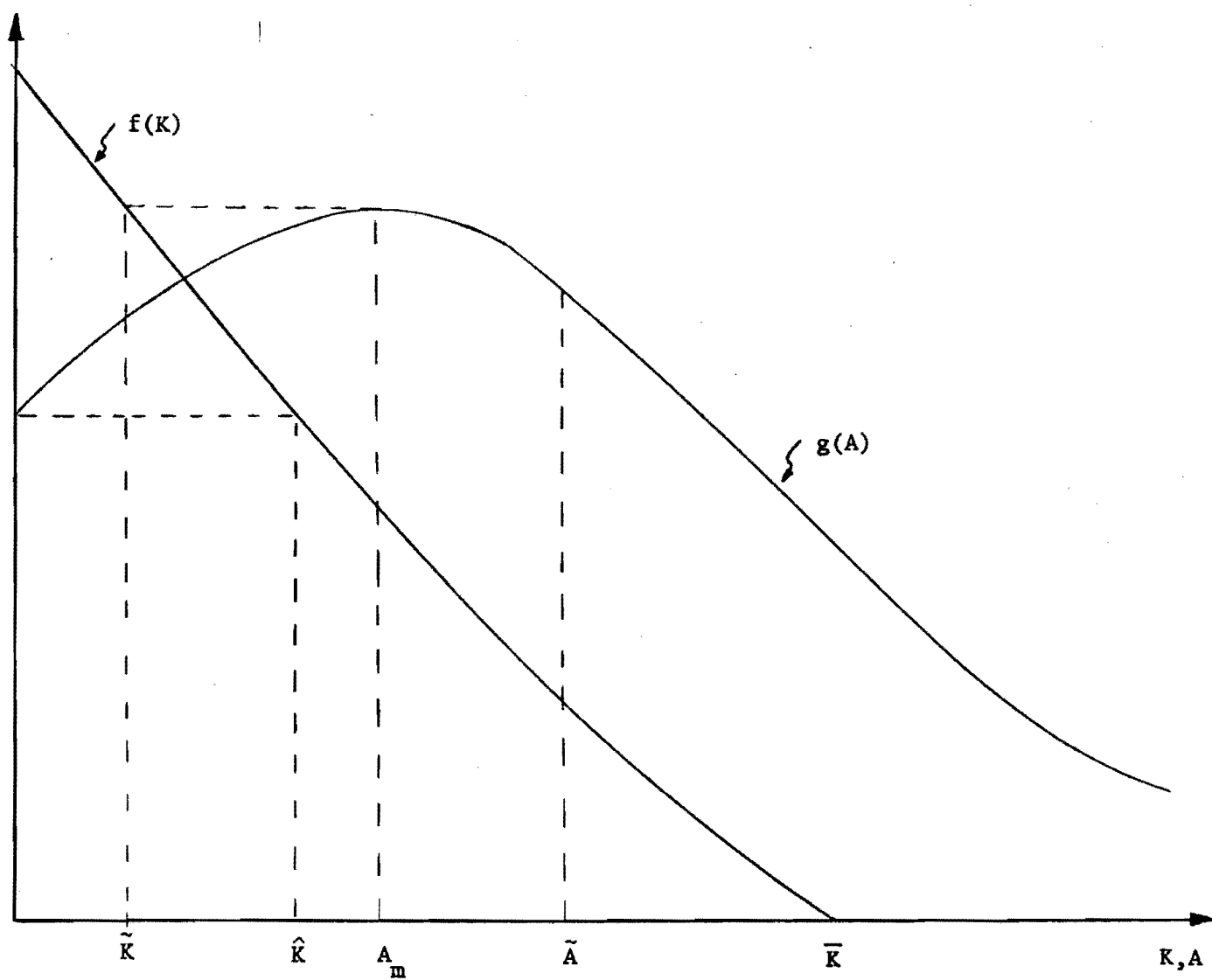


Figure 2

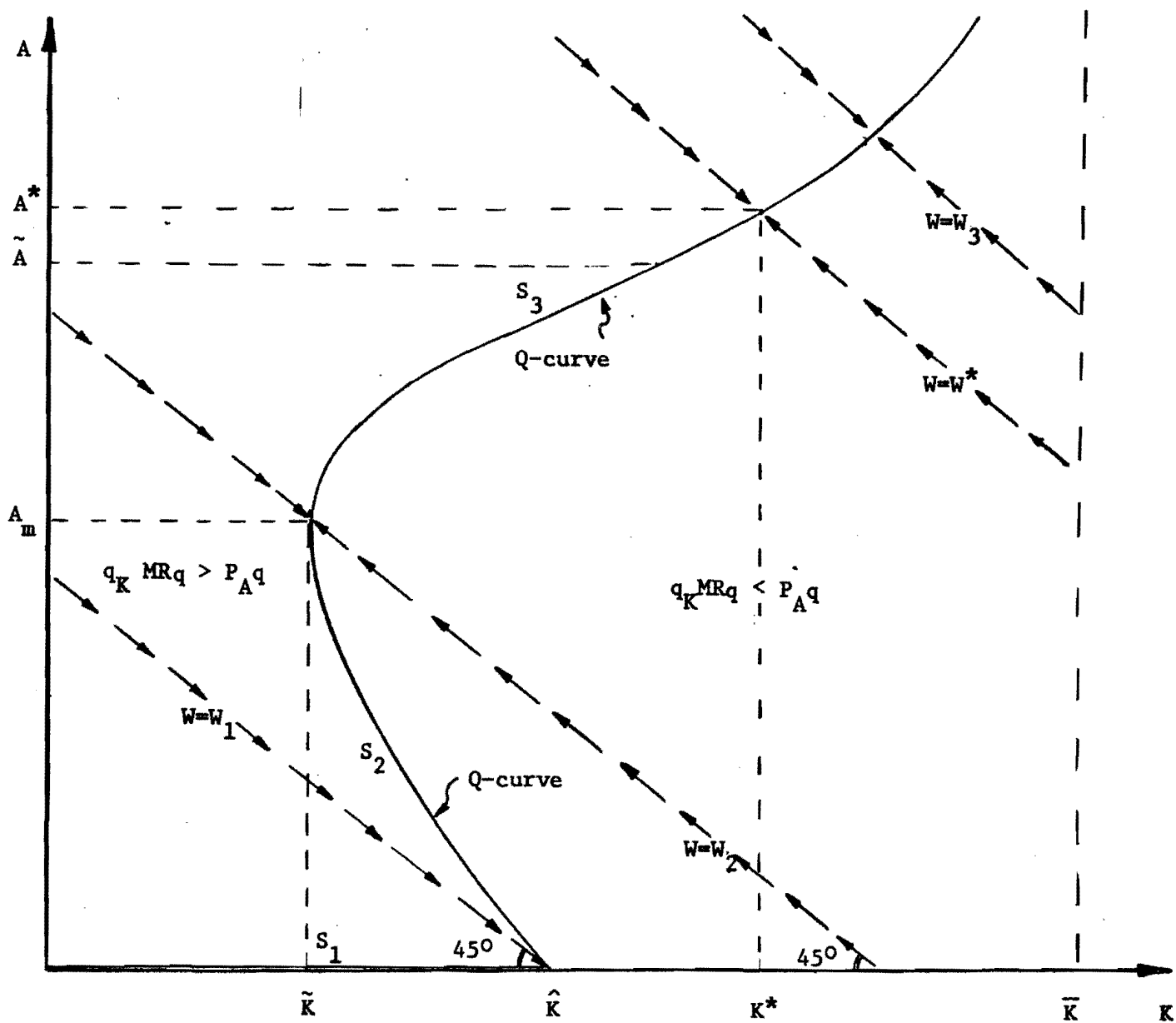


Figure 3

This locus divides the plane into two regions. If the initial resources of the firm ($W_0 = K_0 + A_0$) are such that the firm starts in the region to the left and above the Q curve, where $q_K MR_q > p_A q$, the firm will move instantaneously to the right on a 45° budget line until it reaches one of the three segments of the Q-curve. This instantaneous movement is the result of the assumption we made that transfer of human and nonhuman capital within the firm does not involve costs of adjustment. ^{8/} If initial resources are such that the firm starts in the region to the right and below, there will be an instantaneous movement on a 45° budget line in the opposite direction until one of the last two segments of the Q-curve is reached.

Note that it is only along segments S_2 and S_3 that equation (8) holds and functional relations exist between A and K--the relations of one-to-one correspondence breakdown on segment S_1 . On segment S_1 (which coincides with the abscissa) equation (7) replaces equation (8). The slope of the Q-curve along segments S_2 and S_3 is derived from the total differentiation of equation (9), under the assumptions of weak separability in the demand, yielding

$$\frac{dA}{dK} = \frac{f_K(K)}{g_A(A)} \quad (11)$$

where

$$f_K(K) = [-K^{-2} \eta_{qK} + K^{-1} \frac{\partial}{\partial K} (\eta_{qK})] (1 + \eta_{pq}) + K^{-1} \eta_{qK} q_K \frac{\partial}{\partial q} (\eta_{pq})$$

and

$$g_A(A) = -A^{-2} \eta_{pA} + A^{-1} \frac{\partial}{\partial A} (\eta_{pA}) = \frac{1}{p} \left(p_{AA} - \frac{p_A^2}{p} \right)$$

are correspondingly the slopes of the curves $f(K)$ and $g(A)$ in Figure 2.

Evaluating the sign of $f_K(K)$, we assume the following: (1) $\partial \eta_{pq} / \partial q < 0$ resulting from the assumption of a negatively sloped marginal revenue for all A and (2) $q_K > 0$ and $q_{KK} < 0$ resulting from the assumptions on the sign of the first two derivations of $q(K)$. These assumptions and the fact that $1 > 1 + \eta_{pq} > 0$ for $K < \bar{K}$ imply $f_K(K) < 0$ for all values of $K < \bar{K}$ where \bar{K} satisfies $(1 + \eta_{pq}) = 0$. The sign of dA/dK will, therefore, be the opposite

^{8/} Here, too, the assumption that rechanneling resources between the two types of capital does not involve costs of adjustment implicitly assumes the existence of a pooled stock of "capital." Thus, we neglect costs of transferring existing resources from productive use to demand-creation use (the only case where such a transfer occurs in our model). Only the costs of acquiring capital goods outside the firm are taken into account here.

of $g_A(A)$. Note that by the S-shaped curve in Figure 1 we assumed $p_{AA} > 0$ for $A < \tilde{A}$.

At $A_m < A$ in Figures 2 and 3, the following equality holds: $p_{AA}/p_A = p_A/p$, i.e., the elasticities of p and p_A , both with respect to A , are equal;

and we conclude that $g_A(A) \geq 0 \Leftrightarrow A \leq A_m$. Thus, on segment S_2 the slope of the Q -curve is negative and increases in its absolute value until it reaches infinity at A_m . Segment S_3 starts from A_m , with an infinitely positive slope, decreasing at first and then increasing. A increases to infinity while K approaches \bar{K} . Without loss of generality, we assume that $dA/dK < -1$ at $(\bar{K}, 0)$. Otherwise, there will be a subsegment where $0 > dA/dK > -1$, which will represent a local minimum; the firm will not stay on this subsegment but will move instantaneously to the left along the 45° budget line until it reaches the "right" part on segment S_2 .

The optimal behavior of the firm is described by the movement along the Q -curve from any initial state (given by its intersection with a 45° budget line) toward a steady state which we will assume lies in segment 3. ^{9/} The steady state may occur only in segments 1 and 3. If it occurs in segment 1, a steady state without demand-creating capital exists. The case in which the steady state is in segment 3 is far more interesting and, therefore, was chosen to be represented here.

If the firm starts from segment S_1 , K increases up to \bar{K} , while $Q(K, 0) > 0$. Along the segment S_2 , K decreases; and A increases until the point A_m is reached. At this point, both K and A increase toward the steady state (K^*, A^*) . Along S_2 and S_3 $Q(K, A) = 0$ holds; note that, though K decreases along S_2 , the total resources of the firm are increased. This is demonstrated by the movement to higher equal wealth lines represented by the 45° budget lines ($W^* > W_2 > W_1$). On the other hand, if the firm starts at initial wealth $W_3 > W^*$, K and A decrease monotonically; and the firm will move along S_3 toward the steady state value (K^*, A^*) .

We will assume that the following transversality conditions are satisfied:

$$\lim_{t \rightarrow \infty} K_t \lambda_t e^{-rt} = \lim_{t \rightarrow \infty} A_t \lambda_t e^{-rt} = 0 \quad (12)$$

^{9/} The steady state will be analyzed later when phase diagrams are introduced.

Equations (6) and (12) constitute a set of sufficient conditions for the firm's problem.

THE DYNAMIC BEHAVIOR OF THE FIRM

The functional correspondence between K and A makes it possible to construct alternatively phase diagrams in either the (K, λ) plane or the (A, λ) plane representing the patterns of optimal productive investment and optimal demand-creation investment, respectively. To construct phase diagrams we use the following set of equations derived from conditions (8): ^{10/}

$$\begin{aligned}
 (a) \quad \frac{d\lambda}{dK} \bigg|_{\dot{K} = 0} &= \sigma w_{cc} \left(1 + \frac{dA}{dK} \right) \\
 (b) \quad \frac{d\lambda}{dA} \bigg|_{\dot{A} = 0} &= \sigma w_{cc} \left(1 + \frac{dK}{dA} \right) \\
 (c) \quad \frac{d\lambda}{dK} \bigg|_{\dot{\lambda} = 0} &= (r + \sigma)^{-1} \left[q_{KK}^{MRq} + q_K^2 (p_{qq}q + 2p_q) + \frac{dA}{dK} p_A (1 + \eta_{pq}) \right] \\
 (d) \quad \frac{d\lambda}{dA} \bigg|_{\dot{\lambda} = 0} &= (r + \sigma)^{-1} \left[q(K) p_{AA} + p_A q_K \frac{dK}{dA} \right] \tag{13} \\
 (e) \quad \frac{\partial \dot{K}}{\partial \lambda} \bigg|_{K = \text{constant}} &= \frac{\partial I}{\partial \lambda} \bigg|_{K = \text{constant}} = \frac{1}{w_{cc} \left(1 + \frac{dA}{dK} \right)} \\
 (f) \quad \frac{\partial \dot{A}}{\partial \lambda} \bigg|_{A = \text{constant}} &= \frac{\partial a}{\partial \lambda} \bigg|_{A = \text{constant}} = \frac{1}{w_{cc} \left(1 + \frac{dK}{dA} \right)}
 \end{aligned}$$

^{10/}This geometric method is generally used for problems characterized by only one state variable. In our problem, the functional correspondence between K and A (equation 11) allows us to consider K and A in two separate phase diagrams.

$$(g) \quad \left. \frac{\partial \dot{\lambda}}{\partial \lambda} \right| \begin{array}{l} K = \text{constant} \\ A = \text{constant} \end{array} = r + \sigma$$

where $dA/dK = f_K(K)/g_A(A)$.

The slope of the curve $\dot{K} = 0$ in the (K, λ) plane (Figure 4) and the slope of the curve $\dot{A} = 0$ in the (A, λ) plane (Figure 5) are determined by conditions (13a) and (13b), respectively. The slopes of the curves $\dot{\lambda} = 0$ (in Figures 4 and 5) are determined by conditions (13c) and (13d), respectively. Since there is an overlapping in phases in Figure 4, Figure 6 is used for the exposition of the horizontal and vertical arrows in the (K, λ) plane. The direction of the horizontal arrows in Figures 5 and 6 can be verified from conditions (13e) and (13f), correspondingly, and the direction of the vertical arrows from condition (13g).

In the analysis that follows, we distinguish between three phases which correspond on the Q-curve to the three segments.

Phase I

If the initial amount of resources is such that the firm is on segment 1, the firm starts at phase I where all investments are implemented into productive capital. This will characterize the optimal demand for investment as long as $Q(K, 0) > 0$. From Figure 2 and Figure 6a, it is clear that the firm will expand first at a decreasing rate and then at an increasing one. However, the rate of investment in productive capital is accelerated in comparison with the case where demand creation is impossible, although at this phase no investment in demand creation has as yet been made. Note that at this phase some of the Treadway [17] inferences about optimal demand for investment in productive capital hold even though we deal with a monopolistic firm, especially if we are willing to assume without loss of generality that $f(K)$ has a rising part at low values of K before obtaining the negative slope and thus allows for different production structures. ^{11/} At the level of \hat{K} , the firm moves into phase II.

^{11/} Thus, for example, under increasing returns to scale in production, conditions may arise (see the discussion in Treadway [17, pp. 236 and 237]) that the firm should leave the industry.

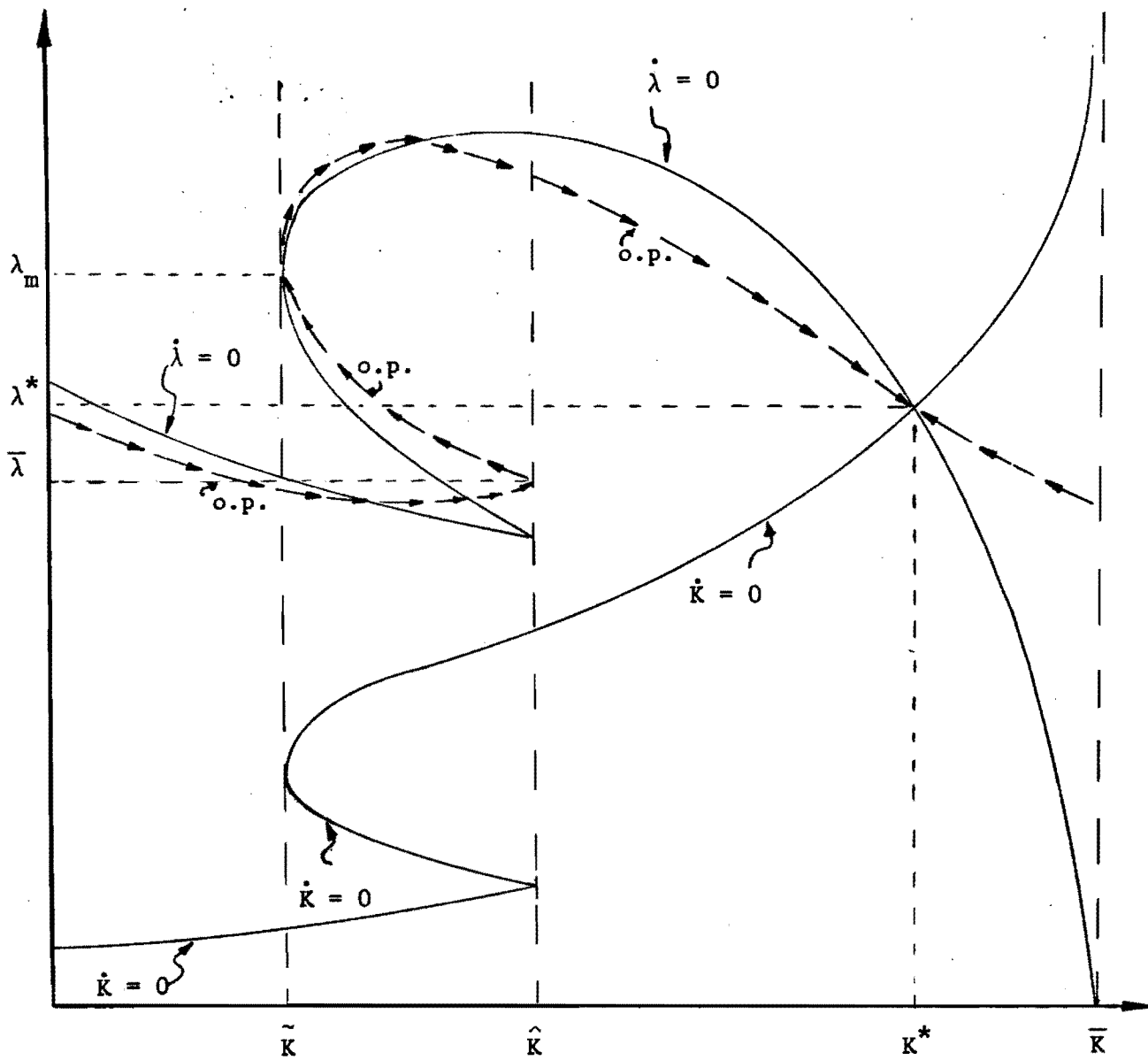


Figure 4

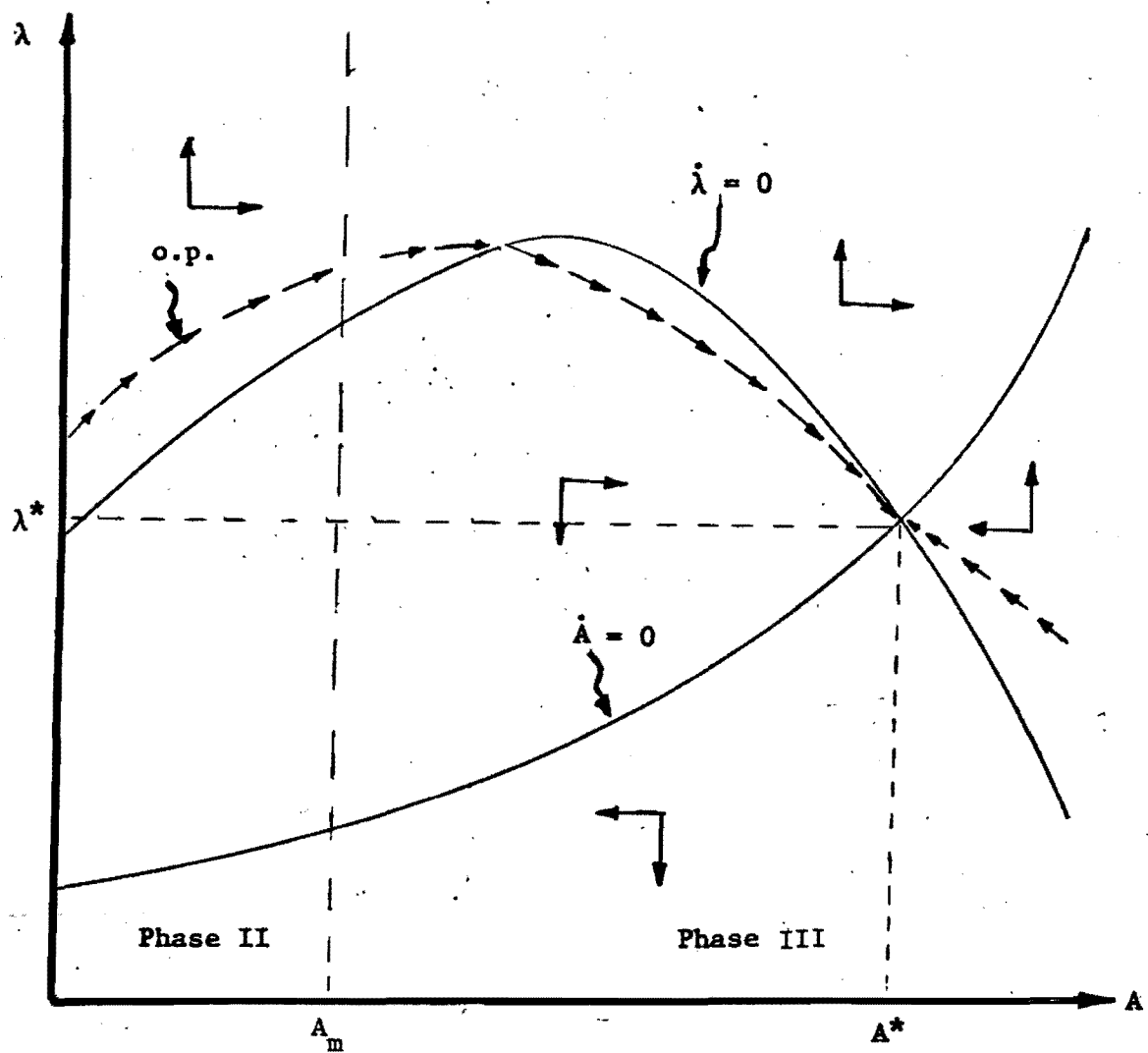


Figure 5

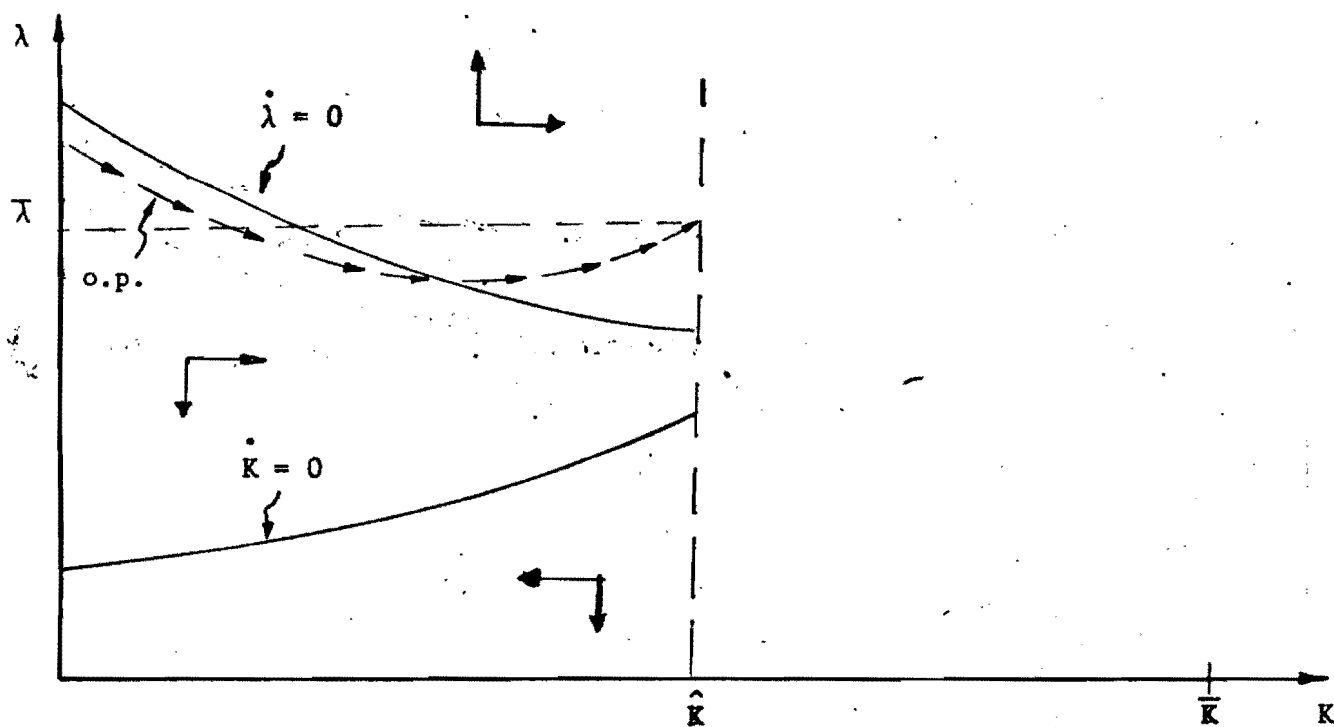


Figure 6a, Phase I

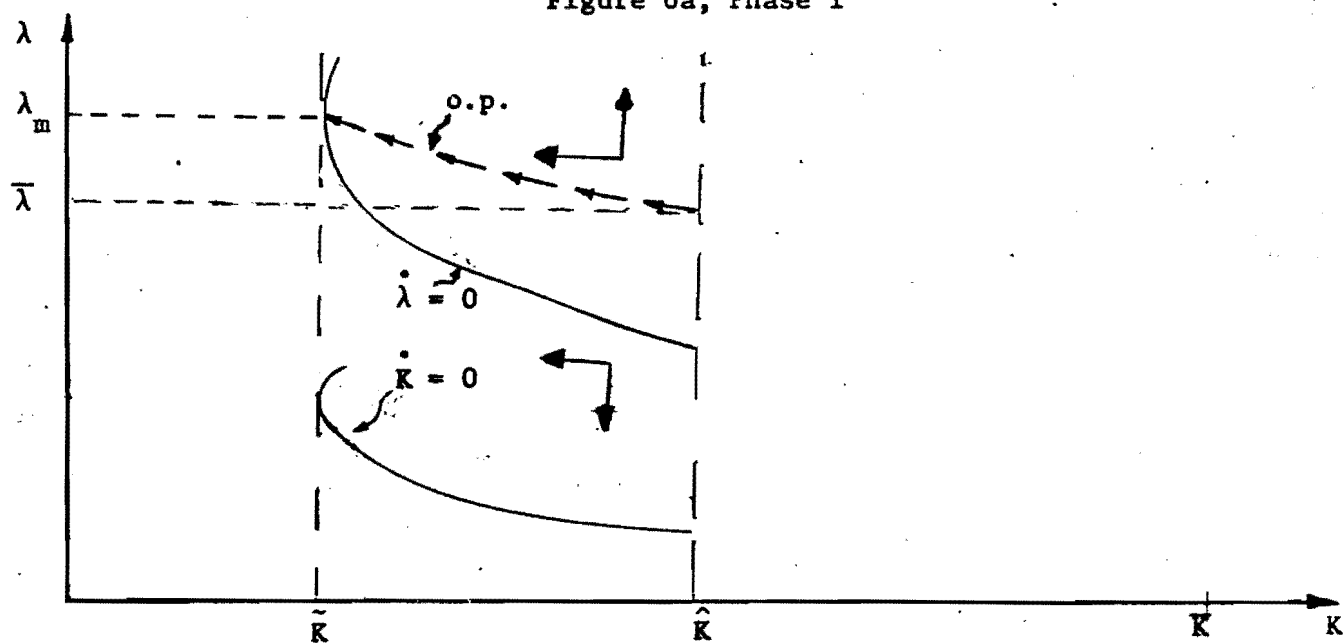


Figure 6b, Phase II

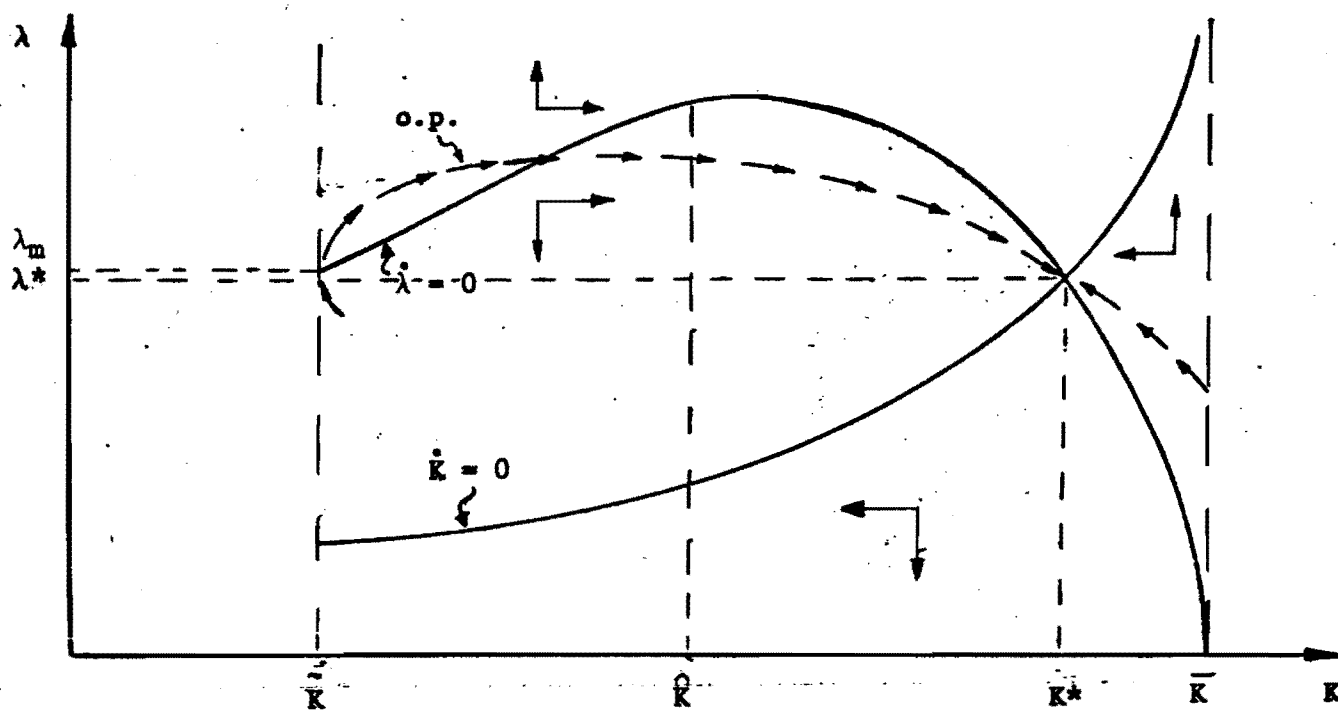


Figure 6c, Phase III

Phase II

At this phase (which coincides with segment S_2), the firm uses all of its new resources and parts of the existing resources (accumulated in the form of productive capital at phase I) to build its demand-creation capital. In doing so the firm takes advantage of the increasing marginal returns to demand creation ($p_{AA} > 0$) described by the lower part of Figure 1. Along the optimal trajectory, conditions (8) hold; and the values of the marginal products of both types of capital are equal. The dynamic behavior of the firm is described by the phase diagrams. The point $(\bar{K}, \bar{\lambda})$ where phase I ends and phase II begins is a discontinuous point of the controls (i.e., I becomes negative from positive and a becomes positive from zero). It is not a differential point of $\lambda(t)$, $K(t)$, and $A(t)$. A cycle in $K(t)$ begins at this stage where K decreases instead of increasing, and it goes on decreasing until the end of phase II is reached at point (\bar{K}, λ_m) . At this point I acquires a zero value. The direction of the optimal trajectory in the (K, λ) plane is explained by the horizontal and vertical arrows in Figure 6b, and the direction of optimal investments in A is explained by the optimal path within phase II in Figure 5.

Phase III

In this phase, both K and A increase toward their steady state values (K^*, A^*) . At early stages both rates of investments are increasing though both $g_A(A)$ and $f_K(K)$ are negative; the monopolist firm still has the advantages of $p_{AA} > 0$ for $A < \bar{A}$ and the relatively high elasticities of demand $(1/\eta_{pq})$. At later stages, as p_{AA} changes to negative and the elasticities of demand continue to diminish, K and A increase but at a decreasing rate until a steady state is reached.

If the initial amount of resources is such that the firm starts on segment 3, say, at $W_3 > W^*$, both K and A decrease until steady state (K^*, A^*) is reached. These processes can be verified from Figures 4, 5, and 6c.

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EVALUATION OF GENERIC ADVERTISING EFFECTIVENESS WITH ECONOMETRICS

Ronald W. Ward*

INTRODUCTION

An application of econometric techniques to the field of advertising measurement and its effectiveness has exhibited varying degrees of success. Common problems associated with most of the advertising studies applying econometrics can be generalized as [2]:

1. How to isolate the effects of advertising from the many other variables influencing the index of response.
2. How to measure the quantity of advertising taking into account that advertising dollar expenditures affect alternative choices of media, psychological appeals and copy.
3. How to identify the relationship which reflects the influence of advertising upon sales.

These problems will be addressed as we look at the application of econometric techniques to the measurement of advertising effectiveness in the Florida citrus industry.

Advertising is an integral part of the Florida citrus industry's total marketing program. Over \$60 million has been spent on generic and branded advertising in the past six production seasons. The results from these expenditures have been measured primarily by qualitative indicators of the consumer's perception of the given advertising effort. However, to provide meaningful guidelines for allocating advertising expenditures, it is also useful to measure the dollars generated as a result of the advertising expenditures.

Frequent questions arising from the present citrus advertising programs are [4]:

1. How sensitive are retail processed citrus dollar sales to generic and branded advertising?
2. How is the effectiveness of annual generic advertising expenditures related to changes in branded expenditures and brand allocation policies over time?
3. What gains can be realized by allocating the advertising expenditures among quarters of the marketing year?

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4. What levels of generic expenditures appear to be optimal and how would the allocation of these expenditures differ among quarters?

Through the use of econometric techniques these questions can be addressed in a quantitative framework thus giving substantial insight into the nature of advertising effectiveness to the citrus industry.

If initially a quantitative relationship between advertising and some index of industry response can be estimated, then this information can be used to measure the sensitivity and effectiveness of generic advertising given different assumptions about other factors. In essence, an industry is operating at a given time period with a predetermined set of advertising programs. It would be useful to experiment in the market place to measure how sales respond to changing advertising policies. However, the cost of such experimentation is generally high and quite difficult to control. Also, adequate data needs are sometimes impossible to obtain through experimental designs. For example, cross sectional data and data generated from experiments frequently do not facilitate measuring the lagged effect of advertising. Whereas, time series data do accommodate this measurement.

An alternative is to simulate similar experiments through the use of computers. The cost of this procedure is minimal, yet it is limited by the ability to model and quantify the necessary advertising response functions. Using this alternative, then the specific procedures for studying the effectiveness of citrus advertising were to:

1. Develop a structural relationship showing the influence of advertising expenditures on citrus industry dollar sales.
2. Incorporate the empirical results of the sales response function into a sales response model and then measure the sales changes resulting from different advertising policies.

ADVERTISING STRUCTURE

The structural relationship between advertising and the total dollar sales will, no doubt, vary with the industry analyzed. Nevertheless, a priori theoretical considerations suggest some structural components of an advertising function that may be common to many industries. They are [3,5]:

1. There will always be some positive sales response to advertising even though this increase may occur at a decreasing rate.

2. There exists some upper asymptotic limit to sales for a given set of economic conditions in a given time period.
3. The effects of a given advertising effort may be distributed over time.
4. The marginal return from different types of advertising efforts may differ.

These a priori considerations have been incorporated into the structural relationship relating citrus sales to both branded and generic advertising.

The model illustrated in Figures 1a and 1b contains the assumptions set forth above. Sales are shown to be positively related to the advertising expenditure; yet, as advertising increases indefinitely, sales approach the asymptotic limit B. Advertising allocations less than A', Figure 1a, yield increasing marginal returns to the advertising expenditure; while advertising in excess of A' yields decreasing marginal returns. The downward concavity of Figure 1b further illustrates the changing nature of the marginal return to advertising. The marginal return equals or exceeds the marginal advertising cost up to point C'. Beyond C', additional advertising expenditures prove to be a wasted marketing effort. Therefore, advertising allocations in the range of A' to C' represent a critical decision area to the advertiser.

The total impact of a given advertising program may not be realized immediately, rather the effectiveness may be distributed over time [1]. Figure 2 portrays three of many possible distributions of advertising effectiveness over time. Curve A shows a rapid advertising decay rate. Curve B suggests a short lag before the maximum impact is felt, while C shows advertising effectiveness to be distributed over a long period of time.

These advertising structural assumptions are explicitly illustrated in equation 1. The changing nature of the marginal returns is easily shown with this equation, and the weight ω_j provides a measure of the decay rate.

$$(1) \log_e S_t = \beta_0 - \beta_1 \sum_{j=0}^{\infty} \frac{\omega_j}{A_{t-j}}$$

S_t = \$ SALES in period t,

A_{t-j} = \$ ADVERTISING in period t-j,

β_0 = constant

β_1 = advertising coefficient

ω_j = advertising decay weight.

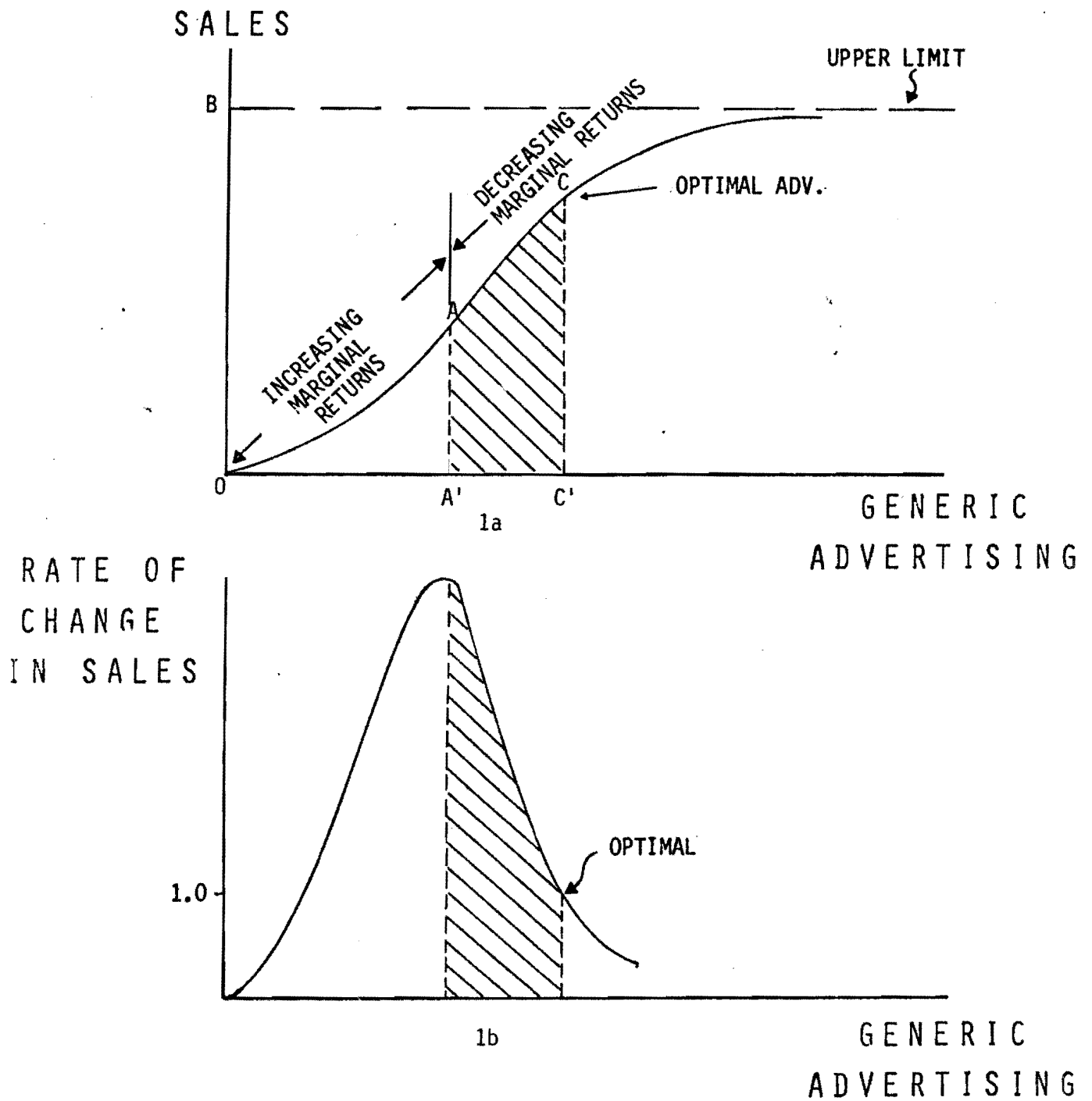


Figure 1. Advertising response model.

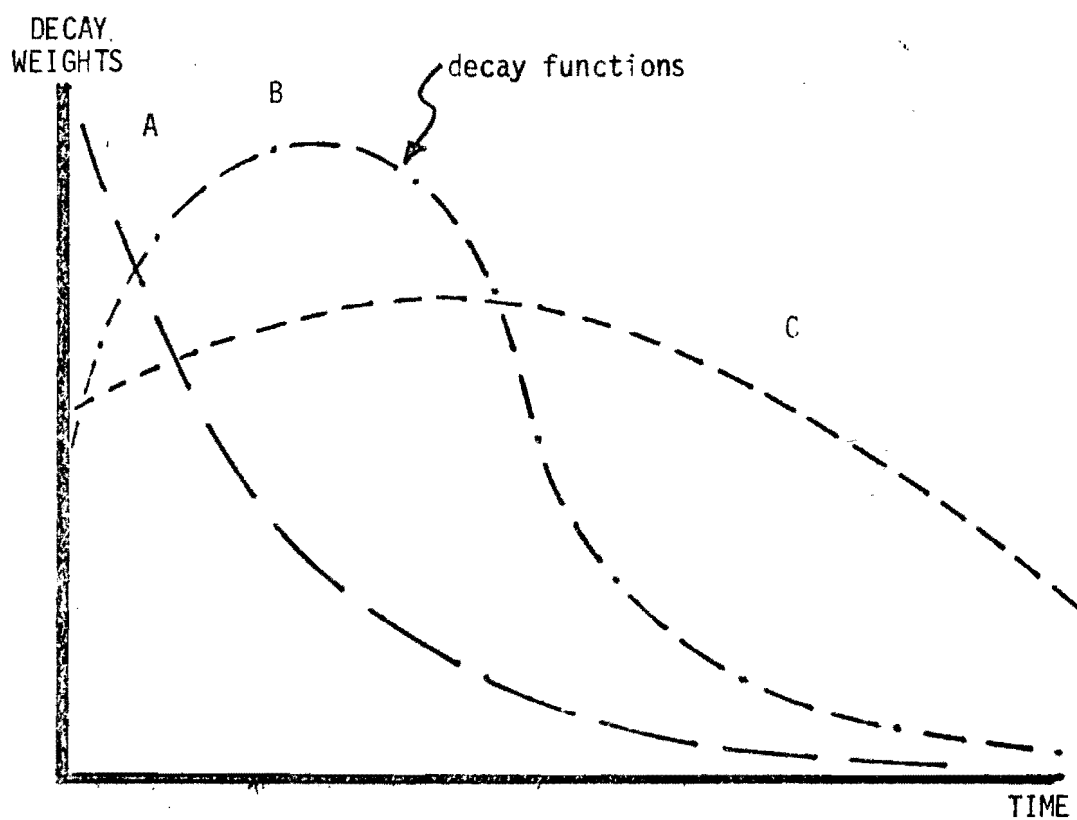


Figure 2. Advertising decay weights.

That level of advertising separating the two major stages of effectiveness is easily calculated from the hypothesized model. Marginal returns to the advertising dollar are at a maximum at that point dividing the increasing from the decreasing stage of returns. Hence, an initial policy decision may be to expand the advertising program at least up to the point of decreasing marginal returns or $\beta\omega_0/2$. ^{1/}

The stages of return to advertising are influenced by the decay weight ω_0 . ω_0 is in turn one weight derived from a distribution function relating the distributed lag effects of previous advertising efforts. Likewise, $\beta_1\omega_j$ indicates the weighted effect advertising in period t will have on sales in period $t+j$.

If $\omega_0 = 1$, the advertising exposure has the greatest impact in the initial period. For $\omega_0 < 1$, then the maximum impact may occur after some delay. It immediately follows from footnote 1 that for ω_0 approaching 1, the level of advertising expenditures could be increased up to $\beta/2$ before decreasing marginal returns from the initial response are experienced. Likewise, if the initial advertising effort has a minimal initial impact, then decreasing returns set in at a very small level of advertising. Those combinations of decay weights and advertising in the initial period that separate the two stages of marginal returns are illustrated in Figure 3. At this point the advertiser would allocate his funds, at least, to the level along the diagonal line of this figure in accordance with his knowledge of the decay weight ω_0 . This precludes alternative uses of the given funds. The relationship between the decay weights and the upper limit to advertising will change according to previous advertising activities; however, the general positive slope of the upper curve shown in Figure 3 must hold. That is, as ω_0 increases, the marginal returns to

^{1/}This point is derived by calculating the advertising level where the curve in Figure 1b reaches a maximum or

$$\frac{\partial^2 S_t}{\partial A_t^2} = \frac{S_t \beta \omega_0}{A_t^3} \left(\frac{\beta \omega_0}{A_t} - 2 \right) = 0.$$

$$A'_t = \frac{\beta \omega_0}{2},$$

hence $A_t > A'_t$ implies decreasing returns in period t ,

$A_t < A'_t$ implies increasing returns in period t .

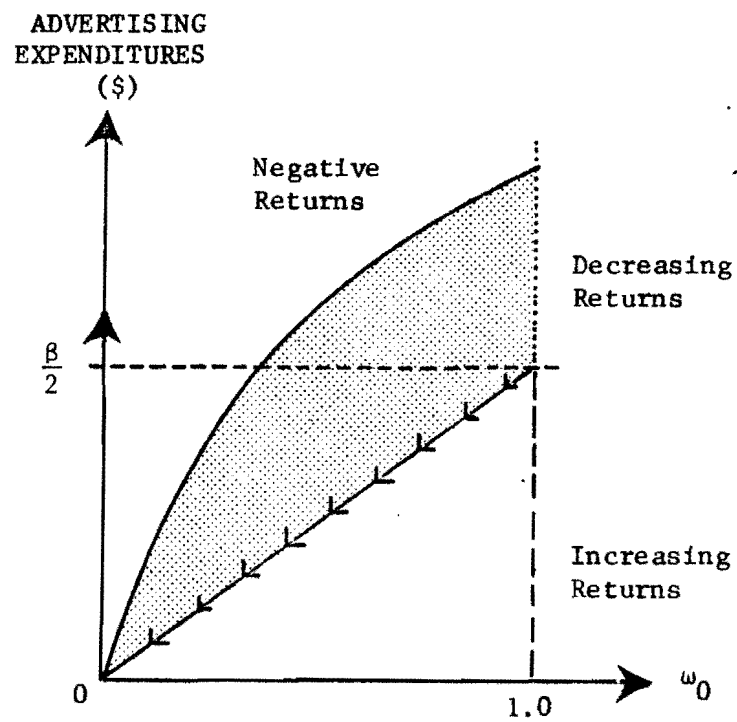


Figure 3. Increasing and decreasing returns to advertising assuming values of ω_0 .

the advertising program in the initial period increase. This then raises the upper limit to the advertising effort.

If the function in equation 1 reflects a very rapid decay, then the decision limits as set forth in Figure 3 should give good guidelines for establishing advertising policy levels. For a smaller ω_0 , the less useful Figure 3 is for analyzing advertising levels. Smaller initial weights imply a greater delayed effectiveness from an initial advertising effort, or, in fact, the marginal returns to an initial advertising program are distributed over time. Recognizing that the marginal returns may be distributed over time, then the decision maker must devise some criteria which incorporate these delayed returns when setting advertising policies. The concept of an advertising multiplier is useful when measuring these delayed returns [6].

Given the delayed effect, then the skewness and kurtosis of the decay function is critical to the process of setting advertising policies. If most of the effects of advertising are realized in the n th period following the initial exposure, then a policy where the advertising is set according to the delayed effect in the n th period would provide useful guidelines. In contrast, if the distribution tends to be relatively flat, then a multi-period decision framework must be employed. 2/

Assuming that ω_j of equation 1 follows a geometrically declining distribution, then the reduced form for equation 1 is expressible as in

$$(2) \quad \log S_t = (1 - \alpha)\beta_0 - \beta_1 \left(\frac{1}{A_t} \right) + \alpha \log S_{t-1} + v_t$$

$$v_t = \varepsilon_t - \alpha \varepsilon_{t-1}$$

equation 2. 3/ A more general case of 2 applicable to the citrus industry is shown in equation 3 [5].

2/ Empirical results from the study of citrus advertising indicate that the effectiveness of the advertising decays very rapidly; hence, advertising policies based on the marginal responses in the initial period of exposure are applicable.

3/ Both the geometrically declining and the Pascal distribution functions were initially used to estimate the nature of citrus advertising decay. Although the Pascal distribution facilitates estimating a broad number of different shaped decay functions, the initial estimates suggest that a geometrically declining function is, in fact, the appropriate distribution. Therefore, we will limit our discussion in this paper to that incorporating only the geometrically declining weights or

$$\omega_j = \alpha^j$$

where $0 \leq \alpha < 1$.

$$(3) \log S_t = (1 - \alpha)\beta_0 - \beta_1 \left(\frac{1}{AG_t} \right) - \beta_2 \left(\frac{1}{AB_t} \right) + \alpha \log S_{t-1} + \beta_3 T + v_t$$

AG_t = \$ GENERIC ADVERTISING during period t ,

AB_t = \$ BRANDED ADVERTISING during period t ,

T = Time trend variable.

Generic advertising policies can be controlled by an industry while branded policies are generally determined by the separate firms making up an industry. Hence, a sales response model of the form outlined in equation 3 has its greatest usefulness to generic policies since the branded measurements are for the aggregate of all firms rather than for individual firms.

Given equation 3, then those levels of generic advertising corresponding to points A' and C' of Figure 1a can be calculated. The results for A' are shown in footnote 1. The upper limit to the generic advertising effectiveness varies with the levels of past advertising efforts as well as with the branded efforts occurring in the period being analyzed. ^{4/}

DISTRIBUTED LAG ESTIMATION

Data on the branded and generic advertising programs of Florida processed oranges can be used to illustrate an application of the distributed lag model. Let:

S_t = quarterly retail dollar sales (\$1000 units) of processed orange products (FCOJ, COJ, CSSOJ),

AG_t = generic advertising expenditures (\$1000) for processed oranges in quarter t ,

^{4/}The "optimal level" or that level where marginal returns equal the marginal advertising cost (point C', Figure 1a) is derived where

$$\frac{\partial N_t}{\partial AG_t} = \frac{\partial S_t}{\partial AG_t} - 1 = 0,$$

$$\text{or } AG_t^2 - S_t \beta_1 = 0,$$

$$\text{and } N_t = S_t - AG_t.$$

From these equations the optimal level of generic funds can be approximated [5].

Table 1. Retail processed citrus dollar sales response to citrus advertising.^a

	GEOMETRICALLY DECLINING MODEL	
	Ordinary ^b Least Squares (OLS)	Maximum ^c Likelihood Estimators
INTERCEPT $\beta_0(1 - \alpha)$	11.19899	7.29328
GENERIC ADV β_1	-10.26635	-10.26953
BRAND ADV β_2	-24.87057	-15.12500
TIME β_3	.02335	.01537
DECAY RATE α	.0163	.3600
AUTOREGRESSIVE ρ	(ignored)	-.1500
R^2	.89347	.8298

^aCitrus sales measured in thousands of dollars.

^bOLS will give biased and inconsistent estimates when $\rho \neq \alpha$.

^cMLE will give consistent estimates; however, computational problems arise with large numbers of observation or with small values for α . The results shown here do not represent the final solution from the application of MLE over a large range of ρ and α . Additional work must be completed to determine, precisely, the best estimates. For this reason, the remaining discussion and equation application have been based on the OLS results. See the Appendix for the derivation of the MLE procedures.

Chart 1. A computer model incorporating this general framework can best be illustrated by the example output shown in Table 2. Table 2a lists all of the initial inputs for one simulated run. This corresponds to the circle values of Chart 1. Table 2b gives the estimated quarterly and total sales response to quarterly generic advertising allocations given the inputs shown in Table 2a. The results of each quarter provide inputs for estimation of the response in the next quarter. Table 2c provides a comparative analysis of annual gains that could be realized for various quarterly generic allocations. Finally, Table 2d indicates the optimal generic total and quarterly allocation for the inputs specified in 2a ignoring the generic input. This output can be iterated over branded allocations and various generic and branded annual totals.

An application of the distributed lag equation in the citrus advertising model (see Chart 1) to the 1972-73 season led to the following conclusions [8]:

1. Retail sales increase as generic expenditures increase; however, decreasing marginal returns to generic advertising are obvious in Figure 4 where equal incremental increases in generic advertising result in decreasing incremental increases in retail dollar sales. The increments to sales resulting from generic increases are relatively insensitive to the level of branded advertising.
2. The effectiveness of brand is generally greater than generic advertising. At an annual level of one million dollars for each, generally the branded effectiveness is over twice as great as generic. The difference in the effectiveness decreases, however, as either program is expanded. These relationships are shown in Figure 4.
3. A generic allocation policy giving an equal distribution (POLICY 1) of advertising funds by quarters of the marketing year proved most advantageous, while a program with heaviest emphasis on the summer quarter (POLICY 6) would generate the least amount of retail sales. The order of generic policy ranking proved to be insensitive to the levels of both generic and branded advertising.
4. The actual gains that can be realized from changing generic policies will vary with the level of annual funds to be spent. Assume for the moment that a \$3 million branded program is expected for the 1972-73 season and that, initially, \$1 million in generic advertising is to be spent (see Figure 5). A comparison of POLICY 1 to POLICY 6 indicates that nearly \$13 million in additional retail sales could be realized by reallocation from POLICY 6 to POLICY 1.

As the level of generic advertising increases, the difference between the worst and best policies considered narrows as shown in Figure 6. For larger generic advertising

Chart 1

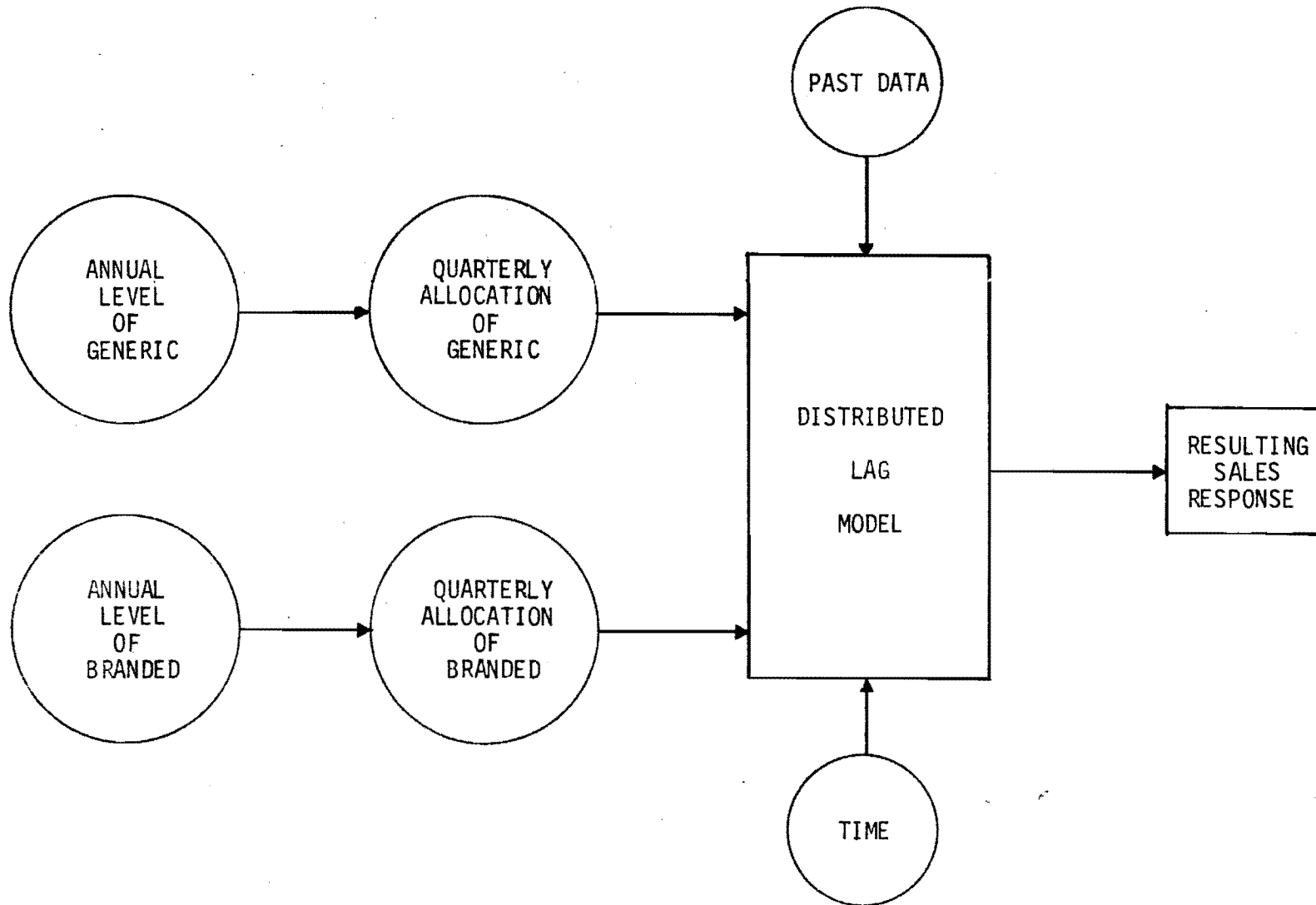


TABLE 2. SIMULATED PROCESSED CITRUS RETAIL DOLLAR SALES RESPONSES FOR ALLOCATIONS OF
GENERIC ADVERTISING EXPENDITURES AND BRANDED EXPENDITURES FOR 1972-1973 SEASON

TABLE 2A. INITIAL INPUTS

INITIAL SALES (\$1000)	130800.030
ANNUAL GENERIC ADVERTISING BUDGET	1000.
ANNUAL BRANDED ADVERTISING BUDGET	1000.
QUARTERLY PERCENTAGE OF BRAND ADVERTISING	
FALL	0.250
WINTER	0.250
SPRING	0.250
SUMMER	0.250

TABLE 2B. TOTAL SALES RESPONSE TO GENERIC ADVERTISING POLICIES
GIVEN THE BRANDED DISTRIBUTION OF TABLE A.

QUARTER	POLICY1		POLICY2		POLICY3		POLICY4		POLICY5		POLICY6	
	X	\$1000	X	\$1000	X	\$1000	X	\$1000	X	\$1000	X	\$1000
FALL	0.250	131331.137	0.550	124456.464	0.250	131331.137	0.330	132711.045	0.125	125788.808	0.075	118761.114
WINTER	0.250	134442.682	0.250	134494.231	0.500	137372.569	0.330	135878.431	0.125	128678.573	0.175	131764.824
SPRING	0.250	124991.855	0.175	122704.064	0.125	119755.128	0.170	122502.372	0.500	127624.590	0.250	124950.871
SUMMER	0.250	124203.544	0.075	112281.905	0.125	118875.110	0.170	121668.782	0.250	124245.751	0.550	127158.574
TOTAL	1.000	514969.218	1.000	503936.665	1.000	507341.544	1.000	512760.629	1.000	506337.722	1.000	502635.363

TABLE 2C. COMPARATIVE ANALYSIS OF GENERIC ADVERTISING POLICIES GIVEN THE INPUTS OF TABLE 1A.
(VALUES = SALES FROM ROW POLICY - SALES FROM COLUMN POLICY)

ROW POLICY	COLUMN POLICY					
	1	2	3	4	5	6
1	0.0	11032.553	7627.274	2206.589	8631.496	12333.835
2	0.0	0.0	-3405.279	-8823.965	-2401.058	1301.282
3	0.0	0.0	0.0	-5418.686	1004.221	4706.561
4	0.0	0.0	0.0	0.0	6422.907	10125.247
5	0.0	0.0	0.0	0.0	0.0	3702.340
6	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 2D. OPTIMAL GENERIC ADVERTISING POLICY.

	ADV \$	X	SALES \$
FALL	1203.538	0.248	135895.065
WINTER	1224.835	0.252	139213.908
SPRING	1239.530	0.255	129442.685
SUMMER	1194.090	0.246	128583.586
TOTAL	4861.997	1.000	533135.644

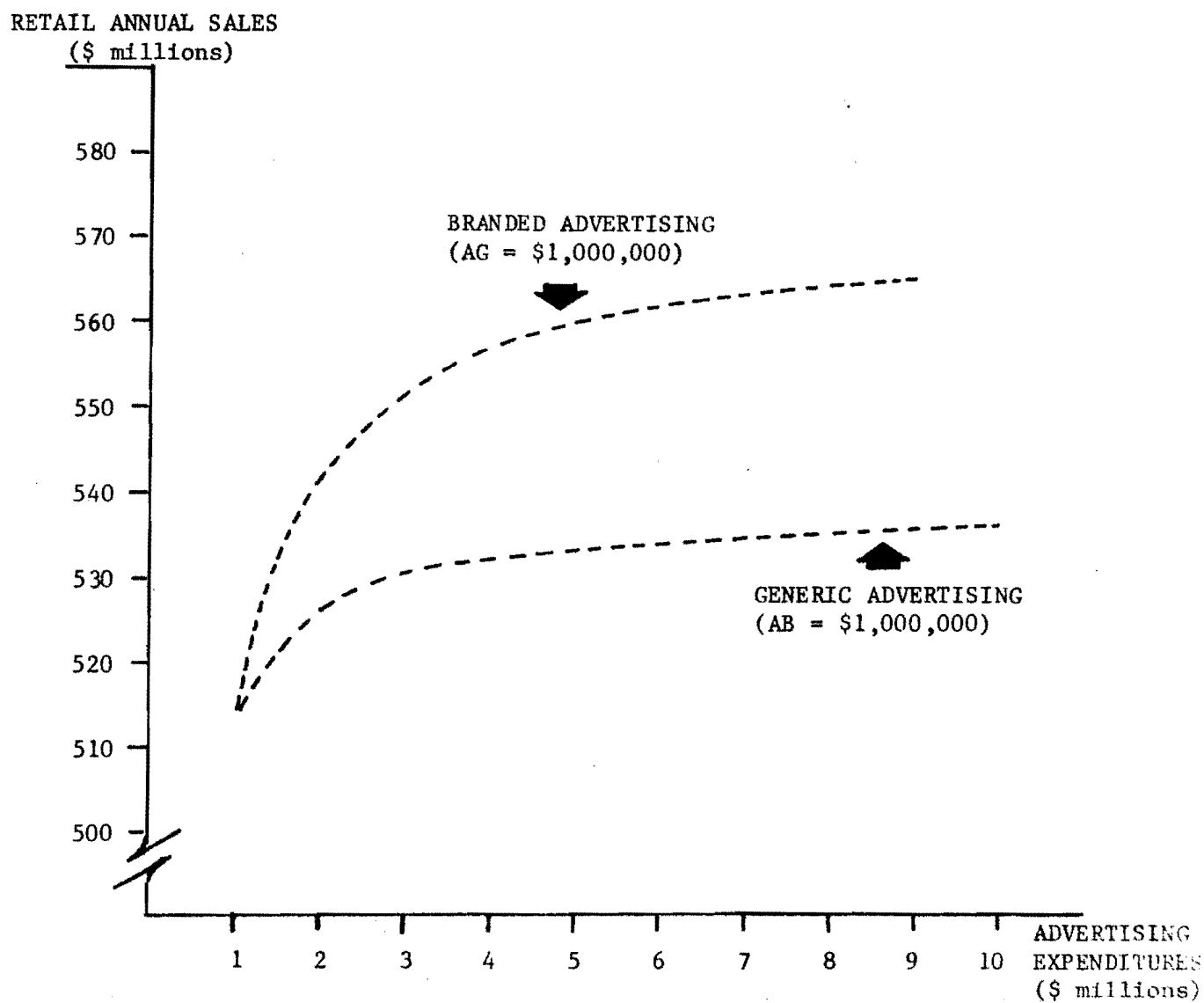


Figure 4. Retail dollar sales resulting from increases in branded or generic annual levels of advertising.

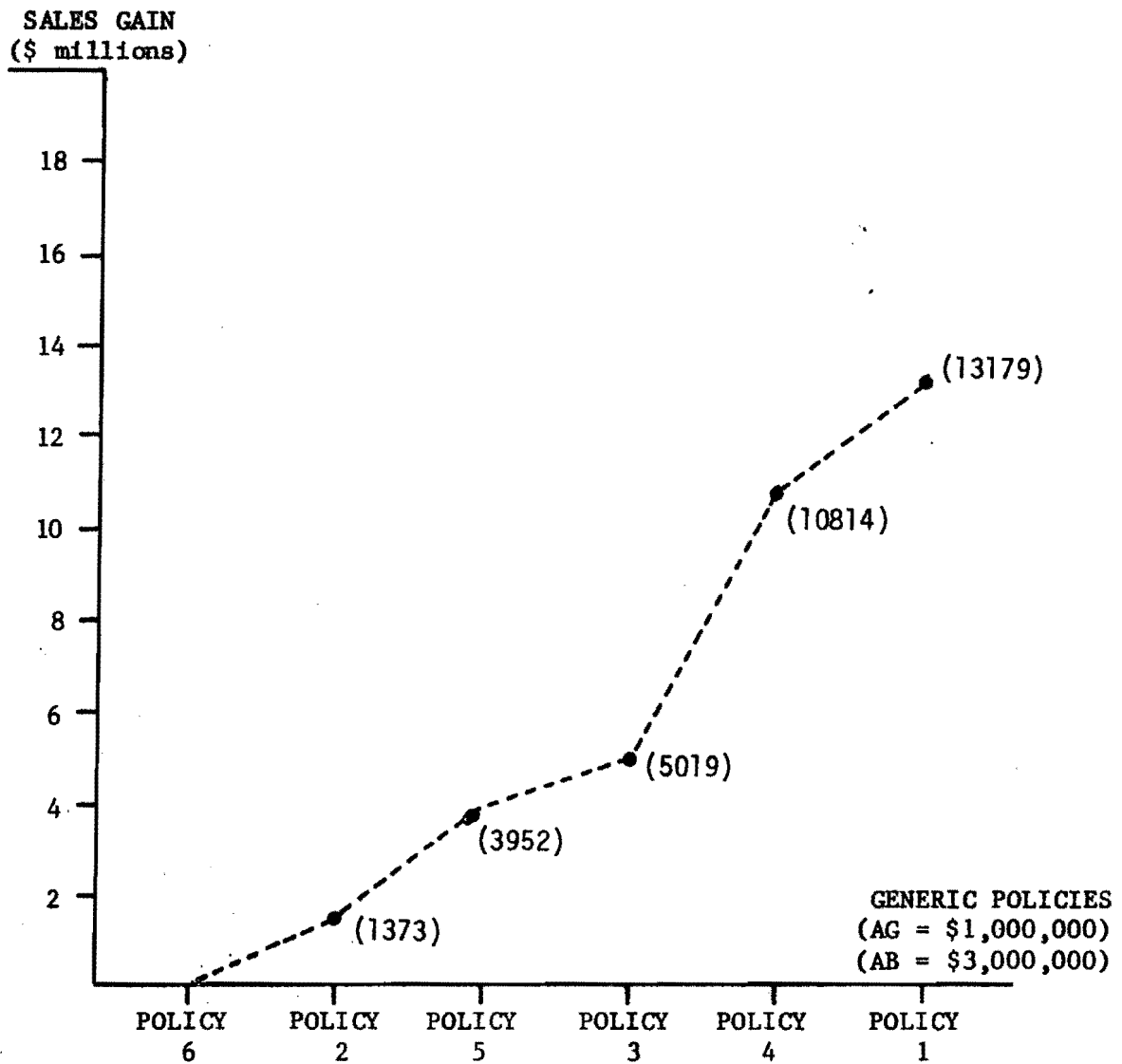


Figure 5. Gains in retail sales resulting from different generic advertising policies.

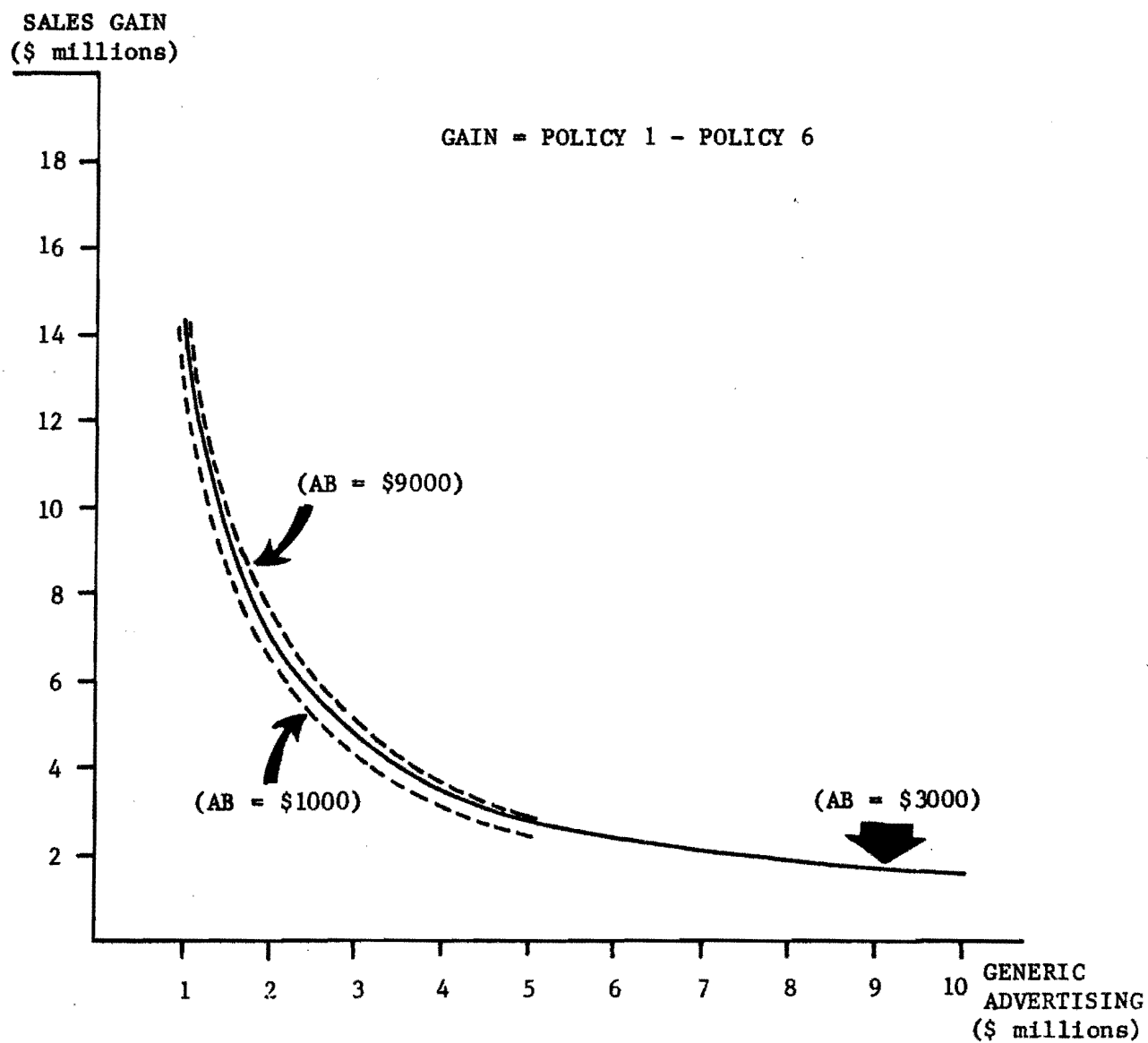


Figure 6. Gains in retail sales resulting from different generic advertising levels.

budgets, the opportunity cost from failure to reallocate generic funds on a quarterly basis becomes small and hence less important to the decision process. The more critical problem is to determine the optimal level.

5. Optimal generic advertising on an annual basis varied from \$4.8 million to approximately \$5.2 million. Generic advertising programs in excess of these ranges would represent an economic waste since the additional sales gains would be less than the added cost of the program.
6. The level of annual branded advertising expected will have a minimal influence on the optimal generic level as illustrated in Figure 7. Therefore, an exact knowledge of the annual level of branded advertising to be expected is not critical to the decision process of setting the annual generic budget according to the optimal criteria.
7. The quarterly distributions of branded advertising dollars have little if any consistent influence on the optimal generic advertising level. This conclusion in conjunction with the effect of branded levels, reveals that most generic expenditure decisions can be made independently of branded considerations. See Figure 8.
8. Although the level of generic advertising remains somewhat stable under changing branded conditions, the actual retail sales will change. Once the optimal generic level is determined, then any sales deviations would be attributed to changes in the branded programs.

Assuming brand POLICY 1 is in effect, then the retail sales performance under the optimal generic program is shown in Figure 9. If branded advertising is expected to be in the range of \$4 million and optimal allocation of generic funds is assumed, the retail sales for the 1972-73 season should be near \$575,000,000.

SUMMARY AND CONCLUSION

Quantitatively, the effectiveness of citrus advertising has generated positive results. However, such advertising programs can only be increased up to some limit, beyond which the additional effort loses its effectiveness. Intuitively, the marginal returns from increased advertising would be expected to decrease since a relatively large share of the U. S. population is presently consuming orange juice at some time during a specified period. One would expect a greater marketing cost to stimulate those consumers presently not responding to present advertising efforts. Likewise, the cost to persuade the consuming public to consume an additional unit of citrus must be greater than when consumption was lower. In essence, the marginal return to advertising must be smaller for the

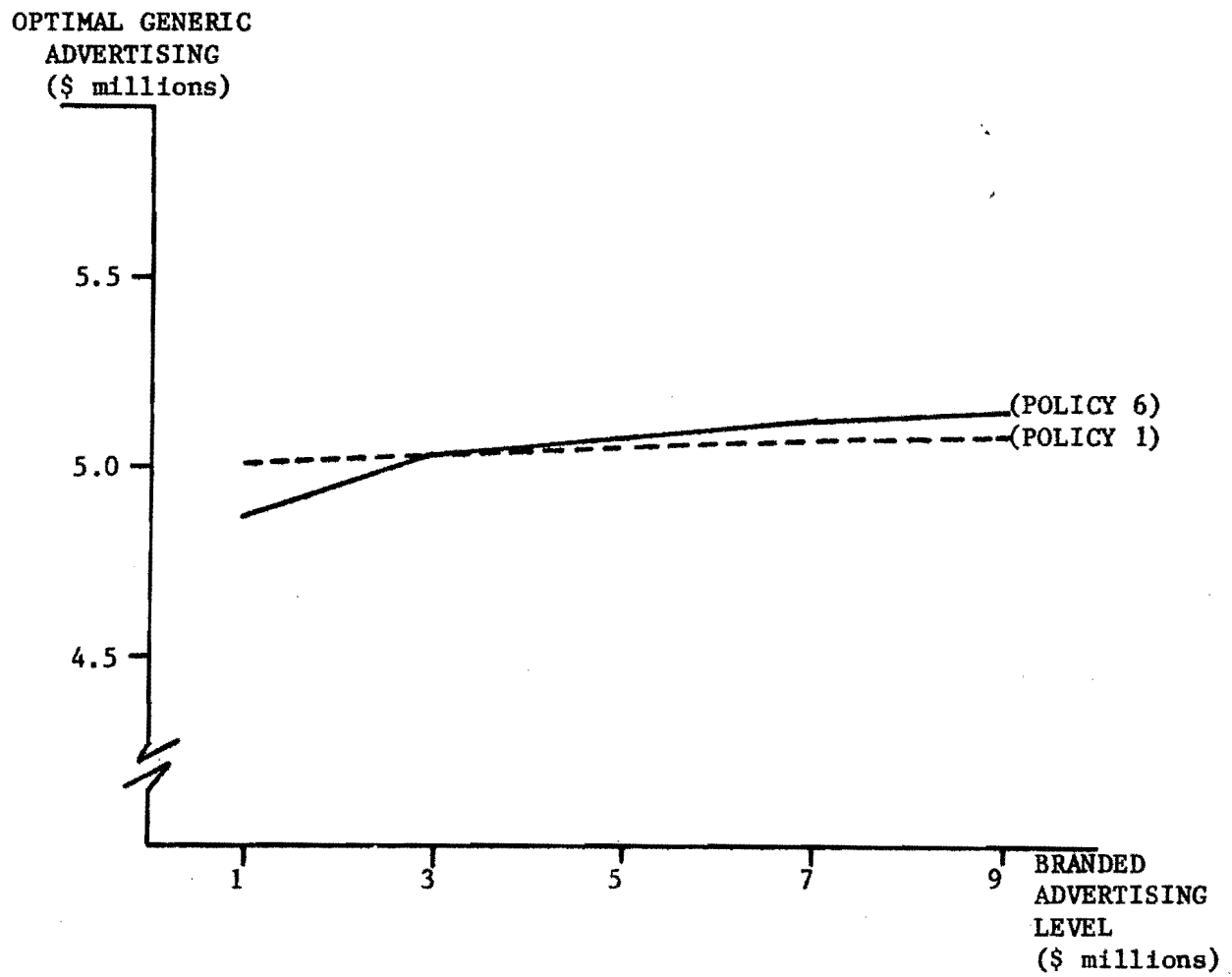


Figure 7. Sensitivity of the optimal generic advertising level to changes in annual levels of branded advertising.

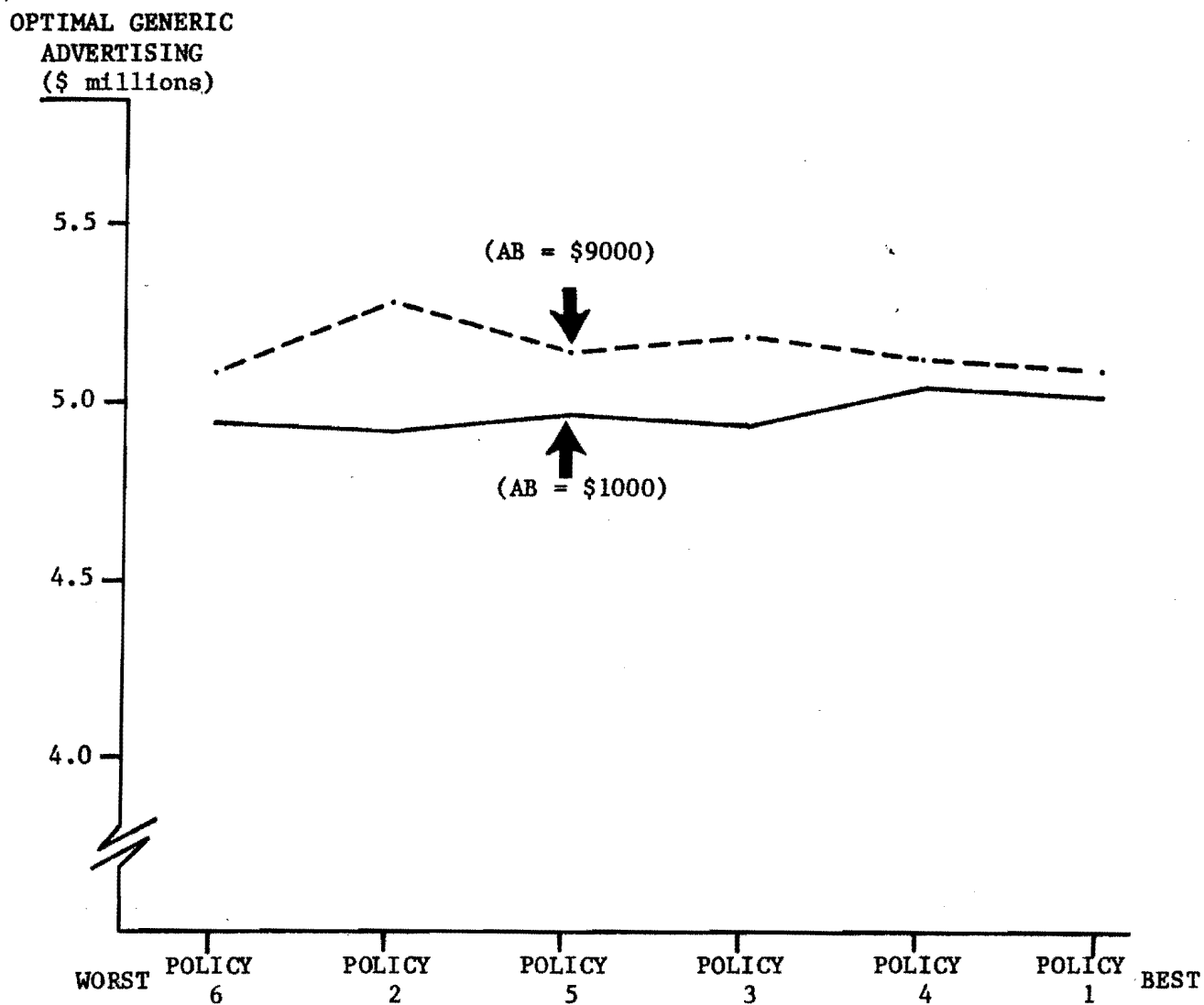


Figure 8. Sensitivity of the optimal generic advertising level to changes in the branded advertising policy.

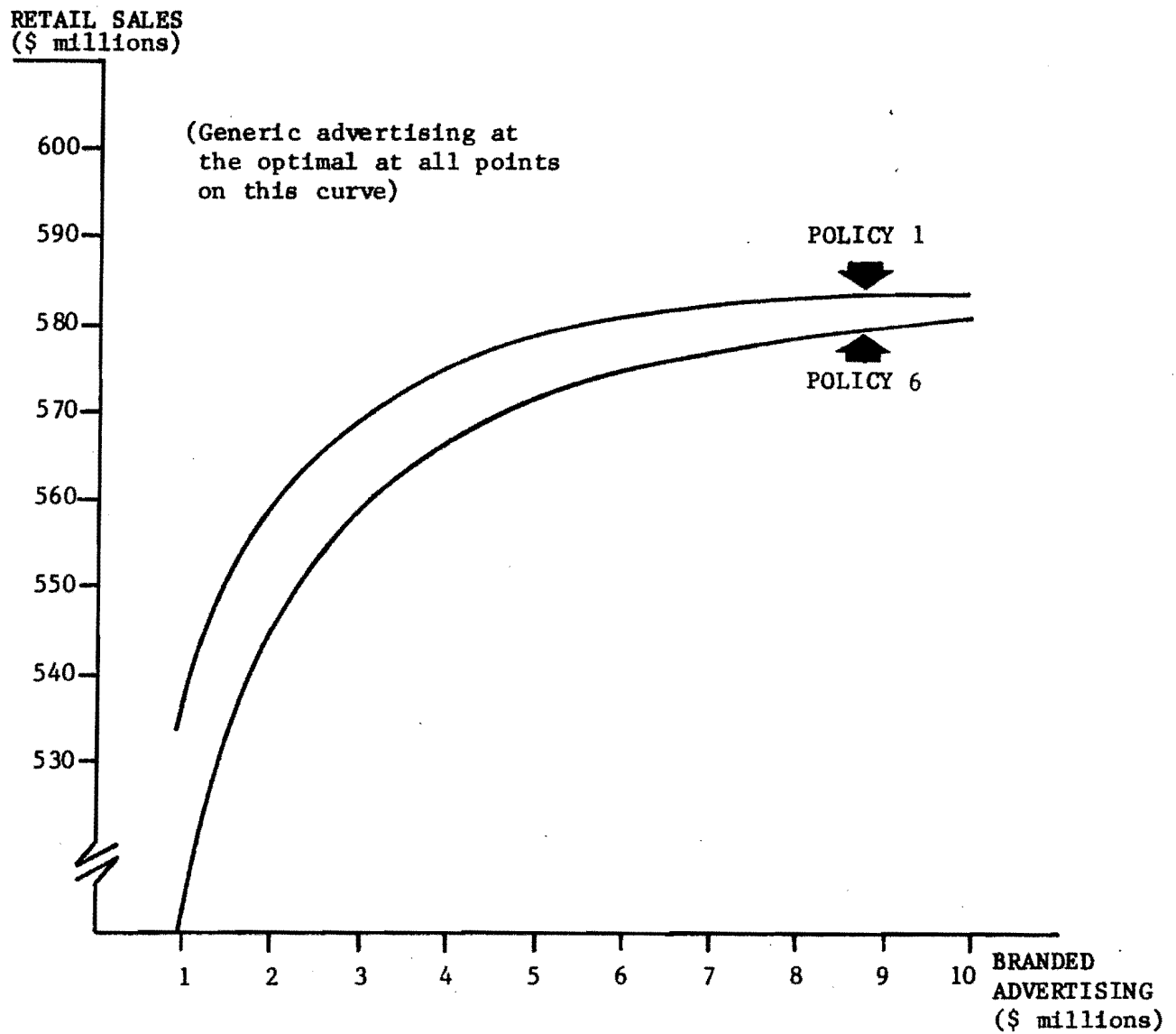


Figure 9. Forecasted sales resulting from an optimal allocation of generic advertising funds assuming different brand levels.

peripheral consumers versus those already consuming processed orange products. In general, the decreasing marginal returns to processed orange advertising along with the low carryover effect of advertising are two key factors leading to the conclusions outlined in the text.

The analysis presented in the text is applicable to the 1972-73 season. The model facilitates an experimentation with future marketing periods given specific variable updates. Likewise, the model assumes no change in the media and copies used. If major revisions in the present generic programs (other than expenditure levels) are made, then the model and hence the results presented here must be revised.

APPENDIX

The distributed lag model shown in equation 3 was estimated using both OLS and MLE. However, the reduced form estimations are generally biased and inconsistent with OLS. Only under the restrictive assumption that $\rho = \alpha$ does OLS satisfy the properties of BLUE. MLE provides an alternative estimation procedure when OLS results are inconsistent.

Assume that the model follows a first order autoregressive process where $\rho \neq \alpha$. Then for simplicity we write equation 3 as

$$Y_t^* = \beta_0(1 - \alpha) + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \alpha Y_{t-1}^*$$

where X_1 and X_2 decay at the same rate and

$$Y_t^* = Y_t - \varepsilon_t,$$

$$Y_{t-1}^* = Y_{t-1} - \varepsilon_{t-1},$$

$$\varepsilon_t = \rho \varepsilon_{t-1} + \mu_t.$$

Correcting for ρ and substituting subsequent values for Y_{t-1}^* results in the new form

$$Y_t^* - \rho Y_{t-1}^* = \beta_0(1 - \alpha)(1 - \rho) + \sum_{i=1}^3 \beta_i (X_{it} - \rho X_{it-1}) + \alpha(Y_{t-1}^* - \rho Y_{t-2}^*)$$

and

$$\begin{aligned} Y_t^* - \rho Y_{t-1}^* &= \beta_0(1 - \alpha)(1 - \rho)(1 + \alpha + \alpha^2 + \dots + \alpha^{t-1}) \\ &\quad + \sum_{i=1}^3 \beta_i (X_{it} - \rho X_{it-1}) + \alpha(X_{it-1} - \rho X_{it-2}) + \dots \\ &\quad + \alpha^{t-1}(X_{i1} - \rho X_{i0}) + \alpha^t(Y_1^* - \rho Y_0^*). \end{aligned}$$

Now define

$$\begin{aligned} Z_{it}^{(\rho, \alpha)} &= (X_{it} - \rho X_{it-1}) + \alpha(X_{it-1} - \rho X_{it-2}) + \dots + \alpha^{t-2}(X_{i2} - \rho X_{i1}) \\ &\quad + \alpha^{t-1} X_{i1}, \end{aligned}$$

$$\theta = Y_1^* - Y_0^* - \frac{\sum_{i=1}^3 \beta_i \rho X_{i0}}{\alpha} - \beta_0(1 - \rho)$$

Then

$$Y_t - \rho Y_{t-1} = \beta_0(1 - \rho) + \sum_{i=1}^3 \beta_i Z_{it}^{(\rho, \alpha)} + \theta \alpha^t + \mu_t.$$

If we assume various values for ρ and α where

$$-1 \leq \rho \leq +1$$

$$\text{and } 0 \leq \alpha < 1,$$

then Z_{it} and α^t are simply variables and the equation can be estimated

with OLS. Those parameters leading to the smallest error sums of squares are then selected given a priori sign restrictions.

The major difficulties with this procedure are its cumbersomeness and probability of approaching a null vector with small values of α and/or a large number of observations. Also, in some cases the ESS may not converge to an absolute minimum and the difference in ESS for values of ρ and α may be small.

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LIMITED CONTROLLED EXPERIMENTATION
THE TIMELINESS, EXECUTABILITY, QUALITY COMPROMISE

Doyle A. Eiler and Olan D. Forker*

As we examine the focal point of this seminar, the "Quantification of Sales Response to Generic Promotion Efforts," there appears to be two major, but interrelated, problems.

1. The estimation of sales for generic products.
2. The relating of the changes in generic product sales to the promotional efforts.

The primary thrust of our paper will be directed toward the latter problem. However, it is critical that we not ignore or depreciate the importance of the first problem, because without reasonably accurate estimates of sales, it is impossible to proceed to problems relating sales to the promotional effort. 1/

The development of meaningful sales estimates for a generic product can be difficult and frustrating. Aggregate, secondary data of the type available from the USDA and many state agencies provide gross estimates of utilization or disappearance. While these data are usually available for identifiable geographic production regions, they are usually not identified according to meaningful market areas. Comparability of data from different time periods can also present a problem.

While this is the general situation, some agencies have the resources, inclination and legal power to generate analytically useful sales estimates for a generic commodity. In New York State, the Department of Agriculture and Markets is in the process of collecting monthly sales data for the major fluid dairy products for each of the state's seven Standard Metropolitan Statistical Areas. Although these market areas are not quite congruent with media coverage areas for example, they are with market areas for which other economic and demographic data are available.

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1/ While total sales estimates may be desirable, accurate estimates of changes in sales are adequate. For generic products, an accurate estimate for changes in per capita consumption would provide a good and usable quantity substitute for changes in sales. For a good discussion of the advertising measurement problems, see Advertising Measurement and Decision Making, ed. by P. J. Robinson and published by Allyn and Bacon, Inc. Boston, 1968.

Frequently, sales or consumption data are acquired through store audits, consumer panels or consumer surveys to supplement the data available from secondary sources. While the panel or survey approach cannot be used effectively to estimate total sales, it can provide estimates of relative changes in sales over time. Survey or panel data also provide detailed demographic and socioeconomic information which can be utilized in the analysis of changes in various market segments.

MEASUREMENT AND DECISION MAKING

There are many different decision makers in a generic promotion program. Each has his own perspective and information needs. An individual producer would like information on how the promotion program affects his net returns or as a minimum how it affects total sales so that he can be more comfortable in his decision to support or not to support an industry program. If the promotion program is voluntary, the producer can and does continually reevaluate his decision to contribute or not to contribute. With a mandatory program, producers usually have periodic opportunities to change their decisions through a voting procedure. Regardless of whether the promotional program is voluntary or mandatory, additional information is needed by the producer to enable more rational decisions.

In most promotion programs, a board of producers is charged with the responsibility of allocating the promotion funds. The board members must decide among various types of broad promotion efforts and levels of expenditures. They also must select an organization to implement and execute this promotion program. Board members need a continuing flow of information on the effectiveness of the programs so that they can periodically reevaluate their decision. Somehow they need to monitor performance and build a stockpile of experience to facilitate the decision process. Such information will allow the board to make responsible recommendations to supporting producers for continuation or cessation of the promotion program.

To provide meaningful research inputs for the above decisions, the relationships between the promotional effort and the sales of the generic product must be estimated and understood to the best of one's ability.

In comparing alternative research procedures, not only do we need to examine their "methodological quality" but we must look at the timeliness of the research results and evaluate their executability within the decision constraints perceived by the promotion board.

Timeliness, executability and "quality" form the impossible triangle. These are the criteria of the research design. However, pragmatic compromises are necessary in order to generate the highest "quality" estimates

possible within the time and executability constraints prescribed by the given situation.

ALTERNATIVE PROCEDURES

There are a range of alternative procedures available for relating sales to promotional effort. These procedures can be arranged on a continuum from what we call "naive inference" to fully controlled market experimentation. The "naive inference" approach provides a simple and uncomplicated, but not very satisfactory, way of relating sales to promotion. The naive inference approach simply stated involved the observing of aggregate sales during the duration of the promotion effort. If sales increase, the promotion effort is responsible; if sales decline, they would have been substantially less without it. This technique is timely and executable but the "quality" of its estimates are considered to be poor. While we may tend to scoff at the appropriateness of this procedure, we must recognize that it has been used and will continue to be used when human and other resource constraints prohibit further sophistication.

The other end of the spectrum is the fully controlled market experiment. This is an experiment designed in such a way that the effects of variables other than promotional effort are either controlled or statistically removed. The USDA/ADA six market study is an excellent example of a fully controlled experiment. ^{2/} While this procedure can give us a definitive answer to the relationship between sales and promotion for a particular situation, the transferability of the results to other commodities, time period or advertising programs is not known. The quality of answers provided by this procedure may be superior to others on the continuum but in terms of timeliness and executability limitations may abound.

The limitation on executability can result from the unwillingness (for rational reasons) of the promotion board to allow or require variation in promotion effort required by the experiment. An inadequate number of separable markets with which to experiment may appear as another constraint. Timeliness can also hinder the implementation of a fully controlled experiment. Depending upon the type of promotional effort employed, the experiment may require more time than is available before a decision must be made.

We would propose a pragmatic alternative between these two extremes (i.e., naive inference and fully controlled market experimentation). This would be one which provides an executable program with the possibility of

^{2/} Clement, Henderson and Eley. "The Effect of Different Levels of Promotional Expenditures on Sales of Fluid Milk." Economic Research Service, USDA ERS-259, 1965.

timely results of an acceptable quality. ^{3/} It has been observed that most generic promotion efforts are executed with a rather constant level of expenditure over time and among markets. Usually this is done according to some formula that has a political genesis and is based on the money available. ^{4/} As long as expenditures are fairly constant over time and among markets, little more than "naive inference" can be used to estimate the sales response. This would be true even if one had very reliable estimates of changes in aggregate sales. As Waugh concurs, "The statistician cannot measure the effect of advertising expenditures if they are kept at a fixed level - or even at a fixed percentage of gross profits. The statistician must have records that cover substantial variations in the advertising budget from time to time." ^{5/} While a fully controlled market experiment may be impractical, planned variation in expenditure levels among markets and time periods seems necessary.

In the limited controlled experimentation approach, all promotion funds would be used to provide for a systematic variation of a few selected promotion variables among markets and over time. Measurements of sales changes (or changes in consumption) would be collected for the various markets and time periods. Initially, we would expect this approach to lead down some blind alleys. But as experience is accumulated and data are generated, the choice of alternative approaches, alternative expenditure levels and measurement tools could be more finely tuned.

To develop this proposition in more detail, let us describe in brief the program with which we are now associated in New York State, the problems which we face in the quantification of sales effect and our attempted solution.

THE NEW YORK MILK PROMOTION PROGRAM

A state marketing order requiring a mandatory check-off from each producer of five cents per hundredweight became effective in June 1972. To continue the mandatory program beyond its current three-year life, a producer referendum must reaffirm the dairymen's support of the order.

^{3/} The requirements of acceptability depend upon how the results are to be used.

^{4/} L. Spencer, "Programs for Promoting Increased Sales of Milk." Cornell Agricultural Economics Research No. 133 (Ithaca, New York: Dec. 1963).

^{5/} Frederick V. Waugh, "Needed Research on the Effectiveness of Farm Products Promotion." Journal of Farm Economics, Vol. XLI (2), May, 1959. pp. 364-376.

An Advisory Board comprised of dairy farmers together with a representative of the State Department of Agriculture and Markets allocate the funds generated by the marketing order. UDIA/ADA has been contracted to conduct the promotion campaign. The Board has given Cornell University a grant to conduct economic research and help them to evaluate the effectiveness of their program.

As part of the evaluation efforts, we purposed a limited controlled experiment whereby funds would be allocated among all markets in such a way that there would be variation in the level of promotion effort among markets over time. Over the strenuous objections of the advertising agency, the Board decided that some experimentation was necessary. After much debate the decision was made to experiment in two markets - Syracuse and Albany. In these two markets the annual expenditure of approximately ten cents per capita was condensed into six month periods. Thus, for six months, Albany and Syracuse will be experiencing a promotion program at an annual rate of twenty cents per capita; during the subsequent six month period, no advertising. During the course of this experimentation the other markets in the State will be advertising at an annual rate of ten cents per capita.

During January 1975, New York dairy producers will vote on whether to continue the promotion program. By that time we will have completed an "off" period, an "on" period and an "off" period in Albany and Syracuse. This is certainly limited experimentation and will provide improved inference quality over the aforementioned "naive inference."

An attempt is being made to compensate for the lack of variation in input by obtaining more information than aggregate sales data for the individual markets. Surveys will be used to monitor awareness, attitude and consumption levels. These will be related to various economic and demographic characteristics of the consuming population in each market surveyed. Thus, changes measured by the surveys can be compared to changes in the aggregate monthly sales data for each market as reported by the State Department of Agriculture and Markets.

The surveys will consist of both personal and telephone interviews. Attitude changes will be monitored through an annual personal interview of adults 13 years old and older in the five largest markets in New York State. Telephone surveys will be used to measure changes in consumption and to determine awareness or exposure to the advertising efforts. ^{6/} The telephone surveys will be conducted in the two test markets, Albany and Syracuse, and in New York City every six months. The surveys will coincide with the end of each treatment period.

^{6/} A recent study, "Self Administered Written Questionnaire or Telephone Interviews," by J. J. Wheatley in the Journal of Marketing Research, February 1973, p. 94f, concludes essentially no difference in the nature of responses to the same questions whether done personally or over the telephone.

Information is being collected on all beverages so that substitution effects can be approximated. Those interviewed are asked to report beverage consumption by kind and amount for the 24 hour period prior to the interview. They are asked also to identify any and all beverage advertisements that they have seen, heard, or read during the previous few days or the previous few months. Hence, an index of relative exposure on milk ads compared to other beverage ads can be developed. Each person interviewed is also identified as to sex, age, race, family size, employment and income.

With the above approach target audiences or consumer groups can be identified by specific group characteristics. Analysis can be made to explain variations in consumption of milk among consumers in each market in each time period. Various statistical techniques can then be used to test for significant differences in the coefficients associated with the explanatory variables. In this way, we will attempt to determine not only how much change occurred but identify the market and consumer group in which the change occurred.

SUMMARY AND CLOSING STATEMENT

Of the two problems existing in the title of this seminar, the one of relating changes in sales to the promotion effort is the most difficult to resolve in a practical, yet acceptable way. However, producers and advisory boards need information on sales response if they are to make intelligent decisions on the size of check-off or which agency to hire.

It is necessary to recognize the compromises required by the impossible triangle of timeliness, executability, and quality in relating sales of a generic product to promotional effort. The proposal of limited controlled experimentation is a way of gradually moving away from "naive inference" toward a higher "quality" inference procedure. Only as data are accumulated along with and concurrent with variation in major promotion parameters can meaningful application of econometric models become a reality. It would seem desirable for persons concerned with the appropriate level of investment or expenditure in promotion to systematically control variation in the promotion parameter rather than rely on natural or fortuitous events.

NEW HORIZONS FOR AGRICULTURAL PRODUCT MARKET DEVELOPMENT

Robert E. Branson*

It is both interesting, as well as useful for gaining perspective, to review some of the history of agricultural economists' efforts to scale the walls of agricultural market development. That history has been, at one and the same time, a battle of frustration and of victory. If anything, there have been more of the former than the latter. A new horizon is perceived, however, which should mean much to the future for market development endeavors. Much of the effort in the past has been grossly misunderstood, and perhaps most of all by fellow economists. But times change. It appears that a new chapter is emerging in American agriculture--one that properly recognizes the place, the function and the role of agricultural market development in a progressive social and economic society.

I was especially struck by a 1970 statement of John Kenneth Galbraith [8]. He commented:

One of the few reassuring things about economics is its tendency to adopt, on occasion, the sensible ideas of the ordinary citizen. Sometimes the citizen is well out in front.

This commentary equally applies to market development. The food or fiber producer has felt, inherently, that his product would, somehow, benefit from active support in the market place. By the end of this decade, I predict that the ordinary citizen who in this case is the American farmer, will be proven to be right.

It has been reported from various battles, "We have met the enemy and he is ours." In this case it is more accurate to say, "We have met the enemy and he is us." This leads to two major theses of my remarks.

First, as market development economists we have failed to listen to what those about us have said, not just recently but some years ago.

I turn to the remarks, for example, of two participants in the conference on "Promotion of Agricultural Products" sponsored by the Western Agricultural Economic Research Council, Salt Lake City, in April, 1959. Oris V. Wells, then Administrator of the Agricultural Marketing Service of the U.S. Department of Agriculture, made the following opening remarks at that conference [15].

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I assume that our main interest is in farm food commodities and raw fibers, although we must necessarily be interested in the finished products as they move at retail.

I assume the term 'promotion' covers a wide range of activities--that is, the use of field service men, various educational activities, advertising, and related market development activities along with considerable attention to price and production policies which are likely to make such efforts successful.

I assume that we are chiefly interested in efforts of farmers or associations of farmers or ranchers and the kind of market development activities which they may best carry forward. We [must] recognize that a great volume of the activity...is [how] farmer oriented activities can be tied to this larger effort.

Therefore, my first thesis is that we have failed to listen and have largely interpreted market development only in the narrow constraints of advertising and/or in-store promotions.

Wells made the further comment:

Also since we are centering our attention on what farmers and ranchers can themselves do, we came up against the problem of financing and equally important, what I term the problem of 'leadership accommodation.' How do farmers associate themselves together...to do a job?

Therein lies the second thesis. We have been too prone to overlook the organizational requirement essential to effective market development. Wells notes specifically the need for farmers to have a suitable organizational mechanism with proper internal functions and responsibilities to do the job. As market development economists, we have given little heed, much less effort, toward the solution of that facet of the problem. We must be more concerned with this aspect of the task.

Here in 1973, fourteen years later, it is advisable to further ponder these points, their relation to present events, and their implications for future research in agricultural market development.

From all appearances we are entering the leading edges of a major transformation in the nation's agricultural economy. Its final warp and shape will not be known for some time. The farm programs that have revolved

around the old CCC wagon for four decades are being unloaded and the wagon is being substantially redesigned.

The general citizenry, now largely urbanized in background, do not comprehend the agricultural economy. They do not visualize the stabilizing and low food price effect of past government farm programs. All that is seen is the federal monetary cost. Educating them regarding benefits is so herculean a task it is not likely to be undertaken, much less accomplished. Consequently the CCC type farm support programs are destined for substantial revision. The result will be to put agriculture on its own economic base rather than a government partnership like that of the past.

Clearly, the new policy is toward more self-determination by the agricultural sector of the nation's economy. The significance of this development is that it will ultimately put marketing and market development in a key role in the guidance of the total agribusiness economy.

Until recently, farmers and ranchers have had to pay comparatively little attention to the real gut aspects of marketing. Almost the total agricultural system, directly or indirectly, has been hinged on a government program that has either stabilized or stood ready to be the "market" whenever the nature or quantity of food, feed and fiber production was not geared to market realities. With that structure either gone or seriously modified, producers must become as knowledgeable about marketing as they presently are about production, if they are to economically survive. We now, and only recently, have agricultural production leaders coming to us asking what can be done about marketing. Previously concern was centered on insects, fertilizers and other production matters.

Given this potential, and rather seismic, shift in farmer and rancher concern, what have marketing economists available to offer for assistance?

Recognition has to be given first to one of the most essential requirements for effective market development. It is simply that market development cannot be achieved without an organized marketing group that can properly implement it. This requirement, I might add, also serves as one of the keystones in the program of the Market Research and Development Center at Texas A&M University. Consequently, we insist that this requirement be met before we invest the producer group's resources into a marketing problem.

What are some of the developments pertinent to organization for marketing as we view the present national scene? Some information is available in the recent work of the North Central Public Policy Education Committee in its series of statements relating to the question of "Who Will Control U. S. Agriculture?" Sundquist and Guither note that 56 percent of all agricultural sales, according to the 1969 U. S. Census

of Agriculture were made by only 8 percent of the farms [14]. Large commercial farmers, we find, are the active ones in seeking answers to marketing questions. Naturally they are the first to realize that the high investment in large scale farming demands assurance of markets and an adequate market performance for their products. Otherwise those production investments are in serious economic jeopardy.

Another facet of the food and fiber economy is equally important to the evolving situation. It will be interesting to note what the 1972 Census of Business reveals about further consolidation, integration and concentration in the food processing and distribution sector of our economy. Even in 1967, the eight largest companies marketing each of the following specific commodities controlled 30 percent of the value of fluid milk shipments, 38 percent of the meat packing and 46 percent of the flour and other grain mill products [14].

Ronald Knutson has noted that in the ready-to-eat cereal industry there are basically only six firms. The four largest--Kellogg, General Mills, General Foods and Quaker Oats--had over 90 percent of the sales in 1970 [9]. Other citations could be offered to confirm the increasing concentration in the food processing and marketing industry.

Thus we are faced with increased concentration among producers, among processors and among marketers. Greater and better coordination of production and marketing is becoming essential. But coordination requires organization to implement it. To match the concentration and coordination among processing food and fiber industries, there are arising such conceptual entities on the food and fiber production side as the American Grain and Cattle Co., and the Business and Professional Farmers Association on the national scene. In the Southwest, as only one example, are active producer groups concerned with marketing such as American Rice Growers Association, the Texas Peanut Producers Board and the Plains Grain Sorghum Producers. Each of these are at different levels currently in marketing programming and market development know-how. With respect to cotton, there is Calcot in the West, Swig and Plains Cotton Producers in the Southwest and Staplcotn in the South. These are now implementing a national Amcot marketing entity. In dairy, we cannot overlook Associated Milk Producers, Inc.

What O. V. Wells indicated was necessary for effective market development action--producer associations for action--is now finally beginning to move more fully in place. It is only a beginning. A long distance is yet to be traveled. The question is whether our cadre of market development expertise is sufficiently and broadly enough developed to serve their needs.

It is quite likely that the producer associations, together with their industry processing and marketing counterparts, will jointly shape

the future of U. S. agriculture. Harold Breimeyer has concluded that giantism and market control must be prohibited if a dispersed, open agriculture is to survive. He recognizes, however, that some major changes in present policies and some drastic measures will be necessary to support it if an open, dispersed agriculture is to survive [3]. The central question, I submit, is not small farms versus giant farms, but rather one of effective organization for marketing of whatever shape and form the production enterprise may assume. Concentration for marketing seems destined to continue. So the question again is what can those of us in market development provide as a guidance rudder to this agribusiness effort?

Logic seems to suggest that the better the marketing knowledge on both sides--producer and processor--the better the ultimate solution that will be derived. It is precisely here that the challenge emerges.

Having laid the foregoing predicate, it appears that the only meaningful answer is to reevaluate the posture and goals in the marketing profession and set requirements for their achievement.

The challenge today in agribusiness is exactly that which faced us fourteen years ago. Then, as now, we were usually confronted with requests to build market development programs for a generic product grown largely by a multitude of unorganized producers. Many of the producers were isolated from the "truth" of markets by federal support programs of one kind or another. Thus there was no compulsion to organize for marketing.

Now our help is increasingly being sought by those who are willing to organize for marketing. Wells commented, if you recall, that there is more to market development than advertising. However, thus far we have frequently made market development and advertising synonymous. Howard Diesslin, then with the Farm Foundation, in summing up the 1959 conference, said in essence that recognition was given to market development as being more involved than just advertising. Yet, he commented, most of our discussion was almost exclusively about advertising [7].

Interestingly, when the 1959 conference participants jointly drew up a regional project proposal its objectives were:

1. Analyze the economic characteristics of the product that could be related to promotion.
2. Determine the physical characteristics that could be related to promotion.
3. Determine the characteristics of the market for the product that could be related to promotion.
4. Interrelate the three to determine promotion feasibility.

The conference, therefore, was still enveloped only with the charisma of advertising.

In our 1973 session here in New Orleans, we too have been somewhat the victims of our own web of intransigence. Market development is considered to be synonymous with promotion and promotion is viewed as synonymous with advertising. This web we must break away.

Reference may be made, as an example, to the experience of the Texas Agricultural Market Research and Development Center at Texas A&M University. Perhaps there are some insights to be gained from its experience that have general application to the question.

During the past four years the core staff of eight men in the Center have tackled and become market development researchers and counselors to several agricultural groups. Where groups have had both the fortitude and determination to seriously tackle market development, we can say with reasonable confidence that their programs have been reasonably successful.

At the same time, it would be the consensus of the Center staff that advertising, as a market development weapon, has been but a partial weapon within the overall arsenal of market development tools utilized in market development strategies outlined by or for them.

For most agricultural producer groups, starting from where they are, there are equally if not more important strategies than advertising. This is not to say that there are not some reasonable exceptions, for there are.

A few case histories can be cited. One is the Texas citrus industry. Among the most significant market development research, and resultant strategies, in this case concerned matters of

1. Fruit grading [10]
2. Packaging design [11]
3. Package size [11]
4. Market allocation between fresh market and processing [6]
5. Market allocation among fresh market outlets [6]
6. Use of in-store point of purchase material [13]
7. Use of in-store demonstrations [5]
8. Awareness of newspaper generic advertising ¹
9. Allocation of advertising effort among alternative markets ²

Only four of the nine pertain to advertising. Oddly enough in all of those pertaining to advertising the answers generally were to either reduce or modify their allocative use of them. According to our best calculations, the following of the research indications and recommendations for market development returned an additional three to five million dollars to growers last season. There were additional returns to other segments of the industry which we did not attempt to measure.

¹Unpublished consultive analysis of industry data.

²Ibid.

Another case concerns the Texas-Louisiana rice industry. An overall market organization and strategy plan was formulated which involved primarily the following steps [1].

1. Centralized consolidation of producers supplies for marketing purposes.
2. Introduction of a new, more relevant, rice grading system.
3. Implementation of a sophisticated, computerized market flow and information system.
4. Bargaining with mills regarding terms of delivery, pricing and marketing services performed.
5. Consideration of forward integration to participate in processing.

Thus far steps one through four have been invoked at a profit to producers of approximately one million dollars the first year and 1.9 million dollars during the 1972-3 marketing year according to American Rice Growers, Inc. own records. The payoff is expected to increase further in 1973-4. No advertising was involved. However, advertising and market promotion functions are largely served by another organization representing producers and industry. If American Rice becomes involved in or associated with marketing milled rice, advertising will become relevant. As a part of the market development research and analysis, probable costs of retail market development for several key metropolitan markets were examined.

A further case involves Southwestern peanuts. Research concerning a national overview market development study is essentially completed [12]. Findings will be released soon. However, we were not over eight weeks into the market development research until we struck a significant pay-out because of the need for a change in the comparative pricing system for whole versus split kernels. The latter are used mostly by some peanut butter processors.

Finally there is in progress a national marketing study concerning cotton [2]. Interesting is the breadth of subject matter viewed as associated with market development and marketing strategy thereto.

A comprehensive marketing management program in this instance involves three major operation sub-areas: supply, marketing and finance. Each has specific activities within it as noted in the following listing.

Components of Marketing Management

- A. Supply Administration
 1. Production controls to fit supplies to effective market needs and strategies
 2. Quality control to meet end-use market requirements
 3. Inventory reserves to maintain pipe-line supplies and price stability

4. Forward contracting to coordinate production, quality and markets
5. Production pools to assemble effective supplies for marketing implementation
- B. Marketing Administration
 1. Advertising to aid sales expansion
 - a. Domestic market by end use to serve as a demand pull
 - b. Foreign market by country to maintain markets and expand volume
 2. Pricing policy
 - a. Single pricing for comparable cotton end uses
Domestic end use markets
Export end use markets
 - b. Multiple pricing
Domestic by end use or to foster development of new uses
Export by country to deal effectively with conditions in different foreign markets
 3. Market allocation
 - a. By market segments to serve priority markets and evolve others
 - b. Export markets to build competitive position
 4. Market control
 - a. Forward integration as needed to assure cotton usage
 - b. Sales program control to support coordinated marketing effort
 - c. Joint ventures in market and product experimentation
 - d. Forward contracting to guarantee markets
 5. Sales staff programming
 - a. Domestic by end use markets including technical service assistance
 - b. Foreign by country to develop new outlets
 6. Market information
 - a. Sales performance analysis by market segments
 - b. Competitive products pricing and market share performance
 - c. Market trend analysis as measure of program performance and future planning guide
 7. Market research
 - a. Product evaluation at processor and consumer level by end use
 - b. Foreign market opportunities analysis
 - c. New domestic market exploration
 - d. New product concepts and testing
 8. Research and development
 - a. Improvements of existing products
 - b. New product prototypes and development
- C. Financial Administration
 1. Production financing as needed to assure proper quality and supplies
 2. Inventory financing to manage inventory reserves
 3. Sales financing assistance as marketing back-up
 4. Capital requirements for market development innovations
 5. Provision of an equity reward system to production, marketing management and capital

One may differ regarding the designation given some of these functions or their specific location in the list. Nonetheless, and more importantly, they all must be active for a good, sound marketing program.

The greatest immediate threat to cotton market development at this particular time is not the need for advertising. Rather it is the urgent need for stability of supply and price at reasonable and competitive levels.

From the foregoing few examples, what are the implications for market development research. Quite obviously the foregoing calls for a systems analysis approach to market development opportunities insofar as research for agricultural producer groups is concerned. Therefore, market development must break out of the shell of highly compartmentalized research fragmentation. Viable team market development research groups must be created with diversified expertise capabilities. Such groups are needed at the Department of Agriculture level and within the Land Grant universities. We must almost carve out a new marketing discipline insofar as most agricultural economics departments are concerned. Their history has been steeped in "farm gate" first sale aspects of raw product marketing. Unless such changes are made, synthetics backed by comprehensive market development expertise, will continue to pin major segments of our natural food and fiber producers against the marketing wall.

Finally, we must not conclude that new product concept development, for example, is only for Polaroid or Eastman Kodak, General Mills or General Foods. We even need to reevaluate our overall national policy in this regard. Harvey Brook, President of the American Academy of Arts and Sciences and Dean of Engineering and Applied Sciences at Harvard University recently addressed the question of what is happening to the U. S. lead in technology [4]. He noted the share of public research and development expenditures that supported economic objectives in agriculture, manufacturing and services in 1968-69. The United States was last on a list of seven nations, having only 6 percent so designated compared with 48.9 percent in Canada, 25 percent in Japan and 22 percent in the United Kingdom. Others ahead of us were France, Sweden and the Netherlands.

In the Agricultural Science Review for the Second and Third Quarter of 1970, the following was noted about the role of the State agricultural experiment station food scientist.

In a State agricultural experiment station setting, choice of endeavor becomes extremely important. Obviously, a station scientist or his institution cannot exploit the product by marketing it in competition with private industry. The station food scientist can, however, do the work necessary to show the potential of a product, determine the properties of the agricultural commodity--

and he can generate product ideas. He can identify basic properties of agricultural commodities. He can plan how to improve present products thereby enhancing their convenience, value and identity. The scientist must ask: Will this work fit my program of research? Is it likely to be picked up and exploited by industry?

In outlining the means to successful market development to producer groups, we must ask ourselves our counterpart of the same questions. Once this is done, and we can do it, market development will assume its proper role and can become the fulcrum it necessarily must be for a vigorous producer involved agribusiness economy.

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