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INTRODUCTION

If manufacturers do not understand or are not able to evaluate advertising, it is not from a lack of interest or a shortage of available theories, systems, or research. If manufacturers do not understand, or are not able to evaluate the effect of promotions, it is probably from lack of trying. In a survey of the top advertisers conducted in the summer of 1972, over two-thirds of the 84 companies responding stated that they do not use any marketing model which considers the effect of promotional activity on sales [2]. The lack of interest in effectively evaluating promotions is not only a shortcoming in the business community, but is also evidenced in the academic community by the "scarcity of professional literature on the subject" [2]. Yet promotions are an important ingredient of a total marketing mix in helping a manufacturer develop control over the middleman in each channel to insure that the manufacturer's policies are coordinated and properly implemented [3]. Control, of course, implies a process in which an organization of persons determines, that is, intentionally effects the behavior of another person, group, or organization [4, p. 5]. Without effective control by the manufacturer, the middlemen in each channel are left to try and develop procedures for optimizing their individual profits. This type of marketing plan, if left to market forces alone, often results in less than optimal decision patterns for both the operators of the system and for the consumers it serves [3]. It follows that a total marketing program should be formed in concert with both control opportunities and costs [1] of manipulating the channel partners, with choice of specific strategies made on the basis of their expected effectiveness, their cost, and their legal risks [3]. Of the forces that have a strong short-run influence on the success of promotions, trade inventory levels are one of the most critical, least understood, and toughest to measure of all the marketing forces and exogenous variables that a manufacturer must be concerned about.

The failure to measure changes in trade inventory levels during periods of promotions cannot only result in a failure to determine which promotions have been successful, but can actually make unprofitable promotions appear to be profitable. Trade inventories are an extremely volatile factor, causing wide fluctuations in factory sales over short periods of time with almost any significant change in economic or marketing conditions. Significantly, these wide variances in factory sales often occur in spite of a level consumer consumption. Unfortunately, this critical force which both causes and is affected by changes in the level of factory shipments, is almost totally ignored by most marketing systems and generally assumed (usually implicitly) to be constant when marketing plans are developed. The importance of this factor has long been recognized by major durable goods manufacturers and the United States government, who consistently use trade inventories in preparing sales forecasts and economic predictions.

Yet, despite the obvious importance of trade inventory levels to the sales of any product, nondurable consumer goods companies continue to ignore or seem unconcerned with this factor in preparing product forecasts and in developing tactical marketing plans. While marketing executives are sophisticated enough to recognize that trade inventories can and do substantially effect sales, they do not try to develop even a crude tool for measuring inventory changes and usually ignore any potential changes in trade inventories when ac-

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tually planning such critical activities as consumer promotions (which, not surprisingly, are very dependent on and concurrently effect trade inventories). The objective of this proposed system is to develop the means to measure changes in trade inventory levels which can be used to help more accurately measure and predict the effect of different marketing strategies.

This article will: (1) review an actual example of the importance of trade inventory levels in evaluating and planning trade promotions; (2) present a conceptual and theoretical framework for measuring trade inventory levels using data that are currently available to all companies; (3) present the concept and theory as a mathematical model; and (4) present a numerical example to help clarify the mathematics and show how the model can be used.

THE SIGNIFICANCE OF TRADE INVENTORY LEVELS

The following example, while dramatic, is probably typical of phenomena happening to many consumer products, but is hardly understood and is rarely considered in the tactical planning of most product managers. The brand being studied is a consumer product with good market share, sells for under one dollar, primarily but not exclusively through chain and wholesale grocery stores, and has wide distribution with over 90% consumer awareness.

Figure 1 shows the monthly trade sales of this major consumer product for a 60-month period. During this 5-year span, trade promotions were a frequently used

Figure 1

FACTORY SALES BY MONTH

Years 1–5

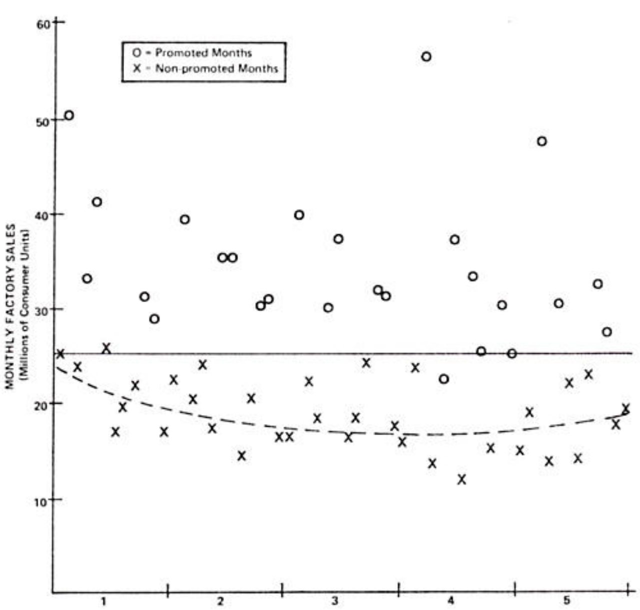
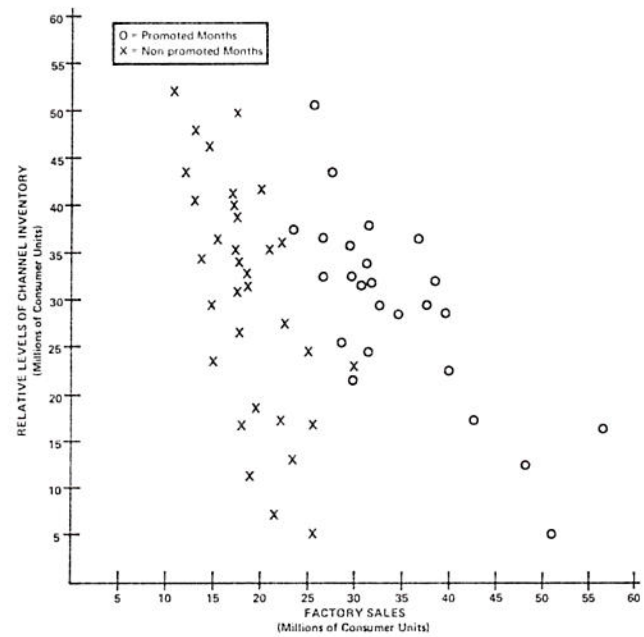


Figure 2

MONTHLY FACTORY SALES VS. RELATIVE LEVEL OF CHANNEL INVENTORY



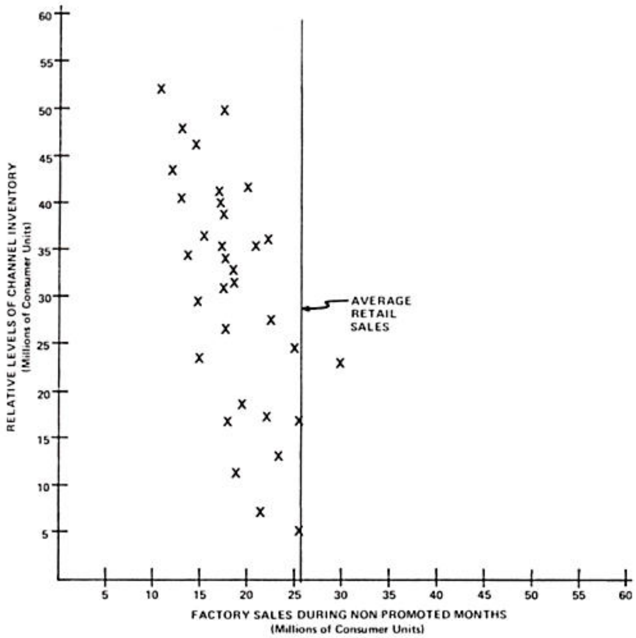
marketing stimulus, with total trade promotion expenditures amounting to millions of dollars. The dotted line represents an estimate of the normal level of demand, calculated by measuring average factory shipments (adjusted for trend, season, and other marketing factors). During promoted months (indicated by circles), sales increased significantly, often doubling expected normal demand. Because of the long period of time under study and a consistent level of the other major market forces, there seemed to be no doubt that the effect of promotions on sales was quite high. However, when sales are plotted against estimated levels of trade inventory, a different picture begins to develop.

Figure 2 shows monthly sales plotted against estimated trade levels. It is evident that those months that were promoted consistently outperformed those months that were not. What is really happening, however, becomes clear when Figure 2 is split into two graphs showing nonpromoted months (Figure 3) and promoted months (Figure 4) separately. In both cases, estimated monthly retail sales are also shown. (This level was later confirmed by an independent retail audit by one of the major syndicated services.) Figure 3 shows that trade sales during nonpromoted months are lower than the average monthly retail sales.

In this particular case, factory shipments would increase during promotions because the trade had entered into a typical cyclical pattern of high purchase during promotions, building up excess inventories, and then lowering sales in order to reduce inventories. When the manufacturer took the product off promotion, the

Figure 3

MONTHLY FACTORY SALES DURING NONPROMOTED MONTHS VS. CHANNEL INVENTORY LEVELS



middlemen would not wish to buy more than they could sell to the next level in the channel. And, of course, they would only be willing to buy what could be sold to the next channel partner if their inventories were not higher than would normally be carried to support demand. However, if trade inventories were high, then the trade would actually purchase less than they could sell, making up the difference from their inventories. This inverse relationship can be clearly seen in Figure 3. The higher trade inventories are, the lower the quantity of product which must be purchased to support a given level of sales to the next level of distribution in the channel.

Figure 4 shows the reverse pattern. Since all the months shown in this diagram are promoted, the objective of the middleman (at least as he perceives it) has changed. The middleman, now wishing to take advantage of the lower costs, wants to build his inventories as high as possible to increase his selling margin. (All middlemen would presumably only increase purchases as long as the promotion was worth more than the cost of carrying the inventory.) Figure 4 shows that when inventories are low, the trade will purchase a great deal of a product, until the trade inventories increase to the point where the savings from the promotion no longer compensate for the cost of carrying higher inventories. Once inventories reach a certain level, about all the trade can do is purchase the same amount of goods that they can sell at retail.

Referring back to Figure 1, a new picture begins to emerge. The dotted line does not represent the normal expected demand, but represents the expected level of normal sales during periods when the trade is working off high inventories. However, until this point the analysis, no matter how logical and well done, still is unproven. Fortunately, the management of this product was willing to change, and a decision was made to stop promoting the item.

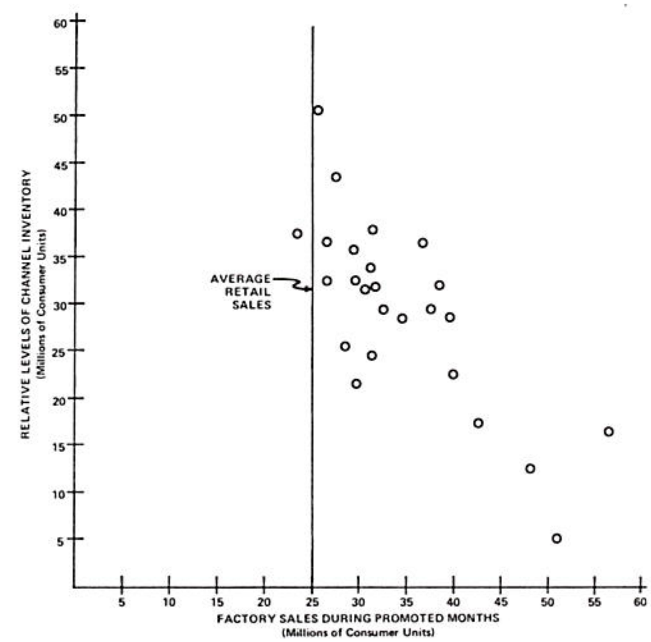
Figure 5 shows the five promoted years and a period of three years in which the item was only promoted once. It can be seen that sales leveled out, increasing production and distribution efficiencies. The effect of the trade inventory build-up can clearly be seen when only one period was promoted. The solid line in Figure 5 is shown to be the true expected normal demand, and the dotted line, instead of representing demand, represents demand in the periods just after a promotion when trade inventory levels are high.

The last piece of rather convincing evidence that trade promotions were not really succeeding in maintaining increases in the sales of this item are seen in Figure 6 which shows annual sales for 8 years. The first five years were heavily promoted, the next two have no trade promotions, and the last year has one trade promotion. Annual sales continued at the same levels, but trade promotion costs were reduced by $1,000,000.

What if trade inventories effect sales? How can this be used? The level of trade inventories, particularly in an oligopolistic market, suddenly becomes one of the most, if not the most important tactical factor in determining the success of a trade promotion. A trade promotion

Figure 4

MONTHLY FACTORY SALES DURING PROMOTED MONTHS VS. CHANNEL INVENTORY LEVELS



occurs when trade inventories are low, and the promotion (all other factors being equal) will be considerably more effective than a trade promotion when trade inventories are high. How many times has a brand manager been puzzled about why supposedly equal promotions have had unequal results when all other marketing conditions seemed similar? The level of trade inventories was probably never considered. If competition promotes and succeeds in building up trade inventories, a promotion against their high inventories is going to have a tough time succeeding. Clearly, trade inventory levels are a very important tactical factor in deciding on the timing of a promotion. A major objective of a promotion should be to build up trade inventories to a high level before the competition builds up the trade inventory with its brand.

FRAMEWORK AND OVERVIEW OF THE THEORY

Earlier attempts by consumer product companies to build a general model to measure changes in trade inventory levels have failed because of the inability to measure or estimate a wide range of key variables, such as length of trade channels, product perishability or durability, cross-product elasticity, change in consumer demand, and levels of trade inventories.

When the major grocery chains began to sell warehouse withdrawal data to SAMI (Selected Area Marketing Information) to measure product movement out of the central warehouses of most grocery store chains in selected areas, the theory for developing a means of measuring changes in trade inventories for each class of trade by geographic area became possible. The data inputs needed to build a model are SAMI data and a company's factory sales to groups of accounts that have similar purchasing behavior (i.e., class of trade,

Figure 5

FACTORY SALES BY MONTH

Years 1–8

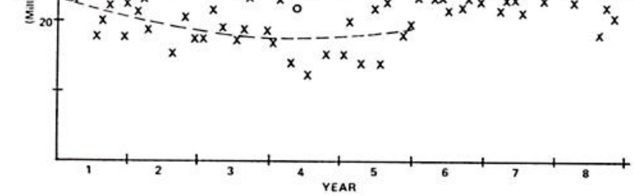
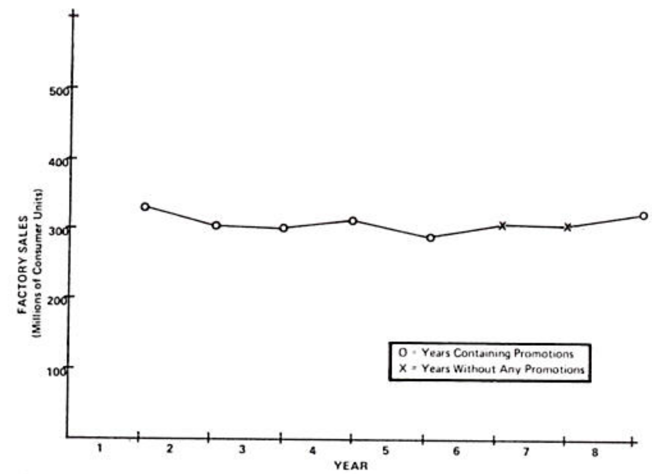


Figure 6

FACTORY SALES BY YEAR



customer size, geographic area, or any other meaningful classification). These customer groupings can be called sales channels.

The first step is to generate the historical relationship between various sales channels. Let Channel W represent the channel of sales represented by those grocery chains audited by SAMI. Let us assume that a sample historical relationship between factory sales to Channel 1 and Channel W during some historical period has shown that sales to Channel W are twice as high as sales to Channel 1:

$$S(W) = 2S(1) \qquad S(1) = \text{Sales to Channel 1.}$$

When a marketing force is introduced (i.e., trade promotions), sales to Channel W can decrease in proportion to Channel 1, increase in proportion to Channel 1, or remain in proportion to Channel 1.

It should be pointed out that no assumptions are made at this point about the reaction of any class of trade in relationship to what it had been buying. All that is being done is to measure the relative change in purchasing patterns among different groups of customers during a promotional period.

After the promotion ends, the same measurements are taken for a period of time sufficiently long enough for the effects of any trade inventory build-ups to be shown. If sales to Channel W are proportionately higher than sales to Channel 1, this indicates that the trade inventory in Channel W is proportionately lower than the trade inventories in Channel 1. Conversely, if sales to Channel W are proportionately lower than sales to Channel 1, the reverse is true. If after the promotion ends both trade classes go back to purchasing goods in the same proportion that they did before the promotion, then any change in trade inventory levels in Channel 1 was proportioned to the change in trade inventory in Channel W.

A promotion that has been able to significantly increase permanent distribution in trade Channel W could result in a distortion. Since sales to Channel W will be proportionately higher to Channel W after the promotion ends, it will initially appear that Channel W has put less of the factory sales into trade inventories and hence yielded a more successful promotion. While this is true, the success of the promotion in Channel W is because it increased sales, and because it increased permanent distribution. After a few periods of measurements, it will become clear that the ratio of sales between Channel W and Channel 1 is not going to return to the previous relationship. In this case, it can be seen that not only were sales to Channel W more successful in the short run, but were also successful in generating long-run gains. It should be noted that trade inventories are only one of many factors that can influence the success of a promotion, and the more forces that are operating at any one time, the more difficult it is to measure any individual factor. One of the major advantages of an approach that measures sales in one channel against sales in another channel is that most marketing forces that effect one channel will often be concurrently effecting the other. In a sense, it is almost like running a continual series of experiments.

At this point, a review of what can be learned shows that only the relative level of trade inventory in Channel W as measured against the change in trade inventory in Channel 1 is known. The absolute level of inventory change in Channel 1 or Channel W cannot be measured from what has been examined so far. To complete the analysis, in-house sales data can be used. A measure of the drop in factory shipments after the promoted period can yield a measure of the sales lost after the promotion because of a trade inventory build-up. While this particular technique is theoretically sound, real world data are such that it is very difficult to generate this measurement with any confidence. While it can and has been accomplished, the level of sophistication in most companies, and the detail of the data they keep, are such that the alternate approach is preferred.

Data supplied by one of the syndicated services must be used and, based on work that has been done to date, SAMI seems to have the best data available. In essence, two ratios are generated: (1) ratio of factory sales to Channel 1 to retail sales in Channel 1, and (2) ratio of factory sales to Channel W to retail sales in Channel W. Since Channel W represents those accounts audited by SAMI, factory sales are known from internal data and retail sales are known from SAMI data. This information and the knowledge that consumer sales must equal trade sales over time allow the changes in trade inventory for each class of trade to be calculated. From a knowledge of factory sales to each channel (from internal sales data) and audited retail sales in Channel W (from SAMI data), it is possible to calculate the retail movement in Channel 1, since three of the four variables in the ratio are known. And from a knowledge of retail and factory sales, a measure of changes in trade inventory is easy to calculate.

DEVELOPMENT OF MATHEMATICAL MODEL

While a development using the more conventional mathematical or verbal explanations is possible, the use of set theory very succinctly enables us to represent a cumbersome process of manipulating data. Since a very fundamental objective of this section is to allow others to develop and use this system using real world data without having to modify the mathematical relationships, it is developed in a manner that is conceptually a little more difficult to follow, but will considerably ease the burden of those who wish to test and expand the system in new areas.

The fundamental relationship of the practical application of the theory is the ability to get subsets of accounts that are represented in two or more sets of accounts. This, of course, is merely the intersection of the two primary sets. For example, Set A contains sales to accounts a, b, c, d which are in New York, and have a volume of over $1,000,000. Set B contains the national jobber accounts, which are b, c, e, f, g, h.

If all the jobber accounts in New York with a volume of over $1,000,000 are needed, it can be verbally explained or represented mathematically as the intersection of Set A (a, b, c, d) and Set B (b, c, e, f, g, h) which yields Set C (b, c). While the use of set theory in this context is unusual, it should reduce the amount of mathematical notation that would otherwise be needed. The definition of the intersection of matrix $\mathbf{C}(i, j)$ and matrix $\mathbf{G}(e, j)$ is the intersection of each element of $\mathbf{C}(i, j)$ with each element of $\mathbf{G}(e, j)$.

Definition of Variables

Define:

$c(i, j)$ = sales to the $j + 1$ level of distribution in channel i, by the jth level of distribution ($j = 1$ at the manufacturer).

$a(i, j)$ = inventory at the jth level of distribution in channel i.

$g(e, j)$ = sales to the $j + 1$ level of distribution in geographical area e, by the j level of distribution.

$b(e, j)$ = inventory at the j level of distribution in geographical area e.

$w(e, j)$ = sales to the $j + 1$ level of distribution from the jth level in geographical area e for all accounts audited by SAMI. Note that $w(e, j)$ is also the intersection of sets $g(e, j)$ and $c(i, j)$.

$d(e, j)$ = inventory at the j level of distribution in area e for accounts audited for warehouse withdrawal information. $d(e, j)$ is the intersection of the two sets $b(e, j)$ and $a(i, j)$.

In switching from a static to a dynamic system, the time period will be shown as the third subscript, i.e. c(i, j, t).

Let $i = 1 \cdots, n; j = 1, \cdots, m; e = 1, \cdots, p;$ and $h = 1, \cdots, np$, where: n = number of channels, $n = 1$ for the channel audited by SAMI, m = number of levels in the channel, and p = number of geographical areas.

The following three ratios will be set up using the variables that have just been defined. The significance of these ratios will become clear at a later point.

r(i, 1) = factory sales to those accounts audited by SAMI divided by factory sales to channel i.

$$r(i, 1) = \frac{c(1, 1)}{c(i, 1)}$$

s(e, 1) = factory sales to accounts audited by SAMI in geographical area e and divided by total factory sales to geographical area e.

$$s(e, 1) = \frac{w(e, 1)}{g(e, 1)}$$

t(1, j) = sales to accounts monitored by SAMI in the jth level of distribution divided by sales from these same accounts to the next level of distribution.

x(e, i) = total factory sales to the channel audited by SAMI divided by factory sales to channel i in geographical area e.

$$x(e, i) = \frac{c(1, 1)}{\text{intersection of } c(i, 1) \text{ and set } g(e, 1)}$$

y(e, i) = total factory sales to accounts audited by SAMI in geographical area e divided by factory sales to channel i in geographical area e.

$$y(e, i) = \frac{w(e, 1)}{\text{intersection of set } c(i, 1) \text{ with set } g(e, 1)}$$

z(e) = factory sales to accounts audited by SAMI in geographical area e divided by factory sales to all accounts audited by SAMI.

$$z(e) = \frac{w(e, 1)}{c(1, 1)}.$$

Definition of Matrices

$\mathbf{C}(i, j) = \text{MAT}(c(i, j));\quad i = 1, \cdots, n \quad j = 1, \cdots, m-1$

$\mathbf{G}(e, j) = \text{MAT}(g(e, j));\quad e = 1, \cdots, p \quad j = 2, \cdots, q-1$

$\mathbf{A}(i, j) = \text{MAT}(a(i, j));\quad i = 1, \cdots, n \quad j = 2, \cdots, m$

$\mathbf{B}(e, j) = \text{MAT}(b(e, j));\quad e = 1, \cdots, p \quad j = 2, \cdots, q$

$\mathbf{W}(e, t) = \text{MAT}(w(e, t));\quad e = 1, \cdots, p \quad t = 1, \cdots, q-1$

$\mathbf{D}(e, t) = \text{MAT}(d(e, t));\quad e = 1, \cdots, p \quad t = 2, \cdots, q$

$\mathbf{R}(i, 1) = \text{MAT}(r(i, 1)); i = 1, \cdots, n$

$\mathbf{S}(e, 1) = \text{MAT}(s(e, 1)); e = 1, \cdots, p$

$\mathbf{T}(1, j) = \text{MAT}(t(1, j)); j = 1, \cdots, m - 1$

$\mathbf{X}(e, i) = \text{MAT}(x(e, i));\quad e = 1, \cdots, p \quad i = 1, \cdots, n$

$\mathbf{Y}(e, i) = \text{MAT}(y(e, i));\quad e = 1, \cdots, p \quad i = 1, \cdots, n$

$\mathbf{Z}(e) = \text{MAT}z(e);\quad e = 1, \cdots, p.$

ESTIMATION OF BASE PERIOD INDICES AND OTHER PARAMETERS

Prior to the promoted period (assuming that a period of no unusual marketing activities exists) the base period indices should be calculated. To determine whether the base period indices have been generated during a "steady state" period, they must be monitored for a sufficient time to insure that the ratios do not change. These ratios can also be compared for different periods prior to the promotion to be sure that they do not deviate significantly from one time period to the next. In the event of significant deviations, additional research must be done to determine the cause of these fluctuations and permit the appropriate adjustments.

From historical measurements of $\mathbf{R}(i, 1)$, $\mathbf{S}(e, 1)$, and $\mathbf{T}(1, j)$, it is possible to develop an estimate of an "average" value of each of these ratios for some base period, represented by $\mathbf{K}(i, 1)$, $\mathbf{M}(e, 1)$, and $\mathbf{L}(j)$ respectively.

The elasticities referred to here are similar to the standard economic elasticities which are the relative change in one variable to the relative change in another variable, for example, if:

$$\frac{(r(i, 1, t) - r(i, 1, t - 1))/r(i, 1, t - 1)}{(r(i - 1, 1, t) - r(i - 1, 1, t - 1))/r(i - 1, 1, t - 1)}$$

is greater than 1, then sales to channel i during period t have increased faster than sales to channel $i - 1$.

Since what is being measured is relative changes in sales to different groupings of accounts, it is necessary to start off with a standardized period that can establish the relationship of sales to one group of accounts relative to other groups of accounts. In order to establish these base period indices, it may be necessary to make seasonal or trend adjustments for groups of accounts that represent different geographical areas or purchase patterns. This is an obvious requirement in developing data for any system and common sense must be exercised. Evaluations of the type presented in this article would probably not be successful for new products in unstable markets, but are ideally suited for products that have reached a more mature and stable point in the product life cycle. The seasonal and trend adjustments can be made by any one of a number of standard and well-documented techniques that need not be elaborated.

Significance of Key Ratios

1. If $r(i,1)$ is equal to $k(i,1)$ after a promotion has ended, then channel i is decreasing its trade inventory at the same rate as channel 1.
2. If $r(i,1)$ is greater than $k(i,1)$ after the promotion ends,

channel i is selling its excess inventory at a slower rate than channel 1.

3. If $r(i, 1)$ is less than $k(i, 1)$ after the promotion ends, channel i is selling its excess inventory at a faster rate than channel 1.
4. A similar analysis can be made for $x(e, i)$ and $y(e, i)$ using $n(e, i)$ and $p(e, i)$ respectively as the constant values estimated during the base period.
5. Using $z(e)$, the concept of relative sales elasticity can be applied to each geographical area for channel 1 by measuring the relative percentage change in each geographical area as compared to other geographical areas. When the elasticities are greater than one, factory sales in area e respond better to promotions than factory sales in area $e - 1$.

Relative Elasticity =

$$\frac{(z(e, t) - z(e, t - 1))/z(e, t - 1)}{(z(e - 1, t) - z(e - 1, t - 1))/z(e - 1, t - 1)}.$$

Summary, Interpretation, and Use of the Ratios

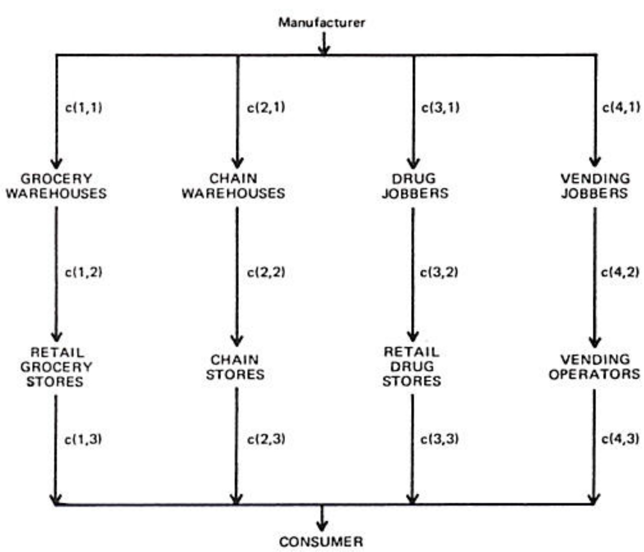
1. Calculate a value for $\mathbf{R}(i, 1)$ for each period from $t = 1$ to q.
2. This set of $\mathbf{R}(i, 1)$'s ($q\ i \times 1$ matrices) will be necessary to yield an estimate of the base value of $\mathbf{R}(i, 1)$ since observed values for $\mathbf{R}(i, 1)$ will have distortions stemming from noise in the real world.
3. Set $\mathbf{K}(i, 1)$ equal to the estimate of $\mathbf{R}(i, 1)$.
4. A comparison of $\mathbf{K}(i, 1)$ and $\mathbf{R}(i, 1)$ determines if an excess of sales has shifted from one channel to another.
5. By continually monitoring $\mathbf{R}(i, 1)$ and comparing it with $\mathbf{K}(i, 1)$ [until $\mathbf{R}(i, 1)$ equals $\mathbf{K}(i, 1)$], the amount of excess goods purchased and held in trade inventory in relation to channel 1 can be calculated.
6. Comparing $\mathbf{T}(1, j)$ to $\mathbf{L}(j)$, the amount of product purchased for inventory in trade channel 1 can be calculated.
7. $\mathbf{N}(e, i)$ is analogous to $\mathbf{K}(i, 1)$ in the type of analysis that can be performed with the key difference being that $\mathbf{N}(e, i)$ represents a subset of buyers (the intersection of the set of buyers in channel i and the geographical area e). Both $\mathbf{N}(e, i)$ and $\mathbf{K}(i, 1)$ represent base period indices which are compared with post-promotion ratios $\mathbf{X}(e, i)$ and $\mathbf{R}(i, 1)$.

   Using the union of these sets, each ratio can be calculated for manufacturer's regions, metro areas, and/or any combination of geographical areas and/or channels that are meaningful to the manufacturers.
8. By tracing the historical pattern of $\mathbf{Z}(e)$, changes in geographical sales patterns due to seasonality or other marketing forces can be estimated.
9. Comparisons of $\mathbf{Z}(e)$, $\mathbf{R}(i, 1)$, and $\mathbf{Y}(e, i)$ show if any changes in sales patterns are due to changes in the purchase patterns of different channels or due to shifting purchasing patterns caused by regional differences.

From these ratios, the susceptibility of different sets of buyers to promotions and other key information related to demand elasticities can be estimated. Again, the elasticities are percentage changes in demand for one set of accounts, $c(i, j)$, relative to percentage changes in demand for another set of accounts. While information generated up to this point comes primarily from the manipulation of data, it is only the first step in calculating a vital link between channel inventories and factory sales. This link comes when warehouse withdrawal information is included in the ratios that are calculated. With the integration of $\mathbf{M}(e, 1)$, $\mathbf{L}(j)$, and $\mathbf{K}(i, 1)$, the following information can be calculated: (1) the amount of inventory built up (in channel i in geographical region e) during promoted period t, and (2) the number of periods it takes (channel i in geographical area e) to reduce the trade inventory built up during the promotion to a normal level. From these two key building blocks of information, sales and inventory in any channel can be determined by aggregating the appropriating data.

Figure 7

DISTRIBUTION CHANNELS FOR THE SALE OF WIDGETS



EXAMPLE

For illustrative purposes, a simple example using four national channels will be used. Figure 7 represents the four channels of distribution, and Table 1 contains the actual sales data by channel. The following variables are defined by the inventory model:

$c(i, j)$ = sales to the $j + 1$ level of distribution in channel i, by the jth level of distribution ($j = 1$ at the manufacturer).

$a(i, j)$ = inventory at the jth level of distribution in channel i.

$g(e, j)$ = sales to the $j + 1$ level of distribution in geographical area e, by the j level of distribution.

$b(e, j)$ = inventory at the j level of distribution in geographical area e.

$w(e, j)$ = sales to the $j + 1$ level of distribution from the the j level in geographical area e for all accounts audited by SAMI.

$d(e, j)$ = inventory at the j level of distribution in area e for accounts audited by SAMI.

Table 1

WIDGET SALES FOR 11 PERIODS FOR GEOGRAPHICAL AREA 1

Period	*Total accounts*	*Wholesalers monitored by SAMI*	*Trade channel 2*	*Trade channel 3*	*Trade channel 4*	*Shipments out of monitored warehouses*	*Description of promotion*
		c(1, 1)	*c(2, 1)*	*c(3, 1)*	*c(4, 1)*		
1	6,730	1,016	509	2,200	2,016	989	
2	14,251	2,159	1,180	4,216	4,390	2,306	
3	19,289	2,916	1,496	5,980	5,896	3,001	
4	49,750	8,538	4,321	17,420	12,891	6,580	48¢ CS, off invoice
5	13,420	2,106	1,008	2,100	4,306	3,900	
6	6,725	1,015	508	2,199	2,015	988	
7	24,394	4,002	2,016	5,958	8,102	4,316	
8	29,779	5,089	2,601	8,214	6,625	7,250	Consumer coupon 12¢ CS trade discount
9	36,100	6,899	3,506	11,687	7,800	6,208	
10	18,339	3,001	1,489	8,214	3,210	2,426	
11	17,565	2,950	1,517	4,002	5,980	3,110	

The following relationships can now be developed; the sales data in Table 1 are for a given geographical area ($e = 1$).

1. Only one geographical area is to be studied ($e = 1$), therefore: $g(e, j) = g(1, j)$
   $b(e, j) = b(1, j)$
   $w(e, j) = w(1, j)$.
2. Three levels of distribution exist: factory, wholesaler, and retailer ($j = 3$).
3. Four channels of distribution exist and ($n = 4$).
4. $a(i, 1)$ is constant. (Since $a(i, 1)$ has no direct effect on the analysis, it is held constant for convenience).
5. $a(1, 3)$ is constant based on the rationale underlying SAMI.
6. $h = np = 4 \times 1 = 4$.

The following ratios are defined by the inventory model:

1. $$r(i, 1) = \frac{c(1, 1)}{c(i, 1)} \quad i = 1, 2, 3, 4$$

2. $$s(e, 1) = s(1, 1) = \frac{w(e, 1)}{g(e, 1)} = \frac{w(1, 1)}{g(1, 1)}$$

3. $$t(1, j) = \frac{c(1, j)}{c(1, j + 1)} \quad j = 1$$

4. $x(e, i) = x(1, i)$

$$= \frac{c(1, 1)}{\text{the intersection of set } c(i, 1) \text{ with set } g(e, 1)}$$

$$= \frac{c(1, 1)}{\text{the intersection of set } c(i, 1) \text{ with set } g(1, 1)}$$

5. $y(e, i) = y(1, i)$

$$= \frac{w(e, 1)}{\text{the intersection of set } c(i, 1) \text{ with set } g(e, 1)}$$

$$= \frac{w(1, 1)}{\text{the intersection of set } c(i, 1) \text{ with set } g(1, 1)}$$

6. $$z(e) = z(1) = \frac{w(e, 1)}{c(1, 1)} = \frac{w(1, 1)}{c(1, 1)}.$$

By definition, $w(1, 1)$ is equal to $c(1, 1)$ since only channel 1 is audited by SAMI.

$$s(1, 1) = \frac{w(1, 1)}{g(1, 1)} = \frac{c(1, 1)}{g(1, 1)}$$

$$z(1) = \frac{w(1, 1)}{c(1, 1)} = \frac{c(1, 1)}{c(1, 1)} = 1$$

$g(1, 1) =$ the total universe of accounts.

The intersection of a universe, with any other set x_2, is the set x_2. Therefore:

$$\frac{c(1, 1)}{\text{the intersection of set } c(i, 1) \text{ with set } g(1, 1)} = \frac{c(1, 1)}{c(i, 1)}$$

$$= x(1, i) = r(i, 1) \text{ and}$$

$$\frac{w(1, 1)}{\text{the intersection of set } c(i, 1) \text{ with set } g(1, 1)} = \frac{w(1, 1)}{c(i, 1)}$$

$$= \frac{c(1, 1)}{c(i, 1)} = y(1, i) = r(i, 1).$$

At this point, each set of ratios has been expressed in terms of $r(i, 1)$, $t(1, j)$, $s(1, j)$, 1, and $s(1, 1)$.

Summarizing these relationships yields:

$$r(i, 1) = \frac{c(1, 1)}{c(i, 1)}$$

$$t(1, 1) = \frac{c(1, j)}{c(1, j + 1)} = \frac{c(1, 1)}{c(1, 2)}$$

Matrices $\mathbf{R}(i, 1)$ and $\mathbf{T}(1, j)$ are:

$$\mathbf{R}(i, 1) = [r(1, 1), r(2, 1), r(3, 1), r(4, 1)]$$
$$\mathbf{T}(1, j) = [t(1, 1)].$$

The following examples for periods 1–3 show how **R**(i, 1) and **T**(1, 1) can be calculated to develop the base period indices.

Period
1. t(1, 1) = c(1, 1)/c(1, 2) = 1,016/989 = 1.03
2. t(1, 1) = 2,159/2,306 = .94
3. t(1, 1) = 2,916/3,001 = .97

Period
1. r(2, 1) = c(1, 1)/c(2, 1) = 1,016/509 = 2.10
2. r(2, 1) = 2,159/1,180 = 1.83
3. r(2, 1) = 2,916/1,496 = 1.95

Period
1. r(3, 1) = c(1, 1)/c(3, 1) = 1.016/2.200 = .46
2. r(3, 1) = 2,159/4,216 = .51
3. r(3, 1) = 2,916/5,980 = .49

Period
1. r(4, 1) = c(1, 1)/c(4, 1) = 1,016/2,016 = .50
2. r(4, 1) = 2,159/4,390 = .49
3. r(4, 1) = 2,916/5,896 = .49

r(1, 1) = c(1, 1)/c(1, 1) = 1 by identity.

From periods 1–3, based indices **L**(1) and **K**(i, 1) can be estimated by the use of simple regression or some form of weighted averaging.

$$\mathbf{L}(1) = 1.00$$
$$\mathbf{K}(i, 1) = (k(1, 1), k(2, 1), k(3, 1), k(4, 1)) = (1, 2.0, .5, .5).$$

The results of similar calculations for periods 4 to 11 are shown in Table 2.

By comparing **K**(i, 1) with **R**(i, 1), and **L**(1) with t(1, 1), it can be seen that the promotion in period 4 has had an equal effect on channels 1, 2, and 3 with a less of an effect on channel 4.

The following is a summary of **K**(i, 1) and **R**(i, 1) for period 4:

COMPARISON OF K(i, 1) WITH R(i, 1) FOR PERIOD 4

	i = 2	3	4
K(i, 1)	2.00	.50	.50
R(i, 1)	1.98	.49	.66

L(1, 4) = 1.00
t(1, 1, 4) = 1.30

Since t(1, 1,4) is greater than 1.00 (1.30), some of the goods in channel 1 are being used to build channel inventories and are not being sold to the consumer.

Sales Activity

Since r(2, 1, 5) and r(2, 1, 6) remain constant during two additional periods, a conclusion of parallel action by channels 1 and 2 is correct. Since r(3, 1, 5) has increased to 1.00 from an average of .50, it means that while channel 3 appeared to buy in a pattern similar to channel 1 during the promotion, most of the increase in sales to this channel only went towards building channel inventory levels, causing a post-promoted drop in sales. In this case, parallel action did not occur between trade channels 1 and 3 at the retail and consumer level.

As r(4, 1, 6) is .5, this means that channel 4 is acting parallel to channel 1, working off any inventory build-up, and the initial conclusion of the promotion being generally less effective in channel 4 is correct. **R**(i, 1, 7) is equal to **K**(i, 1) except for element 3, 1 (which indicates an increase in inventory in channel 3). r(2, 1, 7) and r(4, 1, 7) indicate that no basic changes in the sales patterns have occurred at this point.

Table 2
SIGNIFICANT RATIOS FOR PERIODS 1–11

Period	*t(1, 1)*	*r(2, 1)*	*r(3, 1)*	*r(4, 1)*	*Comment*
1	1.03	2.10	.46	.50	Base Period
2	.94	1.83	.51	.49	Base Period
3	.97	1.95	.49	.49	Base Period
4	1.30	1.98	.49	.66	$.48/CS off invoice
5	.54	2.09	1.00	.49	
6	1.12	2.00	.46	.50	
7	.93	1.99	.67	.49	
8	.70	1.96	.62	.77	Consumer coupon $.12/ CS trade discount
9	1.11	1.97	.59	.88	
10	1.24	2.02	.37	.93	
11	.95	1.94	.74	.49	

Trade Inventory Effects

In channel 1, as can be seen from t(1, 1), inventory started to decline during the precouponing period [t(1, 1, 7) = .93], dropped sharply during the coupon redemption [t(1, 1, 8) = .70], and slowly rebuilt during periods 9 and 10. r(2, 1) remained equal to k(2, 1) during the promotion indicating that channels 1 and 2 continue to react similarly.

In channel 3, inventory decreased relative to channel 1 in period 7 and in period 8. The sharp drop in r(3, 1, 10) indicated the eventual predicted increase in channel purchases needed to rebuild trade inventory. The sharp increase in r(3, 1, 11) shows a decrease in sales necessary to reduce channel inventory. Since the base index was not yet reached by period 11, it is possible that this trade channel is inherently unstable, constantly overstocking, underordering, then overstocking again. An alternate explanation acceptable in period 8 (not having yet seen data for periods 9–11) is that inventories are not dropping, and the coupon had little effect. This would yield a prediction of r(3, 1) approaching k(3, 1) as t(1, 1) approached 1, which did not occur.

The precoupon trade inventory build-up shown by r(4, 1, 7) is parallel to inventory increases in trade channel 1. In periods 8, 9, and 10, r(4, 1) was substantially higher than k(4, 1), indicating that the coupon didn't reduce trade inventories in channel 4 as it did in channel 1. By period 11, r(4, 1) was back to normal.

SUMMARY

In the more mature markets serviced by most consumer products manufacturers, a system to continually and accurately measure the effect of different market strategies and feedback critical information to help make and evaluate tactical decisions is becoming a necessity if loss of market share is to be prevented. To date, most companies have gone in the direction of using outside services to supply retail data to meet these objectives and measure the movement of their products. Unfortunately, outside services are fairly expensive, and are often lacking in detail or the flexibility to yield the types of accurate measurements necessary to measure the effects of marketing forces. As an alternative to this approach, factory sales can be used to help measure the effect of marketing forces when changes in inventory levels can be measured directly or calculated from other easily available data.

The model reviewed in this article shows how channel inventory levels can be measured by using factory shipments and data generated from SAMI. The use of this system, combined with in-house data, will enable a consumer products company to evaluate the effects of trade promotions (or other marketing forces) quickly, accurately, inexpensively, and continually—by geographical area, by channel, and by different time periods.

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