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EXPERIENCES WITH A SALES DISTRICTING MODEL: CRITERIA AND IMPLEMENTATION*

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Previously reported research documented the analogue between sales districting and legislative apportionment and described the first applications of computer techniques to the redrawing of sales and service areas.

This paper summarizes what we have learned from these seven applications. We emphasize

—motivation for re-alignment: Better coverage, fairer work load and change in size of sales force,

—criteria for measuring "good" districting: Single, multiple and weighted measures of salesman activity; relationship to sales objectives; and correlation between activity measures,

—implementation: Top management involvement and presentation to the sales force,

—demonstrated effectiveness of the new alignments.

Introduction

This paper will discuss our experience with the applications of a sales territory model. A brief review of the mathematical formulations is presented along with the observed motivations for utilizing the approach. Emphasis is placed on the rationale for and formulation of appropriate input data.

In particular, the development of an activity measure—a generic term used to describe various formulations of salesman workload or sales potential—is stressed. We have found unanimous difficulty on the part of sales management in expressing clear-cut goals for constructing sales areas. Only after protracted discussions have sales territory objectives, i.e., activity measures, emerged. Although the model is quite general and can accomodate any activity measure, our experience has been that construction of this measure involves more effort and is more crucial to ultimate success than any other aspect of the model.

Consequently, this paper reviews in detail some of the activity measures ultimately employed, as well as an evaluation of their effects. It is our hope, that subsequent applications of this territory model or similar models by other management scientists will benefit from our experience and avoid many of the time-consuming operations we found necessary.

We also present a detailed description of the implementation of the model to the sales of a large pharmaceutical company and general suggestions for improving the probability of successful model utilization.

Motivation for Realignment

Before discussing our experience with several applications of computerized sales territory realignment, we should examine the factors which motivate a company to change its present sales territories. First an increase or decrease in the number of salesmen obviously requires some adjustment in the sales call pattern and territory boundaries. This is particularly true when all of the *geography* of an area was already being

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covered by the prior sales force. With a change in the number of men, this geography must be reallocated, along with changes in the assignment of clients or prospects to salesmen.

A motivating factor to modify territory configurations when the sales force size does not change is a desire to achieve better coverage with the existing men. The ramifications of even a small change in the efficiency or the average number of calls per day are extremely large. A one percent increase in coverage, for example, for a sales force of 200 men is equivalent to providing two "free" salesmen.

While better coverage is a primary object of sales management, it is certainly not the only goal. Every sales manager has gone through the effort of attempting to develop sales territories which are equitable with respect to work load, sales potential or some other measure. If unequal territories exist and if it is generally known by the salesmen that work load or territory potential is disproportionate, this can lead to low morale, poor performance, a high turnover rate, and an inability to assess the productivity of individual territories or districts. By realigning territories to make them more equitable with respect to work load or sales potential, a more optimal utilization of each individual salesman can be achieved. This state of territory equality can be put to good use in increasing the morale and effectiveness of the sales force. In addition, by developing a condition of parity among the sales territories, a more straightforward and objective evaluation of individual salesman performance can be made than was possible under a disproportionate arrangement. A good sampling of noncomputer approaches to sales territory design has been compiled by The Conference Board [1]. Determination of the appropriate number of salesmen [8], [11] and routing of salesmen are beyond the scope of this paper.

Origin: Legislative Districting and the Computer

Our sales territory realignment approach is an outgrowth of eight years of research in the development of a computer technique for legislative districting. The legislative districting problem—the "one man-one vote" problem—is to subdivide a state into a specific number of compact and contiguous districts of nearly equal population. Historically, requirements of compactness and contiguity were assumed to minimize gerrymandering, but compact districts also tend to have a common community of interest.

The apportionment research was by six operations research analysts and engineers from Delaware chemical companies who as a civic service developed a technique for drawing nonpartisan legislative districts by computer. [14], [7]. The activity was a volunteer one, although subsequently out-of-pocket expenses were funded by the Ford Foundation and the National Municipal League.

The key finding in the Delaware research was their proposed measure of compactness . . . the second moment of the population distribution about the legislative district center, i.e., the population moment of inertia. Minimizing this moment of inertia, or equivalently the squared distance between each person and his district center, compacts population, not geography . . . people—not trees. The Delaware technique, REDIST [10], tends to create districts whose centers coincide with areas of high population density, since the closer the high density area is to the district center, the smaller its distance squared "cost" and the lower the moment of inertia.

Legislative districts designed by the REDIST computer program have been implemented twice. In 1967 the Delaware volunteers provided the legislature three alternative districting plans which were the basis for the apportionment finally enacted

[6]. In a subsequent application for New Castle County, Delaware, the County Council selected a computer solution which was enacted into law without any hand changes whatsoever [9].[1]

Implementation of other computer-prepared legislative districts includes Bellow [2] and Gearhart and Liittschwager [4] and Mathematica [5].

Application to Sales and Service Territory Realignment

The analogy between legislative districting and sales and service territory alignment is obvious. For "legislative district" read "sales territory" and for "population" read "salesman activity". The "one man-one vote" criterion becomes "equalize the workload in each territory." A salesman with excessive workload must neglect good customers and prospects. If the salesman's workload is to light, he will probably fill in with calls on unprofitable prospects or simply "goof-off." Appropriate definition of the sales territories should provide a balance of workload from territory to territory. In a subsequent section we discuss the various measures of salesman workload or *activity* which might be equalized.

For a predetermined sales force size, the prime objective is to draw territories so that each salesman's limited time may be most efficiently used. One way to improve the salesman's efficiency is to reduce his unproductive travel time. Compact sales territories have geographically concentrated sales activity, therefore less travel, more selling time and hopefully higher sales. Unlike legislative districting, for sales districting compactness is more important than equality.

In both sales and legislative districting minimization of arbitrary change in territorial boundaries is important. The salesman (and legislator) has established close relationships with many of his clients; he "knows the territory". Unnecessary shifting of boundaries is disruptive, and if salesmen must be relocated the "out-of-pocket" costs can be high.

Model and Solution Procedure

An integer programming formulation of the equivalent legislative districting problem is in [7]. That formulation seeks to partition the state into a predetermined number of mutually exclusive and exhaustive legislative districts that maximize the total compactness of all districts subject to upper and lower bounds on the population of each district. The number of integer variables precludes solution of practical sized problems with currently available IP algorithms. Garfinkel and Nemhauser [3] have successfully solved real, but very small problems, with a branch-bound code and a slightly different formulation.

Our heuristic, dubbed GEOLINE, follows the same logical flow as the legislative districting program REDIST. It differs significantly in input-output, file structure and use of internal storage and transfer. GEOLINE in short is the REDIST system efficiently adapted to the requirements of sales districting.

The heuristic constructs a predetermined number of compact sales territories comprised of smaller geographical units (counties, five-digit zip code areas or a combination of both). Salesman activity measures from territory to territory are constrained to be nearly equal. By starting the heuristic procedure with existing assignments, changes in territorial boundaries can be minimized.

[1] Subsequent implementations in 1971 include the Nevada legislature and several county councils in Virginia.

A flow chart of GEOLINE is in Figure 1. Essentially, the calculation procedure consists of a sequence of transportation linear programs.

Input to the program consists of

the number of sales territories desired, m, and

for the jth ($j = 1, 2, \cdots, n$) geographical unit (county or five-digit zip code area)

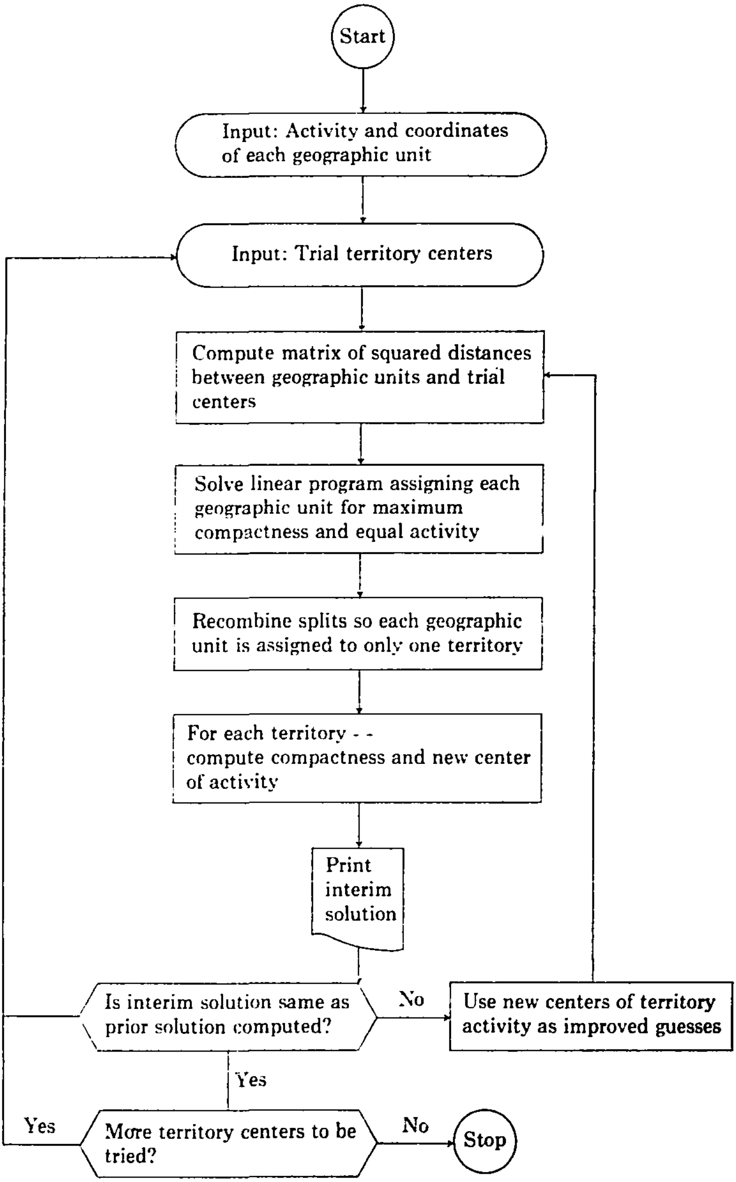

FIGURE 1. GEOLINE Flow Chart. (Read Down.)

its center given by
northing or y coordinate, n_j, and
easting or x coordinate, e_j, and its total activity, a_j.

The activity of the jth geographical unit is the salesman's workload within j. It may be the number of calls, the number of accounts, the time to service the accounts or any of several other activity measures. We discuss the activity measure more fully in the next section. For now consider it only as a measure of the desired workload of the salesmen in j. The a_j become the destination demands of our transportation linear programs.

Next we input an initial set of m territory centers. These are the sources in our first transportation problem. For centers $i = 1, 2, \cdots, m$ and transportation problem number $k = 1, 2, \cdots$

N_{ik} = northing or y coordinate of ith center.
E_{ik} = easting or x coordinate of ith center.

For the first transportation problem, k is of course one. The availabilities of each source are the average activity per territory, $\sum_{j=1}^{n} a_j/m$.

We have found that homes or offices of the existing salesmen are frequently excellent initial territory starting centers. These tend to be central to their territories, except in metropolitan areas. Centroids of existing territories have also been good starting centers. By using these as centers we, in effect, are perturbing the original sales territory alignment by means of the transportation algorithm. Where the number of territories in the district is different from that of the existing plan, centers may be deleted or added consistent with known shifts in activity within the district.

Any or all of the initial centers may be chosen randomly, but at the expense of increased computer running time. Arbitrary choice of centers may also be used to provide alternate plans for the decision maker to consider. Typically neither random nor arbitrary choice, however, provides solutions which minimize changes in territorial boundaries.

The cost matrix for the transportation problem is defined by the squared distances between origin and destination, i.e. jth center and ith geographical unit. Thus the "cost" in assigning the ith geographical unit to the jth initial center is c_{ij0}. More generally for the kth transportation problem

$$c_{ijk} = (N_{ik} - n_j)^2 + (E_{ik} - e_j)^2. \tag{1}$$

Formally the kth transportation problem is

$$\text{minimize} \quad \textstyle\sum_{i,j} c_{ijk} X_{ijk} a_j \tag{2}$$

$$\text{s.t.} \quad \textstyle\sum_j X_{ijk} a_j = \sum_j a_j/m \quad \text{for} \quad i = 1, 2, \cdots, m, \tag{3}$$

$$\textstyle\sum_i X_{ijk} = 1 \quad \text{for} \quad j = 1, 2, \cdots, n, \tag{4}$$

where X_{ijk} = proportion of jth geographical unit assigned to the ith territory center. Let X_{ijk}^0 = optimal assignment from the kth LP solution.

The solution $[X_{ij0}]$ to the first LP provides the minimum "cost" solution about the initial centers subject to equality among territories. Except for degeneracy the number of assignments in each transportation solution is one less than the sum of the number of territories and the number of geographical units. Geographical units having assignments to more than one territory are reassigned to a single territory in a separate subroutine. Specifically we modify the LP solution by calculating

$$\begin{aligned} \text{integer } X_{ijk} &= 1 \quad \text{if} \quad X^0_{ijk} = \max{}_i(X^0_{ijk}) \\ &= 0 \quad \text{otherwise,} \end{aligned}$$

and including a simple tie breaking procedure to insure the jth geographical unit is assigned to one and only one territory.

Minor deviations from equality result from the recombination of these split assignments. Because approximately one geographical unit is split per territory, the magnitude of the percentage deviation depends directly on the number of geographical units per territory. We have found 20 to 1 is more than adequate to provide territories whose activity is within $\pm 10\%$ of average.

Territory centroids are now computed and become improved centers for the next transportation problem. Thus for $i = 1, 2, \cdots, m$,

$$N_{i,k+1} = \textstyle\sum_j (\text{integer } X_{ijk}) a_j n_j / \sum_j a_j (\text{integer } X_{ijk}), \tag{6}$$

$$E_{i,k+1} = \textstyle\sum_j (\text{integer } X_{ijk}) a_j e_j / \sum a_j (\text{integer } X_{ijk}). \tag{7}$$

The calculation sequence—centroids, transportation algorithm, centroids, transportation algorithm—continues. Calculation terminates when successive LP's give identical solutions or a predetermined number of transportation problems have been solved. If $N_{i,k+1}$ and $E_{i,k+1}$ were calculated from X^0_{ijk} rather than (integer X_{ijk}), the sequence of transportation problems would converge monotonically to a local optimum. Since maximum compactness (i.e., minimum cost) is not the only criterion—equality and minimal change from the existing plan are the others—we prefer to examine every transportation solution and therefore recombine split assignments after each. Monotonicity and convergence are no longer guaranteed so we provide programmed termination to prevent looping for the 10% of the cases that do not coverage.

The compactness driving force generally prevents noncontiguity. Rare exceptions have been

coordinate errors mislocating the geographical unit,

separation by nontraversable obstacles, e.g., unbridged body of water,

pathological shape of a geographical unit ··· the computer considers all of the geographical units activity to be at the unit center.

In the first case coordinates must be corrected and the problem rerun. In the last cases we find solutions may be easily corrected by hand modification.

The converged solution is a local not a global minimum moment of inertia. In practice, therefore, the entire procedure is repeated with other sets of starting centers in search of a solution good with respect to all criteria: compactness, equality, and minimal change from existing alignments.

The Activity Measure

At the heart of the GEOLINE process for sales area realignment is an element of input data which can be thought of generically as an activity measure, or a description of sales potential or salesman workload. An important objective of good territory design, as has been pointed out previously, is to achieve some balance of this activity from territory to territory. Thus the selection of an activity measure takes on critical importance since by definition it affects the degree to which a meaningful balance between salesmen is obtained. It is also the activity measure which GEOLINE compacts. GEOLINE does not compact geography, but rather it achieves maximum compactness with respect to the activity measure employed. Thus, if the activity measure is sales potential, a higher concentration of sales potential will be achieved around the center of the territory. If the activity measure is workload measured in terms of sales calls, then a higher number of calls will be concentrated around the center of the territory.

It should be readily apparent that the exact information utilized as an activity measure in the GEOLINE system depends to a large extent upon the objectives of sales management. The model is completely general and can accommdate any activity measure deemed relevant by sales management. In this way, complex objectives involving multiple criteria can be handled in the same fashion as more basic goals.

Because of the model's generality, sales management's lack of well-defined objectives, at least in terms of an activity measure, and the importance of the activity measure in the evolution of new territory plans, a large amount of our effort has been expended in the formulation of activity measures which management feels accurately represent their objectives. Since future applications of the model will undoubtedly involve similar situations, we feel it would prove highly instructive to review our experience with various activity measures.

As we detail some of the activity measures that have been employed by various companies (Figure 2), we will also describe the relationship between these measures and the particular sales objectives involved. Although our efforts have been concentrated primarily in the pharmaceutical industry, analogies with other industries should be readily apparent.

Number of Sales Calls Activity Measure

We believe the most appropriate activity is some measure of the salesman's time. If a rational basis exists for determining call frequencies by customer (or class of customer) equalizing on the number of planned sales calls is most appropriate. Rationally planned call frequencies will also help allocate the salesman's effort within the territory.

The number of calls required to a given physician has been determined in several ways. One of the methods employed has been for sales management to set overall call objectives based on the specialty interest of the physician and then to permit the inindividual salesman to override or modify this objective predicated on personal knowledge of the physician's practice. Thus, sales management may say that all General Practitioners (GP's) should receive eight calls per year but an individual salesman may make only one or two calls per year on a specific GP. This lower call

Company	Number of Salesmen Nationally	Proportion Realigned	Activity Measures				
			Customer Count	Calls	Potential	Sales	Weighted Measure
A	400	All	√				
B	800	3% test		√			√
C	50	All					√
D	60	All			√		
E	800	1% test			unknown		
F	200	All			√		
G	400	2% test			√		

FIGURE 2. GEOLINE Applications

rate may be because the doctor in question is so busy that he does not normally have time to see a pharmaceutical salesman or, conversely, because the doctor has a small practice or is semiretired.

Another common practice is for every salesman to rate all of the doctors in his territory and then have sales management set call frequencies predicated upon the ratings provided. As an illustration of how this might be done, suppose each member of a sales force of 400 men was instructed to rate every doctor in his territory as either "A", "B" or "C", defined as follows:

"A"-rated physicians comprise the top 10% of the doctors in any territory as measured by the volume of prescriptions generated.

"B"-rated physicians make up the next 40% of the territory, again judged on prescription volume.

"C"-rated physicians are the remaining 50%.

Either before, during, or immediately after the above process, sales management must decide upon the call frequencies each category of physician should receive. A convenient method for establishing these goals is employed by Smith, Kline & French Laboratories. [13] Sales management is asked the following questions:

1. Suppose there are just three doctors in a given territory, one rated "A", one rated "B", and the third rated "C". If only one sales call can be made, which physician should be contacted?

2. If a second call can now be made, should it be to the same doctor who received the first call or should a different individual be approached?

This process of "adding" one more call continues until a discernible sales pattern is established.

To continue our previous illustration, assume sales management has answered the above questions resulting in the call pattern:

First call	"A" doctor
Second call	"A" doctor
Third call	"B" doctor
Fourth call	"A" doctor
Fifth call	"B" doctor
Sixth call	"C" doctor.

We thus have a surrogate for a sales response curve.

One-half of the total calls would be made to "A" doctors, one-third to "B" doctors, and one-sixth to "C" doctors. This information, together with the total number of calls available and the total number of doctors, can then be utilized to calculate the desired number of calls for each class of physician and the average number of calls per physician of each class.

With the salesman's count of the numbers of doctors by class and geographic unit (zip code or county), the total number of calls required for any geographic area can be calculated. This is the value that would be employed as an activity measure.

With either of the above activity measures, a GEOLINE solution would create territories with approximately the same number of total yearly calls thereby balancing workload. Because the compactness measure being minimized is calls, a higher proportion of these calls will tend to be located at the center of the territory.

Implicit in the use of calls as a measure of activity is the assumption that the call capacity of each salesman is the same. But call capacity is a function of the total time

face to face with the customer,
waiting to see him, and
travel between offices.

Desired calls per territory can reflect these differences by appropriate change in the right-hand side of the transportation tableau. In our only application with this activity measure, Company B(Figure 2) assumed that increased travel time in the rural Midwest versus the East Coast would be compensated for by less waiting time in the rural doctor's office. Presumably the rural physician sees salesmen so infrequently, he does not wish to keep them waiting. Where travel time differences are significant, the coordinate system could be "stretched;" so far we have not found this necessary.

Sales Potential Activity Measure

Rather than number of sales calls, sales management in three companies chose to utilize sales potential as the activity measure in their territory realignment projects. This objective is often motivated by the desire to have each salesman responsible for equal amounts of market potential. This situation facilitates the evaluation of performance simply by measuring sales for each territory rather than having to make adjustments because of disproportionate potential.

Utilizing this sales potential activity measure, GEOLINE would produce sales territories of approximately equal sales potential, each with its sales potential tending to cluster around the center.

An activity measure predicated upon total calls and an activity measure based upon sales potential will produce identical GEOLINE solutions for a given company when call frequency is directly related to sales potential. Our experience has been that in the majority of companies call frequency should not be related to sales potential.

Intuitively, it would seem that a physician with twice the sales potential of another doctor should receive twice as many calls. In fact, this may not be the case when sales return per call, the effects of competing salesmen's calls, and other relevant factors are considered.

Equalizing on territory sales potential can cause inappropriate allocation of manpower. One company's salesmen (not a pharmaceutical company) call on supermarkets primarily to fill shelves, stock and set up promotional displays. The time for a supermarket sales call is independent of the store's volume. Supermarkets in the East average almost twice the volume of supermarkets in the remaining parts of the country. Volume per man was to be equal. Because of the larger volume per store, the Eastern salesmen had one-third fewer accounts than salesmen in the rest of the country. Eastern salesmen, therefore, were calling more frequently, checking shelf stockage more often, and, not surprisingly, having significantly higher market share and sales per man than in the rest of the country. Obviously too few men were in the rest of the country.

A parallel to this in the pharmaceutical industry is not hard to visualize. No evidence suggests a high-prescribing physician (i.e., large sales potential) is more or less easily converted from one brand of drug to another than is a low prescriber. If probability of conversion is an increasing function of the number of sales calls, we can show (e.g., if response is a saturating exponential:

$$\text{Probability of conversion} = 1 - \exp[-b(\text{Number of Sales Calls})]$$

that the optimum allocation of selling effort is not proportional to the physician's sales potential. Only if the distribution of physician potential is similar over the entire country is equalizing on potential safe. This is a very big "if". We do not propose to resolve this question at the present time, only to indicate that it may be a fertile area for subsequent research.

Customer Count Activity Measure

A form of activity measure that has been employed by one company involves a complete population or customer enumeration. For a pharmaceutical company which markets prescription drugs, the utilization of this type of activity measure would require the tabulation of each physician who might possibly write a prescription for any of the firm's products. (This will probably differ from a census of *all* physicians.) The GEOLINE program would construct sales territories (or districts) which were approximately equal and maximally compact with respect to the specific population measure employed. Thus each territory would contain essentially the same number of physicans. The compactness achieved would result in a greater concentration of doctors near the center of the generated territory as contrasted with marketing prospects being distributed "randomly" throughout the area.

The complete enumeration activity measure is meaningful only under two circumstances neither of which is likely. The first is where a salesman devotes equal numbers of calls on all prospects or customers implying that: (1) the first call has the same value or produces the same return regardless of which physician is contacted, and (2) repeat calls to the same physician produce a smaller return than the initial contact. (If repeat calls had the same value as the initial call, i.e., sales return were a linear function of the number of calls to any given physician, then a compelling argument could be made for each salesman calling on one doctor as many times as possible before attempting to see a second physician.) The second circumstance justifying the complete count measure is if the mix of customer type is uniform over the nation. Then the proportion of high, medium, and low call customers would be the same in each territory.

Sales Activity Measure

A fourth criterion for an activity measure is actual sales dollars. This is particularly important when salesmen are compensated largely by commission. Realigning territories for equality of sales rewards the inferior salesmen at the expense of the good. A salesman who has developed a territory to a high level of sales is unfairly penalized when his new territory after realignment has sales and hence compensation equal to the inferior salesman. To date we have not considered how to use this criterion equitably as our experience has been only with other measures of activity.

Weighted Activity Measures

The last activity measures we have experienced are weighted measures encompassing two or more individual measures. One company used the weighted sum of potential and calls. Another company weighted physician specialty by importance, the weight presumably being a relative measure of the contribution of that particular medical specialty to the company's sales and profits. The weighted physician count was then multiplied by a previously established call frequency for the physician classification. The predetermined call frequency already reflects physician importance so the overall weight is more exponential than linear with importance. Whether this is right or wrong is really unknown, but the important point is that any activity measure can be developed which involves combinations of criteria.

Applications

CIBA Pharmaceutical Company

While developing a sales call reporting system, CIBA discovered that some of its salesmen had territories with three times as many physicians as other territories.

Sales management felt such disparity was unjustified. High-prescribing physicians in the large territories could not be called upon as often as desirable. Salesmen in the smaller territories were operating well below capacity.

Sales management decided to realign territorial boundaries while keeping the same size sales force—about 400—and essentially the same 40 sales districts. They selected three districts as a test of the GEOLINE computer technique and of their proposed "activity" measure—the total number of doctors in five specialties.

Each district was solved separately and several alternatives mapped. The doctor count in no proposed territory deviated more than 10 per cent from the average. The proportion of doctors currently called-on by the company's salesmen was also reasonable in each of the proposed territories.

CIBA changed the activity measure to be the total number of doctors in seven specialties and authorized preparation of territorial plans in all districts. At least three alternative plans were mapped for each district; one of these utilized salesmen's current homes as trial territory centers. Geographical units were 5000 five-digit zip code areas in 137 counties and whole counties in the remainder of the country.

In the 126 mapped plans (at least three for each district) the maximum deviation from average territorial doctor count was:

less than 4% deviation in 27% of the district plans,
less than 6% deviation in 61% of the district plans,
less than 10% deviation in 95% of the district plans.

The average maximum deviation was 5.7%, the largest 13%. The large deviations occurred in cities with high doctor density and therefore small numbers of zip code areas per territory. For each district at least one alternative had a maximum deviation of less than 10 per cent.

The original plan for implementation was to have each of the four regional managers review all alternative plans for his ten districts, select one plan for each district and review that plan with the district manager. In general the regional managers could not make an informed selection and instead left the choice to the district managers.

The individual district manager was free to
reject all plans submitted and ask for additional computer plans—none did,
accept any one plan as is—most did, or
make his own changes to the prepared computer plan—a few did.

In the latter case he only had to report the reason for his change. For example, one boundary was adjusted to permit the same salesmen to continue to service an important new clinic. Management accepted all modifications without question. Generally the managers were pleased with the computer-prepared territories, felt the solutions were imaginative but releastic and useable, found them to incorporate some changes he himself had been considering, and relieved him of a major clerical burden.

The only major problem encountered resulted from the choice of activity measure. By equalizing on number of physicians one region of the country would suffer a major reduction in number of salesmen. This particular region had the highest average sales per salesman, and, therefore, the highest average sales per physician. The regional manager argued his performance was directly related to the high call frequency his men were able to sustain. He won his point and his region was permitted to continue with a smaller but equal number of physicians per territory.

The lesson here is that choice of activity measure must not be taken lightly. While excellent territorial plans were prepared by the GEOLINE heuristic, they suffered by an inappropriate choice of activity measure. This is why we belabored our discussion of activity measure earlier in this paper. Finally, we should point that management *assumed* the sales force size to be correct. The size had not been studied objectively. In fact the experience described in the previous paragraph suggests a larger sales force might be more profitable.

Two years have passed since the GEOLINE plan was implemented. In retrospect, CIBA sales management feel the equalization of workload was good. During the first year of operation under its realigned sales territories, CIBA achieved the largest dollar increase in the company's thirty-year U.S. history. The gain was achieved in a declining economy with no new products of merit and an actual decrease in advertising promotion. If only 0.2% of the profit improvement could be traced to realigned territories, GEOLINE paid for itself in a year.

IBM World Trade Corporation

IBM found that the computer prepared better districts than they could by hand. The field test involved locating typewriter servicemen territories in a northern city. As more and more typewriters are sold and as machines age, more service time and men are required. Realigning the service territories required several days of the branch manager's time.

IBM wished to equalize the workload from serviceman to serviceman. Estimates of maintenance time per machine were already available and geographically located in units of approximately 50 typewriters. For each geographic area estimates of service hours per month were computable.

The branch manager and the operations research analyst estimated coordinates of each geographic area. (These same coordinates can be used for subsequent applications.) The capacities of some of the service territories were increased or decreased by 10 per cent to recognize slower or faster repairmen. The branch manager picked approximate centers for the territories. Total data preparation required one and a half days.

The total problem required constructing seven territories from 80 small areas. The first solution was so good that no further starting centers were needed. The system is being implemented in other cities now.

Implementation

As with all management science applications, the development of a "good" model and the subsequent generation of a problem solution in no sense guarantees a successful application. Too many technically correct solutions never get beyond the analyst's office.

The potential for a similar fate befalling a GEOLINE solution is quite real. Yet, in all national applications to date, GEOLINE solutions have been successfully implemented and have garnered the endorsement of the salesmen being realigned. This successful record is the result of three highly important conditions.

First, application of the technique in a small portion of the country demonstrated its benefits without a complete study. This permits the company to experiment with different activity measures before realigning the entire country.

Two companies satisfied themselves by preparing hand plans in parallel with the computer. They found the computer solutions were as good or better than those developed by hand. The set-up effort required, however, did not seem to warrant using the computer unless several regions needed to be realigned. A single districting problem —the result, for example, of adding a tenth man to a district of nine territories—could more easily be done by hand.

Second, and more important, the GEOLINE applications have had the endoresement of top management. In many cases, the sales director has participated in the development of the activity measure and has been committed to implementing the solutions developed. This involvment of high level sales management is crucial; it is far too easy for a sales director or vice-president who has not been involved in the actual project, other than possibly to approve the required expenditures, to dismiss the generated solutions as inappropriate because the activity measure utilized does not conform with his concept of what should have been calculated. Involvement precludes this condition occurring.

The third and equally important factor which has led to successful implementation has been involvement of the sales force. Rather than simply implementing the solutions and indicating to each salesman his new territory configuration, successful studies have involved a "top to bottom" presentation of results to the sales force. First regional managers are brought together and, if not already familiar with the concept, are briefed on what GEOLINE is and, more importantly, on the benefits they and their men will derive from its implementation. Again the most convincing and desirable approach is to have the sales director or vice-president, rather than an analyst or staff individual, be the primary person presenting the information. Generally two or more alternative computer plans are available for consideration.

Next, regional meetings are held at which each regional manager briefs his district managers. Each district manager is permitted to make hand modifications to suit his own local conditions, in effect, to incorporate criteria not included in the model. After all, the computer solution is the *model solution*, not necessarily the *real world solution*. It should be so considered. In practice district managers we have interviewed found the computer plans to be excellent and necessitate little if any modification.

Finally, each district manager meets with his salesmen and discusses with them the upcoming changes. By stressing the benefits that the individual salesman will derive, much of the natural aversion to change can be converted to enthusiasm and anticipation.

Can We Do Better?

Our experience is that the technique described can produce many very good sales territory plans. The choice among them is generally left to field management. They would like a plan which is most compact, most equal in activity and most similar to the existing plan. A fruitful area of research would be to ascertain relative weights for these three criteria and incorporate them in the model. Some effort in this direction has already been reported [12].

Although GEOLINE does not provide optimum sales territories, we find the solutions are at least as good, and usually better, than those that can be developed by hand. Invariably certain qualitative considerations, not incorporated within the program or input data, exist. The computer plan provides an excellent starting point for field sales management who can make changes for considerations not implicit in the computer technique. While algorithmic techniques might eventually be developed to provide "global" optimum districts, we think this is ill advised.

The weakest links are outside the GEOLINE model; they are determining the number of salesmen and the sales call frequency. We have found these typically based on past history without any validation either theoretical or experimental. These are the problems most needing research.

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