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COSTA: Contribution optimizing sales territory alignment

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Manuskripte
aus den
Instituten für Betriebswirtschaftslehre
der Universität Kiel

Nr. 408

Bernd Skiera and Sönke Albers

COSTA: Contribution Optimizing Sales Territory Alignment

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COSTA: Contribution Optimizing Sales Territory Alignment

The decision model COSTA is based on sales response functions at the level of sales coverage units (SCUs) and uses a new concept to take travel times into account. It simultaneously assigns SCUs to territories and allocates the selling time available within the territories across SCUs such that profit contribution is maximized.

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keywords: salesforce research, industrial marketing, forecasting

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Abstract

The alignment of sales territories represents a major problem in salesforce management with considerable impact on profit. The common approach to this alignment is the balancing approach, which establishes territories balanced as well as possible with respect to one or more attributes such as potential or work-load. Unfortunately, this approach does not necessarily guarantee an alignment that maximizes profit. As a consequence, it does not allow evaluation of the profit implications of any alignment proposal in comparison with the existing one. Because of this, several authors have already proposed nonlinear integer optimization models that attempt to directly maximize profit by simultaneously considering the problems of selling time allocation across accounts as well as the assignment of accounts to territories. However, these models proved to be too large to be mathematically solvable, such that the authors have either simplified the problem or proposed application of heuristic solution procedures. The latter is based on the principle of equating the marginal profit of time for each salesperson. We show here that an optimal solution does not possess the property of equal marginal profits of time. We thus propose a new approach, COSTA, for the derivation of contribution optimizing sales territory alignments. COSTA is based on sales response functions at the level of sales coverage units incorporating selling time as independent variable and using a new concept designed to take travel times into account. This makes it possible to simultaneously solve the allocation and assignment problem. Furthermore, COSTA provides the structure for evaluating the effects on profit of different salesforce sizes and different locations of the salespersons. The suitability of COSTA for practical problems is supported by a real-world application in which COSTA improved an existing territory alignment by 5.8% in terms of profit contribution.

Contents

1 Introduction

Companies often assign accounts exclusively to individual salespersons. Reasons for employing this exclusive type of assignment are the establishment of long-term relationships between accounts and salespersons, avoidance of competition among salespersons, better conditions for evaluation and control of the salesperson's performance, and increase in the salesperson's morale and effectiveness (Albers 1989). Due to considerations of travel time, this assignment is usually made on the basis of regional characteristics by establishing sales territories (Krafft 1995). To reduce the complexity of the sales territory alignment problem, companies generally operate with small geographical subareas known as sales coverage units (SCUs) instead of working with individual accounts. These SCUs frequently represent political districts or postal areas (Zoltners and Sinha 1983, Churchill, Ford and Walker 1993). The problem of aligning sales territories can thus be viewed as the question of how best to assign these SCUs to the sales territories to be covered by individual salespersons.

This territory alignment problem is of considerable importance to companies for at least two major reasons. First, it has significant sales and profit implications (Churchill, Ford and Walker 1993). According to Zoltners and Sinha (1988), territory adjustments can raise sales anywhere from 2%-7%. Support for sales increases along those lines is provided by LaForge, Cravens and Young (1986), who summarize results of studies in literature showing similar improvements in comparable problems. Second, the decision of how best to align territories must be made on a regular basis: market conditions change frequently, and any adjustments in salesforce size in particular must be reflected immediately in the alignment of the sales territories (Albers 1989).

1.1 Balancing Approach

Currently, the most popular approach to the alignment of territories is the balancing approach, establishing territories that are as well balanced as possible with respect to one or more territorial attributes (Zoltners and Sinha 1983). The most commonly viewed attributes are potential and work-load, whereby work-load is usually measured by the number of sales calls (Churchill, Ford and Walker 1993). The ideas underlying the establishment of territories with equal potential are, first the provision of each salesperson with the same income opportunities and, second, facilitation of an easily achieved evaluation of individual performance. Territories having equal work-loads are considered to strive for fair treatment of the salespersons, because it is assumed that all salespersons have the same amount of work to do (Churchill, Ford and Walker 1993).

Unfortunately, the balancing approach described above suffers from the following shortcomings. First, it does not guarantee territory alignments that maximize profit contribution. Second, this approach offers no information concerning possible improvements to be made on existing territory alignments in terms of profit contribution. Third, the same holds true regarding evaluation of salespersons' modified locations and different salesforce sizes.

Moreover, the balancing approach often fails to reach the goals set, because it neither successfully establishes territories offering equal income opportunity nor guarantees fair treatment of all salespersons. Numerous factors exist that play a part in influencing sales in a territory. Aside from the determined potential, these could include a territory's size as an indicator for the required travel time, intensity of competition, and advertising activities of the company among other factors. See Ryans and Weinberg (1979) and Albers (1988) for an overview. As a consequence, it is by no means made clear why territories with equal potential should necessarily yield comparable income opportunities. Placing the focus on equal work-load causes similar problems. Companies would first need to be thoroughly familiar with all of their accounts (defined here as current or potential customers) as well as the calling policies to be followed for each. This, however, is not the case in every company. Second, if calling-time is defined as the time a salesperson is in actual contact with the account, travel time as the time it takes the salesperson to get to the account, and selling time as the sum of both, fair treatment would mean that selling times are made equal among all salespersons. Due to the differing sizes and traffic infrastructures of the territories, the required travel time for the same amount of calling-time often varies substantially. Therefore, as work-load is commonly measured only by the number of sales calls, i.e. calling-time, it is unrealistic to assume that a measure of this sort for work-load would lead to comparable selling times. Hence, the goal of a fair treatment of all salespersons is not achieved. Third, the specification of a calling policy represents an optimization problem in which the optimal number of calls for each account depends on the profitability of alternative uses of that calling-time, and on the corresponding travel time for other accounts (Lodish 1975). This, however, is dependent upon territory alignment and the required travel times. It is thus impossible to determine the optimal number of sales calls without first having settled the territories' boundaries (Lodish 1975).

1.2 Profit Maximization Approaches

In order to overcome the above mentioned shortcomings in the balancing approach, several authors proposed, in the seventies, decision models for determining sales territory alignments that maximize profit contribution (Lodish 1975, Shanker, Turner and Zoltners 1975, Zoltners 1976, Glaze and Weinberg 1979). All of the models attempt to solve for both problems of optimal calling-time allocation across accounts and optimal assignment of accounts to salespersons. However, such models represent nonlinear integer programming problems that cannot be mathematically solved with general-purpose optimization software. Therefore, the authors have either opted to simplify the problem or have developed heuristic solution strategies.

Shanker, Turner and Zoltners (1975) simplify the problem by formulating it as a set-partitioning problem in which possible territories must be prespecified as partitions of the set of accounts. It is then possible to precisely calculate the profit contribution of each individual candidate partition (column) in advance and to use it as data. Unfortunately, the number of partitions which must be specified explicitly beforehand increases exponentially with the number of accounts. As a consequence, Zoltners admits in a later article that this approach is not practically feasible for large problems (Zoltners and Sinha 1983). In a further attempt, Zoltners (1976) suggested working with prespecified calling strategies for accounts. Here, it would be possible to determine the profit contribution of such strategies beforehand. The result is a specially structured all-integer programming problem that is solvable with the help of standard software. Again, the difficulty lies in limiting the number of individual calling strategies to a reasonable set of potential candidates.

Lodish (1975), on the other hand, proposed a heuristic solution procedure. He begins with a relaxation of the original problem in that he regards all accounts as belonging to one super-territory. Each account is then being served from the nearest base location of a salesperson. The formal structure of this problem is equivalent to that of the popular selling time allocation model CALLPLAN (Lodish 1971), and can thus be solved with the respective heuristic. Such a relaxàtion does not take the selling time constraints of the individual salesperson into account. Corresponding to the relaxed optimal calling-time allocation and the associated travel times, more or less selling time than is actually available to the given salespersons may have been assigned to territories. Lodish (1975) therefore suggests that the decision-maker should intuitively reassign accounts to other salespersons, rerun the super-territory allocation problem and recalculate the selling times for each individual salesperson. This procedure is then repeated until all individual selling time constraints have been met. The reassignment task should be guided by the idea of subtracting selling time from territories with small marginal profit and adding it to those with high marginal profit. This is based on the assumption that in the optimum a sales territory alignment should exhibit equal marginal profit of time in each territory. Unfortunately, this assumption only holds true for allocation problems without discontinuities. It may not be generalized to sales territory alignment procedures, as any reassignment causes a noncontinuous change of travel time. This can be realized from the following example.

Let us assume that accounts are located either very close to New York or to San Francisco, whereby 50% more of the accounts are situated near New York than San Francisco. Sales in all accounts show the same positive response to sales calls with diminishing returns and the company realizes a positive gross margin. Obviously, to maximize profit contribution a sales manager having two salespersons at his or her disposal will locate one of them in New York and the other in San Francisco. If overnight trips are infeasible, it is then impossible for the salesperson in New York to call on accounts in San Francisco (and vice versa) due to the exhaustive travel times. Hence, the sales manager optimally designs the two sales territories by assigning all accounts around New York to the New York salesperson and all accounts around San Francisco to the salesperson there. In such a situation, sales and profit contribution and, thus, marginal profits of time are certainly not equal for the two salespersons. Equal marginal profit of time would only be realized if the sales manager assigned one third of the accounts close to New York to the salesperson in San Francisco. Naturally, such an assignment would lead to a loss in profit contribution. Although this might be an unusual example, both our experience and our real-world application indicate that marginal profits of time for salespersons are always unequal in territory alignments that maximize profit contribution. Consequently, a procedure based on equating marginal values of time may not produce an optimal solution. In addition, Lodish (1975) does not provide an automated procedure to perform the task of reassigning SCUs to the point where all individual selling time constraints are satisfied.

Glaze and Weinberg (1979) go beyond Lodish's proposal by suggesting an automated procedure, TAPS, for the optimal reassignment of SCUs such that all individual selling time constraints are met. (They also introduce a procedure, which we will not discuss here further, that attempts to determine the best locations for all salespersons themselves). However, while they strive to design territories with equal marginal profits of time, their procedure, like that proposed by Lodish (1975), may not yield to an optimum. The same critique holds for the approach briefly outlined in Zoltners and Sinha (1983). Moreover, Zoltners and Sinha (1983) can only guarantee that calling-time is equal among all salespersons: these calling-times, however, usually require different travel times. Selling time as the sum of calling and travel times may thus differ substantially across salespersons - a situation that might lead to unacceptable solutions.

All of these proposals, attempting to arrive at a profit maximizing sales territory alignment, have emerged from the area of selling time allocation. They have tried to combine the well-developed selling time allocation models with the task of assigning accounts to territories. As a consequence thereof, their unit of analysis is the individual account. When faced with large problems, this may involve the subjective estimation of thousands of response functions, as well as resulting in problems with dimensions too big to be solvable. It is therefore more reasonable to work with aggregated response functions on the level of SCUs. We assume that these functions are concave rather than s-shaped, as is believed to be the case with individual accounts (Mantrala, Sinha and Zoltners 1992). This offers the advantage that less data is needed and simpler algorithms for allocation may be applied. Beswick and Cravens (1977) were the first to work with response functions of SCU-sales dependent upon calling-time. They used the results of their calling-time allocation as input for a sales territory alignment model. This model aimed at creating travel time minimizing territories under the condition that all territories be balanced with respect to calling-time.

Unfortunately, they did not address travel time in their sales response functions. They can therefore neither take travel time into account in their allocation problem, nor predict the effects of changes in travel time (e.g. due to a change of base location of a salesperson). Furthermore, this territory alignment model is unable to guarantee that selling time (not just calling-time) is equal among all salespersons.

1.3 Properties of the New Approach

Although already proposed in the seventies, profit maximizing approaches did not become the dominant approach regarding sales territory alignment. Instead, in a later review by Zoltners and Sinha (1983), the balancing approach is the one described as state-of-the-art. Despite its theoretical inferiority the balancing approach enjoys more popularity, very likely because it is easier to understand, requires only a moderate amount of data, and feasible solutions and their quality can even be produced and evaluated by hand. The aim of this paper is to overcome the weaknesses of the profit maximizing approaches so as to arrive at a model that is both theoretically and practically more appealing than the balancing approach. We shall thereby focus on use of a moderate amount of data, easy estimation of sales response functions and implementation in an attractive software. These goals are realized by means of the decision model, COSTA (Contribution Optimizing Sales Territory Alignment), which simultaneously determines the optimal selling time allocation across SCUs within a territory, as well as the optimal assignment of SCUs to different salespersons characterized by a given number of locations. COSTA offers advantages over previous profit maximization approaches. First, it directly optimizes profit contribution by exchanging SCUs among territories as long as this is associated with profit improvement. It thus avoids the convergence problems of equating marginal values of time. Second, COSTA utilizes a new concept in order to incorporate travel time effects directly into the sales response function per SCU, depending on the assignment to a salesperson with an associated base location. Third, COSTA works with aggregate response functions on the level of SCUs, which are estimated either subjectively or statistically based on company reports on sales and calls. This requires substantially less data and, moreover makes the model applicable for those firms having such a large number of current or potential customers that either individual response functions per account cannot be calibrated, or the allocation of calling-time across accounts is meaningless. Fourth, COSTA is implemented on the basis of readily available spreadsheet and mapping software, enabling the user to link this program easily to related spreadsheet tables and programs. In contrast to the balancing approach, COSTA allows evaluation of any alignment in terms of profit contribution. This makes it possible to really compare the profitability of proposed solutions with the existing situation. In addition, COSTA permits an assessment of the effects that modified locations of salespersons and different salesforce sizes would have on profit contribution.

The remainder of the paper is organized as follows. In Section 2, we describe the new approach implemented in COSTA. We briefly discuss the basic idea of COSTA, introduce the new concept for taking travel time into consideration, describe alternative ways of estimating the sales response functions and, finally, outline the structure of the model. A solution procedure for COSTA is then presented in Section 3. A real-world application is discussed in Section 4. The final section contains conclusions, managerial implications and suggestions for future research.

2 New Approach to Sales Territory Alignment

2.1 Basic Idea

We address the common situation of an alignment of sales territories, in which the number of salespersons and their locations are fixed. The basic idea of COSTA is to then establish a relationship between a sales territory alignment and profit contribution. Such a relationship provides the opportunity to predict the corresponding profit contribution of every possible alignment solution, thus enabling evaluation of all possible territory alignments. With the use of an appropriate algorithm it is then possible to determine the territory alignment that maximizes profit contribution. To establish the identity of such a relation, COSTA works with sales response functions at the SCU level linking the selling time of a given salesperson to profit contribution. Estimating the sales response function at the SCU level rather than the level of individual accounts offers the advantage that less data is required.

$$(1) \qquad PC_{j,r} = m_r \cdot S_{j,r} = m_r \cdot f(t_{j,r}) \qquad (j \in J,\ r \in R),$$

where:

- J: index set of salespersons,
- m_r: gross margin of sales in the r-th SCU,
- $PC_{j,r}$: profit contribution in the r-th SCU if assigned to the j-th salesperson,
- R: index set of SCUs,
- $S_{j,r}$: sales in the r-th SCU if assigned to the j-th salesperson,
- $t_{j,r}$: selling time (including time for traveling and calling) in the r-th SCU if assigned to the j-th salesperson.

Equation (1) shows the general form for these sales response functions. We assume that the sales response functions exhibit a concave shape, and that sales in one SCU are independent of sales made in other SCUs. These are common assumptions in salesforce decision models (for example, see Mantrala, Sinha and Zoltners 1992 and 1994). Using these sales response functions, we solve both an allocation and an assignment problem. The allocation problem deals with how a salesperson should allocate the selling time available to him or her among SCUs in a given territory, whereas the assignment problem addresses the question of how best to assign the SCUs to the individual salespersons. We will solve both problems simultaneously, in such a way that profit contribution is maximized.

2.2 Consideration of Travel Times

Several studies have shown that salespersons spend a considerable amount of their time in traveling (e.g. Krafft 1995). It is therefore very important to adequately take travel times into account in a model for sales territory alignment. Lodish (1975), Zoltners (1976) and Glaze and Weinberg (1979) explicitly incorporated travel times by assuming the number of trips to an SCU to be equal to the maximum number of sales calls to one of the accounts in that SCU. This approximation, however, has two drawbacks. First, as long as the maximum number of sales calls to one of the accounts in that SCU remains the same, the number of trips to an SCU is invariant to the number of sales calls in that SCU. This would mean that calling on only one account in an SCU just once requires the same number of trips (here, one trip) as making single calls to 100 different accounts in the SCU. Likewise, twice as many trips are necessary to call on one account in SCU two times, as compared to calling on 100 different accounts only once. This type of model might thus yield counterintuitive results. The second drawback is that this approximation cannot be directly incorporated into the sales response function. Because of this, these models always need constraints in order to properly calculate the required travel times, but such additional constraints complicate solving such models.

To overcome these problems, we propose the following approach to addressing travel times more appropriately. The basic idea is to split the selling time that the j-th salesperson spends in the r-th SCU ($t_{j,r}$) into two parts: the time available for making the actual calls ($t_{j,r,call}$) and the time required for traveling ($t_{j,r,travel}$).

(2) $t_{j,r} = t_{j,r,call} + t_{j,r,travel}$ ($j \in J$, $r \in R$).

By defining a variable $p_{j,r}$ as the percentage of calling-time to selling time of the j-th salesperson in the r-th SCU, we can rewrite equation (2) in a slightly different form:

(3) $t_{j,r,call} = p_{j,r} \cdot t_{j,r}$ ($j \in J$, $r \in R$).

The fundamental idea is now to express this percentage of calling-time ($p_{j,r}$) as a function of the duration of an average *round trip*, the average *calling-time* and *waiting-time* for an account, the average travel time to the next account, and the average length of a trip of the j-th salesperson to the r-th SCU. For these trips we assume that the salesperson starts from his or her base location, calls on accounts in one SCU and returns afterwards to his or her base location. Data pertaining the duration of an average round trip $RT_{j,r}$ of the j-th salesperson to the r-th SCU can be gathered with the aid of software products such as DISTANCE or AutoRoute[1], which provide information concerning the required travel times between two different locations. This data may be modified if some SCUs are more quickly reached by plane or train than by car. Results of a survey by Krafft (1995) and our own experience indicate that information on the average calling-times $CD_{j,r}$, average waiting-times $WD_{j,r}$ and average travel times $SD_{j,r}$ needed to get from one account to the next within an SCU can be acquired fairly easily by means of subjective estimation by the salesperson. This task is usually further facilitated by the fact that these times are independent of the SCU under consideration (i.e. $CD_{j,r}=CD_j$; $WD_{j,r}=WD_j$; $SD_{j,r}=SD_j$, $\forall r \in R$).[2] With this information, the percentage of calling-time $p_{j,r}$ can then be estimated in the following form:

1 DISTANCE is supplied by ptv, Germany, and AutoRoute by NextBase, England.

2 For more sophisticated methods of estimating the average travel time to the next customer, see Rosenfield, Engelstein and Feigenbaum (1992).

$$(4) \quad \begin{aligned} TT_{j,r} &= RT_{j,r} + ST_{j,r} + CT_{j,r} + WT_{j,r} \\ &= RT_{j,r} + (n_{j,r} - 1) \cdot SD_{j,r} + n_{j,r} \cdot CD_{j,r} + n_{j,r} \cdot WD_{j,r} \end{aligned} \qquad (j \in J,\ r \in R),$$

where:

$CD_{j,r}$: average calling-time for an account of the j-th salesperson in the r-th SCU,

$CT_{j,r}$: total amount of calling-time during a trip of the j-th salesperson to the r-th SCU,

$n_{j,r}$: unrounded average number of accounts called upon on a trip of the j-th salesperson to the r-th SCU,

$RT_{j,r}$: average duration of a round trip from the base location of the j-th salesperson to the r-th SCU,

$SD_{j,r}$: average travel time needed to get from one account to the next one for the j-th salesperson in the r-th SCU,

$ST_{j,r}$: total amount of travel time within an SCU during a trip of the j-th salesperson to the r-th SCU,

$TT_{j,r}$: duration of a trip of the j-th salesperson to the r-th SCU,

$WD_{j,r}$: average waiting-time for an account of the j-th salesperson in the r-th SCU,

$WT_{j,r}$: total amount of waiting-time during a trip of the j-th salesperson to the r-th SCU.

Solving equation (4) for the unrounded average number of accounts called upon on a trip ($n_{j,r}$) yields:

$$(5) \quad n_{j,r} = \frac{TT_{j,r} - RT_{j,r} + SD_{j,r}}{CD_{j,r} + SD_{j,r} + WD_{j,r}} \qquad (j \in J,\ r \in R).$$

The number of accounts called upon on a trip must be integer and non-negative. Therefore, the result $n_{j,r}$ from equation (5) will be rounded to $n^{+}_{j,r}$ if $n_{j,r}$ is positive and otherwise it is set to zero.

$$(6) \quad n^{+}_{j,r} = \begin{cases} \text{round}(n_{j,r}) & \text{if } n_{j,r} > 0 \\ 0 & \text{otherwise} \end{cases} \qquad (j \in J,\ r \in R).$$

The rounding procedure in equation (6) encompasses the flexibility salespersons have in deciding upon the duration of their trips. That is, salespersons who intend to work about 10 hours a day will work somewhat longer if this would enable them to call on another account. The percentage of calling-time $p_{j,r}$ is then calculated using equation (7):

$$
\text{(7)} \quad \begin{aligned} p_{j,r} &= \frac{CT^{+}_{j,r}}{TT^{+}_{j,r}} = \frac{CT^{+}_{j,r}}{RT_{j,r} + ST^{+}_{j,r} + CT^{+}_{j,r} + WT^{+}_{j,r}} \\ &= \frac{n^{+}_{j,r} \cdot CD_{j,r}}{RT_{j,r} + (n^{+}_{j,r} - 1) \cdot SD_{j,r} + n^{+}_{j,r} \cdot CD_{j,r} + n^{+}_{j,r} \cdot WD_{j,r}} \end{aligned} \qquad (j \in J,\ r \in R),
$$

where $CT^{+}_{j,r}$, $ST^{+}_{j,r}$, $TT^{+}_{j,r}$ and $WT^{+}_{j,r}$ are the respective variables for the rounded numbers of accounts called upon on a trip.

Using this approach, we are able to calculate the percentage of calling-time for all assignments of SCUs to salespersons. Due to salespersons' different base locations, the percentages of calling-time for an SCU usually depend on the assignment of the salesperson in question. By distinguishing between the percentage of calling-time and the selling time a salesperson spends in an SCU, we directly incorporate variations in travel time into the sales response functions in (3). This contrasts with the existing approaches to profit maximizing territory alignment: they incorporate calling-time alone into the sales response function, calculating the required travel time for this calling-time separately. Their sales response functions are thus the same for all salespersons as long as they do not incorporate individual performance differences between salespersons. In addition, our approach permits the easy incorporation of overnight stays, as well as the possibility of letting the time for a trip depend on the time during which salespersons will have access to accounts. For example, if accounts are only willing to accept sales calls from 9 a.m. to 5 p.m., the salesperson would need to work approximately from 8 a.m. to 6 p.m. if it takes him or her one hour to get to the first account, or from 8.50 a.m. to 5.10 p.m. in the case that it would take him or her only ten minutes to get to the first account. Modeling such effects is not possible by approximating the number of trips by the maximum number of calls to one of the accounts in the SCU.

2.3 Estimation of the Sales Response Function

The currently available information technologies have improved and increased the amount of accessible data in many companies. Yet there are still companies that experience difficulty in estimating sales response functions statistically. Reasons for this might be that they are either very reluctant to adopt information technologies, causing them to face a lack of data, or that they do not have the statistical expertise for such an estimation at their disposal. We therefore propose two different approaches to estimating the sales response functions, differing in the amount of data and statistical expertise they require. The first approach makes the assumption that there is enough data available to statistically estimate a sales response function using as independent variables: area characteristics of the SCU (e.g. potential, marketing expenditure of the company, competitive pressure), personal characteristics of the salesperson (e.g. selling experience of the salesperson), the percentage of calling-time, and the selling time. Many authors have used - as we do here, as well[3]- a multiplicative form for the sales response function (see overviews in Ryans and Weinberg 1979, and Albers 1989). Profit contribution is then calculated by multiplying sales by the corresponding gross margin.

$$(8) \qquad S_{j,r} = \alpha \cdot \left(\prod_{k \in K} g_{k,r}^{\;h_k} \right) \cdot \left(\prod_{k' \in K'} q_{k',j}^{\;h_{k'}} \right) \cdot (p_{j,r} \cdot t_{j,r})^{b_r} \qquad (j \in J,\ r \in R),$$

where:

b_r: elasticity of sales with respect to calling-time in the r-th SCU,

$g_{k,r}$: value of the k-th area characteristic in the r-th SCU,

h_k, $h_{k'}$: corresponding elasticities of sales with respect to the k-th area (k'-th personal) characteristic,

K, K': index set of the area (personal) characteristics,

$q_{k',j}$: value of the k'-th personal characteristic of the j-th salesperson.

3 We would like to note that although past experiences with multiplicative sales response functions have been positive, there may be, nonetheless, situations in which sales response functions with a saturation level (e.g. the modified exponential function) are more appropriate. The use of such functions complicates solving the allocation problem outlined in section 2.4, as there is no closed form solution. However, because the allocation problem can be solved by applying an algorithm proposed by Luss and Gupta (1975), the general approach to establishing profit maximizing sales territory alignment remains more or less the same.

Several studies in related literature have shown that estimation of this kind yields valid sales response functions (see overviews in Ryans and Weinberg 1979, Albers 1989) and that the parameters of these functions are stable over time (Ryans and Weinberg 1987). Furthermore, in contrast to the sales response functions estimated for entire territories, our SCU-response function in equation (8) uses selling time and the percentage of calling-time as independent variables, rather than using calling-time and simple distance measures. This use of the percentage of calling-time better approximates the required travel time than do simple distance measures also making it possible to model the effect on profit contribution of changes in the percentage of calling-time. Such changes might occur, for example, due to the modified duration of a trip (e.g. overnight stays) or decreased waiting-time.

For the case that a company encounters a lack of either data or statistical expertise, we propose an alternative approach for the estimation. This approach is based upon the idea of defining a territory-quality parameter that summarizes the following part of the sales response function:

$$(9) \qquad c_{j,r} = \alpha \cdot \left(\prod_{k \in K} g_{k,r}^{\ \ h_k} \right) \cdot \left(\prod_{k' \in K'} q_{k',j}^{\ \ h_{k'}} \right) \cdot p_{j,r}^{\ \ b_r} \qquad (j \in J,\ r \in R),$$

such that equation (8) can be rewritten in the following form:

$$(10) \qquad S_{j,r} = c_{j,r} \cdot t_{j,r}^{\ \ b_r} \qquad (j \in J,\ r \in R).$$

It is reasonable to assume that companies are aware of their current sales $S_{j,r}$ in all of their SCUs and the corresponding territories. Furthermore, it should be possible to gather information on the amount of selling time a salesperson has spent in an SCU by inspecting call reports, analyzing the calling strategy pursued or simply obtaining subjective estimates from the salespersons (for the latter, see Beswick 1973, LaForge and Cravens 1985). There are two different ways to get information concerning the sales call elasticity. The first is to ask the sales manager for subjective estimates, a method successfully applied by Krafft (1995). The second possibility would be to cluster accounts or SCUs sharing homogeneous responses to different numbers of calls into groups. A cross-section analysis then allows estimation of the respective sales call elasticity by analyzing the influence of the various numbers of calls within a given group (see Albers 1989 and the related literature cited therein). With the use of this information, it is possible to estimate a territory-quality parameter for all SCUs and for the salesperson currently assigned to that SCU by solving equation (10) for $c_{j,r}$.

$$(11) \qquad c_{j(r),r} = \frac{S_{j,r}}{t_{j,r}^{\,b_r}} \qquad\qquad (r \in R),$$

where j(r) is a function denoting the j-th salesperson to whom the r-th SCU is currently assigned.

Nevertheless, the problem still remains of how to determine the territory-quality parameter (and thus the sales response function) if a given SCU would be assigned to a salesperson other than the current one. By using the first of the two approaches discussed above, this could be accomplished fairly easily by substituting the new values for the variables of the respective salesperson in equation (8).

Using the second approach, we would have to replace the "hard data" of the first approach with subjective estimates and use the value of the current assignment's territory-quality parameter as a reference point. Possible changes in the territory-quality parameters if SCUs are assigned to salespersons other than the current one can be traced back to three effects. First, losses in sales might occur due to the disruption of an existing relationship between account and salesperson. Second, it may be that the new and the old salespersons have different selling abilities. Third, and probably most important, there might be changes in travel time due to the salespersons' different locations. These effects are incorporated in the territory-quality parameter in equation (9) in the form of variables $p_{j,r}$ and $q_{k',j}$. Their influence on the territory-quality parameters is determined by rearranging equation (9), which yields equations (12) and (13). Equation (12) contains the territory-quality parameter in the r-th SCU and its current assignment ($c_{j(r),r}$), while equation (13) contains the territory-quality parameters for salespersons other than its currently assigned salesperson (indexed by j').

$$\text{(12)} \quad \alpha \cdot \left(\prod_{k \in K} g_{k,r}{}^{h_k} \right) = \frac{\left(\prod_{k' \in K'} q_{k',j(r)}{}^{h_{k'}} \right) \cdot p_{j(r),r}{}^{b_r}}{c_{j(r),r}} \qquad (j(r) \in J,\ r \in R),$$

$$\text{(13)} \quad \alpha \cdot \left(\prod_{k \in K} g_{k,r}{}^{h_k} \right) = \frac{\left(\prod_{k' \in K'} q_{k',j'}{}^{h_{k'}} \right) \cdot p_{j',r}{}^{b_r}}{c_{j',r}} \qquad (j' \in J,\ j' \neq j(r),\ r \in R).$$

Equating the right-hand sides of equations (13) and (12) and solving for $c_{j',r}$ yields:

$$\text{(14)} \quad c_{j',r} = c_{j(r),r} \cdot \frac{\left(\prod_{k' \in K'} q_{k',j(r)}{}^{h_{k'}} \right) \cdot p_{j(r),r}{}^{b_r}}{\left(\prod_{k' \in K'} q_{k',j'}{}^{h_{k'}} \right) \cdot p_{j',r}{}^{b_r}} \qquad (j(r) \in J,\ j' \in J,\ r \in R,\ j' \neq j(r)).$$

The procedure outlined in section 2.2 determines the percentages of calling-time when SCUs are assigned to new salespersons ($p_{j',r}$). If performance differs among the salespersons, the sales manager must provide subjective estimates. We propose using a procedure similar to the one implemented by Lodish (1976). His results show a high convergent validity for the estimates of different sales managers. Furthermore, the high response rate (over 75% in a recent survey by Krafft (1995)) to questions about differences in the performance of salespersons indicates that sales managers encounter few problems in providing this kind of information. In addition, the estimation task is usually further facilitated by the fact that the performance differences do not depend on the SCU. Even if this is not the case, the sales manager need only provide information on those SCUs where the salesperson realizes a sufficiently high percentage of calling-time. The effect of losses in sales due to disruption of the existing relationship between account and salesperson can be estimated by asking the sales manager for the additional calling-time a new salesperson must spend with the account to reestablish the relationship. This disruption effect resembles to effect of different travel times and can thus be incorporated in a similar way, because a 10% higher percentage of calling-time is balanced out by an additional 10% in calling-time due to disruption of an existing relationship. Thus, the relationship in equation (14) makes it possible to estimate the sales response functions for all combinations of SCUs and salespersons.

2.4 Modeling the Allocation Problem

To determine the optimal allocation of selling time for a salesperson in a given sales territory, we must solve the following model (15)-(17):

$$(15) \quad PC_j = m_r \cdot S_j = \sum_{r \in R_j} m_r \cdot c_{j,r} \cdot t_{j,r}^{b_r} \rightarrow \max! \qquad (j \in J),$$

$$(16) \quad \sum_{r \in R_j} t_{j,r} \leq T_j \qquad (j \in J),$$

$$(17) \quad t_{j,r} \geq 0 \qquad (j \in J,\ r \in R_j),$$

where:

PC_j: profit contribution of the j-th salesperson,

R_j: index set of those SCUs assigned to the j-th salesperson,

S_j: sales of the j-th salesperson,

T_j: total amount of the j-th salesperson's selling time that is available for making calls and traveling.

Objective (15) represents the profit contribution of the j-th salesperson as given by the sum of gross margins multiplied by the respective sales response over the SCUs assigned to that salesperson. Profit contribution is maximized, while the selling time in all SCUs must be positive (equation (17)), and in total must be less than the amount of selling time available to the salesperson (constraint (16)). Due to administrative tasks, the total amount of selling time is usually less than the total working-time of the salesperson. Results from a survey by Krafft (1995) indicate that, on the average, a salesperson utilizes 62.3% of his or her working time as selling time. This selling time is on average split fairly evenly between calling and travel time (53% versus 47%; details described in Skiera 1996).

Beckmann and Golob (1972) show that, when sales call elasticities in all SCUs are equal ($b=b_r$, $r\in R_j$), formulation of the Lagrangian function for model (15)-(17) provides the following solution:

$$(18)\qquad t_{j,r}=\frac{\left(m_r\cdot c_{j,r}\cdot b\right)^{\left(\frac{1}{1-b}\right)}}{\sum\limits_{v\in R_j}\left(m_v\cdot c_{j,v}\cdot b\right)^{\left(\frac{1}{1-b}\right)}}\cdot T_j \qquad (j\in J,\ r\in R_j).$$

When sales call elasticities differ, model (15)-(17) is solved either by applying an algorithm proposed by Einbu (1981) or by using equation (19):

$$(19)\qquad t_{j,r}=\left(\frac{\left(m_r\cdot c_{j,r}\cdot b_r\right)^{\left(\frac{1}{1-b_j^*}\right)}}{\sum\limits_{v\in R_j}\left(m_v\cdot c_{j,v}\cdot b_v\right)^{\left(\frac{1}{1-b_v}\right)}}\cdot T_j\right)^{\left(\frac{1-b_j^*}{1-b_r}\right)} \qquad (j\in J,\ r\in R_j).$$

In this equation, b_j^* represents a variable for which a value must be chosen such that the sum of selling times $t_{j,r}$ over R_j, calculated by equation (19), fulfills restriction (16). This may be accomplished by using simple unidimensional search procedures (Himmelblau 1972).

2.5 Modeling the Allocation and Assignment Problem

We can determine the optimal sales territory alignment by solving the following nonlinear mixed-integer model (20)-(25) which integrates the allocation and the assignment problem:

(20) $\sum_{j \in J} \sum_{r \in R} x_{j,r} \cdot m_r \cdot c_{j,r} \cdot t_{j,r}{}^{b_r} \rightarrow \max!$

(21) $\sum_{r \in R} t_{j,r} \cdot x_{j,r} \leq T_j$ $\quad (j \in J)$,

(22) $t_{j,r} \geq 0$ $\quad (j \in J,\ r \in R)$,

(23) $\sum_{j \in J} x_{j,r} = 1$ $\quad (r \in R)$,

(24) contiguity of the territory of the j-th salesperson $(j \in J)$,

(25) $x_{j,r} \in \{0,1\}$ $\quad (j \in J,\ r \in R)$,

where:

$$x_{j,r} = \begin{cases} 1 & \text{if the r - th SCU is assigned to the j - th salesperson,} \\ 0 & \text{else,} \end{cases} \quad (j \in J,\ r \in R).$$

Objective (20) maximizes total profit contribution: that is the sum of the profit contributions made by all salespersons. Equations (21) and (22) guarantee positive selling times in all SCUs and that the individual selling time constraints of all salespersons are met. Constraints (23) and (25) provide for the exclusive alignment of an SCU to exactly one salesperson. Constraint (24) ensures the contiguity of the territories of all salespersons. Because we do not use an integer programming algorithm to solve model (20)-(25), we can operate with a simple depth-search algorithm to ensure the contiguity of the territories. More specifically, we create a quadratic adjacency matrix of size $|R|$, containing information concerning the neighborhood of all combinations of pairs of SCUs (for construction of such an adjacency matrix, see Arbia 1989). Using this adjacency matrix, our depth-search algorithm simply determines whether all SCUs in the j-th salesperson's territory are connected either directly or over other SCUs to the base SCU of the j-th salesperson.

In addition to establishing a profit maximizing alignment, model (20)-(25) provides the structure necessary for evaluation of the effects of different base locations and different salesforce sizes. To examine the first effect, we simply modify the salespersons' locations, determine the new percentages of calling-time in the sales response functions for the salespersons in question and solve model (20)-(25) again. The effect of different salesforce sizes is assessed through modification of the size of the index set of salespersons, by adding or deleting salespersons and providing locations for those who were added.

3 Solution Procedure and Software Implementation of COSTA

3.1 Algorithm

We have demonstrated that a solution procedure equating for marginal profit of selling time does not necessarily yield to a global assignment and allocation optimum. We thus directly optimize profit contribution by exchanging SCUs among territories as long as this is associated with improvements in profit contribution. More precisely, the exchange algorithm for our model (20)-(25) is based on the strategy of simulated annealing. We generate a start-solution in which each SCU is assigned to the salesperson with the closest base location. Zoltners and Sinha (1983) showed that this start-solution always determines contiguous territories. A neighborhood solution is then generated by moving one SCU v from the territory of salesperson j1 to a neighboring territory of salesperson j2, such that both territories remain contiguous. That is we simply set $x_{j1,v}=0$ and $x_{j2,v}=1$ and check the contiguity of both territories. The simulated annealing algorithm now proceeds as follows: if the new solution leads to an improved value of the objective function in equation (20), it is "accepted".

Otherwise, it is accepted with a certain probability dependent upon the actual cooling "temperature" (for details on simulated annealing procedures, see for example Eglese 1990, and the literature cited there; for details about the algorithm see Skiera 1996). This simulated annealing algorithm finds a near-optimal solution for alignments of 5-15 sales territories on the basis of the German two-digit postal areas (95 SCUs) within less than 10 minutes on a PC-80486 DX-33. Furthermore, the algorithm is flexible enough to encompass a wide range of structures of the objective function or additional constraints (e.g. preassigned SCUs).

3.2 Software Implementation

The use of decision models depends heavily on the associated software implementation. In order to provide a program which can easily be used, we have implemented the whole model in a spreadsheet environment like EXCEL. This will allow for a convenient data exchange with the sales manager's other spreadsheet applications. The simulated annealing procedure itself is programmed in Visual Basic and embedded in the spreadsheet. The spreadsheet, in turn, is linked via Dynamic Data Exchange (DDE) with a PC-mapping program called DISTRICT MANAGER. This program displays the shape of the sales territories geographically, in map form to the user. In addition, it permits interactive manual intervention, such as the exchange of SCUs for purpose of considerations not modeled via (20)-(25) and performing "what-if"-analyses.

4 Application of COSTA

In this section we present the results of a real-world application of COSTA. In section 4.1 we illustrate the usefulness of the information sales managers obtain by applying COSTA and compare in section 4.2 the sales territory alignment derived from COSTA with that of the balancing approach. Analysis of the marginal profits of time in the different territory alignments is found in section 4.3.

4.1 Results of the Application

COSTA was applied in a mid-sized German company that had traditionally served the market almost exclusively by mail order, but which planned to build up a salesforce in order to better serve the larger accounts of their target group. The company had hired 10 salespersons within the last few months and adopted the 95 two-digit postal areas as SCUs. Territories were set up as shown in figure 1, in which the white shaded numbers represent the salespersons' locations and the number of the territory. The company intended to have the two SCUs in the northernmost part of Germany (territory 11), which is around their headquarters be covered by their back office personnel. In addition, for internal reasons it was decided that the size of territory 10 would remain unchanged.

The company made the assumption that no substantial performance differences between their salespersons existed, and, furthermore believed that it was not close to a saturation level. Therefore, the following multiplicative sales response function was assumed to reflect sales response to salespersons' selling times:

$$\text{(26)} \quad \begin{aligned} PC_{j,r} &= m_{j,r} \cdot \alpha \cdot p_{j,r}{}^{b} \cdot POT_r{}^{\gamma} \cdot t_{j,r}{}^{b} \\ &= 0.353 \cdot 1350 \cdot p_{j,r}{}^{0.375} \cdot POT_r{}^{0.625} \cdot t_{j,r}{}^{0.375} \end{aligned} \qquad (j \in J,\ r \in R),$$

where POT_r was the number of relevant accounts. The underlying information for calculation of the percentages of calling-time $p_{j,r}$ was an average calling-time of 60 minutes, and an average travel time within an SCU of 30 minutes. The average duration for a trip for all salespersons was 8 hours, whereby the salespersons stayed over one night if it took them longer than two hours to get from their base location to the SCU (i.e. $TT_{j,r}$=16 hours if $0{,}5 \cdot RT_{j,r}>2$ hours, otherwise $TT_{j,r}$=8 hours). The yearly total amount of selling time available to each salesperson was 1,460 hours, which allowed approximately 750 calls per year.

Territory	Sales (in DM)	PC after selling expenses (in DM)	Potential (number of relevant accounts)	Number of calls	Percentage of calling-time	Number of overnight stays	Marginal profit of time
1	2,090,504	510,042	2,543	715	49%	45	537
2	841,457	73,784	604	710	49%	35	216
3	2,898,635	799,294	4,394	668	46%	14	745
4	1,184,999	198,798	950	794	54%	10	304
5	2,470,860	651,040	3,232	728	50%	5	635
6	2,385,648	609,833	3,164	689	47%	44	613
7	2,912,532	807,281	4,242	715	49%	5	748
8	2,711,837	726,205	3,723	726	50%	56	697
9	1,627,236	354,816	1,637	743	51%	0	418
10	809,060	120,414	448	973	67%	0	208
11	-	-	385	-	-	-	-
Total	19,932,768	4,851,508	25,322	7,462	51%	214	-

Table 1: Characteristics of the current territory alignment

Profit contribution after selling expenses was calculated by subtracting income, travel expenses and cost for overnight stays from profit contribution before selling expenses. In this respect, cost for each salesperson (income plus social expenses) was 200,000 DM (except for salesperson 10, who was at 150,000 DM), for each overnight stay 200 DM, and for each kilometer driven 0.52 DM (the average distance within an SCU was assumed to be 30 kilometers). Note that we used actual travel times (not Euclidean distances) to adequately take into account the required travel time.

Using this information, sales and profit contribution for the current territory alignment can be predicted as shown in table 1. Sales and profit contribution were highest in sales territories 7 and 8 and lowest in territories 2 and 4. All together the salespersons were able to make 7462 calls and thus, on the average, realize a percentage of calling-time of about 51%. Salesperson 4 made the highest number of sales calls, but realized only low sales and profit contribution. The reason was that this salesperson had only very few accounts to call upon.

To further pinpoint the shortcomings in the current territory alignment, we have found it helpful to use the following measure of effort intensity (EI_r) in the r-th SCU:

$$(27) \qquad EI_r = \frac{\left(\frac{CT_r}{POT_r}\right)}{\left(\frac{\sum_{m \in R} CT_m}{\sum_{m \in R} POT_m}\right)} \qquad (r \in R),$$

where:
CT_r: Calling-time in the r-th SCU,
POT_r: Number of relevant accounts in the r-th SCU.

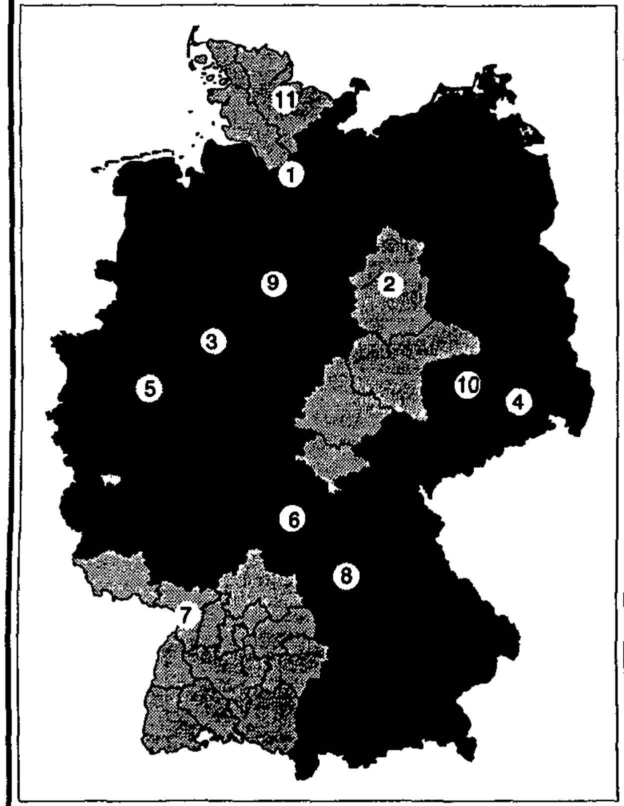
This measure of effort intensity reflects the amount of the calling-time per unit potential compared to the average calling-time per unit potential. Values greater than 1 indicate that effort intensity is higher than average.

Figure 2 shows the effort intensity for the current territory alignment indicating a much higher effort intensity in the northeastern part of Germany than in the southeastern part. This flaw in the current territory alignment is partially reduced by the territory alignment derived from COSTA (see figure 1). In that solution, most territories expand towards the southeast. It is interesting to observe that the potential - measured as the number of relevant accounts - is far from being equal in all territories. Salesperson 4, in particular, has a territory with a small number of relevant accounts. The reason for this is that the base location of salesperson 4 is close to the country's border, the area around this base location containing only few accounts, and salesperson 2 is located nearby. In contrast, salespersons 7 and 8 have territories with large numbers of relevant accounts. They are both located in areas with high numbers of accounts, and salesperson 6 is the only other one fairly close by. The upper part of table 2 indicates that the territory alignment derived from COSTA increases profit contribution and sales by 5.8% and 4.1% respectively. Note that the absolute increase in profit contribution of

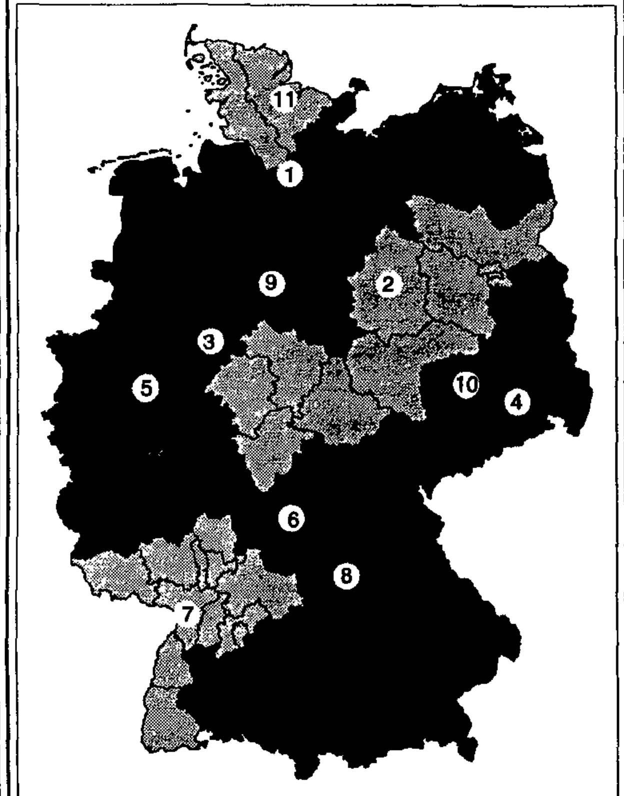
279.138 DM well exceeds the cost of one of the 10 salespersons. The effort intensity figures of the COSTA territory alignment (see figure 2) indicate a much more balanced penetration. It highlights, however, the shortage of salespersons in the Southwest (or, to put it negatively, the abundance of salespersons in the Northeast).

4.2 Results Compared to the Balancing Approach

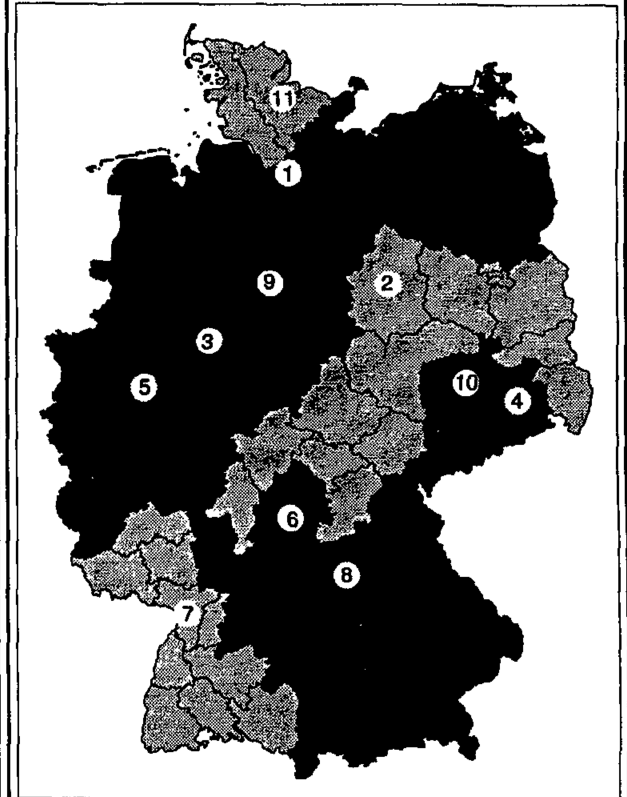
To emphasize the relevance of our critique of the balancing approach, we have established an almost balanced territory alignment with respect to the number of relevant accounts (see figure 1), with the aid of an algorithm developed by Skiera and Jordan (1996). All territories in this alignment have a potential within ±5% of the average potential per territory (see table 2), the exceptions being territories 10 and 11 due to the reasons mentioned above. This alignment yields a higher profit contribution than the current territory alignment (compare tables 1 and 2). However, in terms of profit contribution it is inferior to the territory alignment derived from COSTA by 3.5%. This is because the losses in profit contribution in territories 7 and 8 are not compensated for by the gains in territories 1, 2 and 4. Furthermore, note that both sales and profit contribution in all territories (except for territories 10 and 11) are more balanced than in the other territory alignments. But as sales and profit contribution in territory 1 are still 17.3% and 29.1% higher than in territory 4, we feel that equal sales, and hence equal income opportunities are not being completely realized in this territory alignment. This real-world application thus underlines the relevance of our critique of the balancing approach as it neither establishes profit maximizing sales territories nor leads to equal income opportunities. Hence, we feel that companies might really benefit from using COSTA to establish profit maximizing sales territory alignments.



Current territory alignment



Territory alignment derived from COSTA

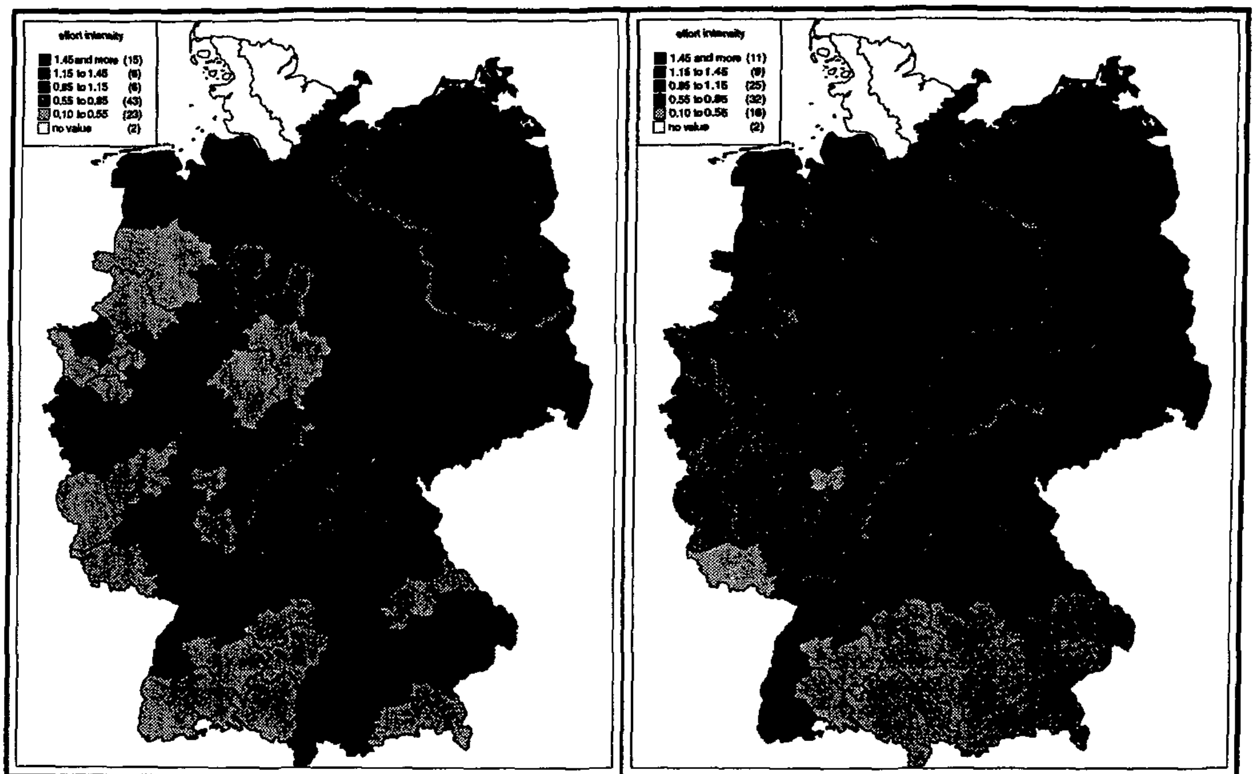


Balanced territory alignment

Figure 1: Territory alignments

Territory	Sales (in DM)	PC before selling expenses (in DM)	Income of salesperson (in DM)	Travel expenses (in DM)	Cost of overnight stays (in DM)	PC after selling expenses (in DM)	Potential (number of relevant accounts)	Number of sales calls	Percentage of calling-time	Number of overnight stays	Marginal profit of time
Results for COSTA											
1	1,782,628	629,268	200,000	16,495	2,600	410,172	1,803	816	56%	13	458
	1,882,689	664,589	200,000	19,821	13,600	431,168	2,132	701	48%	68	484
3	2,157,915	761,744	200,000	19,910	8,600	533,234	2,598	733	50%	43	554
4	1,610,497	568,506	200,000	19,277	8,200	341,028	1,661	717	49%	41	414
5	2,562,958	904,724	200,000	17,783	400	686,541	3,179	812	56%	2	658
6	2,277,988	804,130	200,000	23,065	8,000	573,065	2,890	708	48%	40	585
7	2,696,270	951,783	200,000	18,808	0	732,975	3,585	764	52%	0	693
8	3,081,392	1,087,731	200,000	19,577	14,200	853,954	4,583	721	49%	71	791
9	1,891,554	667,718	200,000	19,625	0	448,094	2,058	755	52%	0	486
10	809,060	285,598	150,000	15,184	0	120,414	448	973	67%	0	208
11	-	-	-	-	-	-	385	-	-	-	-
Total	20,752,950	7,325,791	1,950,000	189,546	55,600	5,130,646	25,322	7,701	53%	278	-
Results for balanced territories											
1	2,311,993	816,134	200,000	18,219	4,400	593,515	2,858	757	52%	22	594
2	2,085,096	736,039	200,000	20,723	14,400	500,916	2,710	632	43%	72	536
3	2,149,344	758,719	200,000	21,850	1,200	535,669	2,704	685	47%	6	552
4	1,970,980	695,756	200,000	23,072	13,000	459,684	2,740	565	39%	65	506
5	2,241,384	791,208	200,000	18,610	0	572,599	2,644	776	53%	0	576
6	2,151,416	759,450	200,000	21,542	5,800	532,108	2,698	685	47%	29	553
7	2,232,555	788,092	200,000	19,810	1,600	566,681	2,740	735	50%	8	573
8	2,220,779	783,935	200,000	19,325	7,600	557,010	2,755	713	49%	38	570
9	2,113,485	746,060	200,000	22,035	4,600	519,425	2,640	683	47%	23	543
10	809,060	285,598	150,000	15,184	0	120,414	448	973	67%	0	208
11	-	-	-	-	-	-	385	-	-	-	-
Total	20,286,092	7,160,990	1,950,000	200,369	52,600	4,958,021	25,322	7,203	49%	263	-
PC: Profit Contribution											

Table 2: Characteristics of territory alignment solutions as derived from COSTA and the balancing approach



Current territories	Territories derived from COSTA

Figure 2: Effort intensity for current territories and territories derived from COSTA

4.3 Marginal Profits of Time in the Different Territory Alignments

Another very important result seen in table 2 is that marginal profits of time differ among salespersons in the solution derived from COSTA. Apart from territory 10 which remains unchanged, salesperson 4 realizes the lowest marginal profit of time. Salesperson 8 has the highest marginal profit of time: it is almost double that of salesperson 4. The reason for this is that salesperson 4 is located at the German border in an area with only limited sales opportunity whereas salesperson 8 is located in the South of Germany (Bavaria) where more accounts are at his disposal, and, hence, higher sales opportunities. The discrepancy in the marginal profits of time for all salespersons decreases in the territory alignment of the balancing approach. However, the downside of this is a decrease in profits, emphasizing the relevance of the criticism we made at the assumption of equal marginal profits of time across territories.

5 Conclusions and Future Research

We have here presented a new approach to profit contribution optimizing sales territory alignment, called COSTA. It aims to revive the rein of research in the seventies that proposed sales territory alignment decision models which attempt to directly maximize profit. Such models are theoretically more appealing than the balancing approach, which strives only to balance one or several balancing criteria such as potential or work-load in hopes of arriving at solutions nearing the profit maximum. Although this hope is questionable, the balancing approach has become state-of-the-art. This is most likely because it is easy to understand, requires only a moderate amount of data, and because feasible solutions and their quality can even be produced and evaluated by hand. In contrast, the profit maximizing approaches of the seventies were very complex, needed a large amount of data and required specialized software that was not readily available. In order to alter this situation, COSTA has been designed as a less complex model, which demands less data and is implemented in user-friendly, widespread software.

COSTA combines the problem of selling time allocation with assignment of sales coverage units (SCUs) to territories. In contrast to the profit maximization approaches of the seventies, COSTA is based upon sales response functions on the level of SCUs as opposed to individual accounts, thus requiring less data. It also works with a new concept of incorporating travel time directly into the response functions rather than determining the number of trips to SCUs separately via constraints. Both of these properties lead to a less complex problem structure that is more suitable for the allocation optimization. For the assignment problem, COSTA does not rely on the questionable principle of equating marginal profits of time. Instead, it improves a starting solution by exchanging SCUs between territories: for this purpose a special simulated annealing algorithm has been developed that makes use of recent advances in solving hard combinatorial problems. The applicability of

COSTA has been further increased by implementing it as spreadsheet software with a link to mapping software.

COSTA's potential has been demonstrated in a real-world application. A comparison of COSTA's results to those of the balancing approach shows that the former produces a solution with a 3.5% higher predicted profit contribution. The structure of the solutions also suggests that making territories as equal as possible with respect to potential is detrimental to profitability. Even more dire is the observation that, despite its justification, the balanced solution of nearly equal potential did not lead to equal sales and, in turn, to equal income opportunities. We may thus conclude that the balancing approach is theoretically inferior to the profit contribution maximizing approach and, in fact, becomes obsolete when the latter is properly modeled and implemented. It should be noted here that compensation issues (as indicated by the request for equal income opportunities) can be wholly separated from the design of sales territories by basing variable incentives not on the absolute figure of achieved sales but on the relative figure of achieved quota. We are under the impression that this fact is still frequently overlooked by sales managers. Another interesting result is that the marginal profits of time are not equal in the profit maximizing territory alignment. A comparison with the balancing approach's solution shows that it also exhibits more balanced marginal profits of time. This implies, as argued above, that an approach equating marginal profits of time across territories will not yield to a profit maximum.

It is clear, from the discussion in section 2.2, that the concept of incorporating travel time considerations directly in the response function was essential to both simplifying the allocation task and increasing the face validity of its impact. As our allocation task is equivalent to Lodish´s CALLPLAN-problem, future research should investigate whether or not the allocation submodel of COSTA having account (as opposed to SCU) sales response functions is better suited for allocating selling time across accounts than CALLPLAN itself.

This modified incorporation of travel times permits us to abandon the constraints for calculating required travel times. Hence, the resulting model contains less constraints and ought to be easier to solve.

The solution procedure for the assignment problem is currently based on the idea of simulated annealing. Yet, several other promising approaches have been suggested for solving hard combinatorial problems such as tabu search or genetic algorithm (for an overview, see Glover and Greenberg 1989). It might thus be worthwhile to test other algorithms for their suitability regarding our assignment problem. Although COSTA is capable of evaluating the profit contribution for different sets of locations or different salesforce sizes with corresponding locations, it does not provide a procedure that systematically searches for optimal or improved sets of locations. Hess and Samuels (1971) and Glaze and Weinberg (1979) have already proposed to iterate between adjusting the locations to the travel time minimizing locations, and optimizing the sales territory alignment until the locations no longer change. Future research ought to investigate the extent to which such a procedure converges to the global profit contribution maximum and whether good heuristics are available. Finally, we need more experience in practical application of COSTA in order to assess the magnitude of profit improvement that can be achieved.

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