Sales Force Sizing and Deployment Using a Decision Calculus Model at Syntex Laboratories

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A series of subjectively parameterized models was developed and implemented, beginning in 1982, to aid Syntex Laboratories in deciding how large their sales force should be, and how it should be deployed. The response functions of the models were estimated by a team of knowledgeable managers and salespeople using a modified Delphi technique. The model structure and parameter estimation techniques were developed in response to constraints unique to Syntex Laboratories and its available data. The original response functions were significantly better predictors of the sales of each Syntex product for two years in the future than were the existing forecasts. Use of the models helped the corporation to decide to significantly increase its sales force size and to try to change its deployment. This decision resulted in a documented continuing $25,000,000, eight percent annual sales increase. The model had important impacts on the strategic direction of the firm, helping to change its focus to product markets with better future potential.

Deciding on the appropriate amount to spend on the sales force is a very difficult practical problem. Theoretically, money should be invested in the sales

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INDUSTRIES — PHARMACEUTICAL

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force as long as marginal returns on that investment are greater than other alternative places for corporate investment. However, determining the rate of return on different sales force investments is very difficult for most marketing managers. The biggest determinant of investment in the sales force is the number of people in the force. Relating incremental sales to incremental changes in the sales force size and then relating those incremental sales to profitability over different planning horizons is very difficult. It is hard to isolate the effect of the sales force from all the other effects in the marketplace that might cause sales to go up or down. These effects include pricing, advertising, changes in distribution, changes in market needs, and changes in competitive behavior.

For ethical pharmaceutical firms, the sales force investment decision is even more crucial, because the sales force is the prominent way of marketing their products. Early in 1982, Syntex Laboratories' management realized that the decision on sales force size for the next three years would be very important for the company. One of the idiosyncratic characteristics of decisions on sales force size is that they involve what may be the worst kind of costs for a company. They are variable costs when they are added, that is, each salesperson adds an amount of compensation plus expenses plus sales management time to the cost of the firm. However, it is difficult to cut back sales force size significantly. The morale of the salespeople who remain may be hurt, and the training costs that have been incurred to get a salesperson up to speed are foregone. Management's primary concern was to determine the size the sales force needed to be to optimally support the existing products.

Since 1982, a model-based methodology has been used by Syntex Laboratories to help determine direction for their sales force size and associated decisions on strategic deployment and the product portfolio. Trade-offs were needed in model building and model implementation to make the model practical and implementable for Syntex.

The Company

Syntex Corporation began in 1940 with topical steroid preparations prescribed by dermatologists and then introduced products for birth control, which were prescribed by gynecologists. By 1982, Syntex Corporation was an international company that developed, manufactured, and marketed a wide range of health and personal care products. In fiscal 1981 (ending July 31), consolidated sales were $710 million with $98 million in net income. Syntex had recorded a 23 percent compound annual growth rate since 1971. Syntex Laboratories, the US human pharmaceutical sales subsidiary, was the largest Syntex subsidiary. Syntex Laboratories' sales for fiscal 1981 increased 35 percent to $215 million and had grown as a percentage of total pharmaceutical sales to 46 percent. Syntex Laboratories' profit percentage of the international operation was greater, however, than their sales percentage, because sales in the US were much more profitable than sales around the world. More detail on the company and the initial model building can be obtained from Clarke, D. [1983].

In 1982, the Syntex product line was made up of seven major products grouped into four categories: nonsteroidal antiarthritic (NSAI) drugs, analgesics, oral contraceptives, and topical steroids. The NSAI product, Naprosyn, was by far the largest and most successful, while birth control and topical steroid products represented the company's early development as a drug manufacturer. Naprosyn, introduced in 1977, was the third largest selling drug in the NSAI therapeutic class in the US. Naprosyn had become quite successful, because the dosage was flexible, it was prescribed twice a day, less frequently than competing products, and it seldom had side effects. Naprosyn had been introduced first to rheumatologists, who specialize in treating arthritis, and then to general physicians. Anaprox, an analgesic, was launched early in 1981. Anaprox was targeted for analgesic use and for the treatment of menstrual pain. The total number of prescriptions written for analgesics was twice as large as for antiarthritic drugs in the US. Naprosyn and Anaprox are chemically similar products.

Determining the rate of return on different sales force investments is very difficult.

Syntex produces two topical steroid creams for treating skin inflammations, Synalar and Lydex. Growth in these products in fiscal 1981 was only slightly ahead of sales in 1980. During 1980's fiscal year, Syntex was the only established company to increase total prescription volume in topical steroids, and two new entries had grown from small shares. Syntex had a very strong following among dermatologists. In 1981, 21 percent of all new topical steroid prescriptions written by dermatologists were for Syntex products.

Syntex's oral contraceptive products, Norinyl 1+35 and Norinyl 1+50, were available in three dosage forms that together garnered 10 percent of the oral contraceptive market. Sales volume for oral contraceptives in 1980 had grown by 23 percent. However, the growth in dollar volume was primarily the result of price increases. The low dose segment was the growth segment of the oral contraceptive market.

Nasalide is a steroid nasal spray for the treatment of hay fever and allergies, and it had just been approved for United States marketing by the government authorities early in fiscal 1982.

Marketing and Sales at Syntex Laboratories

The role of the sales force is to visit physicians and encourage them to prescribe Syntex drugs for their patients. Other marketing elements in the pharmaceutical industry in the US include advertising in medical journals, direct mail, giving physicians samples of products, and other specialized forms of product promotion, such as medical symposia and convention booths. Physicians, the target market for Syntex, could be segmented in many ways. One would be by their specialty (family practice, general practice, internal medicine, orthopedics, rheumatology, Ob/gynecology, dermatology, allergies, and otolaryngology). Data were available on the sizes of each of these

specialty groups. Other means of segmenting physicians by number of prescriptions written or innovativeness in trying new products have also been used in the pharmaceutical industry. However, precise data to segment physicians are very expensive to obtain and were not available in 1982 to Syntex.

When a physician prescribes a Syntex drug for a patient, the prescription can be filled at any pharmacy, not necessarily in the same area as the physician. The pharmacies, in many cases, do not buy directly from Syntex but through large wholesalers. Thus, it is very difficult to isolate specifically sales that are influenced by the salesperson's calls on a particular physician. The salesperson does not know whether a sale is made or its amount.

During a sales call, a sales rep normally provides a physician with samples and information about the dosage levels and possible uses for various drugs. Typically, a Syntex salesman is able to describe or "detail" between two and three products during one sales call. It is difficult in many cases to get appointments with busy physicians, and a number of competing sales reps vie for physicians' time.

In late 1981, Ellen Curtis and Michael Ness of the marketing research department consulted with Len Lodish and Kerry Simpson after surveying the literature on sales force management. They then recommended to marketing management that a new approach be used to better answer the question of sales force size at Syntex Laboratories. These four become the model building and development team. The situation at the time was summed up by the then senior vice-president for sales and marketing as follows:

> Our history had been one of increasing the sales force size in relatively small steps. I've never been really satisfied that there was any good reason why we were expanding by 30 or 40 representatives in any one year other than that was what we were able to get approved in the budget process. Over the years, I'd become impatient with the process of going to the well for more people every year with no long-term view of it. I felt that if I went to upper management with a more strategic, or longer-term viewpoint, it would be a lot easier to then sell the annual increases necessary to get up to a previously established objective in sales force size and utilization. [Clarke 1983, p. 9.]

Syntex Laboratory's management felt it needed a more substantive long-term approach to the issue of optimal sales force size. Corporate management was in turn requiring more thorough analysis to support major expenditures.

Model Building Trade-Offs

The model-building trade-offs that were needed to handle this problem were challenging. First, because of the way products are distributed in the pharmaceutical industry, there was no available data for trying to estimate empirically what the response had been to sales force size in the past. Syntex did not have data that some pharmaceutical firms do have, which describe wholesaler shipments to small geographical areas. Second, as this decision on sales force size was risky, because of the difficulties of reversing it, convergent procedures to develop sales force size estimates would have been useful. Third, if subjective estimates were to be used, management would devote only a limited amount of time to estimating parameters for a procedure that had not been proven

or used in the past by the company. If management were to estimate parameters, it was important that they be able to estimate response realistically. That is, could managers and other people making estimates realistically imagine response scenarios? The problem also had to be structured so that the solution was realistic and made sense. Therefore the model needed to be complete on the important issues of sales force size. It was also very important to involve the managers who were to implement the solution in the model-building process. Summarizing the model-building objectives, the team felt that we should do the best we could with the people and data available.

The Initial Models

We first had to decide what kind of sales response estimates to use. We felt that having managers estimate directly what sales response would be with different size sales forces was too broad. To make such direct estimates a manager would need to know (at least implicitly)

(1) Where the increase or decrease in sales force personnel would be employed,
(2) What products would have more or less effort applied to them, and
(3) Which market segments would have more or less effort applied to them.

Alternatively, the response estimates could be made at a very micro level, such as for physicians of a certain specialty in one region. In this case, it would be very difficult for anyone to make response estimates to details for a particular product. Hundreds of estimates would be needed for each product, region, and specialty. Thus, the way the problem was structured or the market divided in order to estimate sales response was a critical trade-off the team had to make.

We decided to develop two similar but separate versions of the model, each one to help estimate sales response to increased or decreased sales force size. The first model sought to determine the optimal number of sales presentations (details) to be allotted to each Syntex product; the second sought to decide the number of sales representative visits to physician specialties. The first model involved sales response estimates of the effect on sales if the emphasis on particular products were changed, while the second model looked at estimates of sales changes if the effort applied to various market segments were changed. By estimating or approximating the effects of sales force size independently of each other, the two models could provide convergent estimates and thus reduce risk.

The structure of the two models was mathematically identical. Each was based upon the existing strategic plan for the next three years. This plan had been constructed following the same method Syntex Laboratories had used for many years. The plan assumed the sales force would remain the same for the next three years but did include all other changing elements of the environment and competition of which the planners were aware when they made the forecast. Also included in the models were hard data on the cost per sales representative, which included compensation, expenses and prorated management time for regional and district managers in the sales force. The variable cost for producing and

distributing each product was also a necessary input to convert sales to incremental contribution to fixed costs. These costs were estimated both by product and on average for sales by specialty, depending on the average product mix that was anticipated by specialty. The final bit of hard information utilized by the models was the current allocation of sales force effort by products and market segments. These data were available from company records and syndicated sources. In each sales call (visit), the sales rep makes several presentations (or details). The required transformation of salespersons to number of presentations (details) and the number of calls was available also from syndicated data.

The important element of the models for which data was not available was the sales response of products or market segments to changes in sales force effort over a future three-year period. We chose the three-year period as long enough for new products to achieve maturity and get through the introductory diffusion process. A time period shorter than three years would not allow this to happen. Some managers felt uncomfortable with a longer time horizon because they felt they could not estimate sales response over such a long period.

The Models

Both the models for product and segment allocation were based upon the strategic plan for fiscal year 1985. Each model modified the plan's sales levels by a response function which related sales changes to changes in sales effort. These sales levels were multiplied by an adjustment factor that reflects incremental contribution margin or other corporate product/segment priorities. The mathematical program maximizes adjusted sales subject to sales resource constraints. See the appendix for a detailed description of the model and solution procedure.

Subjective Parameter Estimation

Estimating response functions was the most important activity of the model-building and implementation effort. The estimation required knowledge from many different vantage points within the corporation. Different people's responsibilities within the corporation caused them to have different points of view on what sales response might be. For example, a product manager would be very attuned to his particular product's sales response but might not be very familiar with or sympathetic to other products that compete for sales force attention. The estimation procedure also attempted to minimize the group domination that might happen if one strong individual were able to dominate a discussion. The procedure also tried to isolate the relevant assumptions that went into sales response so that they could be looked at and evaluated over time.

A series of special estimation meetings were held in conjunction with the annual marketing planning meetings which took place in a conference center location off-site. The corporate personnel involved in the estimation meetings were the senior vice-president of sales and marketing, the vice-president of sales, two people from the market research department, two product managers, two regional sales managers, and two salespeople. Given constraints on available people, this was

our best attempt at developing a group that would be collectively expert on sales response to sales force effort.

We began the meeting with a short lecture on sales response modeling and an exercise in which a small problem was solved manually by people in the group. We did this so that the group would understand what the model was trying to accomplish and to motivate the participants to go through Delphi estimation sessions.

The main purpose of the meetings was to come to a group consensus on the likely response of each Syntex product and physician specialty to sales rep effort. On Monday, the first day of the annual meetings, we distributed work sheets to the participants which asked them to estimate what change in sales for each of seven Syntex Labs' products and nine physician specialties would result from different levels of sales rep activity. Each manager responded to the following question for each product and specialty: "According to the strategic plan, if the current level of sales force effort is maintained from 1982 to 1985, sales of Product A would be the planned level. What would happen to Product A's 1985 sales (compared with present levels) if during this same time period it received

(1) No sales effort?
(2) One half the current effort?
(3) 50 percent greater sales effort?
(4) A saturation level of sales effort?

These four points would then be used to fit a smooth curve to represent the response function (see appendix).

Each manager filled out his initial response estimates without discussing them with other members of the group. The responses of the group were then summarized on a computer. The summaries included quartiles, medians, and minimum and maximum answers for each of the questions. These summaries were discussed by the group, and those members of the group who were at the far ends of the group norms were encouraged to discuss the reasons for their estimates.

This discussion was extremely fruitful because it isolated a lot of the critical assumptions that were necessary for doing a realistic job of response modeling. Elements, such as the competitive situation, the role and ability of the sales force to influence physicians, and environmental effects, were thoroughly discussed for each product and market segment. After this discussion, we passed out new work sheets, and again each person independently developed his or her response judgments, but in this round participants could take into account the discussion and the summary of the previous estimations. After the second round, the summary showed that the group had reached a fine consensus.

During the three-day national sales meeting, we ran the model and produced output. The group then reconvened after the planning meeting, the model output was presented, and the results were discussed. The initial model output looked reasonable to the group, and it required only a small amount of fine tuning. The senior vice-president of sales and marketing said after the conclusion of the modified Delphi sessions, "Of course, we knew that the responses we estimated were unlikely to be the 'true responses'

in some absolute knowledge sense, but we got the most knowledgeable people in the company together in what seemed to me to be a very thorough discussion, and the estimates represented the best we could do at the time. We respect the model results, but we'll utilize them with cautious skepticism" [Clarke 1983, p. 10].

The national sales manager summarized his feelings: "We did the best we could to estimate the model. At first we were uncomfortable at having to be so specific about things we weren't too sure about, but by the end of the discussions, we were satisfied that this was the best we could do" [Clarke 1983, p. 10].

The Model Results

Table 1 shows the input to the product allocation model. Table 2 shows the first report made available by the model, the step report. This report shows incrementally which products or segments enter the solution, at what levels, as resources are added to the sales force. At any level or step, an output report is available that summarizes the allocation by product or segment that is optimal for that level of resources. For example, the allocation by product of the sales force for 381 representatives (Step 35) and 511 representatives (Step 36) is shown in Tables 3 and 4. The reason that there is such a large difference in resources between these two solutions is that Anaprox was the marginal product to be allocated. It was optimal to allocate either no effort or at least 130 sales reps to it. This phenomenon was due to increasing returns in the parts of the response curve for Anaprox. Table 5 shows the current policy evaluation of

Maximum number of sales people: 1,000
Cost per rep by region: $55,498.70
Effort (details or calls) per salesperson per year: 3,677.4

	Naprosyn	Anaprox	Norinyl 1+35	Norinyl 1+50	Synalar	Lydex	Nasalide
Strategic adjustment factor (contribution) for each product:							
	.811	.633	.837	.837	.616	.616	.616
Minimum effort (calls or details) for each product:							
	0	0	0	0	0	0	0
Response functions based on 100 for each product:							
Number of calls	47	15	31	45	56	59	15
One Half	68	48	63	70	80	76	61
Present number	100	100	100	100	100	100	100
50 percent more	126	120	115	105	111	107	146
Saturation	152	135	125	110	120	111	176
Normal planned effort (details) for each product:							
	357,853	527,581	195,443	88,817.7	101,123	110,351	210,225

TOTAL DETAILS: 1.59139M

Table 1: Model input.

Step	Number of reps	Change in reps	Sales (000)	Change in sales (000)	Change in marginal contribution per rep (000)	Allocated to:
1	0	0	161,129	0	0	NA
2	115.0	115.0	297,965	136,836	909.5	Naprosyn
3	123.9	8.8	307,720	9,754.9	838.8	Naprosyn
4	132.7	8.8	316,326	8,605.8	733.4	Naprosyn
5	152.5	19.8	333,930	17,604.3	690.2	Norinyl 1+50
6	161.3	8.8	341,488	7,558.0	637.4	Naprosyn
7	163.5	2.2	343,136	1,648.1	572.8	Norinyl 1+50
8	172.3	8.8	349,757	6,621.4	551.5	Naprosyn
9	181.2	8.8	355,553	5,795.5	475.8	Naprosyn
10	190.0	8.8	360,626	5,073.6	409.6	Naprosyn
11	192.2	2.2	361,834	1,207.6	404.8	Norinyl 1+50
12	201.1	8.8	366,280	4,446.1	352.1	Naprosyn
13	221.1	20.0	379,083	12,802.9	338.9	Synalar
14	223.6	2.5	380,596	1,512.6	317.2	Synalar
15	232.4	8.8	384,498	3,902.7	302.3	Naprosyn
16	234.9	2.5	385,797	1,298.5	264.5	Synalar
17	243.8	8.8	389,230	3,432.6	259.2	Naprosyn
18	252.6	8.8	392,256	3,026.3	221.9	Naprosyn
19	255.1	2.5	393,362	1,106.0	217.0	Synalar
20	257.6	2.5	394,386	1,024.2	196.9	Synalar
21	266.5	8.8	397,061	2,674.8	189.7	Naprosyn
22	310.0	43.5	409,278	12,216.9	179.7	Norinyl 1+35
23	314.8	4.8	410,602	1,324.7	174.0	Norinyl 1+35
24	323.6	8.8	412,973	2,370.5	161.8	Naprosyn
25	326.1	2.5	413,835	861.6	156.8	Synalar
26	335.0	8.8	415,941	2,106.4	137.6	Naprosyn
27	339.8	4.8	417,027	1,086.4	132.7	Norinyl 1+35
28	342.3	2.5	417,752	725.1	123.2	Synalar
29	344.5	2.2	418,217	464.8	121.7	Norinyl 1+50
30	353.3	8.8	420,094	1,877.0	116.6	Naprosyn
31	362.2	8.8	421,771	1,677.0	98.2	Naprosyn
32	364.7	2.5	422,383	611.6	95.2	Synalar
33	366.9	2.2	422,766	383.4	90.6	Norinyl 1+50
34	371.7	4.8	423,586	819.5	86.5	Norinyl 1+35
35	380.6	8.8	425,088	1,502.5	82.2	Naprosyn
36	511.0	130.4	453,321	28,233.1	81.5	Anaprox
37	524.0	13.0	456,113	2,791.9	80.0	Anaprox
38	526.5	2.5	456,631	517.6	72.1	Synalar
39	553.8	27.3	462,174	5,543.1	69.7	Lydex
40	562.7	8.8	463,523	1,349.6	68.2	Naprosyn
41	564.9	2.2	463,843	319.5	66.3	Norinyl 1+50
42	569.7	4.8	464,514	670.7	60.7	Norinyl 1+35
43	572.2	2.5	464,953	439.9	52.9	Synalar
44	644.9	72.8	477,648	12,694.8	49.2	Nasalide
45	647.1	2.2	477,917	268.9	47.0	Norinyl 1+50
46	649.9	2.7	473,360	442.9	44.5	Synalar
47	654.7	4.8	478,910	550.1	39.3	Norinyl 1+35
48	657.2	2.5	478,286	375.6	37.1	Synalar
49	662.4	5.2	480,060	774.1	33.9	Nasalide
50	675.4	13.0	481,887	1,827.3	33.2	Anaprox
51	677.6	2.2	482,115	228.2	31.5	Norinyl 1+50
52	680.1	2.5	482,437	322.2	23.9	Synalar
53	685.0	4.8	482,890	452.9	23.0	Norinyl 1+35
54	690.2	5.2	483,544	653.5	19.9	Nasalide
55	692.4	2.2	483,739	195.3	19.0	Norinyl 1+50
56	705.4	13.0	485,259	1,519.6	18.3	Anaprox
57	707.9	2.5	485,536	277.7	12.9	Synalar
58	712.7	4.8	485,911	374.8	9.4	Norinyl 1+35
59	714.9	2.2	486,090	168.4	8.7	Norinyl 1+50
60	720.1	5.2	486,629	549.6	8.0	Nasalide
61	722.9	2.7	486,905	276.1	6.8	Lydex
62	735.9	13.0	488,170	1,265.0	5.9	Anaprox
63	738.4	2.5	488,411	240.5	3.8	Synalar
64	740.6	2.2	488,557	146.2	0.2	Norinyl 1+50
65	745.4	4.8	488,869	312.1	−1.4	Norinyl 1+35
66	750.6	5.2	489,331	461.8	−2.2	Nasalide

Table 2: Step report on the sales force strategy model for fiscal year 1985.

433 representatives for comparison.

The recommended optimal sales force sizes computed from either the product or specialty model were reasonably close together (over 700 representatives). The models differed considerably, however, in their estimation of the incremental contribution per added sales rep at levels between the current sales force size of 433 and 600. Both models indicated that the current sales force was too small, and they both showed that the allocation of effort of the current force was suboptimal. For example, even with the solution for 381 sales reps (52 people fewer than the current size) for the model by product, sales would be approximately $50 million higher and profits $45 million higher if the sales force were to reallocate its effort.

The management implications of the model output were somewhat surprising, but they were also ideas that some members of the management team had been thinking about for quite a while but had not really conceptualized or made explicit. After the model had been digested, Mike Ness said,

> When Len (Lodish) asked how far out he should run the thing, we were standing at 430 reps, and I said, "Why don't you run it out to 550 or the maximum, whichever comes first." We knew we weren't paying enough attention to Naprosyn because our major competitors outnumbered us so far, and that's our biggest and most important market. We also knew that Naprosyn was our most important product, but we didn't really know to what *degree* it was our most important product. We had the perception that a lot of the attention given to launching three new products had been at the expense of our smaller products, but the model showed it had come out of Naprosyn and that was exactly what we hadn't wanted to happen [Clarke 1983, p. 14].

A subsequent meeting of the model design and building team developed the four following conclusions:

(1) Until the size of the sales force approached 700 general representatives, profitability would not be a constraint to adding representatives.
(2) From the FY 1981 base of roughly 430 representatives, Syntex Labs should grow to an optimal allocation of sales effort rather than redeploy the current sales force. This could be done by devoting additional sales resources largely to the primary-care audience (general practitioners, internists, and family practice physicians).
(3) Naprosyn was the largest product in Syntex's product line, the most sales-responsive, and highly profitable. Thus Syntex Labs should make it the driving force behind nearly all deployment and allocation decisions.
(4) Syntex should consider itself a major generalist company, since optimal deployment would require the greatest portion of a large sales force to be devoted to the generalist physican audience.

We presented these conclusions and the model-based derivation behind them to senior management at Syntex Laboratories and to the board of directors of Syntex Incorporated. During the next three years, the company added approximately 200 salespeople to the sales force. This was the largest number that could be added because of limitations on the ability to train and deploy salespeople. About one year after the original model had been developed, we developed a more complicated model that simultaneously al-

	Number of reps allocated	Presentations	Sales in dollars
Product			
Naprosyn	257	943,432	308,029,056
Anaprox	0	0	5,475,000
Norinyl 1+35	58	213,211	22,019,448
Norinyl 1+50	29	104,966	38,048,152
Synalar	37	137,894	41,222,456
Lydex	0	0	8,614,000
Nasalide	0	0	1,680,000
Total	381	1,399,503	425,088,112

Table 3: The model output report of the sales force strategy model covering a new policy based on having 381 sales representatives on board in fiscal year 1985.

	Number of reps allocated	Presentations	Sales in dollars
Product			
Naprosyn	257	943,432	308,029,056
Anaprox	130	479,619	33,708,128
Norinyl 1+35	58	213,211	22,019,448
Norinyl 1+50	29	104,966	38,048,152
Synalar	37	137,894	41,222,456
Lydex	0	0	8,614,000
Nasalide	0	0	1,680,000
Total	511	1,879,122	453,321,240

Table 4: The model output report covering a new policy based on having 511 sales representatives on board in fiscal year 1985: run number 3.

	Number of reps allocated	Presentations	Sales in dollars
Product			
Naprosyn	97	357,853	202,001,792
Anaprox	143	527,581	36,500,000
Norinyl 1+35	53	195,443	20,113,592
Norinyl 1+50	24	88,818	35,992,408
Synalar	27	101,123	36,894,000
Lydex	30	110,351	14,600,000
Nasalide	57	210,225	10,471,728
Total	433	1,591,394	356,573,520

Table 5: A model output report of the sales force strategy model covering a continuation of the present policy until fiscal year 1985.

located sales effort to segments and products; it was based on subjective estimates by the same group. Because the conclusions of this model corroborated those of the previous runs, the company continued to increase the sales force. It was difficult to completely reorient the existing sales force to pay a lot more attention to the general practitioner and take effort away from the other products and markets that the company had been serving since its inception. However, the model seemed to cause people to change direction somewhat in terms of allocating incremental resources to products and segments.

One unanticipated outcome of the model occurred when a corporate person whose responsibility was liaison between R & D and Marketing heard a presentation about the model exercise. He realized that a decision to have a new product marketed by the Syntex Laboratories sales force involved trade-offs between sales force time on the new product and time on existing products. He developed a model similar to the one described here to evaluate whether new products could be profitably assigned to the sales force or whether they could be more profitably licensed to other pharmaceutical firms because the opportunity costs of time taken from the established products were too great to put those new products into the line. Thus the resource allocation model not only affected strategic sales force size and deployment decisions, but also affected strategic decisions on the product portfolio for Syntex Laboratories as a whole.

The Impact of the Model Implementation

Early in 1985 we analyzed the actual deployment since the development of the model. We compared model forecasts with the strategic plan forecasts. We developed the model forecasts by taking the actual deployment over the previous two years for each product and applying the response function estimated by the Delphi group for that level. That response function was then multiplied by the base forecast from the strategic plan for fiscal year 1984 (see appendix). Both the model forecast and the base strategic plan forecast were adjusted for three unforecastable events. One of them was the withdrawal from the market of Zomax, a product competitive to Anaprox. External estimates said that that was worth $9.3 million in sales for Anaprox. We therefore adjusted both forecasts by $9.3 million. A new way of dispensing the birth control pills caused a $6 million increase, which we added to both forecasts. Finally a solution form developed for Synalar added $0.6 million to its sales for filling up the pipelines at the wholesale level.

Table 5 shows the forecasts for the strategic plan and for the model for fiscal year 1984, two years after the estimates were developed. In only one instance did the model do significantly worse than the strategic plan in predicting sales. That was for Nasalide, the new product introduced in 1982. The strategic plan and the adjustment made by the model significantly underestimated what actually happened (Table 6). However, even at the actual level of sales of $12 million in fiscal year 1984, the opportunity cost in lost sales of other products because of effort given to Nasalide was still not enough to justify the effort that was deployed to it. In all the

other cases the model predictions were excellent. Over all seven products the model had a mean absolute deviation of $1.51 million compared to a median absolute deviation of $6.44 million for the strategic plan. The model's forecasts were much better than those of the strategic plan.

Sales were $25 million higher than the strategic plan forecast. These sales changes were in the direction forecasted by the model and are directly related to changes in deployment and sales force size in the directions recommended by the model. Considering the extra cost of the additional salespeople and the incremental profitability of the sales increase, the return on the sales force investment is at least 100 percent. All indications are that the increased sales due to increasing the sales force size will continue for at least the next few years. Another outcome of the modeling effort was that management realized how important response function estimates are. During the last year, the market research department has begun developing data so that empirical estimates of response functions can be developed. So far these empirical regressions have supported the basic directions that the subjective estimates encouraged.

Transportability of the Technique

The general technique used by Syntex Laboratories has been used by at least 10 other pharmaceutical firms and by other firms whose businesses are largely dependent on their sales forces, including banks and chemical, steel, and rubber companies. The same technique is also being used to determine where charity solicitors should deploy their limited resources.

Observations from 20/20 Hindsight

The group that developed and implemented the model would have done some things differently had we perfect 20/20 hindsight. One important task we could not convince management to spend the time to do was to develop estimates for one year out as well as three years out.

Product	Strategic Plan "Base" FY84 Forecast	Strategic Plan Base + Adjustment	Actual FY84	Model + Adjustment	Model FY84 Forecast
Naprosyn	$175	$175	$204	$203.2	$203.2
Anaprox	26	35.3	28	27.6	18.3
Norinyl 1+35	15.2	20.7	20.4	20.7	15.2
Norinyl 1+50	36.8	37.3	39	38.8	38.3
Synalar	33.8	36.2	34.9	33.8	31.4
Lydex	14	14	13.1	12	12
Nasalide	7.3	7.3	11.9	5.2	5.2

Table 6: How accurate were the original response estimates? How to read this table: Using the Anaprox example, the "base" fiscal year 1984 forecast for Anaprox, according to the strategic plan, was $26 million. This number was adjusted to reflect the positive impact of the Zomax withdrawal (+$9.3 million) to equal $35.3. The model forecast for fiscal year 1984, at the actual detailing level, was $18.3. The Zomax adjustment was then added, showing that the deployment model was a better predictor of actual sales achievement than the strategic plan.

One year after the model had been developed and sales force size had started to increase significantly, management asked the natural question, "How are we doing compared to what we should be doing?" It was difficult, if not impossible, to answer that question, because no group consensus was available on how long it would take for salespeople to get up to speed and what would happen one year after sales force size had been changed. A difficult period ensued when no one was sure whether the increase in sales force size was working because in fact it took over a year for sales growth to change incrementally as a result.

This kind of problem occurs many times in model-building activities. The criteria for judging the application and its success are not operationally defined at the beginning of the project. Had we 20/20 hindsight, we would have done this much more explicitly than we did.

"I've never been really satisfied that there was any good reason why we were expanding by 30 or 40 representatives in any one year."

We also would have tried to influence more greatly the evaluation, motivation, and control of the sales force to ensure that a greater part of the possible increases in sales and profits would be obtained, as they could have been by a more severe reallocation of sales force resources.

There was much opportunity to improve the deployment of the sales force during the first two years of the increase in its size which was not seized. We compared the actual fiscal year 1984 sales with the fiscal 1984 sales predicted if the optimal details recommended by the model had in fact been applied. The difference of $36 million in sales was foregone because deployment was not changed as radically as would have been desirable. It proved very difficult to change the patterns of salespeople who had been habitually visiting specialty physicians selling products which were now supposed to receive much less emphasis according to the model.

Conclusion

Even though the building, estimation, and implementation of the model could have been improved, it had a significant positive impact on the performance of Syntex Laboratories in the three-year period, 1982-1985. Sales were eight percent higher than they would have been if the status quo had continued, and management and research personnel realized how important the size and deployment of the sales force is to the strategic success of the company.

The one-time, out-of-pocket cost for developing and running the model was $30,000. This small investment resulted in an ongoing yearly revenue stream $25,000,000 higher than it would have been without the use of the model. The return is extremely high and recurs each year. There are now on-going efforts to continually improve and evaluate sales force deployment and sales force size using both subjective and empirically-based methodologies.

APPENDIX

The Models

Both the models for product and segment allocation were based upon the strategic plan. Let S_p be the strategic plan forecast for fiscal year 1985 for product p, ($p = 1 \ldots P$) with the status quo sales force allocation. Let $r_p(x_p)$ be the sales response of product p to a level of sales effort x_p where x_p is scaled as an index with $x_p = 100$ being the current sales effort for product p. r_p is also scaled as an index where 100 is equated to the strategic plan forecast, S_p. Let a_p denote the contribution margin per incremental dollar of sales for product p. Given the model objectives, this factor may also reflect corporate priorities on products. If one dollar of sales is worth more on product A than product B because of long term considerations, then the a_A factor for product A would be higher then a_B. Thus, in general we can term a_p a strategic adjustment factor. The strategic plan sales resource allocation by product is denoted e_p for effort per product. For a particular sales force size S, the mathematical programming problem becomes

$$(1)\quad \text{Maximize } z = .01 \sum_{p=1}^{P} r_p(x_p)\, S_p a_p,$$

$$(2)\quad s.t. \sum_{p=1}^{P} x_p e_p \leq S.$$

The segment model is identical in structure to the model above with segments replacing products.

This knapsack problem can be solved by incremental marginal analysis of a concave envelope of the r_p functions. These concave envelopes cause the solution procedure to take advantage of all economies of scale in allocations of sales effort to products or segments. These concave envelopes overlook parts of the response functions which show increasing returns to scale. The incremental analysis procedure for this "loose knapsack" problem will only solve for certain sales force sizes which take advantage of economies of scale. However, these solutions are optimal for those sales force sizes. Furthermore, any sales force sizes that are not picked by the incremental analysis routine would not be optimal in the sense that the marginal return on sales resources would be higher at the levels picked by the "loose" knapsack incremental analysis routine.

Solution Procedure

Each $r_p(x_p)$ function is discretized so it is evaluated for increments of x_p. This discretized function is then approximated by a piecewise linear, concave function r'_p which is always above or touching the original function at each discretized increment of x_p. For more detail, see Lodish [1971] from which this section is adopted.

These approximations are constructed for each product p as follows:
Let $x_{p,o}$ = either 0 or a required minimum amount of effort. Let $x_{p,1}$ be a value of x_p such that $\{(r_p(x_p) - r_p(x_{p,o}))/(x_p - x_{p,o})\}$ is a maximum over all possible values of x_p.

In general, $x_{p,1}$ is the value of x_p such that $\{(r_p(x_p) - r_p(x_{p,1-1})/(x_p - x_{p,1-1})\}$ is a maximum for all possible values of x_p greater than $x_{p,1-1}$. Let $b_{p,1}$ denote this maximum value. These b's are the slopes of the piecewise linear, concave approximations to the original r_p function, denoted r'_p. r'_p is defined recursively.

$$(3)\quad r'_p(x_p) = r_p(x_{p,o}) + b_{p,1}(x_p - x_{p,o})$$
for $x_{p,o} \leq x_p \leq x_{p,1}$, and

$$(4)\quad r'_p(x_p) = r'_p(x_{p,1-1}) + b_{i,1}(x_p - x_{p,1-1})$$
for $x_{p,1-1} \leq x_p \leq x_{p,1}$.

Note that r'_p has constant or diminishing returns and that at every point where r'_p changes slope the approximation is exact, that is $r'_p = r_p$.

The mathematical program (1) and (2)

is solved "loosely" as follows:

Step 1: Calculate the incremental ratio IR_p for each product, where $IR_p = b_{p,1} S_p a_p/e_p$. IR_p is the incremental adjusted sales (gross margin) per sales effort unit for product p.

Step 2: Choose the product p that has the highest IR_p and allocate effort to it up to the highest effort level that has the slope used in the IR_p calculation.

Step 3: For this product, change its slope to the next one in the IR_p calculation. Update the sales effort units used so far.

Step 4: If the sales effort allocated violates any constraints, then stop. Otherwise, go to Step 2.

Fitting the Response Curves

The model used pieces of two four-parameter curves for different areas of the response curve. The four-parameter curve is of the form

$$(5)\quad r_p(x_p) = ZER + \frac{(SAT - ZER)\, x_p^{DEL}}{GAMMA + x_p^{DEL}}.$$

The parameters *ZER*, *SAT*, *GAMMA*, and DEL are uniquely determined by four input data points. This curve is used twice to obtain the complete response function. For fitting the points from zero through the present effort level, the curve in (5) is fit through the zero, one half percent level, present level, and saturation points. For fitting points greater than the present level, the curve is fit through zero, present, present + 50 percent, and saturation. This procedure for generating smooth curves has some possible theoretical problems, but works very well in practice. See Lodish [1971] for details. Little [1970] introduced the function to marketing.

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