DEVELOPMENT AND APPLICATION OF A SIMPLE PRODUCT DEVELOPMENT AND MARKETING STRATEGY MODEL

A. J. Lipinski, D. W. Ross, and D. M. Salmon

Stanford Research Institute
Menlo Park, California

SUMMARY

A P&L statement (the operating statement) was used as a foundation for a simple strategy model that helped evaluate changes in marketing and product development strategy. The usefulness of the model is being extended by an optimization technique and by adding the value model of the decision-maker.

INTRODUCTION

This paper describes a simple dynamic, and deterministic financial P&L (profit-and-loss) computer model that was found useful in exploring the implications of strategy decisions in manufacturing companies. Such decisions include the selection of new products, the distribution of marketing effort, the division of budget allocation between marketing and engineering, and the allocation of funds to product development. The specific model described here was developed for a medium-sized company ($50 million annual sales) engaged in the manufacture of communication products for the domestic telephone market and then adapted for a smaller company serving the same market.

In the type of planning problem discussed, decisions must be made in each of the years of a certain period of time. The approach consists of mathematically modeling the behavior of the company by describing the market environment and the internal controlling elements.

A promising optimization technique--the gradient projection method--is currently applied to extend the usefulness of the model as a planning tool.

The model is based on information describing the past and can only extrapolate past trends or their mix. Because the model is deterministic, it should be used only when it is highly probable that past trends will continue. In the telephone industry, both the markets and product prices are very stable; the problem was to direct the company's efforts to satisfy its growth and profit objectives.

In its present form, the model is applicable only to a company that generates new products internally rather than through acquisition. The products are discrete equipments, the design of which is an identifiable and a measurable activity.

STRUCTURE OF THE MODEL

The P&L relationships are described as functions of time, starting with sales by product category, followed by discounts and allowances. Similarly standard costs, variances, general administrative costs, and departmental costs are apportioned by product line. The end result of calculations is the after-tax income. In addition to the standard features of the P&L statement, the model contains features describing the introduction of new products and the decreasing sales of old products.[1]

The company has N product lines and a study of the company projects K years into the future. $S_i(k)$ denotes the sales (at list) of the ith product line in the kth year of the study period ($1 \le k \le K$). The sales at the start of the study period are known quantities (i.e., $S_i(k)$ for $k = 1$ are known). The sales behavior of the company is then modeled by the following set of equations:

$$S_i(k+1) = \left[g_i(k) S_i(1) + \sum_{j=1}^{k} H_i(k,j) F(j) u_i(j) \right] e_i(k)$$

$$\text{for } 1 \le i \le N \qquad (1)$$

where

$g_i(k)$ = Estimated net compounded growth rate in the kth year of sales of the ith product line (due to the combination of obsolescence and market growth or decay).

$H(k,j)$ = The estimated new-product sales of the ith product line in the kth year arising from a unit R&D expenditure in year j.

$F(j)$ = Total R&D expenditure in year j.

$u_i(j)$ = Fraction of $F(j)$ spent of the ith product line.

$e_i(k)$ = Marketing emphasis factor applied to the ith line in the kth year (these factors reflect the marketing expense allocation among the product lines).

Internal Controlling Elements

The internal controlling elements that can be manipulated by the management are:: $F(k)$, the R&D expenditure of the kth year; $u_i(k)$ the fraction of total R&D budget allocated to the ith product line in year k; and $e_i(k)$, the marketing emphasis applied to the ith product line in year k (of course, it is necessary to constrain the emphases within certain bounds, since emphasis beyond a certain point will not bring corresponding increases in sales).

Collection of Data for the Product Generation Mechanism

The length of the development cycle was established by tracing the past history of separate developments--fortunately both companies kept complete records of engineering expenditures. To obtain the length of individual product lives, past sales were analyzed by product categories. The elasticity of individual product sales with respect to marketing effort was estimated by interviewing the sales managers and the salesmen responsible.

EXPERIENCE OF MANAGEMENT WITH THE MODEL

The larger of the two companies habitually uses the concepts employed in the model and, from time to time, updates the model for specific studies. The smaller company's model was picked up by its corporate parent, and the model was adapted for use by the planning group. In both cases, managers found it easy to explore the alternatives but difficult to compare outcomes and to select the most advantageous. This has led us to believe that the use of analytic optimization techniques would improve the usefulness of the model. Nevertheless, the model is being used and has helped to raise the level of understanding and the quality of interdepartmental discussions.

The model describes the company in about 400 statements. The languages employed were FORTRAN II and GE FORTRAN. Including the collection of information (which is really a detective problem), structuring and debugging on a time-share terminal (so that the programming turnaround time problem was minimized), the model took three months in one case and six months in the other.

The simulated exploration time would, of course, depend on the time constants of the particular company and its products; we found five years to be the absolute minimum.

PERFORMANCE CRITERIA AND PERFORMANCE OPTIMIZATION

To extend the usefulness of the model as a planning tool, the "best" strategy must be identified by better than heuristic means. Optimization requires a performance criterion--a quantified value model of the decision-maker or decision team. Possible criteria that could be included in the value model, as applied to the P&L model are: total sales volume, profit margin, and rate of growth of sales.

The dynamic model of Eq. (1) describes the behavior of the company's sales. Management's task is to adjust the internal controlling elements to best meet the goals of the company. The goals are modeled by a performance criterion.

Let $S(k)$ be the vector of product-line sales in year k, and $v(k)$ the vector of internal controlling elements adjusted in year k. In a single year, the performance of the company can be expressed as a function of $S(k)$ and $v(k)$. That is:

$$\text{Performance in year } k = \ell_k\left[s(k),v(k)\right] \qquad (2)$$

Over a period of K years, the overall performance is the function J given by:

$$J = \sum_{k=1}^{K} \ell_k\left[s(k),v(k)\right] \qquad (3)$$

The dynamic equations of the model (i.e., Eq. (1)) are rewritten in the simpler form:

$$S(k+1) = f\left[S(1),v(k),v(k-1),\ldots,v(1)\right] \qquad (4)$$

In our modeling approach, the task of management is to optimize criterion (3) subject to the constraints of Eq. (4). A promising method for performing this optimization is the gradient projection method, which combines features of techniques presented in 2, 3.

The gradient projection method appears to be especially promising as an optimization technique since it is monotonic. That is, each adjustment of the internal control elements by this memethod yields a value of the performance criterion that is greater than or equal to its previous value.

REFERENCES

1. Lipinski, A. J., "Planning for the Company Growth," NAA Bulletin, Vol. XLVI, No. 3, November 1964.

2. Lee, R.K.C., Optimal Estimation, Identification, and Control, M.I.T. Press, Cambridge, Massachusetts, 1964.

3. Zoutendijk, G., Methods of Feasible Directions, Elsevier Publishing Company, Netherlands, 1960.