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

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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.

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 \( i \)th product line in the \( k \)th year of the study period \( (1 \leq k \leq K) \). The sales at the start of the study period are known quantities (i.e., \( S_i(1) \) for \( k = 1 \) are known). The sales behavior of the company is then modeled by the following set of equations:

\[
S_i(k+1) = [E_i(k)S_i(1) + \sum_{j=1}^{k} H_i(k,j)E(j)u_j(1)] e_i(k)
\]

for \( 1 \leq i \leq N \)  

(1)

where

\( E_i(k) = \text{Estimated net compounded growth rate in the } k\text{th year of sales of the } i\text{th product line (due to the combination of obsolescence and market growth or decay).} \)

\( H(k,j) = \text{The estimated new-product sales of the } j\text{th product line in the } k\text{th year arising from a unit R&D expenditure in year } j \).
P(j) = Total R&D expenditure in year j.

u_i(j) = Fraction of P(j) spent of the 
i\text{th} product line.

e_i(k) = Marketing emphasis factor ap-
plied to the \text{i}\text{th} line in the \text{k}\text{th} 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: \( P(k) \),
the R&D expenditure of the \text{k}\text{th} year; \( u_i(k) \) the
fraction of total R&D budget allocated to the \text{i}\text{th}
product line in year \text{k}; and \( e_i(k) \), the marketing
emphasis applied to the \text{i}\text{th} product line in year
\text{k} (of course, it is necessary to constrain the
emphases within certain bounds, since emphasis be-

dy 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 sepa-
rate 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 in-
terviewing the sales managers and the salesmen
responsible.

EXPERIENCE OF MANAGEMENT WITH THE MODEL

The larger of the two companies habit-
ually 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 al-
ternatives 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 collec-
tion of information (which is really a detective
problem), structuring and debugging on a time-

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Growth," NAA Bulletin, Vol. XLVI, No. 3,
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The simulated exploration time would of-
course, depend on the time constants of the par-
ticular 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 iden-
tified 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&I 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 \text{k}, and \( v(k) \) the vector of internal
controlling elements adjusted in year \text{k}. In a
single year, the performance of the company can be
expressed as a function of \( S(k) \) and \( v(k) \). That is:

\[
\text{Performance in year } k = \sum_{k=1}^{K} \beta_k \left[ S(k), v(k) \right]
\]

(2)

Over a period of \text{K} years, the overall
performance is the function \( J \) given by:

\[
J = \sum_{k=1}^{K} \beta_k \left[ S(k), v(k) \right]
\]

(3)

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

\[
S(k+1) = f(S(k), v(k), v(k-1), \ldots, v(1))
\]

(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 tech-

The gradient projection method appears
to be especially promising as an optimization tech-

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