DATA, MODELING AND DECISIONS

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Abstract

Past experience with models--and related methods of analysis--may be
an inadequate guide for managers considering a use of new tools now
available. The latter viewed as multiple-variable systems models, may
differ in their data requirements and decision possibilities in comparison
with predecessors that could handle only a few variables at a time. In
approaching these new tools it is desirable to consider using the models
as guides to data collection as well as decisions. This refers not only
to data variety but also to data quality as judged by reference to the
model itself. It may then be possible to eliminate needless expenditures
of time and money on collecting or refining data.

It is also desirable to consider integrating the modelling and
decision making. Evaluations may then be secured which can guide
alterations to the model and also open new decision possibilities which
would otherwise not be apparent. The value of such a joint approach to
data, models and decisions is examined and illustrated in the following
article with special reference to media mix and new products marketing
applications.

INTRODUCTION

Management science, operations research, systems analysis, and related computer-aided applications, have already demonstrated their value in many areas of management. Production scheduling and inventory control, procurement and transportation scheduling as well as facilities evaluation, financial planning and accounting, and capital budgeting are instances that come readily to mind.

It is not the purpose of the present paper to extend and document the ever growing list of such applications. Instead, we propose (a) to draw upon this background of prior experience (b) join it with like (but relatively recent) experiences in marketing in order (c) to delineate some general propositions which might be of value for guiding or assessing further uses of these ideas in marketing.

When concreteness is regarded as a desideratum two sets of marketing examples will be called upon for specific illustrations: (1) uses of "linear programming" to determine optimum media mixes as these have been developed from the work originally undertaken by D. B. Learner and Milton Godfrey and their associates at BBDO and CEIR, respectively;[1] and (2) extensions and use of the ideas of "chance-constrained programming" such as are now embodied in DEMON,[2] a model designed for use in marketing new products.

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[1] See C. L. Wilson, William Cooper, A. Charnes, David Learner, Milton Godfrey, Herbert D. Maneloveg, Darrell B. Lucas, "Mathematical Programming for Better Media Selection" in Papers from 1961 AAAA Region Conventions, Group IV, 1961. See also J. K. DeVoe, The Marketing Plan in Action, New York Chapter, American Marketing Association, E. A. Richards and M. Mendelsohn, eds., 1964.

[2] See the papers by T. Dillon and by D. B. Learner and J. K. DeVoe for further remark that are pertinent to DEMON and its areas of application. Underlying technical reports have been submitted for publication in future issues of Management Science and, pending such publication, these reports may presently be secured from BBDO's research division in New York.

No attempt will be made to supply simplified examples such as might be contrived to provide conceptual insight into management science constructs such as chance-constrained and linear programming. The latter is not the purpose of the present paper. Its purpose is, rather, to suggest a variety of propositions that bear on the activities of data gathering, modeling [3] and decision making as these might be undertaken with the systems models [4] that are at issue here. For instance, insofar as it is accurate to say that current practice distinguishes sharply and separates these three activities and, more particularly, insofar as data gathering (including forecasting) is accorded a first priority in time, then we shall want to argue that this separation is itself a reflection of a given managerial technology. This is not to say that existing divisions between these activities are not warranted and perhaps even necessitated by the managerial technologies now being utilized. [5] It is only to say that recourse to a different managerial technology may well be accompanied by different needs or opportunities.

In summary, then, the purpose of the present paper is to supply some general guides for consideration when actual uses of management-science, systems constructs are being considered. It is not supposed to serve as an introduction to such concepts per se. Its main concern is with the

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[3] E.g., as set forth in company manuals designed to guide or govern the conduct of their market research.

[4] A more precise characterization would distinguish these as "systems models with explicitly stated optimizing objectives." See, e.g., A. Charnes and W. W. Cooper, Management Models and Industrial Applications of Linear Programming, New York, John Wiley and Sons, Inc., 1961, Ch. I.

[5] See, for instance, the characterizations given by Lyndon O. Brown, Marketing and Distribution Research, New York, The Ronald Press, 1949, p. 21.

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activities of data gathering, mode'ing and d cision making. The DEMON

and media mix models will be used for illustration, where possible, and

further support will be obtained, where necessary, by reference to
6/
experiences distilled from other (non-marketing) applications.

SOME "MANAGERIAL" PROPOSITIONS

It is doubtful, of course, that a complete separation is ever effected

in actual practice relative to data collection, modeling and decision making.

It is also doubtful that data assembly (including forecasting) is always

accorded a first-in-time priority. Nevertheless, there are important issues

of emphasis as may perhaps be seen by considering propositions such as the

following:

1.1 When systems models are to be utilized, data assembly,
modeling and decision making should be treated as an
interacting and continuing integrated process.

    1.1.a. Pertinence to the model's requirements should be
established before extensive programs of data
assembly and treatment are undertaken. Pertinence
should, in general, be judged relative to overall
model properties rather than with reference to
components in isolation from the total model.

    1.1.b. Model synthesis should be guided by reference to
the economy and feasibility of securing the data
that are really essential for its implementation.
In particular, sensitivity testing and like devices
should be employed as part of the process of
model development.

    1.1.c. Decision consequences should also be constantly
explored as new possibilities emerge in the
process of model synthesis. Initial problem state-
ments and existing statements of policy, company
objectives, etc., should be regarded as binding
only after their consequences have been explicitly
evaluated in the light of model developments.

6/ Perhaps we should emphasize that much of this is based on our own
personal experiences.

1.1.d.   Data gathering, modeling and decision making
should be regarded as a continuing dynamic
process rather than as a process which can be
completed or perfected once and for all at
some scheduled time.

Remarks: Consider some of the experiences with media mix.
Initially, all efforts devoted to these models were
directed only to securing a mechanism that could effect
a best (or optimum) selection among alternative media
combinations. Computational byproducts in many cases,
however, came to be viewed as having great significance
in their own right. Such byproducts made it possible to
locate areas or ranges of data refinement which might be
pertinent and to distinguish these from many of the other
possibilities where alteration or improvements in the
underlying data were not likely to affect the decisions
that were at issue. They also made it possible to evaluate
the consequences of particular policies and requirements
that had been previously formulated and imposed without
considering in all detail how they might interact and
produce untoward results in other parts of the total system.
Cases in point involved such things as (a) the same total
advertising budget would produce better results 7/ if "massed"
rather than "flighted" expenditure spreads between periods
could be utilized and (b) overall increases in both reach
and frequency could be obtained by only slight relaxations
in policies that stipulated minimal uses of configurations
of some media vehicles. Still other illustrations could be
cited 8/ and, as might be expected, these uses have also
supplied insight which is guiding the model alterations
and data assembly programs that are now under way.

1.2   Allowance should be made for extending models beyond the confines
of an originally specified area of problems. 9/ Such considerations
should enter into both the choice of problem areas and the modeling
techniques to be employed especially when a series of management
science applications is first being initiated. Otherwise the

7/   E.g., as measured in REU's = Rated Effectiveness Units.

8/   See, e.g., J. K. DeVoe, op. cit.

9/   It is perhaps of interest here to cite a recent report on the use of
linear programming for determining the joint costs of refinery products
whereas, at the outset of such applications, some oil companies formerly
required these costs to be figured by other means prior to effecting
a linear programming implementation of their refinery schedules. Cf.
Business Week, May 29, 1965, pp. 135 ff.

power of these techniques for integrated approaches over a total
problem complex may be lost. Also, needless expenditures may
be incurred as a result of having to initiate completely fresh
starts in each new area of application.

Remarks: New products marketing was selected as a focus for the DEMON
developments because it was believed that the phenomena
and problems that were likely to be encountered in this area
would also be common to many other areas. The methodology
embodied in DEMON was also developed so that it could be
readily adapted for use in other contexts as well. If, for
instance, a dynamic media mix model could be justified by
extending measures such as reach and frequency to their
likely 10/ consequences on sales and profit then the DEMON
methodology could be used to improve current approaches to
media mix in these dimensions as well.

SOME "TECHNICAL" PROPOSITIONS

In order to clarify the import of what has now been covered it is

necessary to consider some further technical propositions which are also

pertinent to issues of data gathering, modeling and decision making. Here

again references are to systems-optimization models of a management-science

variety--but in a loose, rather than strict, sense as will perhaps be evident

from the following formulations:

2.1 It is often useful to distinguish between the problems at issue
and the models to be employed. For instance, merely because a
problem is "nonlinear" it does not necessarily follow that the
model must also be nonlinear. On the other hand, an undue emphasis
on distinctions between "qualitative" and "quantitative" aspects of
a problem can be misleading and possibly even frustrate creative
possibilities for dealing with important aspects of a total problem.

2.1.a. Reference to auxiliary principles such as optimization
guides and constraint alterations, along with a suitable
array of artifacts may be all that is required to
accommodate the supposed nonlinearities. 11/ Approximation

10/ I.e., their "probabilistic consequences."

11/ For further discussion and elaboration of some of these terms see
A. Charnes and W. W. Cooper "Elements of a Strategy for Making Models in
Linear Programming," Ch. 26 in R. E. Machol, et. al., eds., Systems
Engineering Handbook, New York, McGraw-Hill Book Co., 1965.

techniques should, of course, also be considered and so
should the choice of solution methods. In particular, due
care should be given to the properties of different solution
methods for their bearing on the models that might then
be utilized. 12/

2.1.b. Various indirect methods have been developed for dealing
with intangibles such as "goodwill", "customer" or
"employee morale", etc. One method proceeds via a backward
development. These items are first omitted from the model.
Subsequently, the consequences of altering the solution in
order to accommodate such intangibles are then explored. 13/
In this way the known quantitative aspects of the model may
be used to evaluate the possible ranges of values that might
be assigned to such qualities as "goodwill," "morale," etc.

2.1.c. It is desirable to bear in mind the distinction between
figures of merit and the programs with which they are
associated. 14/ This will then invite exploration of
possible model equivalences as alternative routes
for securing solutions to problems with nonlinear or
qualitative features. 15/

12/ This has elsewhere been called "algorithmic completion of a model"
in order to emphasize that solution methods may best be considered
as an integral part of model development--at least when actual
applications are at issue. See the reference cited in the preceding
footnote.

13/ This was, in fact, the method used in the first reported application of
linear programming to the problems of an American industrial firm.
See A. Charnes, W. W. Cooper and B. Mellon, "Blending Aviation Gasolines--
A Study in Programming Interdependent Activities," Econometrica 20, No. 2,
April, 1952, pp. 135-159.

14/ Recall, for instance, that the same program may be optimal for many
different figures of merit. See, e.g., the reference cited in
footnote 4 , supra.

15/ A case in point was the use of sequences of "linear rules" to
minimize unknown and difficult-to-measure costs of production and
these same rules possessed the property of stabilizing employment.
To state the matter differently, if the objective had been to evolve
schedules that would stabilize employment "as much as possible" then
these same cost minimizing rules would (equivalently) have accomplished
this. See, e.g., Chapter XI in the reference cited in footnote 4 ,
supra.

Remarks: The problems dealt with by DEMON are, in general, nonlinear. Nevertheless, a suitable combination of the above devices can be used in ways that make it possible to deal with these via ordinary linear programming models and methods. 16/

2.2 The need for distinguishing forecasting as an activity that is separate from other parts of modelling and decision making should be carefully reconsidered.

Remarks: This is not merely a matter of weighing costs against assumed benefits. In some circumstances improvements in a forecast may worsen the attendant decisions. 17/ Even when this -- perhaps extreme--possibility is not present, improvements in decision rules may yield net benefits which exceed those that are attainable from better forecasts. 18/ A "good" decision rule should, of course, take error possibilities into account. In any event, forecast improvements and decision rule possibilities should be jointly and simultaneously considered and for this purpose it is well to consider their simultaneous incorporation into the models that are being synthesized. 19/

16/ See, e.g., A. Charnes, W. W. Cooper, J. K. DeVoe and D. B. Learner, DEMON, Mark II: Methods of Solution and Approximation, New York: BBDO Division of Research, May, 1965.

17/ Theoretical underpinnings for this statement may be obtained from A. Charnes, J. Dreze and M. H. Miller, "Optimal Rules for Horizon Decompositions in Warehousing Type Models," Econometrica (submitted). See also C. P. Bonini, Simulation of Information and Decision Systems of the Firm, Englewood Cliffs, N.J., Prentice-Hall, Inc., 1963

18/ Cf., e.g., the paint factory study discussed in C. C. Holt, F. Modigliani, J. F. Muth and H. A. Simon, Planning Production, Inventories and Work Force, Englewood Cliffs, N.J., Prentice-Hall, Inc., 1960, pp. 23 ff: "It is worth noting that the cost saving attributable to use of the [mathematically formulated] decision rule is greater than the additional cost saving that would be secured by the complete [italics supplied] elimination of forecast errors. Perhaps forecasting future orders accurately isn't as important as has commonly been thought.... Juding by this particular factory and period, making best use of crude forecasts is more important than forecasting perfectly."

19/ This was, for instance, an explicit consideration in the DEMON designs.

SOME FURTHER OBSERVATIONS

Other features of model assembly, data treatment and decision making might also be commented upon for their bearing on ways of using some of the newer developments in managerial technologies. Thus, in a less formal vein, it may be useful to consider the following quotation from the writings of one company president:[20]

> "...I have learned that the quality of our decisions is in direct ratio to the quantity and quality of assimilable data-- with the emphasis on the word assimilable because, if the volume of data is so great that it cannot be assimilated, then the data are useless."

From another standpoint, this might be rephrased as a challenge to develop improved ways of exploiting data that might otherwise not be assimilable. This, presumably, is the task undertaken by management scientists, and others, concerned with improving the existing machinery of management.

Consider, for instance, the area of new products marketing as the context in which DEMON was developed. Often there is a plethora of data which might be used in different ways. The results of one study may, for instance, point to the need for a further study. When the latter is executed--or at least when a whole sequence of studies has been executed--there is no machinery conveniently available for assembling and exploiting all of the accumulated study results. Another way of making the same point is to say--with only slight exaggeration--that the limitations of currently employed methodologies make it necessary to ignore the results of previous studies in order to focus on assimilation of the last one that has been executed.

[20] Quoted from H. L. Baum, "The Use of Operations Research in a Small Company", AMA Report No. 10 as reprinted in S. J. Shaw and C. M. Gittinger, eds., Marketing in Business Management, New York, The MacMillan Co., 1963, p. 194.

Note, then, that it should be one task of a well designed model to assimilate and exploit all pertinent features of such previously executed studies. Further study possibilities should then also be examined from the standpoint of what they might cost as well as what they might add to the decisions that are at issue. Similar remarks apply, of course, to the choice of estimators, forecastors and other such statistical devices. All such choices and possibilities should be judged relative to the main objective. On the other hand, as already noted, initially stated objectives and other kinds of stipulations [21] should be reviewed and evaluated as new possibilities are opened since these, too, might not have been fully considered for all of their interaction consequences. [22]

These were the kinds of considerations that were used as explicit guides for the DEMON design--*viz.*, the development of a decision model which could guide data choices and treatment as an integral part of the decision-making and review machinery. At this point it is necessary to say, however, that DEMON is only now emerging from the laboratory tests that were deemed to be a desirable preliminary to its use in actual practice.

SOME CONCLUDING REMARKS

The models examined here may be characterized as members of the class of systems models with explicitly stated optimizing objectives. Recourse may

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21/ E.g., the limitations of an initially imposed study budget.

22/ For instance, the reductions in profit possibilities that attended the use of very tight "paybacks" were found to be quite serious in certain past cases that were studied with DEMON.

also be had to other approaches such as those which are sometimes referred
to as "heuristics" or "simulations." These might be considered as possible
alternatives to the approaches suggested here and, of course, there are
even further possibilities which can be formed by appropriate weddings of
optimizing and other types of models.[23]

The existence of such possibilities is itself a good omen for the
further growth and development of management science in the future. It also
offers wider opportunities to management. At a minimum it offers management
an opportunity to challenge and improve (without necessarily abandoning)
its existing practices. A really prudent management will not only seize this
opportunity for challenge and improvement at the present time, but also continue
to utilize the new opportunities that the further developments of management
science may continue to supply.

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[23] Examples and further discussion may be found in A. Charnes and W. W.
Cooper, Management Models and Industrial Applications of Linear
Programming, New York, John Wiley & Sons, Inc., 1961. See, for
instance, the example of an N-person game (optimization) model to
guide traffic simulations for use in the design of a city street
network as discussed in Volume II, pp. 785-798.