APPLICATIONS OF SYSTEM DYNAMICS TO A NONPROFIT RESEARCH ORGANIZATION

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Introduction

A particularly interesting area for the application of system dynamics methodology is in business management; especially the interplay of quantitative (financial, economic) and qualitative factors (motivation, morale), and the decision-making choices which confront management. When a firm has a product which can be measured in economic terms, the construction of a model can be quite straight-forward. Even in non-quantitative areas such as research and development, models have provided insight into the decision-making process. While these models have been informative from both a system dynamics and management science perspective, the practical application of the results has been too often lacking. For a businessman, simulations and models are academic exercises unless they provide some measure of practical guidance.

It was from a basis of requiring that the system dynamics model provide practical decision-making guidance in real-world environments that we have attempted several studies of R & D projects.

Problem Statement

It has been possible to develop models which describe the alternative strategies present in projects where there is a choice of adding staff or using extended working schedules (1).

The introduction of the economic constraints of a real firm resulted in two different model environments. The first, and most common situation is that of the profit-making industrial firm. This firm has a number of convenient quantitative parameters which, while not always applied to a project, do give a sense of "accounting" security to a manager. Return on capital, ROI, discounted cash flow, and net profit will dictate the range and type of decisions acceptable to the firm.

The second situation is the nonprofit (or not-for-profit) organization. While some financial factors such as cash flow and liquidity are similar to a for-profit firm, the measures of "success" are frequently stated in non-financial terms - social benefit or obligation, public expectations and image.

The delay between an initial investment and the realization of a return can be quite different in the two cases. In the case of the nonprofit organization, the firm may operate for an extended period in a condition of accounting bankruptcy as long as cash is available to pay for current operations.

Model Formulation

We have attempted to combine the earlier work on R & D management with models for financial planning, and to extend these models to a not-for-profit firm. The model is not abstract, but attempts to describe the environment of a Provincial Research Organization in Canada. While not-for-profit, the firm cannot operate in a condition where expenditures exceed revenues beyond the available liquid assets. (Depreciation is an interesting concept for a tax-exempt firm, but it does not pay salaries!)

Revenues are derived from contracts and grants; contracts are derived from promotion; promotion is non-productive labor. Delays between promotion and contract revenues must be considered; there being a very real danger of

significant oscillations in revenue caused by a chain:

increased contracts		decreased contracts		increased contracts
decreased promotion	-	increased promotion	-	decreased promotion
revenues up		revenues down		revenues up

If the up-swings provide reserves to cover for the down period, everything can work out for the growth of the firm. But staff generally like stability, and down periods too often extend beyond the best reserves. It is therefore management's job to plan and adjust the levels of contract and promotion to provide stability, while recognizing that traditional accounting measures of financial strength or weakness are of little or no value in assessing current operations.

Cost of operations, pricing of contracts, overhead allocation and recovery, salary and equipment funding are all parameters which must be considered in management planning and decision making. The determination of sensitivity to each parameter is of vital importance to the ongoing operation and selection of strategic alternatives.

Results of Current Work

The fact that a model could be formulated which would display behavior characteristic of the organization was encouraging.

The model continues to show areas of instability which may or may not reflect the real environment of the firm. This has now provided management with a challenge to better understand the model and the environment. Hopefully with the tools of both system dynamics and management science, the firm will be able to manage the future, rather than just react to it.

References

1. V.A. Mode, "Simulation of Alternative Personnel Policies in Project Management", Proceedings of the 1981 Summer Computer Simulation Conference, Washington, D.C., July, 1981.

CLASS II DOCUMENTATION STANDARDS
FOR SIMULATION MODELS

ACCESS TO MODEL:

Name of Model: BUSNES (Model of a Not-for-Profit Firm)

Name and current address of the senior technical person responsible for the model's construction: Dr. V. Alan Mode, Exe. Dir. B.C. Research, Vancouver B.C.

Who funded the model development? B.C. Research

In what language is the program written? Dynamo

On what computer system is the model currently implemented? LSI-11/02

What is the maximum memory required to store and execute the program? 28 K (16-bit)

What is the length of time required for one typical run of the model? 5 min.

Is there a detailed user's manual for the model? No

PURPOSE OF THE MODEL:

For what individual or institution was the model designed? B.C. Research

What were the basic variables included in the model?

Cash reserve
Max. overtime hours
Max. workforce
Delay in communication system
Delay in obtaining workforce
Delay in responding to variance

Over what time period is the model supposed to provide useful information on real world behavior? 1 year

Was the model intended to serve as the basis of:

- an academic exercise designed to test the implications of a set of assumptions or to see if a specific theory would explain historical behavior
- communication with others about the nature and implications of an important set of interactions ✓
- projecting the general behavioral tendencies of the real system ✓
- predicting the value of some system element(s) at some future point in time ✓

MODEL SPECIFICATION AND THEORETICAL JUSTIFICATION:

Provide two diagrams illustrating the extreme behavior modes exhibited by the major model elements:

Not yet fully evaluated

If they are not included in the body of the paper indicate where the reader may find:

- a model boundary diagram that indicates the important endogenous, exogenous and excluded variables: In publication
- a causal influence diagram, a flow diagram, the computer program and definitions of the program elements: In publication

Is the model composed of:

- simultaneous equations
- difference or differential equations ✓
- procedural instructions

Is the model deterministic ____ or stochastic ____

continuous ✓ or discrete ____

4. DATA ACQUISITION

What were the primary sources for the data and theories incorporated in the model?

Data Corporate records, interviews with senior staff

Theory Forrester / Roberts publications and student theses

What percent of the coefficients of the model were obtained from:

- measurements of physical systems
- inference from social survey data 50
- econometric analyses 20
- expert judgment
- the analyst's intuition 30

What was the general quality of the data? Good, basically accounting records

5. PARAMETER ESTIMATION

If they are not given in the publication, where may the reader obtain detailed information on the data transformations, statistical techniques, data acquisition procedures, and results of the tests of fit and significance used in building and analyzing the model? Still being worked on.

6. MODEL PERFORMANCE AND TESTING

Over what period was the model's behavior compared with historical data? 2 years

What other tests were employed to gauge the confidence deserved by the model?

Comparison to other institutions by accountants and senior mgmt.

Where may the reader obtain a detailed discussion of the prediction errors and the dynamic properties of the model? Not yet available

7. APPLICATIONS

What other reports are based upon the model? See ref. in paper

Name any analysts outside the parent group that have implemented the model on another computer system. None

List any reports or publications that may have resulted from an evaluation of the model by an outside source. None

Has any decision maker responded to the recommendations derived from the model? ___
Yes - Senior staff of B.C. Research

Will there be any further modifications or documentation of the model? Yes

Where may information on these be obtained? Author