

A. Simple System Dynamics Model of Cash Budgeting

by

Hussien Shehata
System Dynamics Research Group
University of Bradford.

Abstract

System Dynamics Methodology (S.D.M.) has proved its applicability in several types of policy design (Coyle, 1974). This paper attempts to explore its usefulness in the Formulation of Financial Policies with an application to cash management. After a brief introduction dealing with the difference between SDM and simulation techniques, the structure of the model is developed and described, followed by a discussion of the potential of the proposed model for long-range cash planning and control. Finally, a short summary is given of other possible applications of this methodology in the financial field.

Introduction

Some work has been done in applying optimization models and simulation techniques in financial planning and control. Until recently there have been very few attempts to apply System Dynamics Methodology (SDM.) in that field, for many reasons, among them:

- a) most people still are not aware of the potential of SDM.;
- b) there is some confusion about the difference between SDM and simulation techniques.

These two points attracted us to explore the crucial difference between SDM and simulation techniques and to develop a System Dynamics Model of Cash Budgeting to indicate the applicability of this Methodology in the formulation of long-term financial control policies, which may aid in cash budgeting.

SDM. and Simulation Techniques

A cursory examination of the SDM. literature, would suggest that System Dynamics methods are concerned with the application of systems theory concepts and control theory concepts to socio-economic systems. It enables one to understand, explain and analyze the behaviour of such systems over time (in terms of the Feedback Loops involved) in order to redesign the appropriate control policies and structure.

In this sense, we may state that there is a difference between SDM and Simulation techniques. The latter are basically concerned with experimenting with a model under different conditions in order to select a satisfactory state, i.e., they operate on a "what if" basis (Shehata, H.H., 1975).

System Dynamics methods also answers "what if" questions, e.g. What would be the behaviour of a system if some changes in external environment, in the decision rules, or in the structure of the system take place? This could be achieved by studying the behaviour of the system under different conditions.

It also answers, however, two further questions:-

- a) Why should the system behave in that way? This question could be tackled by analyzing the relationship between the component parts of the Feedback Loops included and the behaviour of the system.
- b) What actions should be taken to improve the behaviour of the system? This could be made by altering the structure of the system, the existing policies or both.

It should be quite clear from the above paragraph that:-

- *SDM is broader and more comprehensive than simulation techniques;
- *Simulation techniques are a component part of SDM's framework and
- *SDM. stresses studying the behaviour of systems in terms of feedback loops.

The Diagnosis of the Problem

The major task in cash planning and control is to determine the appropriate cash level which the firm must hold to protect itself from adverse cash drains at minimum total cost.

Incorrect cash policies, in this context, may cause crises in production, marketing, liquidity and profitability which result in stultifying the growth of the firm and deterioration of its net worth. The results of these crises can also be noticed in the sharp and wide fluctuations in the behaviour of the cash system, some of which are undesirable.

As a consequence, it is necessary to study the causes of such crises and to redesign the appropriate cash control policies so as to minimize the chance of their occurrence. In other words to design a set of cash control policies which:

- a) smooth the undesirable fluctuations; and
- b) smooth and speed the growth of the firm.

In so doing, it is necessary to identify the key variables which are of major interest and to examine the cause-and-effect mechanisms between them. This may require obtaining data about:-

- 1) The objectives of the firm.
- 2) Past trends of the financial position.
- 3) Current status of the cash position. This may include

data about the current balance of the financial assets, and of physical assets, about the current value of the parameters and about the existing financial policies.

- 4) The expected changes in the environment in the future.

The Model Formulation

Having defined and identified the problems boundary, we are in a position to formulate the model that may represent it. This can be made in three separate stages, they are:-

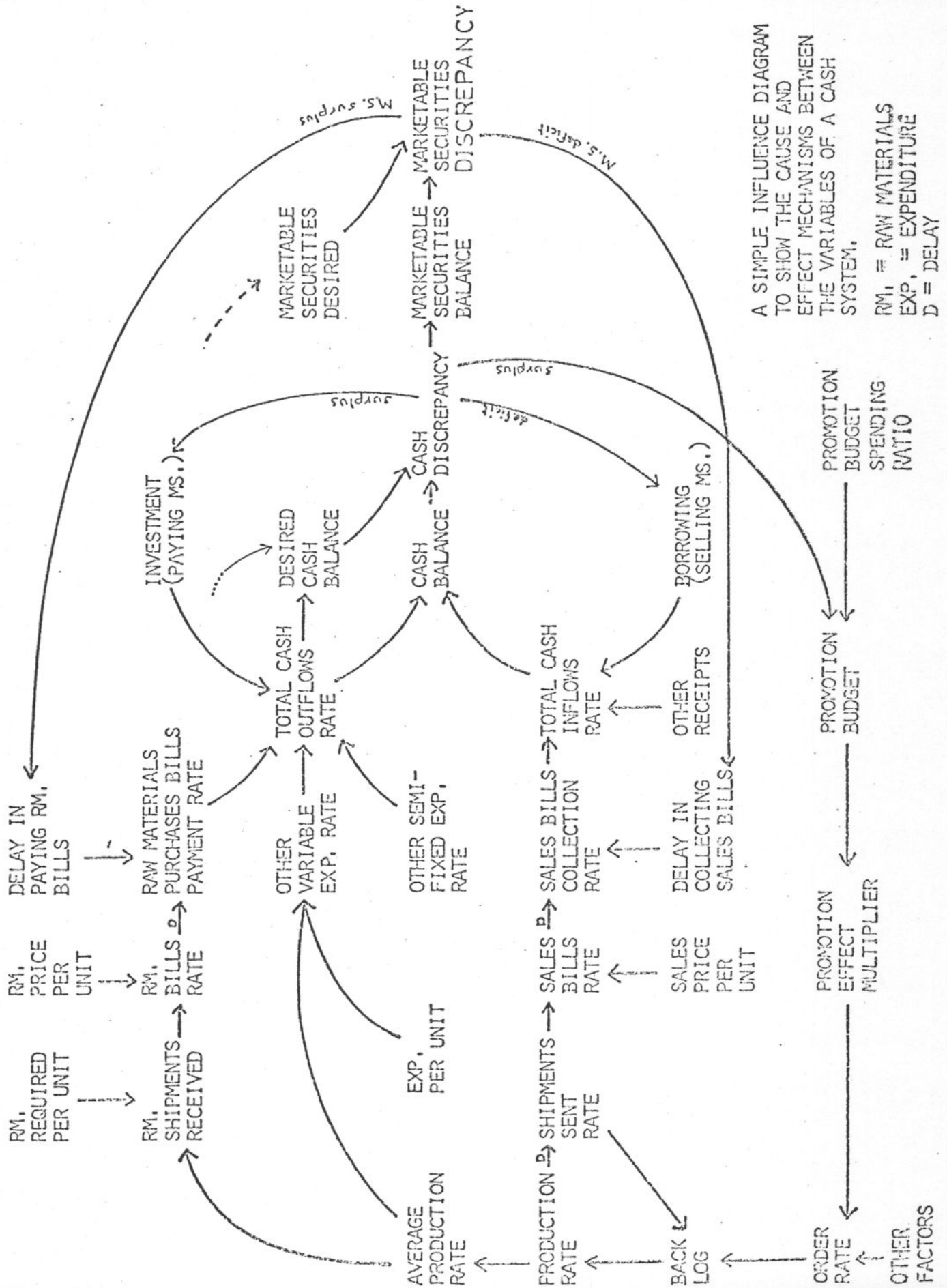
- a) Influence diagram construction;
- b) Feedback Loop analysis;
- c) Equation formulation.

The following is a brief overview on each in turn.

Influence Diagram Construction

The diagram shown on the following page indicates the cause-and-effect mechanisms between the crucial variables of the cash system. It is constructed on the "List Extension Approach" (Coyle, 1974). The following points should be noted in connection with the diagram:

1. The input variable is the order rate (potential demand) which may be influenced by two types of shocks: exogenous such as a sudden increase or decrease in demand and endogenous such as the promotion effect multiplier which depends on the fraction of net cash flows devoted to promotion budgets.
2. The cash balance at any point of time is the integral of the difference between cash in-and-out-flows during the interval period. The actual cash balance is compared with the desired one to determine the cash discrepancy.
3. The desired cash balance refers to the number of months that the firm's cash balance will meet the average expenditure rate of the previous months.
4. The cash discrepancy may be surplus or deficit. If it is surplus the management may invest it in marketable securities. If it is deficit, the management may sell some marketable securities or borrow some funds from a bank. Such actions affect the cash balance and the marketable securities buffer as well.
5. The main source of cash in-flows is the collection of sales bills which is influenced by the receivables policy the firm adopts and on the market situation. The former may depend on the liquidity situation in general and on the level of the marketable securities buffer in particular. For instance, a decrease in the marketable securities buffer beyond certain points may stimulate the management to accelerate the collection of sales bills.



A SIMPLE INFLUENCE DIAGRAM
TO SHOW THE CAUSE AND
EFFECT MECHANISMS BETWEEN
THE VARIABLES OF A CASH
SYSTEM.

$RM, = \text{RAW MATERIALS}$
 $EXP, = \text{EXPENDITURE}$
 $D = \text{DELAY}$

6. The main cash out-flow channels are the payments of purchases bills and other production expenditures such as wages. The former is influenced by the payment policy the firm adopts which mostly depends on the liquidity situation and on the level of the marketable securities buffer. For instance, an increase in the marketable securities beyond the allowed maximum point, may stimulate the management to accelerate the payment of the purchases bills to generate benefits from the high liquidity situation.
7. Other variables can be added if required, this, of course, depends on the problem under examination. However, the influence diagram should be valid and adequate.

Feedback Loop Analysis

The Feedback Loops in the previous influence diagram are analyzed in terms of their properties to indicate how they govern the dynamic behaviour of the system. There are two types: negative and positive loops. The former are responsible for keeping the levels in the system near the desired ones by controlling the rates. For instance, when the cash balance varies from the desired balance, changes in the cash in-flows or in the cash out-flows are initiated, such as investing the excess cash or borrowing the deficit. Similarly, if the marketable securities buffer differs from the desired buffer, changes in the delays in receiving or paying cash may be engendered which change the cash in/out-flows, and so on. The positive loops, on the other hand, may create growth if the firm devotes a fraction of excess cash to finance the expansion in the promotion programs. Such action would create a chain of movements leading to an increase in excess cash. As the latter is increased, the ability of the firm to expand promotion programs may increase and so on.

Equations Formulation

The cause-and-effect mechanisms between the variables are quantified by a set of algebraic equations, according to certain principles. Any computer language can be used for the calculation purposes. Dynamo (Pugh, A.L. 1971) or Dysmap (Ratnatunga, 1975) are preferred.

It has been claimed (Cloot and Charlton, 1969) that DYNAMO cannot be used for financial modelling because of its inability to deal with discrete events, such as dividend or tax payments. In fact, however, there is no difficulty, for the experienced analyst, in modelling such events in either DYNAMO or DYSMAP.

Intuition is sometimes used for quantification when it is impossible to use rigorous methods. In addition, the equations can be formulated on a deterministic or probabilistic basis, or both.

Testing

The model is tested to show the type of response of its variables to a sudden change in the value of the input by using step, pulse and sine functions. The sensitivity of the variables to errors in estimating the value of certain parameters can also be measured by using sensitivity testing techniques. However, no attempt has been made in the present model to use these techniques.

Experimentation

Computer simulation techniques are used to experiment with the model under different cash control policies. Each run is analyzed in terms of Feedback Loops. What is important, in this context, is that the experimentation process depends on an extensive analysis of the results of each run before passing on to the next in order to indicate the causes of the behaviour and what actions should be taken to improve this behaviour. This is unlike other approaches which may depend on trial and error.

The model is simulated under many conditions using artificial data. For the sake of brevity, only two cases are discussed below in order to explore how the analysis is carried out and to show the behaviour of the system before and after introducing some control policies.

Case One - Steady State

The purpose of this run is to show the response of the variables to a sudden increase in the input variable, and also to show the behaviour of the system before introducing some control policies. It is assumed that the order rate has increased at time 24 by 20%.

The curves on figures (1-A) and (1-B) indicate:

- a) The variables are sensitive to the exogenous shock;
- b) They behaved smoothly except cash discrepancy which has behaved in a damped mode;
- c) The transient time ranges between 12 and 19 months;
- d) The marketable securities discrepancy is increased rapidly which may indicate that there must be some control policies to keep marketable securities' buffer relatively near to desired one.

This last point will be recognized in the following run.

Case Two - Growth State and New Marketable Securities Control Policies

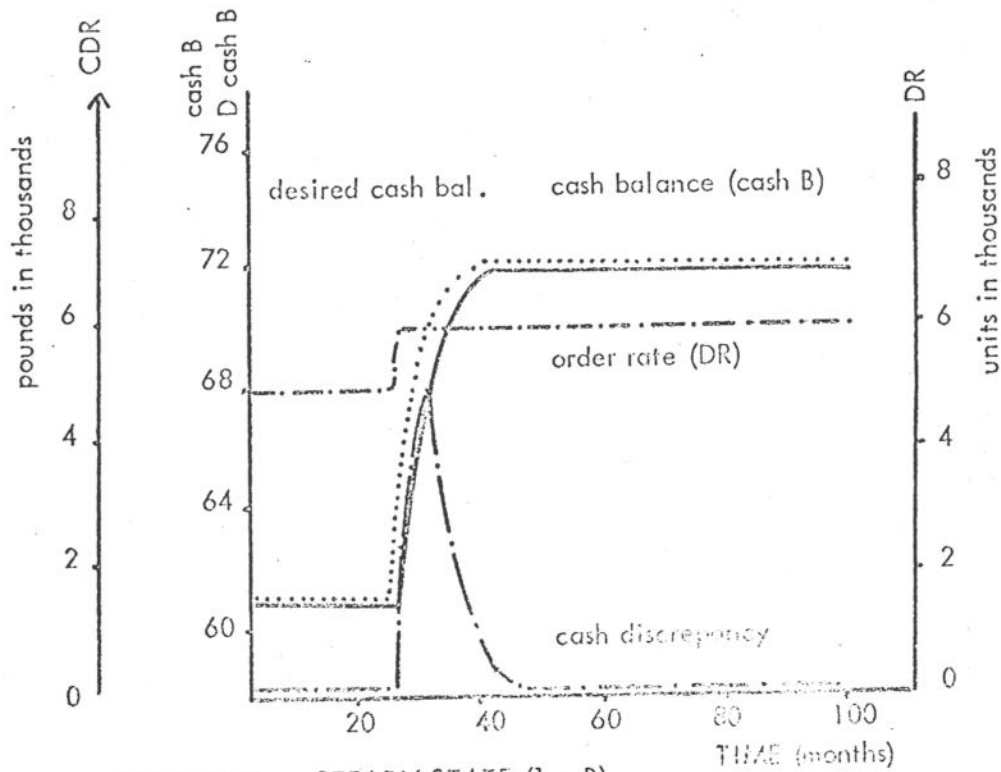
The results of the analysis of the previous run leads us to examine two points:

- a) What would be the behaviour of the system in the case of growth; and
- b) What control policies should be introduced to improve the behaviour of the marketable securities sector?

As a consequence, two control policies are tested, they are: increasing the proportion of excess cash devoted to promotion budget

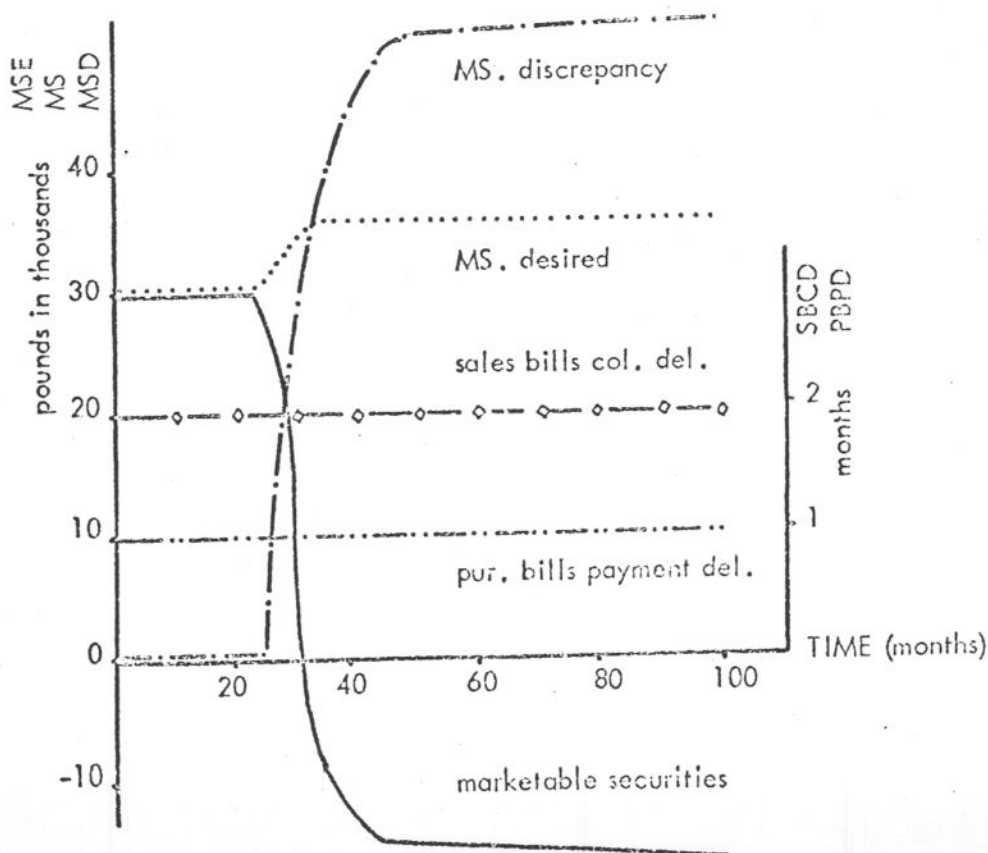
CASE ONE - STEADY STATE (I - A)

CASH SECTOR



CASE ONE - STEADY STATE (I - B)

MARKETABLE SECURITIES SECTOR



to create growth and relating the delay in paying and collecting bills to the marketable securities discrepancy if it exceeds a certain limit.

The results of this run (as shown in figures (2-A) and (2-B)) indicate the following:

- 1) The order rate has grown at a satisfactory rate and mode.
- 2) The negative loops have succeeded in keeping both cash balance and marketable securities relatively near to the desired ones.
- 3) It is also noticed that, when the marketable securities discrepancy has dropped below the minimum limit, the delay in collecting sales bills (from time 25 to 55) has decreased in order to increase the cash in-flows which result in an increase in the marketable securities, and when it exceeded the maximum limit, the delay in paying purchases bills (from time 78 to 95) has decreased in order to increase the cash out-flows which results in a decrease in the marketable securities.

Further experimentation (Shehata, Hussien H., April 1975) has been carried out to examine other problems that have been suggested by this work, for example:

- a) What would be the effect of the delay in transferring marketable securities into cash on the behaviour of the system?
- b) What would be the behaviour of the system under different credit policies, trade discount policies, etc.

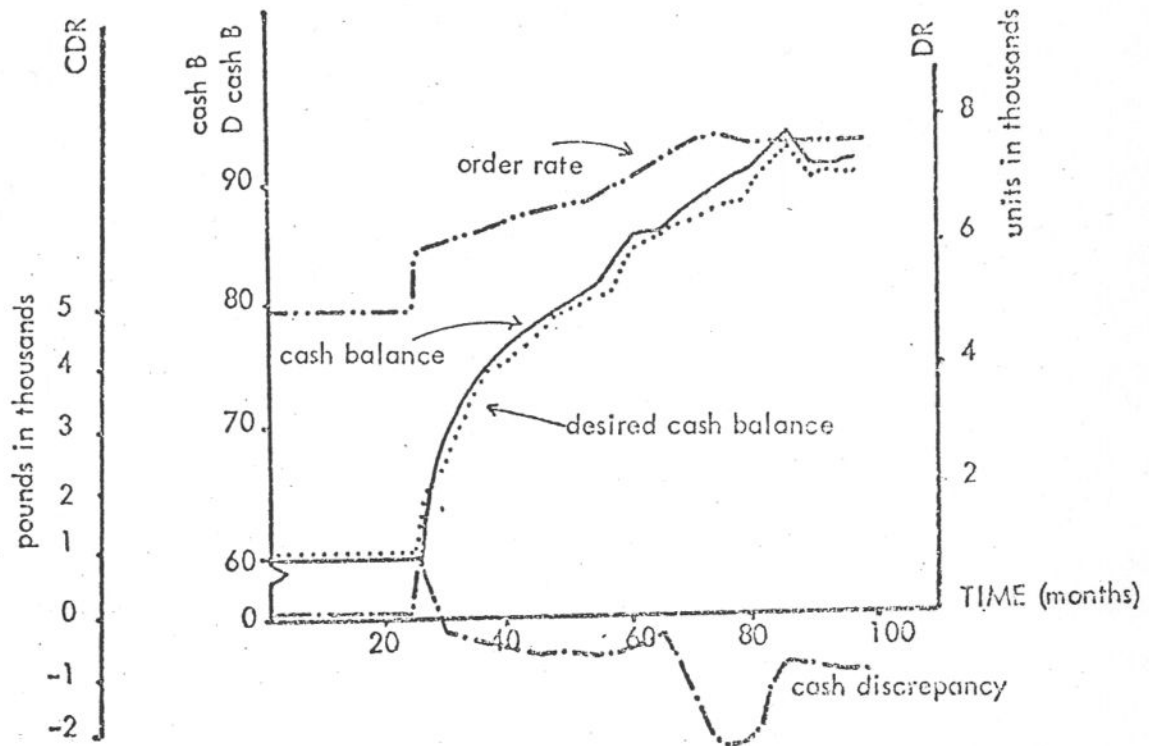
The Potential of the Model

The model provides the following capabilities:

1. It enables one to follow and recognize the cause-and-effect mechanisms between the component parts of the cash system over time. Moreover, it helps the management to know the influence of cash control policies on other organizational sub-systems and on the whole system, and also to know what activities have important effects on the cash system. The latter point, helps management to direct attention to such activities rather than to activities that have less effect.
2. It offers a better understanding of the cash system itself, in particular the relationship between the structure and the behaviour of the system. This helps the financial policy designer to formulate the appropriate cash control policies that may improve the cash position in a quick and efficient manner, and on an overall basis.
3. The model may show the behaviour of the variables to any proposed or unexpected changes in the input variable, more-over, it may indicate the sensitivity of these variables to errors in estimating the value of some parameters, and how the system could be made insensitive to them.

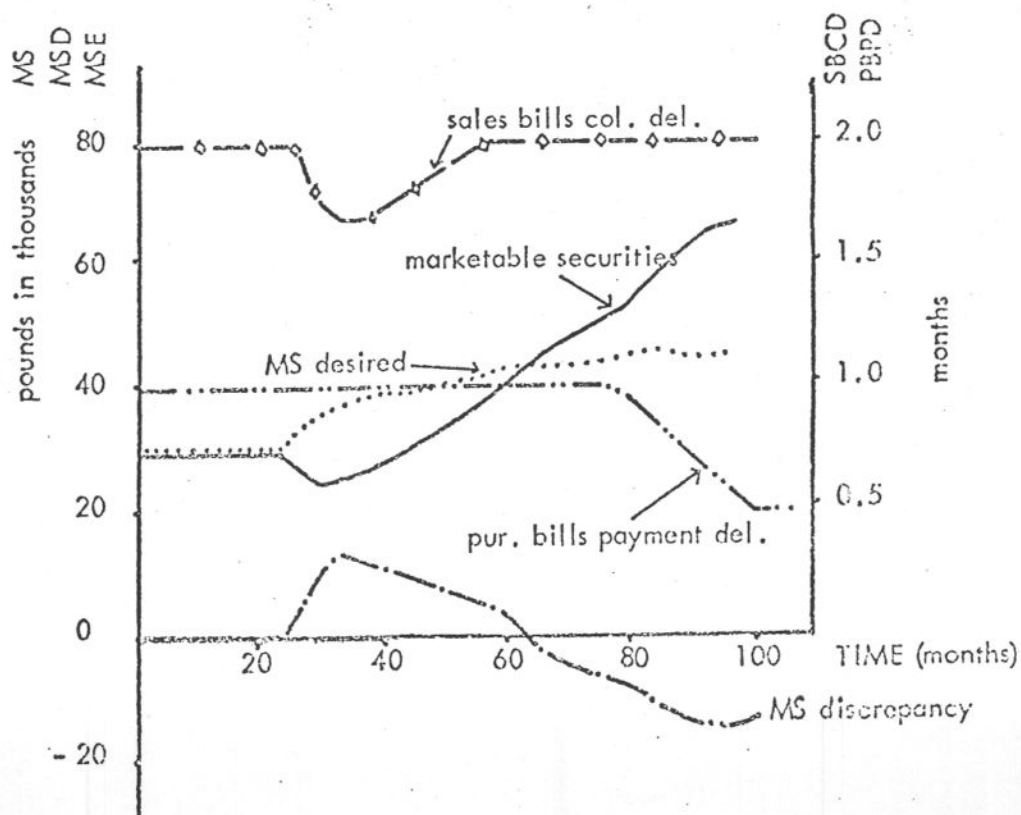
CASE TWO - GROWTH STATE AND NEW MS. CONTROL POLICIES

CASH SECTOR (2 - A)



CASE TWO - GROWTH STATE AND NEW MS. CONTROL POLICIES

MARKETABLE SECURITIES SECTOR (2 - B)



4. In addition, the model provides more information which enables the financial manager to:
 - a) Predict the cash position at any time, determine in advance the credit required to meet the likely deficits and the amounts of excess cash to be invested and to control the size of marketable securities buffer to be held.
 - b) Revise both payment and receivable policies in the light of the cash position with full understanding of the effects of such changes upon the liquidity position.
 - c) Prepare and revise the cash budgeting statements in a quick and efficient manner using a flexible approach.
 - d) Calculate the required financial ratios in a quick manner.
5. This model is deterministic, but stochastic characteristics may be introduced without undue difficulty, so it is highly flexible.

The Applicability of SDM to other Financial Problems

It is crucial to mention that SDM is not applicable to all sorts of problems, but only to dynamic ones which have a systematic relationship, where the past influences the future and where changes over time are of interest. Considering these criteria, we may mention a list of financial areas where SDM could provide useful benefits. This list is far from exhaustive, but it includes a broad spectrum of possible applications:-

- a) The financial aspects of corporate growth. The System Dynamicist may develop a model which deals with long-range financial control policies of the expansion in fixed capacity, R.&D. programs, Training programs, etc. in the case of both internal and external finance.
- b) The financial aspects of workforce planning and control (micro-or macro-level), to formulate a set of financial policies which guide the decision maker in planning the expansion in manpower.
- c) Macro-gearing policies and national growth. To show the effect of raising funds from abroad on the growth rate of the economy.

Acknowledgement

I am indebted to my supervisor, Dr. R.G. Coyle who helped me in writing this paper.

Relevant References

CLOOT, P.L. &
CHARLTON, P.J.

Corporate Financial Planning -
A Computer Model.
Imperial College Centre for Computing
and Automation, Report No. 7., 1969,
P. 16.

COYLE, R.G.,

Management System Dynamics,
S.D.R.G. Bradford University, 1974.

PUGH, A.L., III

Dynamo User's Manual, Cambridge,
Mass., The MIT Press, 1971.

RATNATUNGA, A.K.,

Dysmap User's Manual,
S.D.R.G. Bradford University, Jan. 1975

SHEHATA, HUSSIEN H.,

The Applicability of SDM to the
Formulation of Long-range Financial
Control Policies,
Research Seminar, S.D.R.G.. Bradford
University, Feb. 1975.

SHEHATA, HUSSIEN H.,

A System Dynamics Model of Cash and
Credit Control Policies, working
paper, S.D.R.G. Bradford University
April, 1975.