USING SYSTEM DYNAMICS TO IMPROVE THE MANAGEMENT OF WORKING CAPITAL IN A SMALL BUSINESS
Some Preliminary Results

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ABSTRACT

Many firms use financial ratio analysis to monitor their control over the operating cycle and to serve as the basis for policy formulation. Ratios are based on data produced through the accounting information system which is analyzed according to intuitively plausible concepts in order to make normative judgment about the financial health of the firm. A model is constructed to simulate the operating cycle of a business which generates financial ratios in a manner analogous to the accounting system. It is shown that noise and seasonality produce distortions in the ratio measures and are spread throughout the system in a dynamic and complex fashion. Further experiments reveal that plausible control policies based upon financial ratios may make performance worse rather than better. System Dynamics appears to be a useful approach both to redesigning financial ratio measures and testing policies which could enhance our ability to manage such systems.

SECTION ONE: INTRODUCTION AND SUMMARY

This paper discusses some early findings from a study which seeks to apply system dynamics to issues of working capital management in the small business.[1] High failure rates in such enterprises have often been linked to

[1]The authors wish to acknowledge the cooperation of colleagues at the University of Pittsburgh, Dr. Richard Biscomb of Nova University, and Jeff Sankovitch for invaluable student assistance.

an alledged inability to maintain adequate financial control of the operating cycle. For those businesses who face seasonal demand or make extensive use of credit the problem is an even more acute one. Failure to monitor short -term financial fluctuations may lead to periodic crises which force harmful adjustments to the smooth flow of operations or threaten the very existence of the business.

We review methods commonly used to monitor the firm's financial situation -- principally financial ratios. It is shown that where there are dynamic forces at work such as noise and seasonality the ratios used to measure our effectiveness in achieving financial control are quite inadequate. A model has been constructed to simulate the operating cycle of a small merchandising business. It generates both the accounting data flows and the financial ratios which can be used for control purposes. Experiments confirm that seasonality or random fluctuations in the pattern of sales produce erroneous information about the company's turnover ratios; the ratios fluctuate even though the real value of what is purported to be measured remains unchanged. Furthermore the distorting effects of seasonality spread throughout the financial system to affect payables, inventory, receivables, and cash in a complex and dynamically interrelated fashion. Additional modelling experiments demonstrate that financial ratios have an additional deficiency. Significant changes in system parameters become obscured by quite meaningless information about seasonality as it works its way through the financial control system.

Lyneis [1] has demonstrated the manner in which plausible policies for achieving financial control may be implemented at the expense of harming the

firm's overall performance. Our results confirm this, showing how intuitively fashioned policies to improve turnover harm sales at a later point. Further, the improvement of turnover is accompanied by even greater fluctuations in other financial variables which might call forth further inappropriate corrective action. Our study is still in its early stages but suggests that system dynamics has a considerable amount to contribute to the task of designing more effective financial control systems. It may be possible to provide enhanced control by suggesting financial ratio measures which separate random and seasonal variations from underlying changes in system parameters. System dynamics provides the means to test alternate policies and redesign the system in the light of the dynamic complexity which governs its behavior.

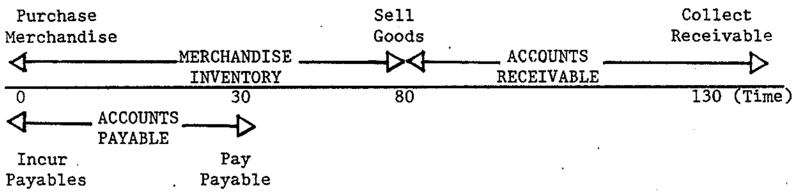
SECTION TWO: REVIEW OF LITERATURE

2.1 Financial Ratio Analysis

The basic purpose of ratio analysis is to reduce the vast amount of information to be found in typical financial statements to a smaller set of more focussed numbers. These should allow more meaningful comparisons both across time and between firms. Financial ratios seek to delineate certain characteristics of the firm such as its liquidity or solvency. These characteristics, as well as the underlying ratios which purport to measure them, are not usually defended on any firm logical or theoretical grounds (Lev [2]). Typically one is left to appreciate their intuitive plausibility through relatively simplified examples.

Consider the following diagram which financial analysts use to conceptualize the operating cycle (Gitman [3]). Throughout our paper we shall assume a merchandising business although broadly similar concepts would apply to a manufacturing environment. In the normal course of the operating cycle merchandise is purchased on credit, thus creating a payable and inventory. After some time the account payable will be paid off through the use of cash while the inventory itself is sold on credit at a later date. After some further period the receivable will be collected and the firm has now completed the cycle. Thus the operating cycle is characterized by a series of accumulations and delays which are dynamically interrelated although these characteristics are not usually explicitly recognized.

DIAGRAM 1: The Operating Cycle



A number of financial ratio measures have been developed to measure the firm's control of the operating cycle.[2] Liquidity ratios measure the

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[2]This paper concentrates on turnover ratios rather than the more popular measures of liquidity such as "current" and "acid" ratios. This approach is adopted because turnover and aging measures are more commonly used for monitoring short-term changes (Stone [4]). The interrelated nature of measures of liquidity and turnover is demonstrated by Gitman [3]:

Current Ratio = Current Assets/Current Liabilities
= Cash + Accounts Receivable + Inventory/Accounts Payable

Quick (Acid) Ratio = Cash + Accounts Receivable/Accounts Payable

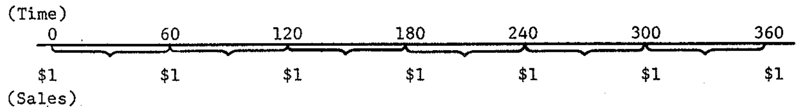
Net Working Capital = Current Assets - Current Liabilities
= Cash + Accounts Receivable + Inventory - Accounts Payable
= Outlays/(Receivables Turnover + Inventory Turnover - Payables Turnover)

relationship between forthcoming financial obligations and financial resources available to meet these obligations. Turnover ratios measure how effectively the firm is employing its resources by comparing the dollars we invest in areas of the business with the results these investments make possible. To illustrate: we offer credit to customers in order to stimulate sales so the effective firm generates many dollars of sales from its investment in receivables; this is receivables turnover. Similarly payables turnover examines the relation between credit provided by suppliers (accounts payable) and the purchases of merchandise we make based on this credit. Again merchandising companies hold inventory levels in order to stimulate sales so the effective firm makes a lot of sales from its inventories. Coloquially, it "turns its inventory over many times". These ratios are shown below:

Receivables Turnover = Sales/Accounts Receivable (1)
Inventory Turnover = Cost of Sales/Inventory (2)
Payables Turnover = Purchases/Accounts Payable (3)

For certain purposes it is useful to transform these activity ratios into ages. To illustrate: Assume we turn over our inventory six times per year. We could also say that our typical inventory is 60 days "old" when it is sold; in other words, a dollar invested in receivables will enable us to make $6 of sales throughout the year if we can turn it over 6 times (i.e., collect the cash after 60 days). This is illustrated in Diagram 2.

DIAGRAM 2: The Operating Cycle - Age and Turnover Measures



Receivables Age - 60 days
Receivables Turnover - 6 times per year

Age of Receivables[3] = 360/Receivables Turnover (4)
Age of Inventory = 360/Inventory Turnover (5)
Age of Payables = 360/Payables Turnover (6)

Notice that equations (4) thru (6) describe the operating cycle in identical terms to Diagram 1. The financial ratios we have described are used to develop judgments concerning the operating performance of the firm. They may be used crossectionally as when we compare, for instance, our inventory turnover with our competitors or with industry averages published by agencies such as Dunn and Bradstreet. Ratios may also be used for time series analysis when we trace, for instance, the effectiveness of our collection efforts by monitoring changes in the age of receivables. Of particular significance to our later analysis is the use of "age measures" to evaluate the firm's control of the operating cycle. It should also be understood that the day -to-day practices of financial ratio analysis do not simply involve rigid formulae like those of equations (1) thru (6); there are many variants or approximations used. Thus financial ratios are calculated and analyzed while fully utilizing the judgment and intuition of the experienced analyst in order to produce the most meaningful analysis.

Since the ratios are used to judge the operating efficiency of the firm, we need to ensure that our measures are adequate and unbiased ones. Implicit in the use of ratios to judge managerial efficiency is the idea that changes in the value of the ratios are indicative of a changing situation facing the firm, i.e., a rise in the age of payables means it is taking us longer on average to pay our bills. This may seem so obvious as to be unworthy of comment but recall that there are a number of dynamic forces at

[3] Also known as "Average Collection Period" or "Days Sales Outstanding".

work during the operating cycle and these will affect the ratios which we caluclate.

2.2 Seasonality and Ratios

The initial analysis of the problems which seasonality can cause for ratio measures was provided in the context of managing accounts receivable. Stone [4] found that some 80% of the firms he surveyed used some systematic method to project accounts receivable and that the vast majority used average age of receivables or some other measure of receivables to sales. Aging schedules were also commonly employed as a control device. Lewellen and Johnson [5] demonstrated that if there was a pattern of fluctuating inter-period sales (i.e., seasonality) a measure of the average age of receivables is an inaccurate guide to the effectiveness of collection efforts. To summarize:

> ...seasonal variations in sales can send false signals to the credit manager even though true collection experience is unchanged ... [further] ... The way the credit manager perceives the collection experience as measured by DSO will depend on which averaging period is chosen. The AS figures can be further distorted if payments on the most recent months are unusually high or low. A high proportion of payments on the most recent months will make up a higher percentage of the end of quarter receivables even though the old receivables may be normal in relation to sales for these months. [6, p. 343]

To understand why such distortions occur, consider the following example. It assumes that our receivables are collected exactly two months after sale and that we calculate our age of receivables on the first day of each month by dividing outstanding receivables by the sales per day calculated over the past 3 months. Table 1 shows the results.

TABLE 1: Receivables Turnover Measures With Seasonal Sales

(1) Time	(2) Sales per Month ($)	(3) Receivables Outstanding at First of Month ($)	(4) Past 3 Months Sales ($)	(5) Sales per Day Col(4)/90	(6) Receivables Turnover Col(3)/Col(5) (Days)
Jan.	100				
Feb.	50				
March	25				
April	200	50+25 = 75	100+50+25 = 175	1.94	38.6
May	200	25+200 = 225	50+25+200 = 275	3.05	73.8

Thus as of April 1st we still have uncollected all of our sales from the previous two months and we compare this with our sales averaged over the past 3 months.[4] We repeat the same procedures at the beginning of May and the results are extremely strange! Recall that receivables turnover is supposed to measure our efficiency in collecting outstanding accounts. Despite the deterioration in the receivables turnover measure we know the "true" collection period has remained constant at 60 days. What we have is a highly defective signalling mechanism. Lewellen and Johnson [5] demonstrate that many commonly employed control mechanisms may signal an improvement or deterioration in the status of accounts receivable even where there has been no change in the distribution of customer payments. They also demonstrate that significant changes in payment patterns could be obscured by the totally erroneous distortions brought about by seasonality. Stone [4] suggests the

[4]Weston & Brigham [6] cite 90 day averaging as being commonly employed.

development of a "payments pattern approach" to overcome this; it represents the use of a variance-type analytical framework. Although this will alleviate the problem, the control reports provided are relatively complex and it seems that few corporations use such measures, relying instead on the simpler if inaccurate measures of receivables age.

To date analysis of the seasonality problem has concentrated on receivables and treats them in isolation from the rest of the firm's operating parameters. Consider, however, just how pervasive the effects of seasonality are. Not only will seasonal sales cause fluctuating receivables, they are also likely to cause changing payables levels (as we purchase merchandise on credit in anticipation of these sales) and fluctuating inventories (as we would probably have to order merchandise in advance of sales). Thus a seasonal pattern for sales has important and dynamically interrelated effects on payables, receivables, and inventory. Will this in turn produce erroneous fluctuations in measures of our ability to control these variables?

What we have is, of course, a situation familiar to the System Dynamacist -- a complex and dynamic feedback control system. To develop a systematic analysis of this phenomenon, the operating cycle of a small business with significant sales seasonality was modelled using system dynamics techniques. The results are described in the following section.

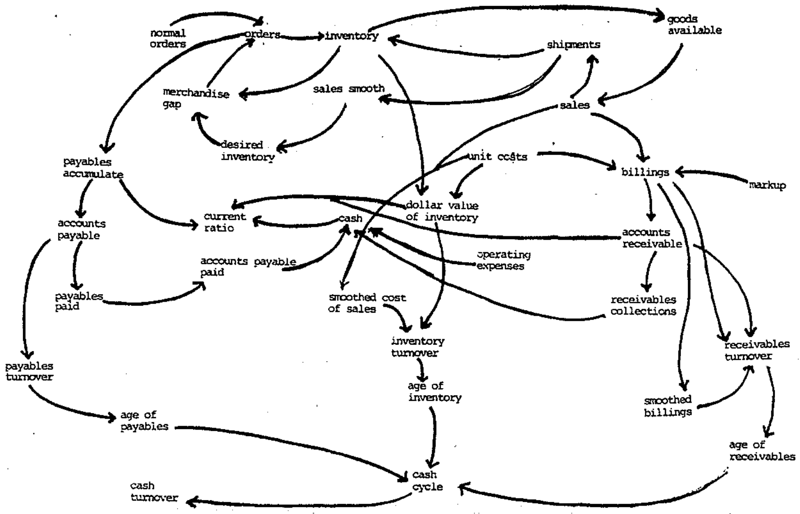
SECTION THREE: SOME EXPERIMENTS WITH FINANCIAL RATIOS

The model illustrated below[5] has been developed to simulate the dyna-

[5] See Appendix for flow diagram.

mics of the operating cycle using system dynamics principles. It is derived from an analysis of a relatively small merchandising business which buys and sells extensively on credit and whose sales exhibit seasonality. We are interested in short-term and seasonal fluctuations rather than the underlying forces of long-term growth and decline. (For an analysis of these see Lyneis [1]). The model which we have developed has elements in common with one of Lyneis' [7] and includes the major financial and accounting variables of the operating cycle as well as ratios of turnover and age as described in equations (1) thru (6). The policy rules which guide the model have also been tentatively identified although the study is in its preliminary stages with respect to validation and much work remains to be done here. We feel

DIAGRAM 3: Financial Aspects of the Operating Cycle of a Small Merchandising Business



confident, however, that the results described in the paper are not sensitive to the forms chosen for the decision variables and that our findings may be reasonably generalized.

3.1 The Base Model

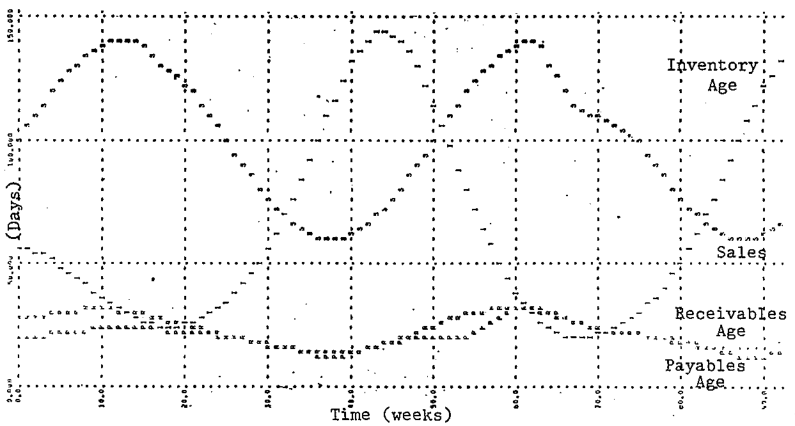
In our initial run sales were steady and the system operated in a stable equilibrium close to breakeven. The model was verified by a series of plausibility tests (e.g., since the delay for paying payables was 3 weeks the model ought to generate an average age of payables of 27 days). To provide comparability with previous studies a 90 day averaging period was used to obtain the numerators in the turnover variables. Had an alternate smoothing period been chosen it would have affected the numerical values calculated (see Lewellen & Johnson [5]) and would have made the ratio comparisons more difficult. It would not, however, affect the general nature of the dynamic behavior which we describe in the following runs. The base run shows stability over time for each of our measures for control of the operating cycle reflecting the fact that true collection experience (i.e., the length of the days) is constant.

3.2 Seasonal Sales

In the next simulation sales were allowed to follow a sinusoidal pattern around the same mean as the previous run. Note that the actual delays between incurring and disbursing payables and receivables were held constant in the model through the use of "boxcar" delay functions which remained unchanged throughout the simulations. There will, however, be fluctuations in the level of these variables as bunching of sales causes inventory to fluctuate and brings about a later bunching of receivables and so on.

The results of such fluctuations on the financial ratios are shown below. They are a clear demonstration of the distorting effects of seasonality. Despite the fact that there is no change in the true age of any of the items concerned, the financial ratios fluctuate over time suggesting changes in our ability to manage the operating cycle. Not only does this confirm earlier findings concerning the distorting effects of seasonality on ratio measures of receivables turnover but it also shows clearly how seasonality causes erroneous fluctuations in the apparent ages of inventory and payables. An examination of Diagram 4 would suggest to most observers not only that there have been significant changes in our ability to monitor the operating cycle over time but also that there are dynamic and complex interrelations between the ages of receivables payables and inventory. Such a conclusion would, of course, be erroneous since all we are seeing is the way in which seasonality plays havoc with our financial ratios. One might, however,

DIAGRAM 4: Ages With a Seasonal Sales Pattern



wonder how a businessperson would respond to such drastic changes in the ratios which purport to measure operating effectiveness.

In order to understand the causes of such superficially puzzling behavior consider equation (7):

$$\text{Receivables Turnover} = \frac{\text{Previous 13 Weeks Sales}}{\text{Present Account Payable}} \qquad (7)$$

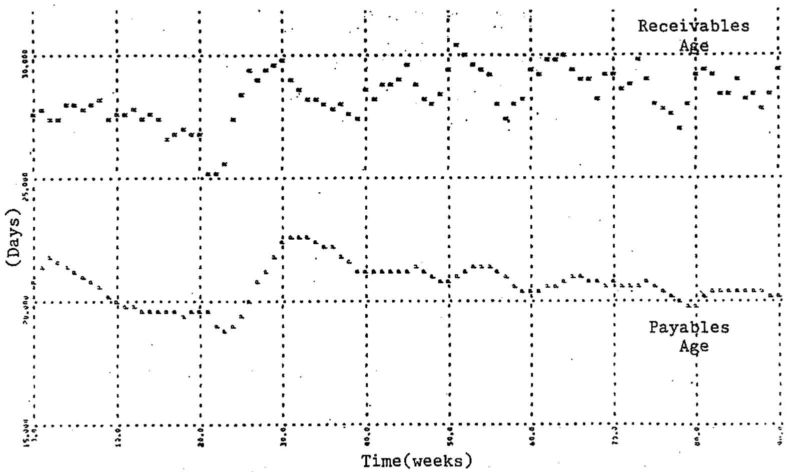
Accounts are collected after precisely 4 weeks through the use of a boxcar delay. Notice that an increase in sales and the accompanying rise in receivables will have a greater impact on the denominator of (7) than upon the numerator because receivables are averaged over 4 weeks where sales are averaged over 13. Thus receivables turnover would tend to fall (average age of receivables to rise) at a time of rising sales and vice versa when sales declined. The fluctuations are made especially acute because of our assumption that all sales are made on credit. An alternate collection pattern would produce a similar although less pronounced and more complex pattern.

The above findings also suggest how we might be able to improve the calculation of ratios. It can be demonstrated that the magnitude of the fluctuations in financial ratios are related to the smoothing periods chosen. By altering this period, making for instance the sales smoothing period equal to the magnitude of the receivables delay, we might be able to eliminate or reduce distortions in our ratio measures. Such an approach would represent an interesting application of System Dynamics methodology. We would aim to examine how well the measurement system holds up in a dynamic and complex environment and how well it succeeds in differentiating true changes in the parameters from erroneous fluctuations caused by seasonality. We have reached only the earliest stages of our investigations in this area although they pose some extremely interesting questions to which we shall return at a later stage in the paper.

3.3 Random Variations in Sales

Even if interpreted sales were constant there could still be a significant random component. What effect would this have on measures of our ability to control the oerating cycle? To test this the sinusoidal sales pattern was replaced by a steady one which had a significant random (noise) component. Some 8 runs were made using different reruns of normally distributed noise. Results did not differ greatly over the reruns and a typical result is shown in Diagram 5.

DIAGRAM 5: Effect of Random Fluctuations in Sales on Age of Receivables and Payables



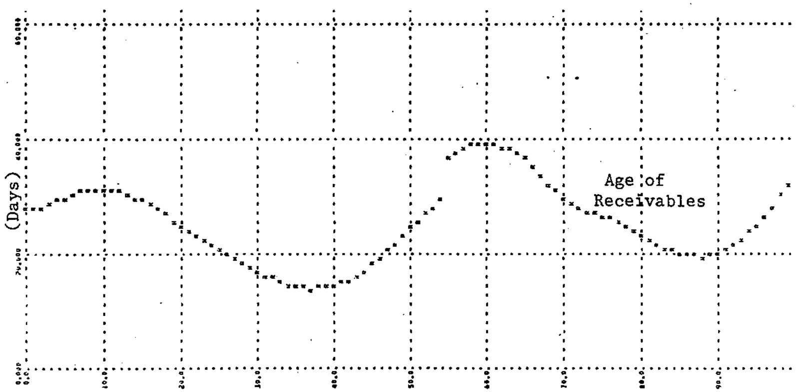
Once again although there is no change in the real ages of any of the variables concerned, we have large fluctuations in their apparent magnitude. These changes give every appearance of being dynamically linked and would not appear to be the result of purely random forces, which is exactly what they are.

We now begin to see why the task of managing the operating cycle of a business can be so complex. Any significant fluctuation in sales can affect the variables used to monitor the operating cycle. If we imagine the typical sales pattern as exhibiting both random and seasonal behavior then we have an even more complex situation especially since the underlying variables are dynamically interrelated. We stress these points because the situation we are modelling is much simpler than that which the financial manager of a large multiproduct firm must deal with. In such situations the fluctuations are likely to be both subtle and highly complex and would probably defeat any attempt at policy formulation on a purely intuitive basis. As we shall show in a later section this is precisely where system dynamics can be of considerable assistance.

3.4 Effect of a Change in the Age of Receivables

Lewellen and Johnson [5] demonstrated not only that seasonal sales could cause apparent changes in the age of receivables, but also that significant changes in the collection patterns could be obscured by seasonality. To examine this phenomena we used a sales pattern containing both seasonal and random elements and introduced a discrete increase in the time it takes to collect receivables. This was accomplished by means of a "boxcar switch" which changed the time between billing and collecting receivables from 3 to 4 weeks at time = 55. This would represent an increase in the time taken to collect receivables from 4 weeks to 5 -- an important change for any business. The way in which such a change would be measured by the accounting system is shown in Diagram 6. The system does identify the change but it is largely obscured by the erroneous information produced by seasonality. Given that the increase in receivables collection is 7 days and the fact that the accounting system distortions caused by seasonality are up to 21 days, it is easy to see how real and significant changes could be missed. Similar conclusions to the above apply to any real changes in inventory or payables turnover being hard to detect beacuse of distortions in the measurement system. In general we are extremely sceptical of the ability of financial ratio measures to separate real changes from the effects of random and seasonal disturbances.

DIAGRAM 6: Effect of a Change in Age of Receivables



Once again we have a problem which appears amenable to system dynamics investigation. Forrester [8] first pointed out how smoothing changes the sensitivity of the system to different periodicities that may exist in data fluctuations. He also demonstrates how smoothing is a dilemma between more smoothing to reduce meaningless noise and less smoothing to reduce the time delay in extracting the information which is desired. Could we thus experiment with alternative smoothing periods to ensure that the information produced is an unbiased representation of what is actually taking place in the system and that irrelevant dynamic fluctuations will not distort our measures of system performance? A system dynamics analysis which could thoroughly analyze the dynamics of the operating cycle could then lead to the design of financial control measures which would reduce the effects of random and seasonal sales fluctuations but would still draw attention to real changes in the system's operating parameters. Such an approach would appear to be both practical and valuable and this is another promising area for investigation which we are currently developing.

SECTION FOUR: THE CASE FOR SYSTEM DYNAMICS ANALYSIS

So far we have demonstrated that problems of dynamics, delays, and interrelations exist in the firm's operating cycle. Even in a relatively small business the fluctuations and interactions among sales, receipts, purchases, and disbursements can produce highly complex patterns. They are likely to make "common sense" policy prescriptions hazardous at best and counterproductive at worst. The dynamic complexity in such situations causes accurate intuitive judgments to be beyond the capacity of even experienced practitioners. The more they rely on ratio measures produced by an accounting system and the more frequently the data are collected, the greater is the likely confusion![6] Much more research on the dynamic implications of accounting measurement systems is called for and system dynamics provides a tool capable of unique insights.

4.1 Lyneis on Financial Control

The present study owes a considerable debt to Lyneis [1], [7] who made some of the first applications of System Dynamics techniques to financial modelling. His model for financial strategy encompasses much more than our current study; it incorporates the entire balance sheet where ours concentrates upon current assets and liabilities. Modelling differences stem from an interest in different issues; where Lyneis addresses issues concerning corporate growth, fixed asset acquisition, and long-term financing strategy, we are focussing on the operating cycle and therefore have much more detailed modelling of the relevant financial ratios. Where Lyneis is interested in the dynamics of processes over the entire business cycle we are interested in seasonal fluctuations. His model considers a manufacturing environment where the dynamics of the production system are relatively complex; our model of a merchandising situation is much simpler. Despite these differences we shall demonstrate that we can draw similar conclusions from both studies which reinforces claims as to the usefulness of system dynamics in this particular area.

Lyneis [1] illustrates how a plausible policy for financial control of

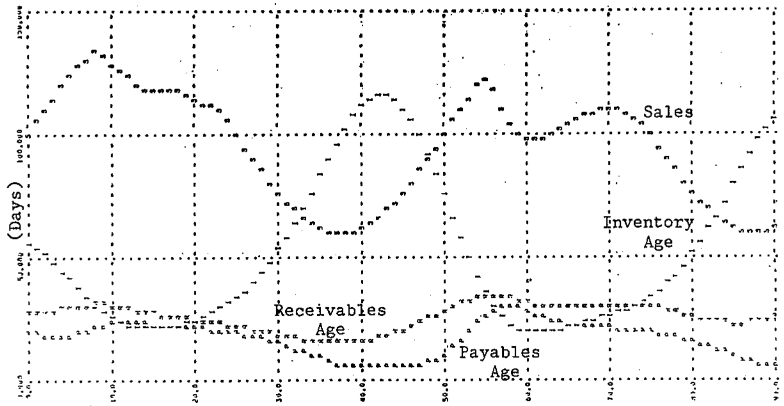
[6] During a previous discussion of this issue, an accountant remarked that they were aware of the problem and "allowed for it". When more closely questioned on the interactions between payables, receivables, and inventory it became obvious that it was "allowed for" in an extremely fragmented and intuitive fashion.

inventory can have harmful effects on the firm. In the model financial control is exercised through a policy which operates as follows: If measured inventory turnover is below a predetermined level, the desired production rate is cut back in an attempt to raise inventory turnover. Thus when perceived inventory turnover is below target levels there are pressures to reduce production rates. The finished goods inventory level influences delivery delay and market share. Lyneis subjects the system to a cyclical sales pattern finding that during a downturn inventory is rising while sales are falling. When the company "corrects" this by reducing production and parts ordering rate, the "improvement" in turnover comes at the expense of market share and profits. Worse, as the upswing begins the company now has inadequate inventories to carry it through a period of rising sales thus causing lengthening delivery delays and even greater loss of market share. It is demonstrated that we can alleviate these problems by altering the period over which inventory discrepancies are corrected, enabling them to peak at roughly the same time as customer orders thus producing relatively stable inventory turnover measures.

4.2 The Effects of Control Policies Based on Inventory Turnover

In this simulation we model the effects of financial control of inventory. It was assumed that if inventory age exceeded a desired value (i.e., inventory target was below some predetermined level) steps would be taken to affect it by reducing orders of merchandise. In the model, however, there is a delay before the level of inventory is altered. Our results are shown in Diagram 7. It can be seen that the results of such a policy are both futile and harmful. There is little improvement in the age of inventory but sales are reduced in the upswing because of the reduced availability of merchandise inventory. This lower sales level also affects the turnover of receivables and payables in an apparently adverse fashion causing fluctuations in the age of payables to be slightly more pronounced and in receivables age to be much greater. If we then imagine managerial policies which respond to this second set of changes we have an extremely complex situation. The policy to improve inventory turnover also increases significantly fluctuations in the current ratio which would again signal that there is something amiss with the firm's financial control. Limitations of space prevent us from analyzing policies control for financial control based upon modifying the turnover of receivables and payables although they would also tend to have similarly complex, and occasionally harmful, effects upon the business' overall performance. Again there is considerable research to be completed into the ways in which apparently plausible policies for short-term financial control may have serious and unintended consequences.

DIAGRAM 7: The Effects of a Financial Control Policy



SECTION FIVE: FUTURE DIRECTIONS

The results we have presented are the early stages of an investigation which is broad in scope and appears to have considerable potential for further exploration. Our future studies will be directed toward a threefold purpose: (1) as a means of improving the performance of the system under investigation, (2) as an illustration of the applications of system dynamics to financial control, (3) and finally as a contribution to an alternate theory of working capital management.

Of immediate interest is the design of policies to help the company perform better in times of fluctuating sales. They would enable the firm to maintain or improve financial control of the operating cycle without sacrificing other desired goals such as sales. At the same time, the development of improved financial ratio measures which separate random and seasonal variations from underlying changes in system parameters would clearly facilitate more effective control. Currently we are extending the model to include short-term borrowing and repayments; this will increase the range of available alternatives for financial strategy. By combining policies which make use of external resources with those alluded to earlier for improving the internal dynamics of the operating cycle we anticipate further improvements in system performance.

Our study also suggests some scope for system dynamics in a relatively neglected area -- that of managerial and financial control systems in small businesses. Given the increasing economies of computing and the availability of DYNAMO for mini- and microcomputer systems such studies are now within the range of quite small businesses. If such studies could be linked to efforts to develop generic models of the processes involved in financial control, then the effort would be doubly worthwhile. An approach to financial control which explicitly recognizes the implications of uncertainties, delays, and interactions might be found to be superior to techniques such as "common sense" ratio analysis with all the defects such as those revealed in this paper.

On a higher level of abstraction we view our work as a contribution toward a theory of working capital management -- an area which Smith [9] argues is a relatively unsatisfactory one. We may envisage the working capital management problem as being a series of interrelated and recurring decisions to affect levels of cash, inventory, receivables, and payables while facing a highly uncertain environment. Analysis of the dynamic complexity to be found in such situations may lead us to an understanding of the symmetries between the structure-behavior theorems of system dynamics and more familiar financial concepts. Financial ratio analysis remains to be integrated into a theory of working capital management. If a generic model of financial control could be developed it would provide the basis for such a synthesis. We have only begun to explore this potentially fruitful line of enquiry first suggested by Lyneis [7].

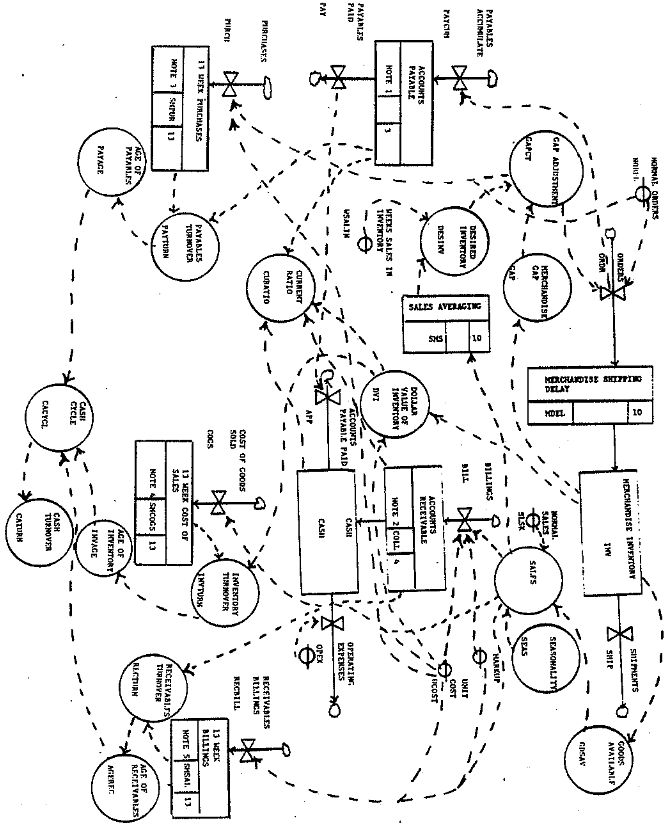
APPENDIX 1

Flow Diagram -- Working Capital Management Model

NOTE 1 represents a 3 week boxcar delay for accounts payable.

NOTE 2 represents a 4 week boxcar delay for accounts receivable.

NOTES 3, 4, & 5 represent a 13 week boxcar delay for purchases, cost of sales, and billings respectively.



REFERENCES CITED

1. Lyneis, J.M. Corporate Planning and Policy Design. Cambridge, Mass: M.I.T. Press, 1980.

2. Lev, B. Financial Statement Analysis -- A New Approach. Englewood Cliffs, N.J.: Prentice Hall, 1972.

3. Gitman, L.J. Estimating Corporate Liquidity Requirements -- A Simplified Approach. Financial Review, 1974, pp. 79-89.

4. Stone, B.K. The Payments-Pattern Approach to the Forecasting and Control of Accounts Receivable. Financial Management, Autumn 1976, pp. 65-82.

5. Lewellen, W.G. & Johnson, R.W. Better Way to Monitor Accounts Receivable. Harvard Business Review, May-June 1972, pp. 101-109.

6. Weston, J.F. & Brigham, E.W. Managerial Finance. Hinsdale, Ill.: Holt, Reinhart & Wilson, 7th ed., 1980.

7. Lyneis, J.M. Working Capital Management -- A System Dynamics Approach. Proceedings of the Eastern Finance Association, April 1973.

8. Forrester, J.W. Industrial Dynamics. Cambridge, Mass.: M.I.T. Press, 1961.

9. Smith, K.V. An Overview of Working Capital Management, in Smith, K.V. (ed.). Readings on the Management of Working Capital. St. Paul, Minn.: West, 1980.