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THE DEBT AND DIVIDEND POLICY OF A FIRM--
A FINANCIAL PLANNING MODEL USING SIMULATION

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THE DEBT AND DIVIDEND POLICY OF A FIRM--
A FINANCIAL PLANNING MODEL USING SIMULATION

by

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ABSTRACT

THE DEBT AND DIVIDEND POLICY OF A FIRM--
A FINANCIAL PLANNING MODEL USING SIMULATION

By

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Throughout the 1960's and early 1970's a number of "financial planning models" were published in the literature. Most of the models were optimizing, short-term financing, accounting output variable, linear programming models. The purpose of this study was to fill a void in the literature and develop a financial planning model that is non-optimizing and long term in nature.

The model developed is a system dynamics model. It does not make point forecasts, but rather is used to determine the behavior of the output variables. The output variables are return and risk measures based on book value of equity and debt. The model developed was not meant to develop new theory but rather to incorporate existing theory.

The development of the model followed a stepwise process that included: review of the literature to incorporate current theory, construction of the basic model structure, collection of data to initialize and determine parameters, interview of management of the firm being modeled, fine tuning of the model, validation of the model, performance of sensitivity analysis, and finally the intervention of policy changes to the model. The policies examined were restricted to long-term financing. Specifically, debt/equity ratios and dividend payouts were modified and the impact on the output variables was analyzed.

The results of the policy interventions were as hypothesized. Risk and return on equity increased with increasing leverage. A break point was identified where the risk continued to rise and return remained constant. Increasing dividend payouts lowered returns because of the need for alternate sources of financing.

The model in its present form can be used to examine the effect of other policy changes, i.e. investment policy. The model can also be modified to investigate mergers, competitive factors and factors of production. The usefulness of the model as a planning and pedagogical tool was concluded.

DEDICATION

In memory of

DR. GILBERT W. LOW
(1940 - 1979)

Assistant Professor of Management
System Dynamics Group
Sloan School of Management
Massachusetts Institute of Technology
Cambridge, Massachusetts

and to

PAM

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*Available upon request from the author.

PART I: The model

CHAPTER I

INTRODUCTION

This chapter states the purposes of the study including the identification of the problem to be solved. A prediction of the results of the study is formulated as a hypothesis. The remainder of the chapter defines the nomenclature used.

A. Statement of Purpose

The purpose of this study was to develop a financial planning model of the firm to fill a void in the financial literature of models that simulate long-term financing policies. The model was generic in structure and was tested using a specific firm's characteristics.

This model determined the behavioral impact of policies without making point forecasts. Although, this model was not intended to test or develop any particular theory, it embraces current theory within its bounds. Financing problems can be examined with this model but an optimal solution to these problems was not determined.

The procedures used in this study involved nine steps. These steps were to:

1. Review the literature
2. Build the basic model structure
3. Collect data to initialize and determine parameters
4. Interview management of the firm to be modeled to determine policy variable values

5. Fine-tune the model
6. Validate the model to a data set
7. Perform sensitivity analysis
8. Perform policy interventions
9. Summarize the results of steps 6, 7 and 8.

Chapter II discusses the results of step 1. Chapter III explains the procedures used in steps 2, 3, 4, 5, 6, 7 and 8. Chapter IV describes the model. Chapter V describes the results of steps 6 and 7. Chapter VI describes the results of step 8. Chapter VII explains the results of step 8 and performs step 9.

The manuscript is divided into two parts. Part I describes the model and the processes used to develop the model. Part II describes the simulation results after the model had been built. Chapters I, II, and III and IV are in Part I. Chapters V, VI and VII are in Part II.

B. Statement of the Problem

The problem was to examine the effects of a particular financing policy or group of policies upon the long-run value of the firm. The financing policies investigated were dividend payout and debt/equity policies. Examination of short-term financing policies was not part of this study.

C. Dynamic Hypotheses

The results expected from policy interventions were stated as dynamic hypotheses. A dynamic hypothesis is the anticipated behavior of the system in reaction to a given stress. The model of the system is also expected to behave as the system. Three dynamic hypotheses were stated.

Dynamic Hypothesis 1: When the debt/equity ratio is increased, the return to the owners and the risk will both rise. If the debt/equity declines, the return to owners and risk will decline.

Dynamic Hypothesis 2: When the dividend payout ratio is increased, the overall return will decline because the income potential of the firm will be lowered. When the dividend payout decreases, the overall return will increase because the income potential will increase.

Dynamic Hypothesis 3: The effect of combinations of changes in the two policies will be additive.

These hypotheses were investigated using the results of the policy interventions performed in this study.

D. Definition of Terms

Five terms used in system dynamics or simulation in general deserve mention. These terms are "macro", "desired level", "normal condition", "smooth" and "table function." The purpose of this section is to define their meanings as used in this study.

"Macro" is a simulation-unique expression that refers to block of simulation statements. These statements serve the purpose of calculating a specific value. As defined the "macro" is independent of the model and can be removed from the model and still perform its function.

"Desired level" is an expression that relates to variables unique to system dynamics and can be likened to an objective of the firm. Desired levels represent targets of management. The dynamic behavior of systems and models of these systems is derived from the discrepancy between the level of a variable and its "desired level".

"Normal condition" refers to a state around which parameter values are determined in the model. Although the use of the word "normal" implies a specific state, the choice can be arbitrary. The intent and purpose of "normal conditions" in system dynamics is to provide a means to normalize parameter values around a state. In this research "normal" was an equilibrium state that the model would move towards without influence from exogenous stress.

"Smooth" is an exponential moving average of some data generated by the model. This function allows for time lags from data generations to data comprehension and accommodates the discrepancy between time intervals in the model and the time intervals used for measurement in the system.

"Table function" is a system dynamics feature that allows the modeler to specify the relationship between two variables in graphical form. The computer package, DYNAMO, interpolates along this graph and can also extrapolate outside of the specified boundaries. This functional form offers an alternative to the analytical function and provides for discontinuities.

The remainder of the text describes the model that was built and the results obtained from testing the dynamic hypotheses.

CHAPTER II

LITERATURE REVIEW

Review of the literature resulted in the collection of a body of information concerning financial planning models and the three major financial policy areas; investment, debt and dividend. The review provided information used to determine the structure of the model.

The literature search on financial planning models was conducted in the following manner. First, a computer data base search was conducted utilizing the AVI-IN FORM Business Journal Data Base and the Social Science Search Data Base. Second, the Dissertation Abstracts and Business Periodicals Index were searched. Third, a review of financial theory was undertaken using textbook references to the literature. Fourth, the System Dynamics Newsletter was reviewed to reference any system dynamic models developed in finance.

The literature specifically addressing financial planning using system dynamics represented a small portion of the total literature reviewed. However, a substantial amount of financial planning models were found using various modeling techniques. In general, the major thrust of these models was that they were optimization models and addressed either decisions concerning the investment mix or short-term financing mix.

The major source of information containing financial planning models was technical business journals. These also were the major source for financial theory of the firm. The literature categories which have an impact upon developing a financial planning model are presented in this chapter as follows:

1. Financial Planning Models
2. Simulation Models
3. Investment Policy
4. Debt Policy
5. Dividend Policy

A. Financial Planning Models

Throughout the 1960's and early 1970's a number of "financial planning models" were published in the literature. The models published could be categorized by five characteristics. One, whether they were optimizing or nonoptimizing. Two, whether they dealt with short-term or long-term planning. Three, by what output variables were generated from the model. Four, whether they investigated the financing or investment decisions. Five, what type of modeling technique was used.

For the most part the models were optimizing, short-term accounting output variable, financing, linear programming models. Exceptions were rarely found in the literature. This section will discuss the first model of a given category.

Robichek, Teichroew and Jones [1965] published an article that modeled the short-term financing decision. The model was a linear program that optimized accounting output variables. The decision variables in the model were different forms of short-term financing, e.g., accounts payable, notes payable, line of credit. Later, Pogue and Bussard [1972] developed a similar model.

Weingartner [1967] published a text that used mathematical programs to solve capital budgeting problems. Linear programming was the predominate technique used. Some models developed sought to maximize net present value or return with constraints on risk preferences and available funds. Other models minimized risk with contraints on minimum acceptable returns and available funds. All models assumed certainty with this technique.

Carleton [1970] published a linear programming model that integrated the level of investment, the dividend policy and the use of debt and equity to maximize share value of the firm. This model is perhaps the most complete financial planning model in the literature. The output variables were accounting-type variables but the value of the firm was the main consideration of the model. The limiting factor of the model was the restrictive assumptions on the firm's investment opportunities function and the inability to test the model.

Yjiri, Levy and Lyon [1968] (ILL) developed a model similar to that of Carleton. It was a linear program financial planning model. The objective function of ILL model sought to maximize net addition to retained earnings. Carleton improved on this model by adding share price effect variables like earnings per share and the number of additional shares resulting from external equity financing.

Warren and Shelton [1971] developed a non-optimizing, simultaneous equation model. This model addressed overall corporate financial planning with both short and long-term horizons. The model looked at "what-if" scenarios and had accounting data relevant to the share price as its output variable mix. Their model is perhaps most similar to the model in this study than any other referenced in the literature.

B. Simulation Models

The Warren and Shelton model could also have been categorized as a simulation. Simulation is defined by Gordon [1969][1] as the technique of solving problems by following the changes over time of a dynamic model of a system. Mattessich [1961] was one of the earliest to publish a simulation model that investigated financial policy issues. His model specifically addressed the issue of corporate budgets. This does not mean that Mattessich was the earliest to develop a financial simulation model. Gerschefski [1969] reported that 63 firms used computerized financial planning models as of 1968. However, the contents of these models were proprietary and thus none were published.

Clarkson [1962] successfully modeled a trust fund using system simulation. This model was developed in order to find the best investment portfolio for a given individual. The work is noteworthy because it was one of the first to include "soft variables" in the model. "Soft variables" are non-quantifiable attributes of a particular investor similar to a utility map in economics.

Bonini [1963] developed a simulation model of the decision activities of a firm. His model included information flow dynamics and their impact on decision-making effectiveness. Here, too, some "soft variables" were constructed to describe human behavior characteristics.

The two aforementioned simulation models highlighted the need to develop dynamic models of dynamic systems, behavioral variables for human systems, and interdependencies of decisions to realize their total impact. Using system dynamics methodology a number of models

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[1]Gordon, Geoffrey, System Simulation, p. 17.

have been developed that include these factors.[2]

The system dynamics work in the area of financial modeling has been mostly macroeconomic or aggregative in nature. An example was the work by Low [1977]. Low modeled financial market dynamics and later added it to the System Dynamics National Model.[3] He investigated the macroeconomic concepts of savings and credit using supply and demand mechanisms.

A system dynamic financial model of the firm was published by Lyneis [1975]. This model looked at short-term asset and liability management. The model had accounting ratios as output variables. The conclusions of the work were directed towards the affects of financial controls on credit and inventory.

A second system dynamics financial model of the firm was published by Coyle [1977].[4] This model was a firm model that included the manufacturing and marketing functions as well as finance. The purpose of the finance segment was to examine cash flow and to determine cash requirements for the firm. The output variables were balance sheet and cash flow items. Financial policy decisions were strictly cash-management oriented.

The two system dynamics financial planning models cited were the only ones found in the literature. They both examined short-term issues. Neither was concerned with risk and return output variables. They could be categorized as asset management models.

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[2] Forrester, Jay W., [1961], [1969], [1976].

[3] Ibid., [1978]

[4] R. G. Coyle, <u>Management System Dynamics</u>, Chapter 12.

C. Investment Policy

This and the next two sections will review the literature for the three financial decision areas; investment, debt and dividend. The literature review for these topics was performed in order to construct the model in this study based on current theory. The age of the articles cited suggests that the theory has had time to gain acceptance by practitioners and investors. It was their behavior that was modeled in this study.

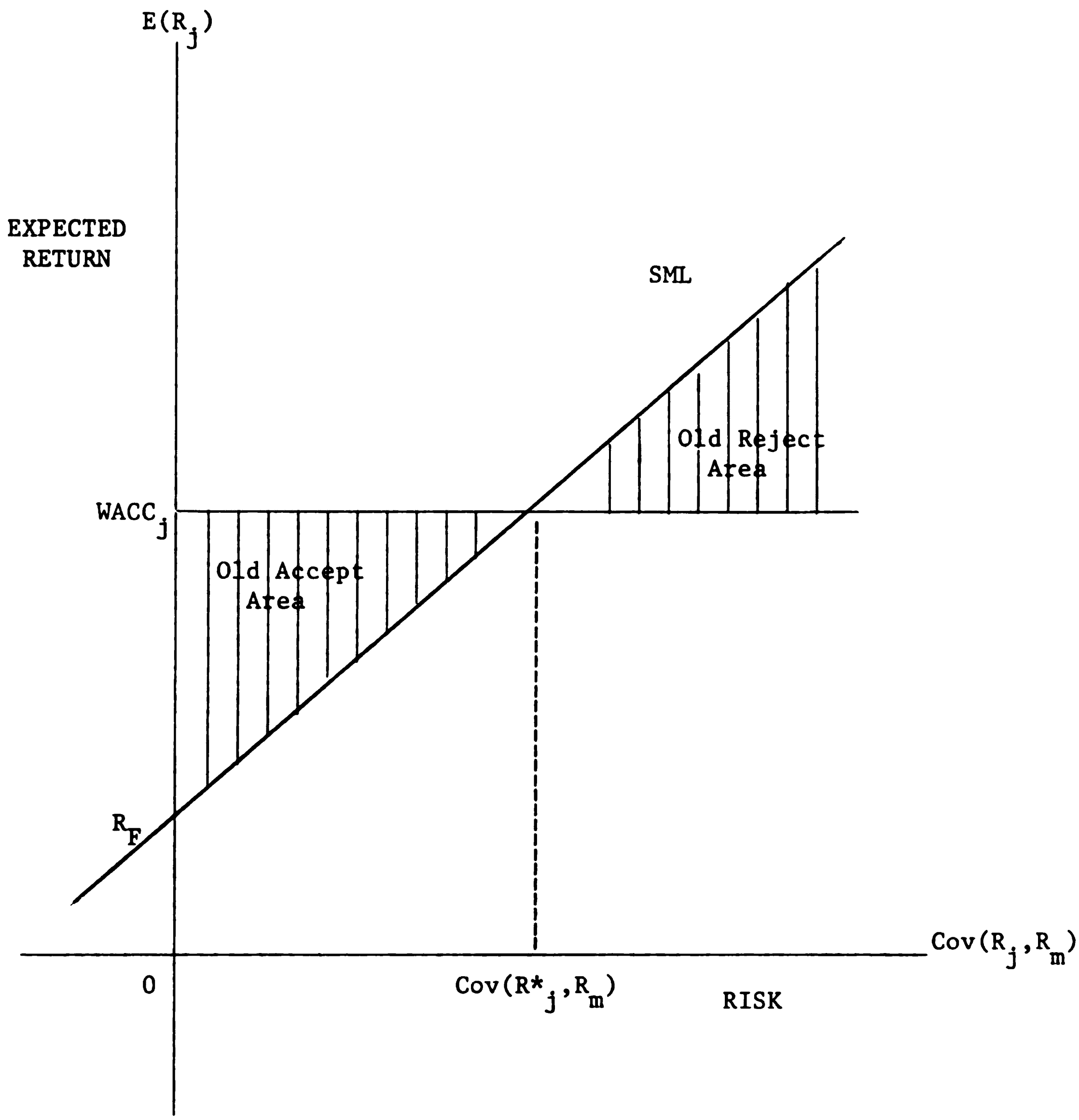
The area of corporate investment policy is probably the least controversial of the three financial decision areas. Hirshleifer [1958] credited with being one of the first to propose the net present value method as the only appropriate method of evaluating investments. He based his argument on the objective of maximizing the value of the firm for the benefit of the shareholders. Modigliani and Miller [1958] (M and M stated in their Proposition III a similar idea and set down the need to isolate this decision from the other two: financing and dividend.

The NPV approach consists of a summation of all future cash flow streams generated by the project (positive and negative) adjusted by a discount factor that accounts for the time-value of money and the riskiness of the flow. Hirshleifer showed that a clear cut "decision rule" exists to accept all projects with positive net present values in order to maximize the wealth of owners. This decision rule is shown in Rubinstein [March 1973] to be applicable to modern portfolio theory. (Figure 1)

The decision rule proposed by Hirshleifer was to use weighted average cost of capital of the firm as the discount factor or denominator in determining net present value. Rubinstein's security market

Figure 1

Criterion for Investment Decisions



where: WACC$_j$ = Weighted average cost of capital of firm j

Cov(R$^*_j$,R$_m$) = Covariance of return on firm j with the market

SML = Security market line defining the functional relationship between riak and return and thus adjusting for risk

RF = The risk-free rate of return

line adjusts this discount factor for varying levels of risk. Therefore, Figure 1 is displaying how the fixed discount factor evolved into a variable, risk-adjusted one.

Myers [1976, p. 280] suggested that an interaction exists between the investment and financing decisions. He based this argument on the fact that acceptance of a project expands the capital requirements of the firm. This contradicts the M and M third proposition but appears to have validity. The M and M argument is based on difficulty in application to their model.

D. Debt Policy

The area of debt policy or capital structure is dichotomous in nature between what are generally referred to as the traditional and the M and M theories. Traditional theory as related in Solomon [1963][5] holds to a weighted average cost of capital curve that is U or pan-shaped with leverage as its argument (Figure 2). This viewpoint necessarily suggests that an optimal capital structure or range of structures exists because value is maximized by minimizing the cost of capital. Higgins [1977][6] points out that a U-shaped curve forces the financing and investment decisions to be interdependent. This is because optimal points exist for both.

The M and M theory that was introduced by Modigliani and Miller [1958] challenged the traditional viewpoint with their assertion and supporting evidence. Their model postulated the irrelevance of capital

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[5] Solomon, Ezra, The Theory of Financial Management, pp. 93-98.

[6] Higgins, Robert C., Financial Management; Theory and Applications, pp. 196-97.

structure to the value of the firm in a taxless world. It was the overall cost of capital that remained constant over all ranges of leverage and it is inversely related to value. When taxes were included by M and M, the overall cost of capital was a downward sloping curve suggesting that a) the more debt the better and b) there is no optimal capital structure other than 100% debt (Figure 3).

In his article, Kim [1978] pointed out that the most suspicious aspect of the traditional viewpoint is that it attempts to value the firm in isolation of the rest of the capital market. Therefore the equilibrium approach first presented by M and M is the more valid approach based on the firm's existence in the market. It still remains disturbing that the average corporate debt ratio, using equity at its market value, is only about 20% according to Blume and Friend [1974]. It appears, therefore, that U.S. corporate management in aggregate does not follow the M and M viewpoint.

One suggestion put forward by a whole host of authors (Baxter [1967], Hirshleifer [1970],[7] Scott [1976], Kim [1978], and Haugen and Senbet [1978]) was that bankruptcy and agency costs are not included in the M and M model. However, Stiglitz [1974] gave a general proof that the M and M viewpoint remains intact even in the presence of a probability of costless bankruptcy. Stiglitz used a costless financial intermediary to maintain the investors' opportunity set even in the face of bankruptcy. Haugen and Senbet [1978] concluded along with Stiglitz that bankruptcy costs are insignificant with regards to an optimal capital structure and the original M and M findings hold.

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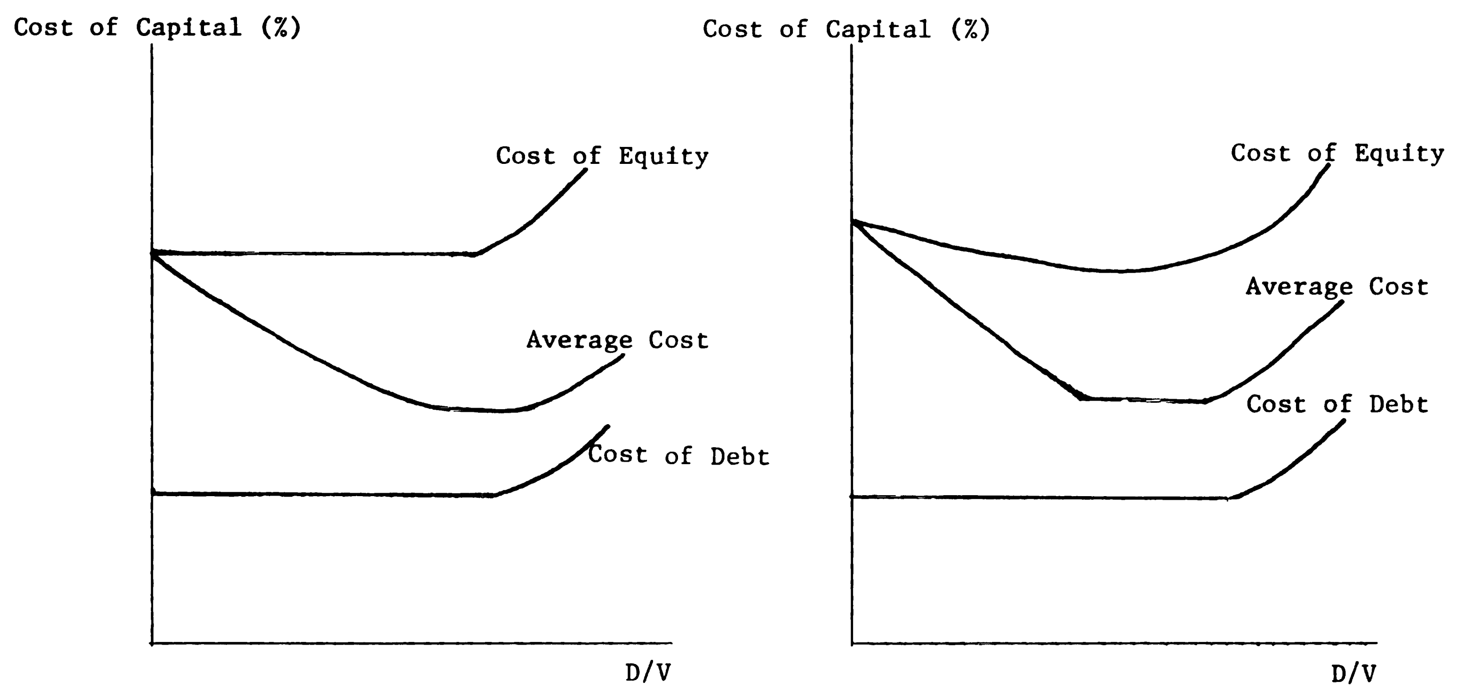
[7] Hirshleifer, J., Investment, Interest and Capital, p. 264.

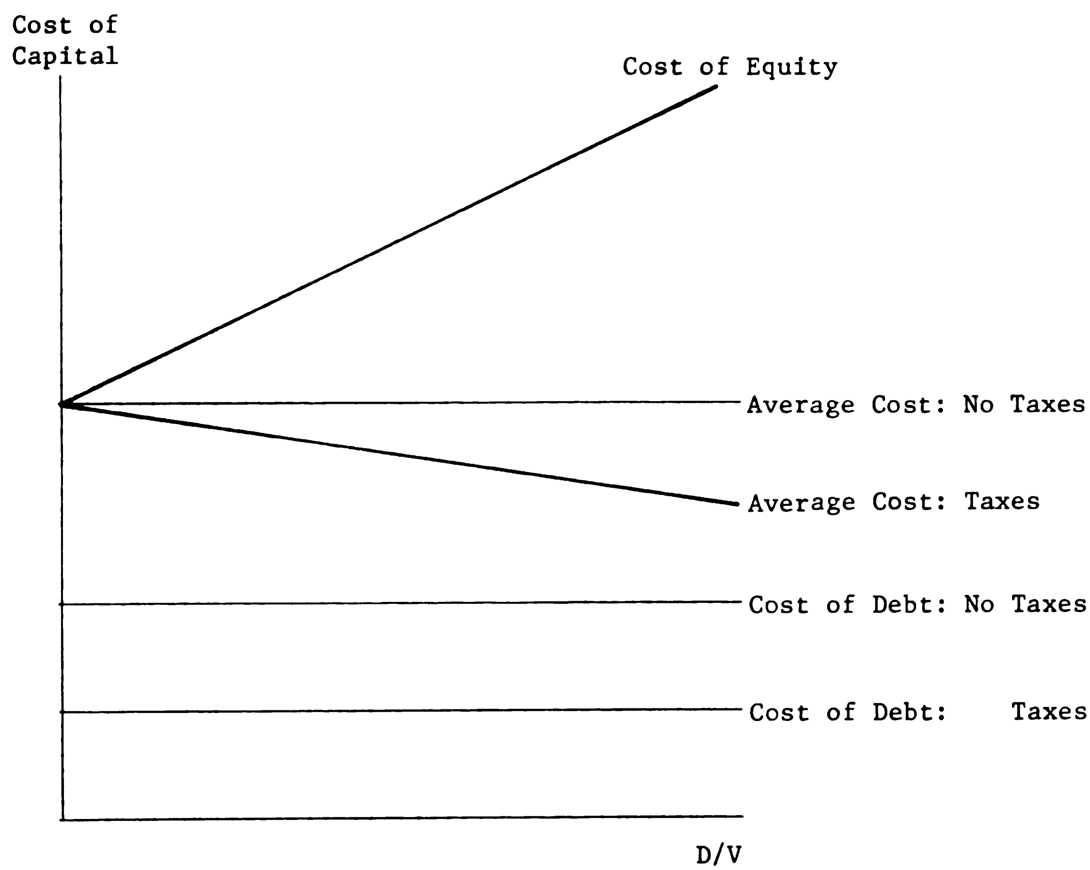
Figure 2



THE TRADITIONAL VIEW
(Hypothesized)

D/V = Debt/Equity Ratio

Figure 3



M & M VIEW
(Specified by equation)

D/V = Equity/Equity Ratio

Modigliani and Miller [1963][8] tried to reconcile the discrepancy between theory and practice. They mentioned the effects of personal income tax which may make retained earnings a cheaper source of financing than debt. Also the flexibility issue which they stated is not comprehensible within the framework of static equilibrium models. They went on to say that the traditional viewpoint cannot reconcile these conditions either.

Donaldson [1963] and Jensen and Meckling [1976] went one step further by stating that management job security is more important than shareholders' wealth maximization. Thus the avoidance of bankruptcy is acute considering the consequences to the decision-maker. In all, the literature leaves unresolved the theoretical and behavioral aspects of debt policy formulation.

The troubling issues (e.g. job security) raised by Donaldson and Jensen and Meckling above leave most decision-makers at a loss in applying the M and M model. It is the degree of job security or the degree of bankruptcy risk aversion that becomes an unknown. Thus decision-makers abandon the model and rely again on intuition. Therefore, they are no better off than before applying the M and M model.

E. Dividend Policy

The area of corporate dividend policy represents the third major financial decision area. Like the capital structure issue, the financial literature is filled with the discussion of the impact of a firm's dividend policy on the valuation of its shares. Historically the best

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[8] Modigliani and Miller, "Corporate Income Taxes and the Cost of Capital," p. 443.

early work was Graham and Dodd [1951] together with Lintner [1956] and Brittain [1966] with their aggregate, empirical studies. These were followed by the theoretical and empirical work of Gordon [1959], [1962] and the now classic dividend-irrelevance proposition of Miller and Modigliani [1961]. Later, Friend and Puckett [1964], Diamond [1967] and Black and Scholes [1974] performed empirical studies that only left the issue substantially unresolved.

If in fact dividend policy is irrelevant, as stated by M and M, when a firm establishes a fixed investment policy then there would seem to be little concern with regards to implementation. However, M and M themselves qualified the results of their study by stating that investors seem to put a premium on higher dividend payouts. They explained this phenomena as the irrationality of the investor and the investment community. Like in the debt policy case the split is seen between the normative and positive with regards to reaction to a given corporate financial policy.

The findings of M and M are distinctly qualified by saying in a perfect capital market dividend policy cannot possibly matter. One so-called imperfection in the market is the "clientele effect." This effect is created by differences in the rates of tax paid by recipients of the dividends; investors. The financing of the firm through retained earnings looks at this effect in sort of a backwards approach. However, in the clientele issue it is investor behavior that is in question.

As stated above, M and M made reference to the possible existence of this effect. In the Black and Scholes article above, mention of this "effect" is made in a manner that challenges researchers to prove its existence. Elton and Gruber [1970] gave supportive evidence with a study of exdividend behavior of common stocks. They developed a model to explain this behavior including differential tax rates. Their conclusions were that stocks attract specific investor types or subgroups. Blume, Crockett and Friend [1974] supported the Elton and Gruber findings but in a milder sense. However, the recent work by Lewellen, Stanley, Lease and Schlarbaum [1978] refuted the existence of such an effect.

In their reply to Durand [1959], M and M [1959] hypothesized the relationship of dividends to future earnings as the information content of dividends. M and M [1961] referred to this phenomena by stating investors will view a change in an established payout as management's views of the firm's future earnings potential. Later articles made reference to this information content hypothesis as a possible cause of observed phenomena between dividends and stock price. In his work, Watts [1973] showed the effect does exist, but transaction costs and other market imperfections make the effect trivial.

The issue of what is the appropriate dividend payout for the firm cannot be considered resolved. Corporate financial managers concern themselves with this policy to such a degree that they certainly are not convinced of its irrelevance. Foremost in importance when trying to resolve this issue is the realistic nature of the assumptions of the models cited. The previous paragraphs question their realism and leave the issue unresolved.

CHAPTER III

METHODOLOGY

A. Introduction

The process of developing a system dynamics simulation model progresses as follows:

1. Develop a dynamic statement of the problem.
2. Propose a set of dynamic hypotheses that could account for the system's behavior.
3. Construct a causal-loop diagram that shows the important structural relationships.
4. Prepare a system dynamics flow diagram.
5. Write DYNAMO relationships for the computer.
6. Compile the model and initialize variable values.
7. Reproduce the reference mode or known system behavior. This provides initial validity to the structural relationships included in the model and confirms the plausibility of the dynamic hypotheses. At this point a theory has been developed that explains observed behavior.
8. Conduct policy tests.

The remainder of this chapter will serve to introduce system dynamics and to clarify the procedures that were followed in carrying out this study.

B. System dynamics

1. Defined

System dynamics is a theory of the structure of dynamic systems, a means for analyzing the resulting behavior from that structure, and a mechanism for examining alternative policies or alterations to improve the system. The dynamic nature of the system is generally modeled by changes within the system in reaction to endogenous or exogenous stress. Therefore, the concept of equilibrium is of foremost importance, however in a dynamic not a static sense. System dynamics focuses on feedback relationships. Information-feedback systems are defined as:

> An information-feedback system exists whenever the environment leads to a decision that results in action which affects the environment and thereby influences future decisions.[1]

Two examples of this type of system or information-feedback control loop systems would be:

1. A thermostat receives temperature information and decides to start the furnace; this raises the temperature, and the furnace is stopped.

2. A profitable industry attracts competitors until the profit margin is reduced to equilibrium with other economic forces, and competitors cease to enter the field.[2]

Feedback loops can be categorized on the basis of polarity of influence around the loop; positive or negative. In the former, a change in system condition leads to actions or reactions which produce further changes in the same direction. An example of this type of system would be a cancer in the human body. See Figure 4. Positive feedback loops,

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[1] Forrester, Jay W., Industrial Dynamics (Cambridge: M.I.T. Press), p. 14.

[2] Ibid., p. 15.

Figure 4

Positive Feedback Loop "Cancer Cells"

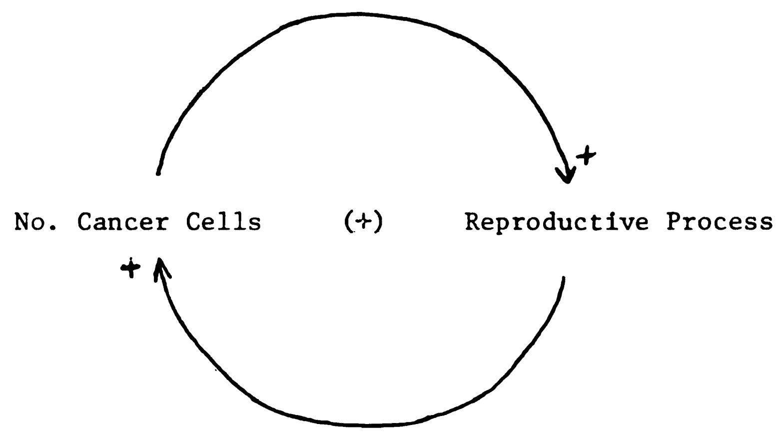
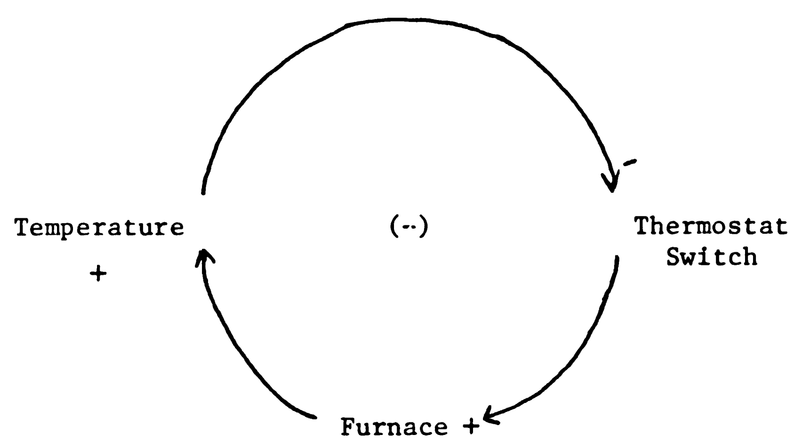


Figure 5

Negative Feedback Loop "Thermostat"



therefore, are sources of growth and instability in a system.

In a negative feedback loop the polarity of action is such as to counteract any deviation from a desired state or condition. If the value of a variable is too large with respect to its desired level the system will put downward pressure on it, and vice versa. An example of this type of system would be the thermostat mentioned above. See Figure 5. It is negative feedback loops that cause the goal-seeking behavior within systems. The polarity issue is the characteristic of amplification in systems and serves as one of the three causes of system behavior.

The second cause of system behavior is structure. Structure relates how the parts of a system are linked. It includes the channels of information and physical flows into, through and out of the system. The third cause of system behavior is delays. As the structure of a system becomes more complex it becomes increasingly difficult to know what all parts of the system are doing instantaneously. Delays are information or material lags.

Returning to the example of Forrester about "a profitable industry attracts competitors" ... suppose the information about competitive entry is delayed. This delay would mean competitors would continue to enter the market after it has been saturated. The result of this would mean bankruptcies and business failures. This information would finally reach the market and scare off further competition perhaps temporarily aiding the survivors. The ultimate result of the information delay is oscillation around the equilibrium instead of reaching it. Delays represent a serious omission in most models particularly those that assume efficient markets, etc. The problems that are created by these two characteristics are too important to be ignored or assumed non-existent.

System dynamics models attempt to describe causal forces which produce change within a system. It is the characteristic of structure that allows models of this type to portray causal relationships because of two reasons. The first is that the structure of the system is defined to include causal links. Second, ceteris paribus is used in determining the mathematical relationships that are developed to model this structure. These are called the causal forces within the system.

One type of causal force is the process of accumulation or integration. For example, the level of equity on a firm's balance sheet is increased by retained earnings and sale of stock, and decreased by losses, share repurchase and dividends. Therefore, a system dynamics model of a firm's equity portion might look like the following relationship:

$$\text{EQUITY }(t) = \text{EQUITY }(t-1) + [\text{EARNINGS }(t-1) - \text{DIVIDENDS }(t-1)]$$

Or a level equals its previous values plus or minus all flows into and out of that level. The flows would be over time and thus integrated. Integrations are largely responsible for the dynamic behavior of real systems and system dynamics models of these systems.

Static relationships are also a causal force in systems. A static relationship is the relationship between two variables at a given time period. An example might be a classic demand curve or:

$$\text{DEMAND }(t) = F\ [\text{PRICE}(t)]$$

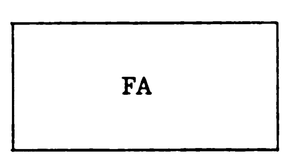
The relationship may be linear or non-linear and system dynamics can accommodate either type. Also graphical representations can be used if discontinuities or limited ranges exist using a DYNAMO table function to be explained later.

In summary, a system dynamics model consists of a set of equations defining various static causal relationships between variables and integration of variables. System dynamics models can be written as a set of first-order difference equations with the variables embedded within positive and negative feedback loops. It is this structure that determines the model's and system's behavior. A recursive simulation on the computer creates this behavioral pattern for examination by the modeler.[3]

2. Symbols for Flow Diagram

Forrester [Industrial Dynamics][4] explains that the complexity of relationships within systems or models of these systems requires a pictorial representation to understand these complexities better. Constructive criticism of the developing model is easier to solicit when the model is visible. This aids in avoiding "gut-feel" or intuitive criticisms based on the overwhelming nature of the model and its myriad mathematical equations. Due to the behavioral aspects of the technique, practicing managers without system dynamics backgrounds, can verify and comprehend the system phenomena that is being modeled. Thus, the need for a system dynamics flow diagram.

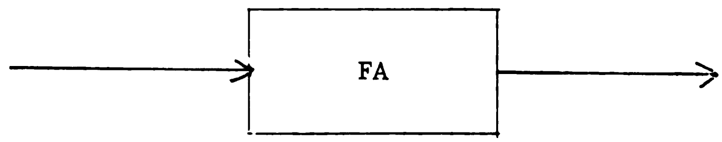
The first symbol to be used will be a rectangle to represent the levels or accumulations of the system. An example would be the level of fixed assets (FA) the firm has, thus:



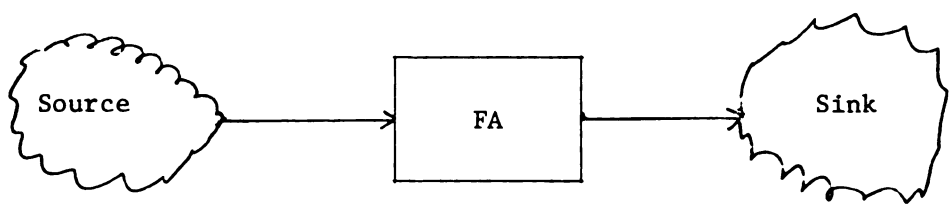
[3]Lyneiss, J., 1975.

[4]Forrester, Jay W., Industrial Dynamics, pp. 81-85.

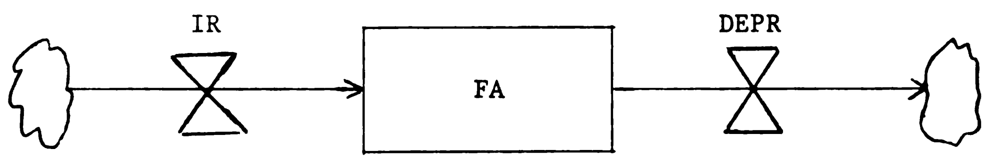
Next, there are physical flows into and out of this pool of fixed assets. These physical flows are represented by solid lined arrows as:



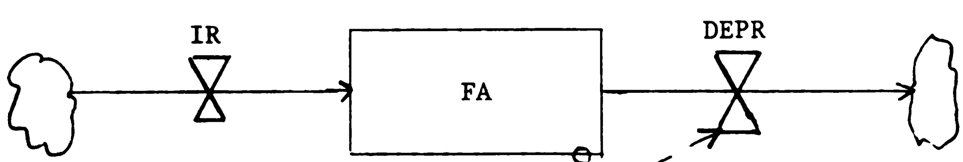
If these flows are initiated from, or are going to, outside the system's boundaries, sources and sinks are represented by amoebic shapes as:



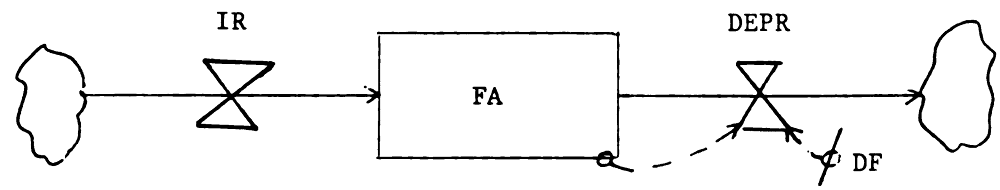
Decision functions or rate equations determine the speed of this physical flow of fixed assets. The inflow would be determined by the investment rate (IR) and the outflow by the rate of depreciation (DEPR) as:



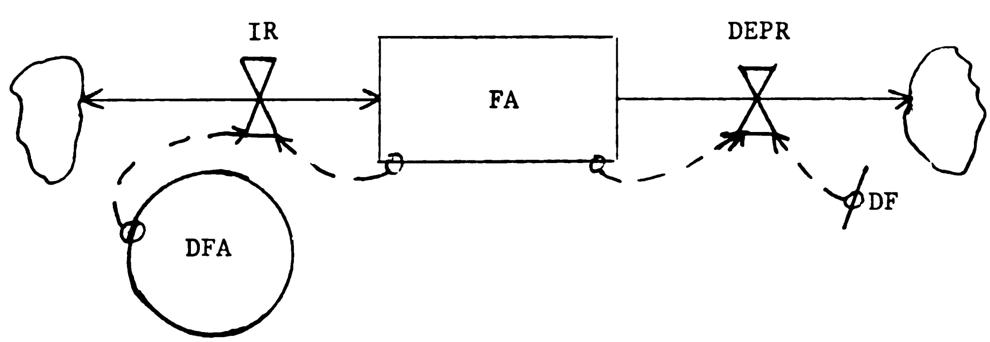
The depreciation rate is determined by the level of fixed assets. This is information that determines the rate. Information flows are represented by broken line arrows and the information take off point or source by a small circle as:



The firm's depreciation policy also determines the depreciation rate. This value could possibly be a constant called the depreciation fraction (DF) and constants are diagrammed as:



Auxiliary variables are concepts that are separated from the decision functions because they have independent meaning. They lie in the information flow path between accumulations and decision variables to model management control. It might be said that auxiliaries represent management interpretation of information to modify the dynamics of the system. An example would be in determining the investment rate. Not only will the level of FA determine IR but the desired level of FA or DFA. This desired level is a concept, thus an auxiliary variable diagrammed as a circle will look like:



Therefore, if the level FA is much lower than DFA, IR is increased. As FA approaches DFA, IR is slowed and is zero when FA equals DFA. If IR can go negative (divestiture), an arrow would point to the source amoeba also.

The determinants of DFA are excluded here because the purpose of this discussion is to illustrate the flow-charting conversions. Additional symbols that might be part of a system are simply variations of these that have been presented.

3. DYNAMO Mnemonics[5]

Continuing with the example in part 2 of this section, conversion to DYNAMO notation follows next in the sequence of development. DYNAMO is the simulation language available on the computer to solve complex system dynamics models. For the sake of simplicity and clarification, reference should be made to the last flow diagram in the previous part. An unusual characteristic of the notation is the subscripting method for time. As in most simulation languages, time is a variable and thus "K" will represent the present period, "J" the previous period and "L" the future period. Levels and auxiliaries will carry single subscripts because they are stock values, whereas rates will have a double subscript i.e. JK because flows take place over a period of time.

The level FA will be formulated as:

L   FA.K = FA.J + (IR.JK - DEPR.JK)*DT

where   FA.K = fixed assets in present period

FA.J = fixed asset level in previous period

IR.JK = investment rate from period J to K

DEPR.JK = depreciation rate from period J to K

DT = time interval on the simulation clock

The letter preceding the equation designates its type, e.g. L = level, R = rate.

---

[5]Pugh, Alexander L., Dynamo Users Manual, 1961.

Then, an initial value or start-up value of FA can be designated by the following two equations:

N FA = F

C F = 100000.

where F = constant (no time subscript)

FA = initial value of FA.K with no time subscript

The rate equation for depreciation could be

R DEPR.KL = FA.K * DF

where DEPR.KL = depreciation rate for the next time period

DF = constant depreciation factor

Auxiliary values are determined in various ways. One way is the functional form e.g. DFA could be a function of interest level INT and growth G

A DFA.K = INT.K * G.J

or the functional relationship could be graphically determined by

A DFA.K = TABLE (DFAT, INT.K. .06, .12, .02)

T DFAT = 180000/170000/160000/150000

where DFA is a function given by the table or graph with ordinate of interest rates and abscissa of the desired fixed asset level. The T function tells what values DFA will have at interest rates of .06, .08, .10, and .12.

Other useful functions are:

SMOOTH - averages or smooths over a period of time

SWITCH - an on-off switching function

NOISE - develops a random function

PULSE - creates a pulse input to system

STEP - increases or decreases a variable at a set time

NORMRN - for a normally distributed variable

CLIP - limits a function, used for discontinuities

RAMP - used to input a value that steadily increases or decreases

TABXT - a table function that extrapolates at the extremities

TIME - a variable that increments with the simulation time clock.

The DYNAMO compiler is a FORTRAN based language and therefore performs all or most FORTRAN arithmetic functions. Various plotting and printing capabilities will be utilized.

4. Validation

A system dynamics simulation model can be an equilibrium model. The model is constructed using the present policies which cause the behavioral patterns exhibited by the system. Given that these policies remain fixed over a time period, a steady-state condition may be approximated. This condition is known as the "base run" and the effects of policy intervention are related to it.

The validity of the base run is tied to the reference mode proposed. Known behavioral patterns of the system, from historical data, must be replicated by the model. The reference mode will be the actual accounting data collected for the study. The model is not designed to make exact point forecasts of parameter values but to exhibit the same behavior as the system. Therefore, the reference mode becomes some graphical mapping of, for example, total assets and the model is designed to follow that mapping closely.

5. Sensitivity Analysis

Once the model is validated to historical data, sensitivity analysis begins. This analysis is performed by modifying table functions and parameter values one at a time. Changes in one table function or parameter should not create large deviations in the model's behavior. If such deviations occur, additional structure is added to the model to better represent the system.

6. Policy Testing

Once the model reproduces the reference mode and sensitivity analysis is concluded, policy testing can begin. To perform a policy test one or more fixed variable values are modified. After this intervention the model is rerun over the same period as the base run. Comparison to the base run yields three possible results:

1. The system's variables return to their base run equilibrium values.
2. The system's variables reach other than the base run equilibrium values but equilibrium is reached at this new plateau.
3. The system reacts by becoming unstable and no equilibrium is reached.

The third result may suggest modeling errors if the system is stable to begin with. One change should not have that much effect on a complex but stable system. Parameter values are then reexamined and the base run model usually undergoes alterations. This, is conditional upon the validity of the specified relationships. The strength of the argument in favor of base run model changes is enhanced if historical data is available concerning the aforestated modification. Unfortunately, soft variable data are not always available and license must be given to the modeler to determine these.

C. Study Procedures

1. Model Construction

A generic model of a large U.S. corporation was constructed first. Three main areas of the model were the asset mix, the liability mix and the equity mix of the firm. The process used for completing this step was as follows:

a. Developing a dynamic hypothesis - This process included examining real data or observed behavior of a firm. The hypothesis is a testable explanation of that behavior.

b. Identifying a reference mode - The model was built to describe behavior. A reference mode of behavior must be identified in order to imitate the system's behavior via the model, e.g., the movement of the share price over time of a given firm.

c. Diagramming the causal-feedback loops of the system - The system is broken down into sub-components and the relationship between these sub-components is diagrammed.

d. Flowcharting the causal-feedback relationships - This step translated the causal-feedback loop diagram into a system dynamics flowchart.

e. Coding the model in DYNAMO - From the flowchart the model was coded into DYNAMO computer notation in order to run the model on the computer.

f. Running on the computer - This step included entering the coded program on the computer, debugging the DYNAMO errors, debugging the FORTRAN errors and storing the file on the disk for future use. Debugging modifications also meant changes in steps d and e above.

2. Validation

The validation process included choosing an actual firm in order to use their data in the model. This step was completed when the model behavior replicated the firm's behavior or reference mode. During this process, alterations of the model's structure took place on several occasions until the validity of the model was confirmed. Thus it became necessary to return to earlier steps in the procedure and make modifications during this process. Chapter V details this procedure.

3. Sensitivity Analysis

This process was performed by testing the model to sensitivity to changes in parameter values or table function slopes. It was a detailed step that included rerunning the model on the computer using various values of one parameter. As the model reacted, the modeler decided if the system behaved in a similar fashion. Sometimes empirical evidence was available to assist the modeler in this judgment.

If the reaction was too severe, modifications in the structure of the model were called for, usually adding structure. If the reaction was not severe enough, the parameter's usefulness in the model was questioned or some buffering structure in the model had to be removed. The iterations in this step were a considerably large number.

This step represented the fine-tuning of the model that also helped anticipate unexpected behavior in the policy testing stage. When structural changes occurred the model had to be revalidated.

4. Policy Testing

When the model had undergone the validation and sensitivity analysis steps it was ready to be used by the decision-maker. The following tests were conducted to investigate policy effects:

a. Modification of debt/equity levels - This policy intervention was conducted by trying a broad spectrum of debt/equity levels from o to 3.

b. Modification of dividend payout rates - This policy intervention was conducted by including the total spectrum of possibilities from 0% to 100%.

c. Modification of both debt/equity levels and dividend payout rates - This policy intervention was conducted by including combinations of a and b above.

5. Analysis of Results

The results of the policy interventions were compared to the base run or the initial model run. The behavior of the output variables representing return and risk were examined and explained. The explanation of the policy intervention results was based on theory. "One purpose of a simulation model is to explain theory."[6]

6. Statistical Tests

The three policy change combinations indicated in section 4 above were performed. Results of these tests were deterministic in nature and thus significance was observed without statistical testing. Any

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[6]Narasimhan, Ram, Lecture notes from MGT 937, System Simulation.

change from prior policy intervention equilibrium was considered significant.

This concludes the description of the methodology employed in this study. The remainder of the text will describe the model and the results of the steps described in section C of this chapter.

CHAPTER IV

MODEL DESCRIPTION

This chapter describes the model developed. First, the modeling and parameter estimation processes are documented. After this, a statement-by-statement explanation of the model's DYNAMO code is given. The causal-feedback loops of the model are described and analyzed. Finally, the model's block diagram is portrayed in order to summarize the content of the model. The purpose of these five sections is to convey a working understanding of the model.

A. The Modeling Process

The modeling process included four steps. Step 1 was to develop the underlying structure of the model. This structure included the accumulation of accounting data for the Balance Sheet and the Income Statement. Step 2 was the addition of decision variables in order to recreate the dynamic nature of the system. Step 3 was the introduction of exogenous variables that act upon the system. Step 4 was the modification or fine-tuning phase. This step included the development of soft variable values.

When empirical data were available they were used. Otherwise, parameter values were estimated by interviewing the management of the firm being modeled or were developed using relationships derived from theoretical context. This technique for estimating system dynamics parameters was suggested by Forrester (1961) and is discussed in the next section.

B. Estimation of Parameter Values

To estimate parameter values empirical data, when available, were used. When empirical data were not available or could not be identified, parameters were estimated from information obtained by interviewing the firm's management. The managers were asked to suggest an appropriate value for a given parameter.

When management was unable to formulate an estimate, the modeler provided the value. A pioneer in the field, Jay W. Forrester, in the classic work Industrial Dynamics suggested the use of the procedures followed above. The following statement explains the parameter estimation technique used in this study.[7]

> The reader may at first object to the arbitrary liberties just exhibited in selecting values of parameters. The preceding is inconsistent with much of the statistical estimating effort exhibited in the management science and economics literature. However, I feel that extensive data gathering and analysis should follow the demonstration of a need for more accuracy in a particular parameter. For many purposes values of parameters anywhere within the plausible range will produce approximately the same results.
>
> It must be true that most industrial and economic systems are not highly sensitive to small changes in parameters; otherwise their whole qualitative dynamic character would be much more changeable than it is. To a first approximation, economic fluctuation continues decade after decade in similar patterns although many details of the system have been greatly modified. In the last two hundred years we have changed our form of government and our banking system; government expenditure has risen to a substantial fraction of our national production; the country has shifted from largely agricultural to largely industrial activity; and transportation and communication speeds have increased by a factor of 100. Yet in spite of these changes our capitalist economic system persists in similar

---

[7] Forrester, Jay W., Industrial Dynamics (MIT press, Cambridge, MA, 1961), p. 171-172.

fluctuations and trends in growth and monetary inflation. We shall find that the complexity of the system structure, the existence of delays distributed throughout, the decisions that introduce amplification, and the time constants that arise from human memory and action and life span all combine to produce system behavior that is independent of reasonable changes in most of the parameters.

An information-feedback system is a system of counterbalancing influences. An error in one factor is often balanced within the system of self-induced changes in other factors. The more complete and realistic the system, the less sensitive we should expect it to be to small changes in most of the individual parameters.

Tests on the model itself can be used to determine model sensitivity to values of parameters. When a peculiarly sensitive parameter is identified, we are faced with more problems than merely measuring its value. Perhaps we can measure it accurately, but we must have confidence that the value is constant with time. Otherwise it may be an important system variable, and if its source of variation cannot be identified, our model behavior may be misleading. Maybe the parameter is one that can be controlled, once its importance is realized. If the parameter cannot be measured accurately, or is not constant, or cannot be controlled, then perhaps we can redesign the structure of the industrial system so that the system behavior is no longer vulnerable to the value of and changes in the parameter.

In the next section of this chapter table functions depict the parameter estimates of soft variables or functions of soft variables.[8] The table functions do not portray the only useful functional relationship that exists between the two variables. The functions show the results of one process used to get a reasonable output. It is possible that other tables would yield reasonable outputs as well.

All of the variables were initialized with empirical values. Seven of the twelve parameters used were estimated with empirical data as well. Those parameters that were subjectively determined are discussed further in the Parameter sensitivity analysis section of Chapter V.

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[8]"Soft variables" are those which are not based on empiricism. They may represent the accumulative thought process of the system's participants, for example.

The model was built using accounting as a measure of assets' value. Initially, accounting measures market value. Three factors cause accounting values to depart from the market's price-level changes, accounting technique employed and changes in investment policy. Thus, there were distortions in the estimation of the value of the firm's wealth and earning power.[9]

In the following section reference is made to a process called "qualitative" in the determination of graphical relationships. This process involved interviews of the firm's management concerning the dynamics of a decision within the firm and converting the results of those interviews into graphical depictions. Therefore, the graphs were developed with a researched, although not strictly empirical, basis.

C. DYNAMO Statement Description

The equations referred to in this section can be found in Appendix 1, Computer Model listing. Statement 100 is a control statement that directed the computer regarding output size. All equations were calculated simultaneously by period, thus order is irrelevant to the compiler.

1. Pink Noise Generator

```
L PKNSE.K=PKNSE.J+(DT/TCN)(SFN*NOISE()+MNSE-PKNSE.J)  (140)
N PKNSE+MNSE                                          (150)
N SFN=SDN*SQRT(24*TCN/DT)                             (160)
C MNSE=1                                              (170)
C SDN=0                                               (180)
C TCN=40                                              (190)
```

[9] APB Statement No. 3, "Financial Statements for General Price-Level Changes," AICPA, New York, 1963.

Sterling, Robert R., "Relevant Financial Reporting in a Period of Changing Prices," Journal of Accountancy, February 1975. See Appendix 7 for market to book depiction.

```
where:  PKNSE = Pink autocorrelated noise (Dimensionless)
           DT = Simulation time clock change (Years)
          TCN = Total noise period (Years)
          SFN = Standard deviation of the pink noise
                (Dimensionless)
      NOISE() = DYNAMO white noise generationg function
                (Dimensionless)
          SDN = Standard deviation of the NOISE()
                (Dimensionless)
```

Statements 140 through 190 constituted a macro that generated random, autocorrelated numbers with a mean value of 1. This macro is called a pink noise generator because the noise is autocorrelated, in contrast to white noise which is not. The macro was used when randomness was required by the model user. Testing, validation and policy runs were performed without this generator in operation, thus a switch, SDN=0, in statement 180 was used. To turn on the generator a standard deviation around the mean value of 1.0 was designated by changing SDN to that value.

2. Invested Assets

```
L INVA.K=INVA.J+(INVR.JK-DEPR.JK)*DT                         (220)
N INVA=IINVA                                                 (230)
C IINVA=300                                                  (240)
R INVR.KL=INVRF.K+STEP(HGHT,STTM)-STEP(HGHT,STTM2)+
  DEPR*INVA.K                                                (250)
R DEPR.KL=INVA.K*DEPF                                        (260)
C DEPF=.30                                                   (270)
A INVRF.K=AFUNDS.K*IF.K                                      (280)
A IF.K=NINMIX*ECRIF.K                                        (290)
C NINMIX=.75                                                 (300)
A ECRIF.K=TABHL(TECRIF,CR.K/TCR,0,2,.5)                      (310)
T TECRIF=0,.75,1.0,1.2,1.33                                  (320)
A CR.K=(FINA.K+FUNDS.K)/LIAB.K                               (330)
C TCR=2.5                                                    (340)
```

```
where:  INVA = Total book value of fixed assets ($)
        INVR = Investment rate in fixed assets ($/year)
        DEPR = Depreciation rate ($/year)
       INVRF = Investment rate in new fixed assets ($/year)
        DEPR = Depreciation fraction (1/year)
          IF = Fraction of available annual funds desig-
               nated for fixed asset investment (1/year)
```

DT = Time clock increment (years)
AFUNDS = Available funds for investment ($)
NINMIX = Normal investment mix (Dimensionless)
ECRIF = Effect of the current ratio on the investment fraction (Dimensionless)
CR = Current ratio (Dimensionless)
TCR = Target current ratio (Dimensionless)

Statements 220 through 340 related the accumulation of fixed assets by the firm over time. The level INVA.K was the book value of the fixed asset pool or invested assets. It equalled its previous time period's level INVA.J plus new investment INVR.JK minus depreciation DEPR.JK times DT. This equation represented a strict cash accounting for fixed assets. INVR.JK was a negative number if the firm was undergoing divestiture. DEPR.JK was always a positive number or zero.

The invested asset or fixed asset pool was initialized at $300,000,000, the 1934 level for Union Oil Company of California, the firm being modeled. INVR.KL or the investment rate in fixed assets equalled INVRF.K plus an additional investment impulse, STEP (HGHT, STTM), which represented investment in a new risk category. HGHT was the amount of that investment increment and STTM was the time of occurrence.

INVRF.K was determined in the statement 280 as the product of AFUNDS.K, the available funds for period K, with IF.K, the investment fraction designated for fixed asset investment. AFUNDS.K was calculated in statement 3040 as the excess of funds over a desired minimum balance.

IF.K, the investment fraction or fraction of new investment for fixed assets, was determined in statement 290. It equalled NINMIX or 75% of new funds available times a multiplier for the effect of current ratio on IF or ECRIF.K. The 75% figure represented a normal condition. The current ratio's effect on IF was included because management has a target level for liquidity. Therefore, in times of low liquidity compared to that target more funds would be channeled to the current asset pool.

Figure 6 shows values of ECRIF at different levels of the current ratio, CR.K. This relationship was determined qualitatively. The steepness of the curve as the current ratio falls below the target current ratio represented management's concern to maintain a liquid position. This would be considered a prudent business practice. Higher than target liquidity levels would create an opportunity loss because fixed capital investment has a higher mean return than investment in liquid assets. Therefore, more funds would be channeled into the fixed asset pool as the target was exceeded. The curve was flatter on the upper end because the behavioral dynamics were not the same as they were at the lower end. Less concern was exhibited for higher-than-target liquidity levels.

The current ratio was determined in statement 330 as current assets, FINA.K+FUNDS.K, over current liabilities, LIAB.K. The effect of the current ratio was related to a target of 2.5. This target was a management determined policy.

3. <u>Financial Assets</u>

```
L FINA.K=FINA.J+FINVR.JK*DT                          (380)
N FINA=IFINA                                         (390)
C IFINA=100                                          (400)
R FINVR.KL=(AFUNDS.K*(1-IF))-STEP(FHGHT,STTM)+
  STEP(FHGHT,STTM2)                                  (410)
```

where: FINA = Level of financial or non-cash current assets ($)

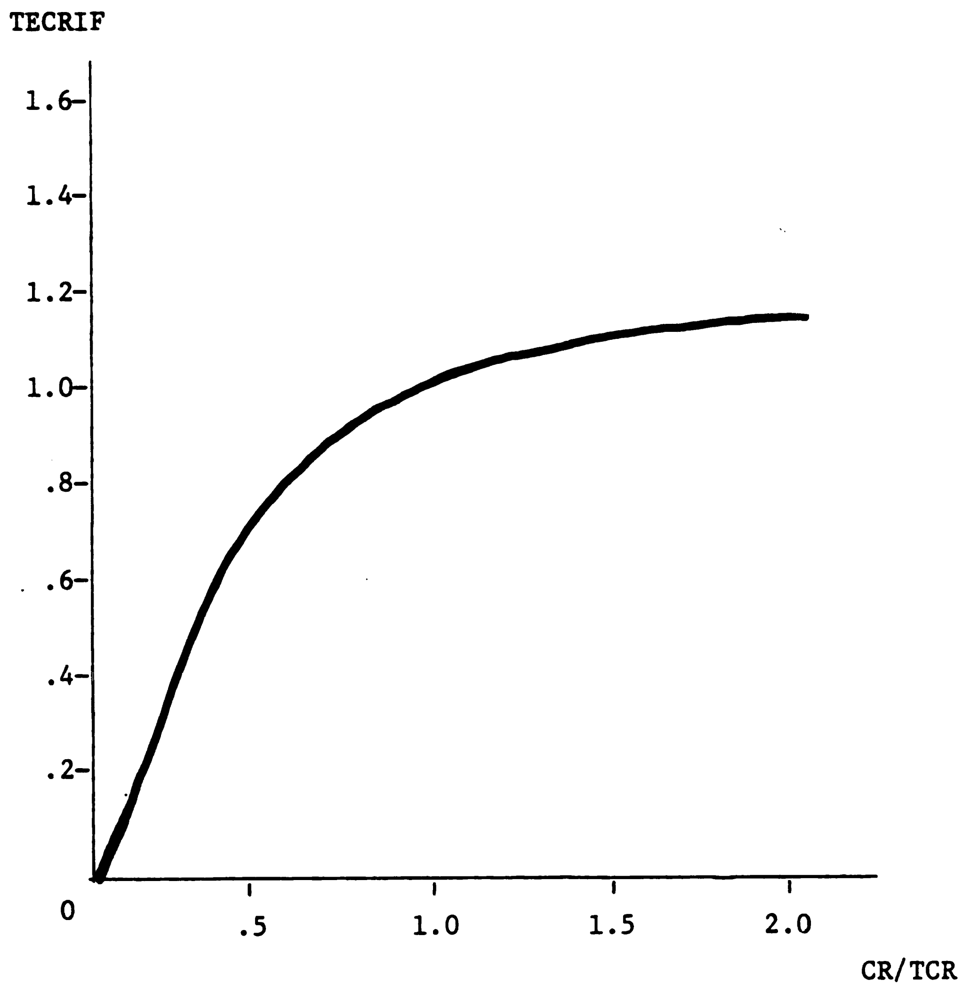


Figure 6: The Effect of Current Ratio on Investment Fraction

FINVR = Financial asset investment rate ($/year)
DT = Time clock increment (years)
AFUNDS = Available funds for investment ($)
IF = Investment fraction for fixed assets (1/year)

Statements 380 through 410 calculated the accumulation of non-cash current assets by the firm over time. FINA.K was the level of these current assets at the present time. It was a function of the previous period's current asset pool, FINA.J, plus the investment rate in financial assets. FINVR.JK. The initial level of current assets was $100,000,000. FINVR.KL, the rate of investment in non-cash current assets was determined by AFUNDS.K, available funds, times (1-IF), the leftover portion of funds after investment in fixed assets. The STEP (FHGHT, STTM) was the impulse of a diversifying (new risk category) investment policy with the amount of additional investment equal to FHGHT at time STTM.

4. Equity

```
L EQ.K=EQ.J+CIE.JK*DT                                    (450)
N EQ=IEQ                                                 (460)
C IEQ=200                                                (470)
R CIE.KL=DEQF.K+STEP(EHGHT,STTM)-STEP(EHGHT,STTM2)       (480)
```

where: EQ = Book value of equity ($)
CIE = Change in equity ($/year)
DT = Time clock increment (years)
DEQF = Desired equity funding ($/year)

Statements 450 through 480 depicted the accumulation of book equity by the firm over time. EQ.K was the level of equity at time K. It was calculated by adding the change in equity, CIE.JK, times DT, the time change, to the period's equity level, EQ.J. Equity was initialized at $200,000,000 and represented all outstanding stock of the firm.

The change in equity, CIE.KL, in statement 400, was determined by a management decision variable desired equity funding, DEQF.K (see Desired Funding section), plus a STEP (EHGHT, STMM) for needed equity in the case of a new investment. DEQF.K was determined by the desire for external funding and a target debt/equity ratio. Rate equations represented the decisions of management and they used these two variables as the basis for this decision. EHGHT was the step height or net increase in equity and STTM was the time the equity would be needed. CIE.KL was positive when the firm sold stock and negative when it repurchased its own stock.

5. Long-term Debt

```
L DEBT.K=DEBT.J+(CID.JK-DRR.JK)*DT                        (520)
N DEBT=INDEBT                                             (530)
C IDEBT=130                                               (540)
R DRR.KL=DEBT.K*(L/NLD)                                   (550)
C NLD=20                                                  (560)
R CID.KL=(DDEBTF.K*(1-MIX.K))+STEP(DHGHT,STTM)-
  STEP(DHGHT,STTM2)                                       (570)
```

where: DEBT = Book value of long-term debt ($)
CID = Change in debt ($/year)
DRR = Debt retirement rate ($/year)
DT = Time clock increment (years)
NLD = Normal length of long-term debt (years)
DDEBTF = Desired long-term debt funding ($/year)
MIX = Debt mix short-term to long-term (Dimensionless)

Statements 520 through 570 portrayed the accumulation of long-term debt by the firm over time. DEBT.K was the level of long-term debt at time K. It was calculated by adding the change in debt, CID.JK, minus the debt retirement rate, DRR.JK, times DT, the time change, to the previous level of long-term debt, DEBT.J. Long-term debt was initialized at $130,000,000.

The debt retirement rate, DRR.KL, in statement 550, was calculated by multiplying the level of debt, DEBT.K, times one over the normal length of debt, NLD, which was set at 20 years. The change in debt, CID.KL, in statement 570, was determined by a management decision variable desired debt funding, DDEBTF.K (See Desired Funding section) times (1-MIX.K) plus a STEP (DHGHT, STTM) for needed debt to fund a new investment. DDEBTF was determined in the same manner as DEQF. DHGHT was the step height, or net increase in long-term debt, and STTM the planned period of the investment. DRR.KL was always a positive number. CID.KL was positive when the firm secured new debt or negative when it called in existing debt. MIX.K was a management determined fraction of desired short-term debt over long-term debt. (See Debt Mix). It was calculated matching long-term debt to long-term assets which is consistent with current financial practice.

6. Short-term Debt

```
L LIAB.K=LIAB.J+CIL.JK*DT                                  (610)
N LIAB=ILIAB                                               (620)
C ILIAB=70                                                 (630)
R CIL.KL=DDEBTF.K*MIX.K+STEP(LHGHT,STTM)-
  STEP(LHGHT,STTM2)                                        (640)
```

where: LIAB = Book value of current liabilities ($)
CIL = Change in liabilities ($/year)
DT = Time increment (years)
DDEBTF = Desired debt funding ($/year)
MIX = Debt mix (Dimensionless)

Statements 610 through 640 portrayed the accumulation of short-term debt or liabilities by the firm over time. LIAB.K was the level of short-term debt at time K. It was calculated by adding the change in liabilities. CIL.JK, times DT, the time change, to the previous period's level of short-term debt, LIAB.J. Short-term debt was initialized at $70,000,000 and represented all short-term liabilities that became due during the accounting period.

The change in liabilities, CIL.KL, in statement 640, was calculated by multiplying a management decision variable desired debt funding, DDEBTF.K (See Desired Funding section) times MIX.K plus a STEP (LHGHT,STMM) for needed short-term debt to fund a new investment. LHGHT was the step height or net increase to short-term debt and STMM the planned period for the investment. CIL.KL was positive when securing more short-term debt and negative when securing less short-term debt than current levels.

7. Funds

```
680=L FUNDS.K=FUNDS.J+(CIE.JK+CID.JK+CIL.JK-
      (DRR.JK+INVRF.JK+                                  (680)
690=X FINVR.JK)+RCF.JK)*DT                               (690)
700=N FUNDS=IFUNDS                                       (700)
710=C IFUNDS=75                                          (710)
720=R RCF.KL=CF.K                                        (720)
```

where: FUNDS = Cash assets ($)
CIE = Change in equity ($/year)
CID = Change in long-term debt ($/year)
CIL = Change in liabilities ($/year)
DRR = Debt retirement rate ($/year)
INVRF = Investment rate in fixed assets ($/year)
FINVR = Investment rate in financial assets ($/year)
RCF = Rate of internal cash flow generations ($/year)
DT = Time increment (years)
CF = Cash flow ($/year)

Statements 680 through 720 modeled the dynamics of the accumulation of cash by the firm over time. FUNDS.K was the level of cash on hand at time K. It was calculated by adding all the cash inflow rates from equity (CIE), debt (CID), and liabilities (CIL) less all the cash outflow rates from debt retirement (DRR) and investment (INVRF and FINVR) to the cash flow rate from operations (RCF) times the time constant, DT, to the previous funds level, FUNDS.J.

8. Retained Earnings

```
A RE.K=FUNDS.K+INVA.K+FINA.K-(LIAB.K+DEBT.K+EQ.K)      (760)
```

where: RE = Level of retained earnings ($)
FUNDS = Cash on hand ($)
INVA = Invested assets ($)
FINA = Invested assets ($)
LIAB = Liabilities ($)
DEBT = Long-term debt ($)
EQ = Equity ($)

Statement 760 calculated the value of retained earnings, RE.K, at time K. The calculation was performed by subtracting total equities from total assets. RE.K may be positive or negative.

9. Debt/Equity Ratio

```
A TE.K=EQ.K+RE.K                                        (800)
A TD.K=DEBT.K+LIAB.K                                    (810)
A DE.K=TD.K/TE.K                                        (820)
```

where: TE = Total equity ($)
EQ = Equity ($)
RE = Retained earnings ($)
TD = Total debt ($)
DEBT = Long-term debt ($)
LIAB = Liabilities ($)
DE = Book debt/equity ratio (Dimensionless)

Statements 800 through 820 were used to determine the book value debt/equity ratio of the firm. First, total equity, TE.K, was calculated by adding equity, EQ.K, and retained earnings, RE.K. Next, in statement 810, total debt, TD.K, was determined by adding long-term debt, DEBT.K, to short-term debt, LIAB.K. Finally, in statement 820, the debt/equity ratio, DE.K, was calculated as total debt, TD.K, over total equity, TE.K.

10. Credit Extension

```
A CEX.K=EBCCX.K*ECRCX.K*EIFCX.K*80                     (860)
A EBCCX.K=TABLE(TEBCCX,BC.K/NBCCFC,-2,2,1.0)           (870)
T TEBCCX=.75,.875,1.0,1.125,1.25                       (880)
A EIFCX.K=TABHL(TEIFCX,INTF.K/PERCIN.K,0,3,.5)         (890)
T TEIFCX=1.2,1.1,1,.9,.8,.7,.6                         (900)
A PERCIN.K=SAMPLE(INTF.K,1.0,.1)                       (910)
A ECRCX.K=TABHL(TECRCX,CR.K/TCR,0,1,.25)               (920)
T TECRCX=0,.6.9,1.0,1.0                                (930)
C NBCCFC=1.0                                           (940)
```

where: CEX = Credit extension from outside sources (%)
EBCCX = Effect of business conditions on credit extension (Dimensionless)
ECRCX = Effect of current ratio on credit extension (Dimensionless)
EIFCX = Effect of interest rate fraction on credit (Dimensionless)
BC = Business condition (Dimensionless)
NBCCFC = Normal business conditions for credit (Dimensionless)
INTF = Interest rate fraction, short-term to long-term (Dimensionless)
PERCIN = Perceived interest fraction (Dimensionless)
CR = Current ratio (Dimensionless)
TCR = Target current ratio (Dimensionless)

Statements 860 through 940 were written to determine the amount of credit extension outside sources of short-term, non-interest bearing funds will allow. Credit extension, CEX.K, at time period K was equal to the product of the effect of business conditions on credit extension, EBCCX.K, the effect of the current ratio on credit extension, ECRCX.K, the effect of the interest rate fraction, EIFCX.K (the short-term rate over the long-term rate), and 80% which represents a normal level of credit extension offered the firm. Credit extension had values from 0 to 100 percent.

Statements 870 and 880 determined the effect of business conditions on credit extension. Figure 7 shows this effect graphically. As the business conditions improved the amount of credit offered was increased. The business cycle was exogenous to the firm and the model. The

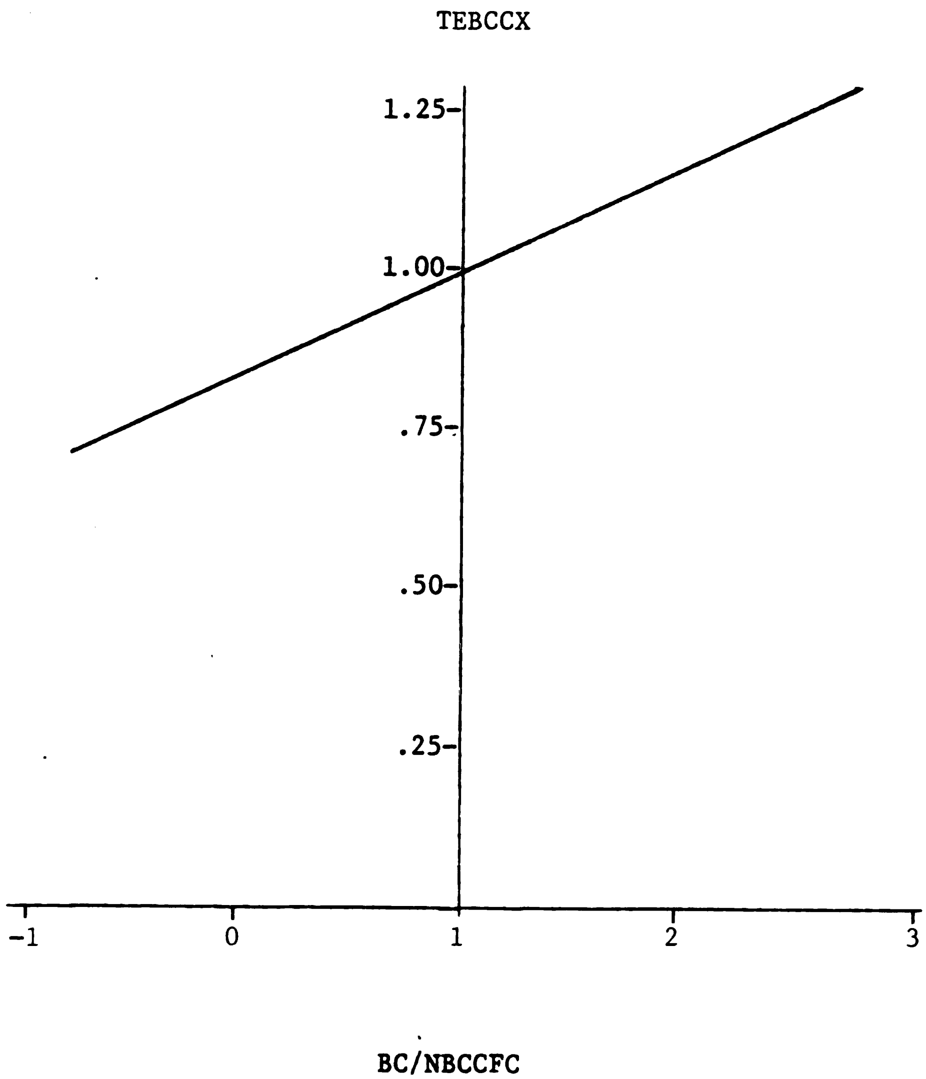


Figure 7: Effects of Business Conditions on Credit Extensions

relationship was qualitatively determined and intends to portray the firm's reaction to degrees of money tightness.

Statements 890 and 900 determined the effect of the interest rate fraction on credit extension. Figure 8 shows this effect graphically. As the ratio of the short-term rate over the long-term rate increased, credit extension decreased. The relationship was consistent with firm behavior. As the short rate increased relative to the long rate, sensitivity to the use of short-term funds grew. This created a reduction in credit extension.

Statements 920 and 930 determined the effect of the current ratio on credit extension, ECRCX.K. Figure 9 shows this effect graphically. The relationship represented creditor concern for liquidity. This concern was deepest when the current ratio neared or went below 1.0. On the positive end the effect was viewed as nonrestrictive.

11. Exogenous Variables

```
A BC.K=TABLE(TBC,TIME.K,0,44,.25)                                  (980)
T TBC=-2,-2,-2,-2,-2,-2,-2,-2,1,1,1,1,2,-1,-1,-1,                  (990)
 X -2,1,1,1,2,-1,-1,-1,-1,-1,-2,1,1,1,2,-1,                        (1000)
 X -2,1,1,1,1,1,2,1,                                               (1010)
 X 0,1,1,1,1,1,1,1,2,-1,-1,-1,-2,1,2,-1,                           (1020)
 X 0,-1,-1,-1,-2,-2,-2,-2,-2,1,1,1,2,-1,-1,-1,-2,1,1,1,            (1030)
 X 2,-1,-1,-1,-2,1,1,1,2,-1,-1,-1,-2,1,1,1,                        (1040)
 X 2,-1,-1,-1,-2,1,1,1,2,-1,-1,-1,2,1,,1,1,1,1,1,                  (1050)
 X 2,-1,-1,-1,-2,1,2,-1,-2,1,-1,-1,-2,1,2,-1,2,1,1,1               (1060)
 X -2,-1,-1,-1,1,2,-1,-1,-1,-2,1,1,2,-1,-1,-1,                     (1070)
 X -2,1,1,1,1,1,1,1,2,-1,-1,-1,-2,-2,-2,-2,                        (1080)
 X -2,1,1,2,-1-2,1,2,2,2,2,1                                       (1090)


 A STOCK.K=TABLE(TSTOCK,TIME.K,0,43,.25)                           (1250)
 T TSTOCK=-2,1,-2,1,2,-1,-1,-1,-2,1,1,1,1,1,2,-1,                  (1260)
 X -1,-1,-1,-1,-2,1,2,-1,-2,-1,-1,-2,-1,-1,-1,-2,                  (1270)
                                                                   (1280)
 X -2,1,-1,-1,1,1,1,1,1,1,1,1,1,1,1,1,                             (1290)
 X 2,-1,-1,-1,-1,-1,0,-1,                                          (1300)
 X -2,1,0,-1,-2,-2,-2,-2,-2,-2,-2,-2,-2,1,1,1,                     (1310)
 X 1,1,1,1,1,1,1,1,0,1,1,1,2,-1,-1,-1,
```

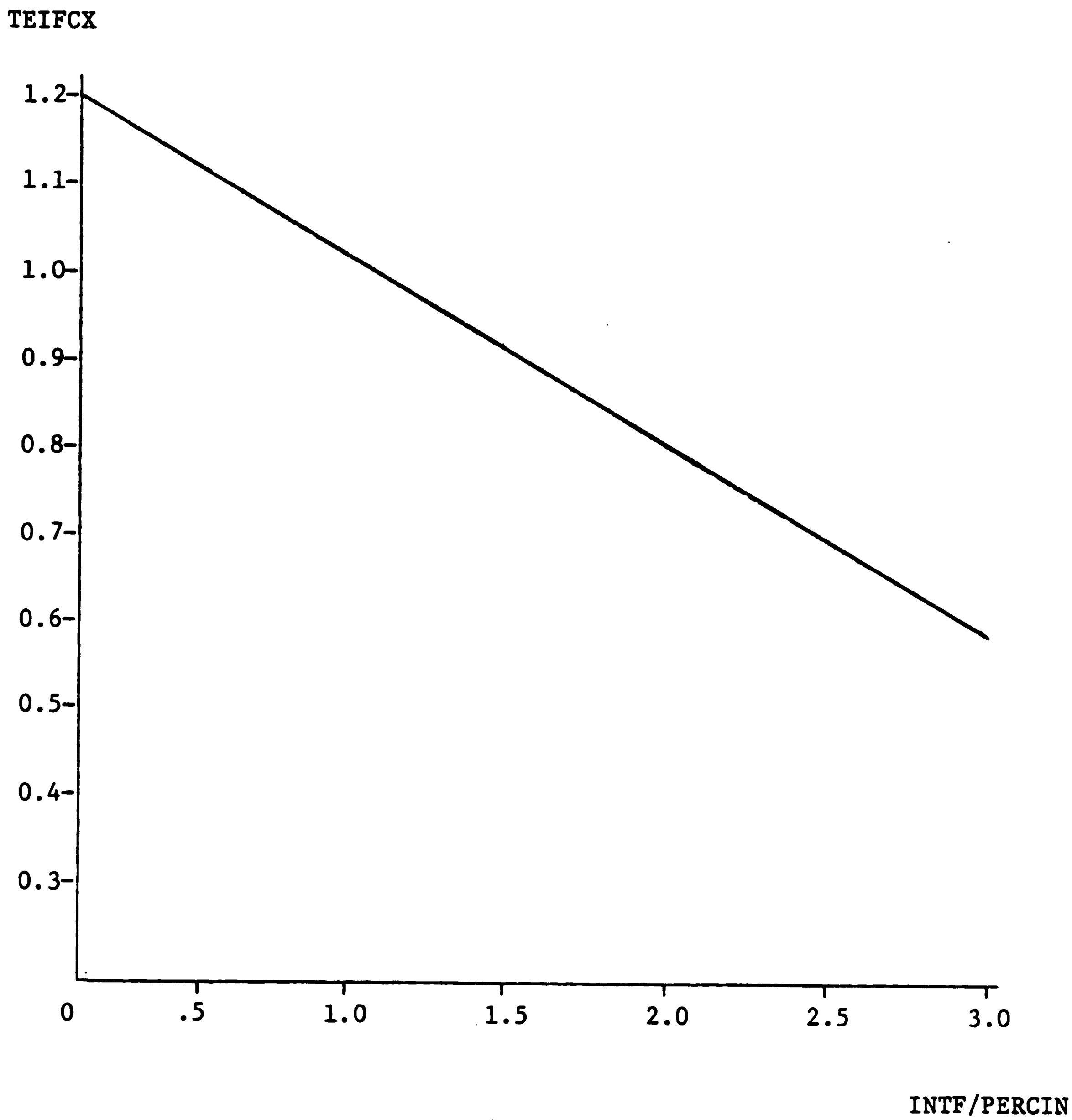


Figure 8: Effect of Investment Fraction on Credit Extension

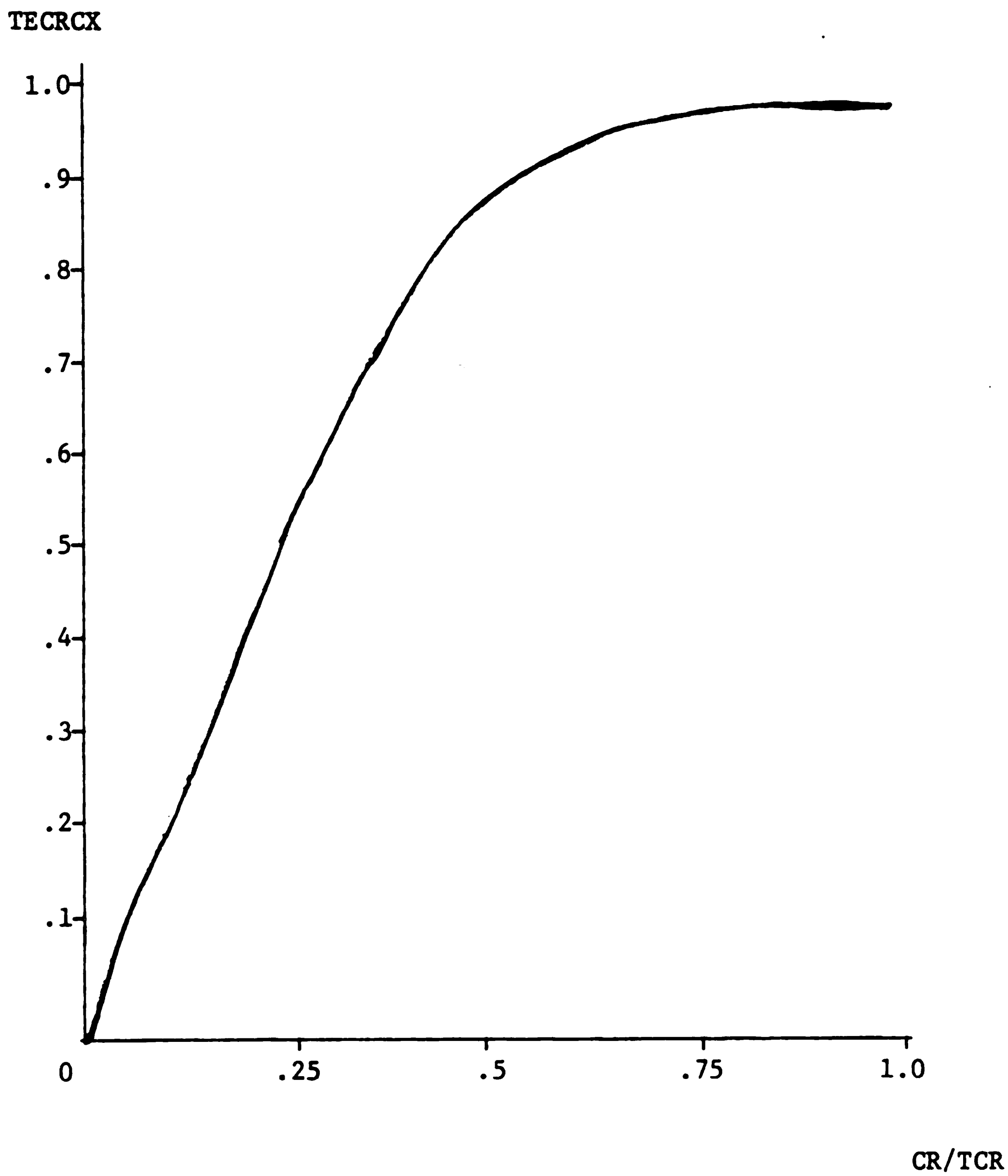


Figure 9: The Effect of Current Ratio on Credit Extension

```
X -1,-1,-2,1,1,1,2,-1,-1,-1,-1,-1,-2,1,1,1,                         (1320)
X 1,1,1,1,1,1,2,-1,                                                 (1330)
X -2,1,1,1,2,-1,-1,-1,-2,1,1,1,1,1,2,-1,0,                          (1340)
X 1,1,1,2,-1,-1,-1,-2,1,1,1,1,1,2,-1,                               (1350)
X -1,-1,-1,-1,-2,1,1,1,1,1,1,1,2,-1,-1,-1,                          (1360)
X -1,-1,-1,-1,-1,-1,-2,1,1,1,2,1,0                                  (1370)
A LTGOV.K=TABLE(TLTGOV,TIME.K,0,43,1)                               (1380)
T TLTGOV=3,2.8,2.8,2.8,2.6,2.4,2.2,2,2.5,2.5,2.5,2.3,2.1,2.2,2.4,   (1390)
X 2.2,2.2,2.5,2.7,,3,2.7,2.9,3.1,3.5,3.4,4.2,4.1,3.9,4,4,           (1400)
X 4.3,4.3,4.8,5,5.5,6.4,7,6.3,6.1,7.1,8.1,8.4,8.1,8.1               (1410)
A TBILL.K=TABLE(TTBILL,TIME.K,0,43,1)                               (1420)
T TTBILL=.2,.2,.2,.3,0,0,0,.1,.3,.4,.3,.3,.4,.5,.8,1.1,1.2,         (1430)
X 1.5,1.7,1.8,.9,1.6,2.5,3.1,1.5,3,2.7,2.1,2.7,3.1,3.5,3.9,4.8,     (1440)
X 4.2,5.2,6.6,6.5,4.4,3.8,6.9,8,5.8,5.1,5.1                         (1450)
A PRIME.K=TABLE(TPRIME,TIME.K,0,43,1)                               (1460)
T TPRIME=1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,   (1470)
X 1.8,2,2,2,2.8,3,3.25,3,3,4,4.5,4.5,4.5,4.5,4.5,4.5,4.5,4.5,       (1480)
X 6,5.5,6.5,8.5,7,5.5,6,9.5,7.5,7.5,7.5                             (1490)
```

where: BC = Business conditions (Dimensionless)
STOCK = Stock market barometer (Dimensionless)
LTGOV = Long-term U.S. government bond rate (%-age/year)
TBILL = U.S. treasury bill rate (%/year)
PRIME = Prime rate of interest (%/year)

Statements 980 through 1090 and 1250 through 1490 were collections of real data used to determine exogenous variable values. Business conditions were inputted on a quarterly basis over the 44-year period of the base run from 1934 to 1977. Business conditions (BC) was formulated in the model from the level of real Gross National Product (GNP). The variable impacted management's investment and credit extension decisions. The use of quarterly data captured management behavior. This behavior centered around managements' feelings about a particular quarter and maintaining that feeling throughout the quarter.

The stock market was tracked via the Standard and Poors 500 index quarter-end values. It was used in the model to determine the appropriate timing of stock issues. In both of these tables absolute level was translated into relative trend data where:

2 means high or peaking
1 means rising
0 means no change at median levels
-1 means falling
-2 means low or troughing

Relative trend data was used in order to obtain perceptual changes to these data. The absolute values were meaningless over such a long period of time due to scaling. Basically, the model attempted to recognize the reaction of management to business conditions and the stock market. Management reacted to perceived levels of the market, i.e. bull market, bear market, recession, recovery, etc. This was the reason for representing these two variables as they appeared in the model.

Business conditions was conceived by reading a chart of real GNP over time and translating it into the above code. The same approach created values for the stock market except the S&P 500 Index was used.

The other exogenous variables used values of long-term government bond rates, LTGOV.K, treasury bill rates, TBILL.K, and the prime rate of interest, PRIME.K. The values were in percentages and cover the base period from 1934 to 1977.[10]

---

[10]Source of data - Board of Governors of the Federal Reserve System, Historical Chart Book, 1977.

12. Gross Margin Determination

```
A GM.K=MFIA.K+MFFA.K                          (1120)
NOTE MARGIN FROM FIXED ASSETS                 (1130)
NOTE                                          (1140)
A MFIA.K=INVA.K*(MFI.K+(BC.K/40))             (1150)
A MFI.K=FI*(1+SWNOI*PKNSE.K)                  (1160)
C FI=.9                                       (1170)
NOTE                                          (1180)
NOTE MARGIN FROM FINANCIAL ASSETS             (1190)
NOTE                                          (1200)
A MFFA.K=FINA.K*TBILL.K/100                   (1210)
```

where:
- GM = Gross margin ($/year)
- MFIA = Margin from invested or fixed assets ($/year)
- MFFA = Margin from financial assets ($/year)
- INVA = Invested assets ($)
- MFI = Margin fraction for invested assets (1/year)
- BC = Business conditions (Dimensionless)
- SWNOI = Switch for the noise generator (Dimensionless)
- PKNSE = Pink noise (Dimensionless)
- FI = Normal return on fixed investment (1/year)
- FINA = Financial assets ($)
- TBILL = Treasury Bill rate (%/year)

Statements 1120 to 1210 were used to determine the period's gross margin from fixed and current assets. MFIA.K was the amount of margin generated from the fixed asset pool. It was calculated by multiplying the total amount of fixed assets, INVA.K, times an average rate of margin the firm normally nets, MFI.K, adjusted for business conditions and random fluctuations. The business condition adjustment resulted from the use of the denominator of 40 as + or - 5%.

Statement 1210 determined the gross margin generated from current or financial assets. MFFA.K was calculated by multiplying the total amount of current assets, FINA.K, times the treasury bill rate which best approximated the margin generated from the financial asset pool. The assumption incorporated in the model was that outsiders grossed the prime rate and Union Oil grossed the lower T-Bill rate. This assumption was made because Union Oil was not in the financial asset business and thus paid higher transaction costs.

The gross margin, GM.K, was the sum of the margin from invested or fixed assets, MFIA.K, plus the margin from financial or current assets, MFFA.K. This calculation was performed in statement 1120.

13. Expenses

a. Interest Expense

```
A IP.K=ABR.K*DEBT.K+STR.K*ALIB.K                                  (1550)
L ABR.K=ABR.J+(DT/(DEBT.J/(CID.JK-DRR.JK)))(BR.J-ABR.J)           (1560)
N ABR=IBR                                                         (1570)
C IBR=.03                                                         (1580)
A BR.K=(LTGOV.K/100)*ERBR.K*EDEBR.K*ECOVBR.K                      (1590)
A ERBR.K=TABHL(TERBR,INCD.K/SMINCD.K,0,3,1)                       (1600)
T TERBR=.9,1,1.1,1.2                                              (1610)
A STR.K=(PRIME.K/100)*ECOVBR.K*EDEBR.K*ECRBR.K                    (1620)
A ECOVBR.K=TABHL(TECOVB,SCOV.K/MINCOV,-5,1,1)                     (1630)
T TECOVB=2.2/2.0/1.8/1.6/1.4/1.2/1.0                              (1640)
N ECOVBR=1.0                                                      (1650)
A SCOV.K=SMOOTH(COV.K,TSCOV)                                      (1660)
A COV.K=(NIBT.K+IP.K)/IP.K                                        (1670)
C TSCOV=.25                                                       (1680)
C MINCOV=2.0                                                      (1690)
A EDEBR.K=TABHL(TEDEBR,DE.K/MINDE,0,6,1)                          (1700)
T TEDEBR=0.9/1.0/1.2/1.4/1.6/1.8/2.0                              (1710)
C MINDE=.5                                                        (1720)
A ECRBR.K=TABHL(TECRBR,CR.K/TCR,0,1,.25)                          (1730)
T TECRBR=5,2.5,1.5,1.1,1.0                                        (1740)
A ALIB.K=NFRIBL*LIAB.K*EALIB.K                                    (1750)
A EALIB.K=1.0-BC/10                                               (1760)
C NFRIBL=.5                                                       (1770)
```

where: IP = Annual interest expense ($/year)
ABR = Average or smoothed borrowing rate ($/year)
BR = Long-term borrowing rate ($/year)
ERBR = Effect of risk on the borrowing rate (Dimensionless)
STR = Short-term borrowing rate ($/year)
ECOVBR = Effect of coverage on the borrowing rate (Dimensionless)
SCOV = Smoothed coverage (Dimensionless)
COV = Interest expense coverage (Dimensionless)
MINCOV = Minimum coverage (Dimensionless)

EDEBR = Effect of debt/equity on the borrowing rate (Dimensionless)
MINDE = Minimum debt/equity (Dimensionless)
ECRBR = Effect of current ratio on short-term rate
INCD = Standard deviation of income ($/year) (Dimensionless)
SMINCD = Smoothered standard deviation of income ($/year)
ALIB = Amount of liabilities that are interest bearing ($)
EALIB = Effect of business conditions on ALIB (Dimensionless)
NFRIBL = Normal fraction of liabilities interest bearing (Dimensionless)

Statements 1550 through 1770 modeled the determination of annual interest expense, IP.K. IP.K equaled the average rate of interest on long-term debt, ABR.K, times the level of long-term debt, DEBT.K, plus the short-term borrowing rate, STR.K, times the amount of liabilities that were interest bearing, ALIB.K. ABR.K was determined in equation 1560 as a level accumulation in order to match funds borrowed to their respective rates of interest. This was a weighted average rate weighted by the amount of borrowing.

The current or marginal long-term borrowing rate, BR.K, was derived from the Fisher bond risk premium.[11] It equaled the risk free rate, LTGOV.K, plus a risk premium that included overall firm risk, ERBR.K, leverage, EDEBR.K and ability to pay for interest, ECOVBR.K. The actual Fisher equation was used in early forms of the model but computer errors occurred. The cause of these computer errors was the fractional powers used in the equation.

The table functions for ERBR.K, ECOVBR.K and EDEBR.K were substitutes for the Fisher and were directly derived from that equation. See Figures 10, 11 and 12. EDEBR.K was a non-linear relationship

[11] See Lev (1974), p. 157.

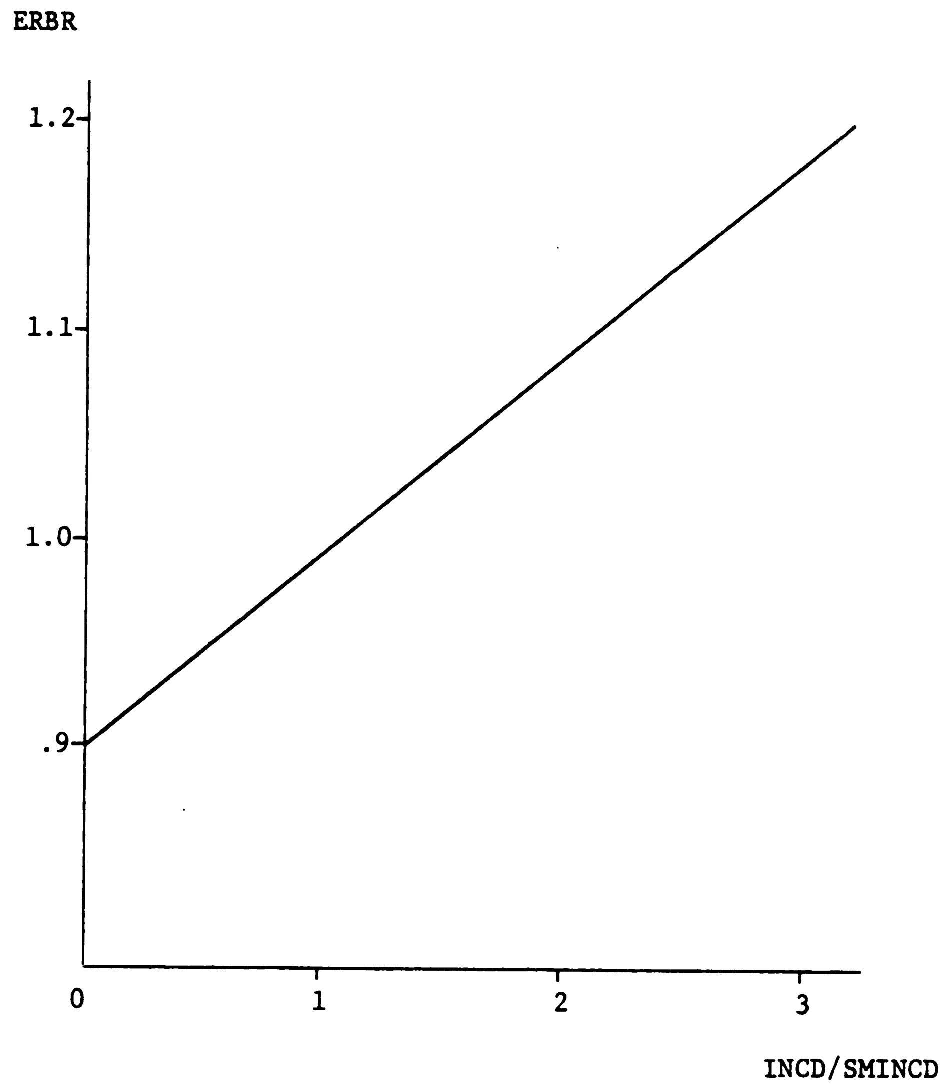


Figure 10: Effect of Risk on the Borrowing Rate

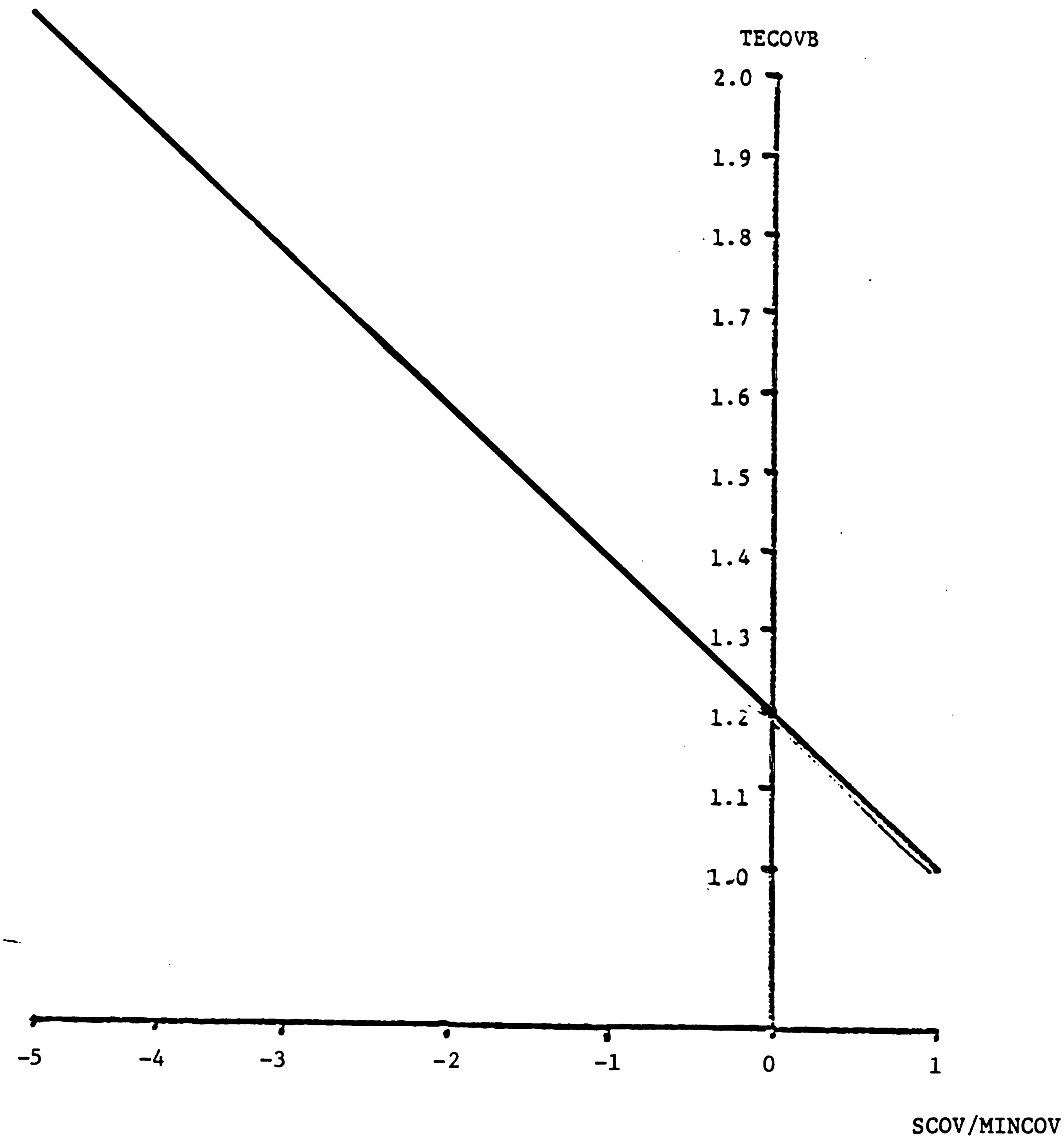


Figure 11: Effect of Coverage on the Borrowing Rate

Figure 12

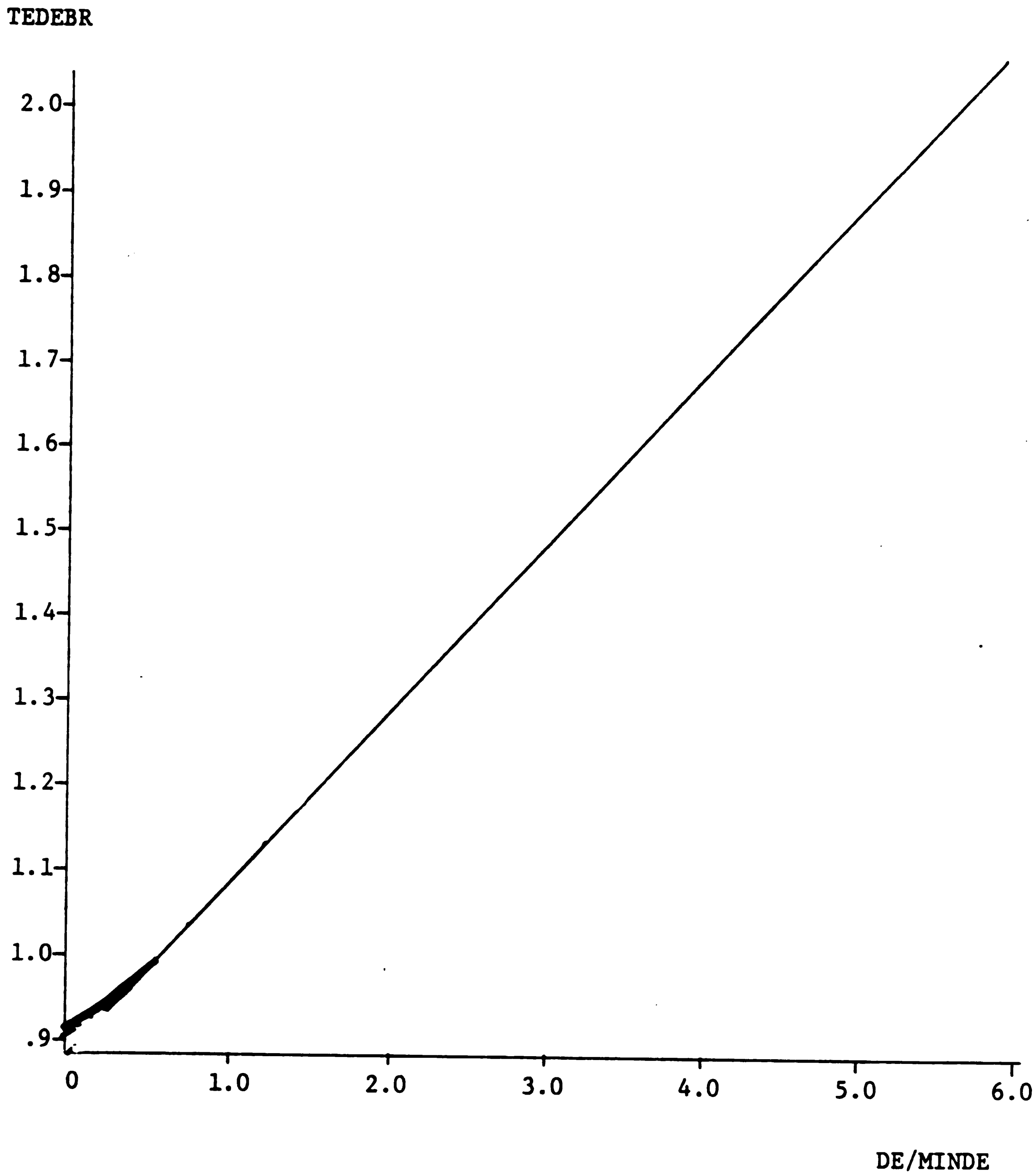


Figure 12: The Effect of Debt/Equity Ratio on the Borrowing Rate

due to agency costs.[12] As debt levels rose, the cost of managing that debt also rose.

The short-term borrowing rate, STR.K, was calculated in equation 1620. The effect of the liquidity of the firm, ECRBR.K, was substituted for the overall risk effect because of the immediate nature of the obligation. Figure 13 depicts the relationship derived for the liquidity multiplier. This relationship was consistent with the effect of the current ratio on credit extension.

Some current liabilities were not interest bearing, i.e. trade payables. The amount of liabilities that are interest bearing ALIB.K was determined in equation 1750. ALIB.K was normally 50 percent of current liabilities + or - 20% based on business conditions. In tight money times many suppliers restricted credit or charged for the use of credit. Equation 1760 reflected this phenomenon.

b. <u>Total Expenses</u>

A TEX.K=DEPR.JK+IP.K

where: TEX = Total financing expenses ($1/year)
DEPR = Depreciation rates ($/year)
IP = Annual interest expense ($/year)

Only interest and depreciation expense were calculated as a separate item in this model. They were financing expenses. All other expenses were determined in the margin section as revenues minus expenses. Total expense was calculated in statement 1840 as TEX.K, total expense, equaled the sum of DEPR.JK plus IP.K.

[12] See Kim (1978).

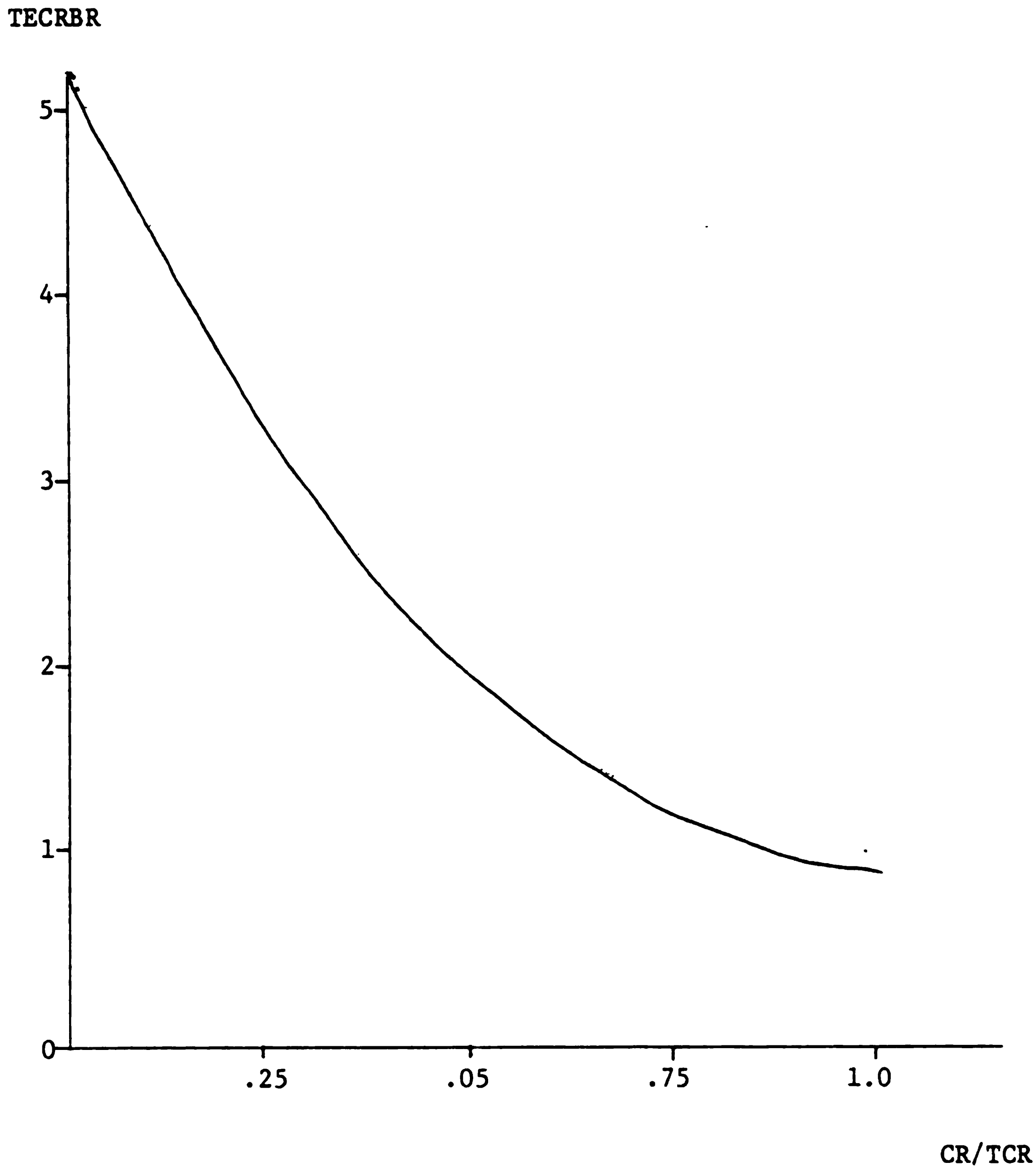


Figure 13: The Effect of Current Ratio on the Borrowing Rate

14. Income Determination

```
A NIBT.K=GM.K-TEX.K+IFAI.K                                    (1880)
A IFAI.K=NORMRN(MEAN,STDV)                                    (1890)
A NIAT.K=NIBT.K=ECTR.K*NIBT.K                                 (1900)
A ECTR.K=TABLE(TECTR,TIME.K,0,44,4)                           (1910)
T TECTR=.07/.3/.18/.24/.15/.04/.1/.25/.11/.21/
        .3/.45                                                (1910)
```

where: NIBT = Net income before taxes $/year)
GM = Gross margin ($/year)
TEX = Total expenses ($/year)
IFAI = Income from additional investment ($/year)
NIAT = Net income after taxes ($/year)
ECTR = Effective corporate tax rate (Dimensionless)

Statements 1880 through 1920 were used to calculate total income values for the firm. Net income before taxes, NIBT.K, was calculated in statement 1880 as the difference between gross margin, GM.K, and total expenses, TEX.K, plus a normally distributed income function for investments made outside of the current mix of assets, IFAI.K. Net income after tax, NIAT.K, equaled NIBT.K minus the effective corporate tax rate, ECTR.K, times NIBT.K. The tax rate was set in statements 1910 and 1920 at its historical effective level. It was empirically determined.

15. Dividend Payment

```
A DIV.K=MAX(NIAT.K*DPR.K,0)                                   (1960)
A DPR.K=TABLE(TDPR,TIME.K,0,44,4)                             (1970)
T TDPR=.7,.9,.75,.5,.35,.4,.48,.4,.4,.6,
       .35,.3                                                 (1980)
```

where: DIV = Dividend payment ($/year)
NIAT = Net income after taxes ($/year)
DPR = Dividend payout rate (Dimensionless)

Statments 1960 through 1980 were used to determine the dividend payment for the period. Although actually declared on a quarterly basis, dividends in this model were paid every DT or 0.025 years.

This was because of the difficulty involved in constructing a model which accumulates and pays dividends quarterly.

Statement 1140 calculated the dividend payment, DIV.K, as NIAT.K times DPR.K, the dividend payout rate. The dividend payout rate is graphically displayed in Figure 14 and was the actual payout of the firm over the 44-year base period from 1934 to 1977. This table was empirically derived.

16. Cash Flow

```
2020=A CF.K=NIAT.K+DEPR.JK-DIV.K                        (2020)
```

```
where:   CF = Cash flow from income ($/year)
       NIAT = Net income after taxes ($/year)
       DEPR = Depreciation rate ($/year)
        DIV = Dividend payment ($/year)
```

Statement 2020 was used to determine internal cash flow. Cash flow, CF.K, was calculated as net income after taxes, NIAT.K, plus depreciation, DEPEX.K, minus dividends, DIV.K.

17. Return Measures

```
A ROA.K=NIAT.K/TA.K                                     (2060)
A CFROA.K=CF.K/TA.K                                     (2070)
A TA.K=INVA.K+FINA.K+FUNDS.K                            (2080)
A ROE.K=NIAT.K/TE.K                                     (2090)
A CFROE.K=CF.K/TE.K                                     (2100)
```

```
where:   ROA = Return on total assets (1/year)
       CFROA = Cash-flow return on total assets (1/year)
          TA = Total assets ($)
        NIAT = Net income after taxes ($/year)
          CF = Cash-flow from income ($/year)
         ROE = Return on equity (1/year)
       CFROE = Cash-flow return on equity (1/year)
          TE = Total equity ($)
```

Return measures were part of the output variables of the model. They were determined in statements 2060 through 2100. First total assets, TA.K, was calculated in statement 2080 as the sum of fixed

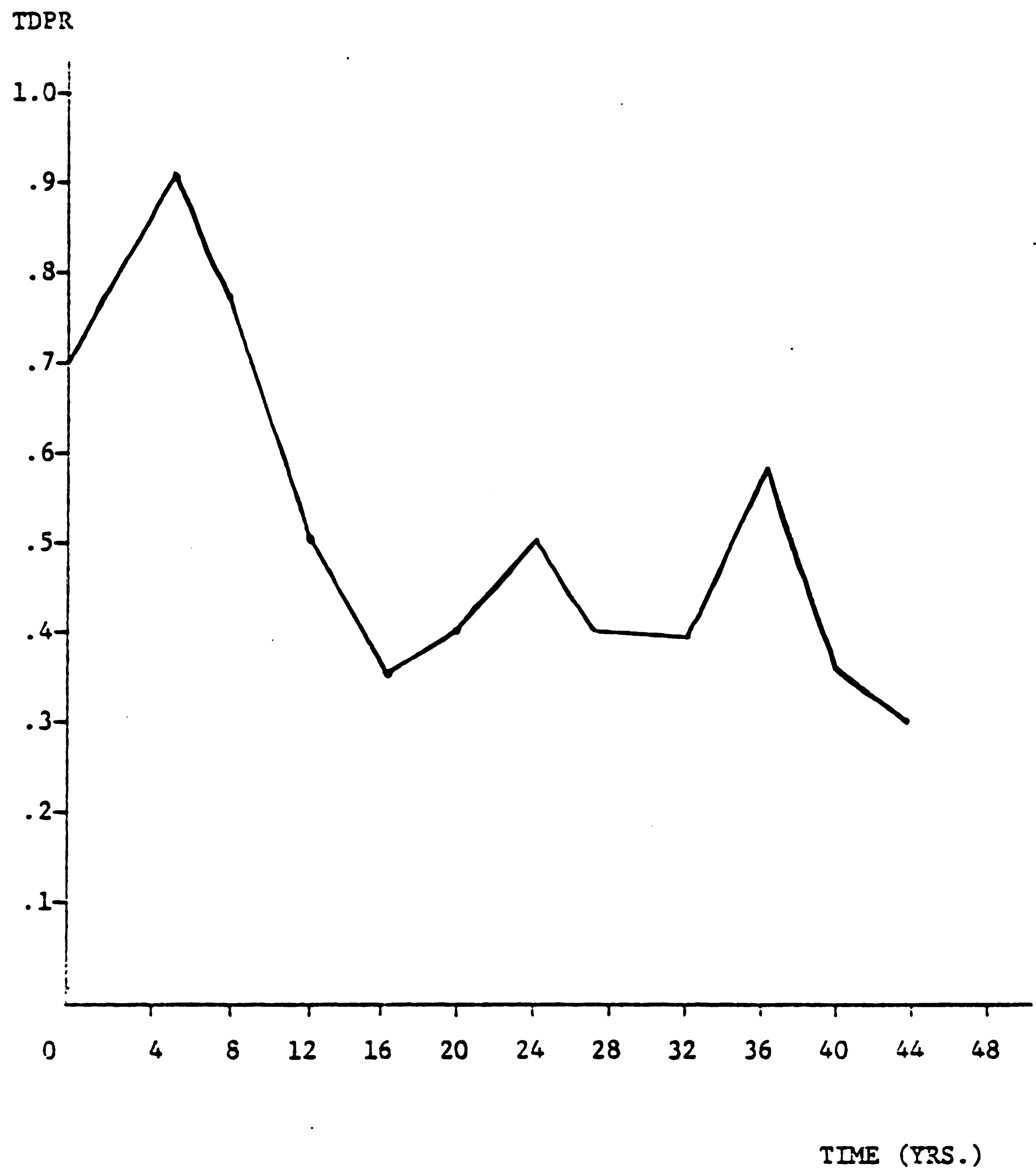


Figure 14: Dividend Payout Rate

and current assets. Then return on assets was calculated in statement 2060 as ROA.K, return on assets, equals NIAT.K/TA.K. The cash flow return on assets, CFROA.K, equaled CF.K/TA.K in statement 2070.

Return on book value of equity was calculated in statement 2090. Return on equity, ROE.K, equaled NIAT.K/TE.K, total equity. Cash flow return on equity, CFROE.F, equaled CF.K/TE.K in statement 2100.

18. Risk Measures

Risk measures were part of the output variables of the model. Six standard deviations were calculated for net income, INCD, cash-flow, CFD, return on equity, SDROE, return on assets, SDROA, cash-flow return on equity, CFROED, and cash-flow return on assets, CFROAD. The identical procedure was used for the six variable determinations. Therefore, only standard deviation of income is explained in depth.

a. Standard Deviation of Income

```
NOTE STANDARD DEVIATION OF INCOME
NOTE
A INCD.K=(SQRT(N*TSINC.K-TINC.K**2))/N                (2160)
C N=20                                                (2170)
A TSINC.K=N*DELAY3(SNIAT.K*SNIAT.K,5)                 (2180)
A SNIAT.K=SAMPLE(NIAT.K,.25,INIAT)                    (2190)
C INIAT=80.306                                        (2200)
A TINC.K=N*EVINC.K                                    (2210)
A EVINC.K=DELAY3(SNIAT.K,5)                           (2220)
```

where: INCD = Standard deviation of net income ($/year)
TSINC = Total squared income ($/year)
TINC = Total income ($/year)
N = Sample size
SNIAT = Quarterly sample of income ($/year)
EVINC = Expected value of income ($/year)

Income deviation, INCD.K, was determined in equations 2160 through 2220. The sample size of N=20 was selected because of evidence that risk is measured in the market over the last five years or 20 quarters.[13] Income figures were sampled every quarter in the model to parallel the publication of quarterly earnings statements. Risk was a market perception and thus public data was necessary for the modeling of that perception.

Third order delays (DELAY3) were used to determine total squared income and total income. These delay functions were approximations of a five-year equal-weighted average. The functions were necessary. DYNAMO does not facilitate the use of moving averages because it cannot remember variable values back beyond one DT in time. The DELAY3 functions yield a rectangular distribution of observations divided by the number of observations over the delay period, 5 years. Observations were approximately equally weighted over this period and prior period observations approximately ignored.

Difficulties in start-up of these delay functions arose in the model. The risk measures were accurate after the start-up period. Thus, inferences drawn regarding risk measures were restricted to later years in a particular simulation run.

b. Coefficients of Variation

```
S INCCOV.K=INCD.K/EVINC.K                                  (2670)
S CFCOV.K=CFD.K/EVCF.K                                     (2680)
```

where: INCCOV = Net income coefficients of variation (Dimensionless)
INCD = Net income standard deviation ($/year)
EVINC = Expected value of net income ($/year)
CFCOV = Cash-flow coefficient of variation (Dimensionless)
CFD = Cash flow standard deviation ($/year)
EVCF = Expected value of cash-flow ($/year)

[13] Lev (1974), Chapter 10, pp. 158-60.

Statements 2670 through 2680 were used to calculate the coefficients of variation of income and cash-flow. Equations divided the standard deviation by the expected value which is a strict definition of coefficient of variation. These variables were supplementary output variables in that their value did not affect the model dynamics.

c. <u>Moving Average of Standard Deviation of Income</u>

```
A SMINCD.K=DELAY3(SINCD.K,5)                          (2720)
A SINCD.K=SAMPLE(INCD.K,.25,IINCD)                    (2730)
C IINCD=0.000001                                      (2740)
```

where: SMINCD = Smoothed income deviation ($/year)
SINCD = Quarterly sample of standard deviation of income ($/year)

Statements 2720 through 2740 calculated the value of the moving average of the standard deviation of net income, SMINCD. Once again the third order delay, DELAY3, was used to approximate this average. Similar start-up difficulties were encountered with this variable as well.

Both the standard deviation of net income, INCD, and SMINCD were used in the model to determine long-term borrowing rates. However, they were used in ratio form and the start-up bias is in the same direction for both. Therefore, the bias was minimized through the comparison by division.

The coefficient of variation of income and cash flow and the standard deviation of the returns were used as risk measures in this model. These measures reflected the total risk of the firm which includes systematic and unsystematic risk. They were used because the model was not a market model and the two types of risk cannot be separated. Also, the coefficient of variation is a relative measure of risk. Considering the growth of the firm over the 40 year base-run period, the relative nature was critical in order to get useful information out of the model. Return measures were relative in nature as well, thus the use of standard deviation of returns.

19. Investment Decision Policy Variables

```
C MEAN=0                                                  (2780)
C STDV=0                                                  (2790)
C HGHT=0                                                  (2800)
C FHGHT=0                                                 (2810)
C DHGHT=0                                                 (2820)
C LHGHT=0                                                 (2830)
C EHGHT=0                                                 (2840)
C STTM=0                                                  (2850)
C STTM2=0                                                 (2860)
```

where:
MEAN = The expected NIBT from new investment ($/year)
STDV = Standard deviation of NIBT from new investment ($/year)
HGHT = Fixed asset investment ($)
FHGHT = Current asset investment ($)
DHGHT = New debt to fund new investment ($)
LHGHT = New liabilities to fund new investment ($)
EHGHT = New equity to fund new investment ($)
STTM = Time when investment begins (years)
STMM2 = Time when investment ends (years)

Statements 2780 through 2860 set the values of the investment decision variables to 0. These would be modified when evaluating an investment into a new risk category. The policy test in this area would include changes in expected cash flows and the standard deviation of those cash flows. This macro included modifications to the financing mix with the new investment. Thus, modifications can be made to long- and short-term debt and equity levels and current and fixed asset pools.

20. Desired Funding

a. Growth

```
A GROW.K=TA.K-SMTA.K                                        (2905)
A SMTA.K=SMOOTH(TA.K,TSTA)                                  (2910)
C TSTA=.083333                                              (2920)
```

where: GROW = Growth in total assets ($)
TA = Total assets ($)
SMTA = Smooth total assets ($)
TSTA = Time to smooth total assets (years)

Growth in total assets, GROW.K, was the difference between total assets now, TA.K, and the previous period's total assets, SMTA.K. The time period to calculate growth, TSTA, was set at .083333 or one month. This represented a normal management growth review interval.

b. Desired Growth

```
A DGROW.K=DGFR*TA.K+DGRFBC.K*TA.K                           (2940)
C DGFR=.5                                                   (2950)
A DGRFBC.K=BCC*BC.K                                         (2960)
C BCC=.1                                                    (2970)
A DGR.K=(DGROW.K-GROW.K)/TAGR                               (2980)
C TAGR=1.0                                                  (2990)
```

where: DGROW = Desired growth ($)
DGFR = Desired growth fraction (Dimensionless)
TA = Total assets ($)
DGRFBC = Desired growth fraction from business conditions (Dimensionless)
BCC = Business conditions constant (Dimensionless)
DGR = Desired growth rate ($/year)
TAGR = Time to adjust growth rate (years)

Desired growth in total dollars, DGROW.K, was a function of a management target growth, DGFR, and current business conditions, DGRFBC.K. Total dollars were used because management used accounting reports to measure growth. Current business conditions affected the growth within a range of + or - 20%. The perception of business conditions by management influenced their investment policy. When management was optimistic they invested more and vice versa.

The desired growth rate, DGR.K, was the difference between desired growth and growth divided by a time constant, TAGR. TAGR was set at 1 year to coincide with the capital budgeting function. This model provided for the delays of management to react to changes due to the planning process. Since planning consumes time, the model captured a real-world phenomenon.

c. Desired Funds

```
A DFUNDS.K=DGR.K*PLH                                         (3000)
C PLH=1.0                                                    (3010)
```

```
where:  DFUNDS = Desired funds ($)
           DGR = Desired growth rate ($/year)
           PLH = Planning horizon for growth (years)
```

Desired funds in total dollars, DFUNDS, was a function of the desired growth rate and planning horizon. The planning horizon of one year assumed that funding for growth was reviewed annually. This coincided with an annual capital budgeting function.

d. Desired External Funding

```
A DEXF.K=(DFUNDS.K-AFUNDS.K)/TANF                            (3020)
C TANF=.60                                                   (3030)
```

```
where:    DEXF = Desired external funding rate ($/year)
        DFUNDS = Desired funds ($)
        AFUNDS = Available funds ($)
          TANF = Time to acquire new funds (years)
```

Desired external funds were the difference between desired funds and available funds. The rate of external funding was based upon a time constant, time to acquire new funds, TANF. TANF was set at a value of .6 which is consistent with current management feelings. The time includes the period of planning, negotiating and acquiring the funds. Seven months was considered an average of this period aggregated over several financing moves.

e. Available Funds

```
A FUNDS.K=FUNDS.K-MINBAL.K                             (3040)
A MINBAL.K=DIV.K*TTPD+DRR.JK*TTPL+DEPF*INVA.K*TRINVA   (3050)
C TTPD=.25                                             (3060)
C TTPL=.83333                                          (3070)
C TRINVA=.25                                           (3080)
```

where: AFUNDS = Available funds for investment ($)
FUNDS = Level of funds in the firm ($)
MINBAL = Minimum balance of funds needed to meet obligations ($)
DIV = Annual dividend payment ($/year)
TTPD = Time to pay dividends (years)
DRR = Debt retirement rate ($/year)
TTPL = Time to pay liabilities (years)
DEPF = Depreciation fraction (1/year)
INVA = Fixed assets ($)
TRINVA = Time to replace depreciated invested assets (years)

Available funds for investment, AFUNDS, was the difference between funds in the firm, FUNDS, and the minimum balance of funds needed for current or expected obligations, MINBAL. MINBAL included a quarterly dividend payment,[14] monthly debt retirement and quarterly renewal of depreciated fixed assets. Thus the time constants were respectively .25, .083333 and .25 years.

f. Desired Debt/Equity

```
A DDE.K=TABLE(TDDE,TIME.K,0,44,4)                      (3090)
T TDDE=.22,.2,.37,.48,.3,.41,.54,.63,.53,.59,.68,.96   (3100)
```

where: DDE = Desired debt/equity ratio (Dimensionless)
TIME = Time on the simulation clock (years)

The desired debt/equity ratio, DDE, was based upon the historical debt/equity ratio of the firm. The ratio was inputted at four-year

[14] This appears to contradict what was written earlier concerning dividends being paid every DT. However, it represents a policy of the firm to carry enough cash to pay anticipated quarterly cash dividends. Although the dividends cannot be paid quarterly, this safety cash level policy can be and is in the model.

intervals in order to facilitate an easy change for policy interventions. This variable was used as a policy variable in the model. (See Figure 15).

g. Desired Debt Funding

```
A DDEBTF.K=DAF.K*DEXF.K+DEBT.K*(1/NLD)                    (3180)
A DAF.K=MIN(DAM.K*EBRDD.K*ESPDED.K*DE.K,1)                (3110)
A DAM.K=TABXT(TDAM,DDE.K/DE.K,0,4,1)                      (3120)
T TDAM=0,1,2,3,4                                          (3130)
A EBRDD.K=TABHL(TEBRDD,BR.K/ABR.K,0,3,.5)                 (3140)
T TEBRDD=2,1.5,1.0,0.95,0.90,0.85,0.85                    (3150)
A ESPDED.K=TABLE(TESP,STOCK.K+1,-1,3,1)                   (3160)
T TESP=1.1,1.05,1,.95,.9                                  (3170)
```

where: DDEBTF = Desired debt funding rate ($/year)
DAF = Debt acquisition fraction (Dimensionless)
DEXF = Desired external funding rate ($/year)
DEBT = Level of long-term debt ($)
NLD = Normal length of debt (years)
DAM = Debt acquisition multiplier from DDE (Dimensionless)
EBRDD = Effect of borrowing rate on desired debt (Dimensionless)
ESPDED = Effect of stock prices on desired debt (Dimensionless)
DDE = Desired debt/equity (Dimensionless)
DE = Debt/equity (Dimensionless)
BR = Long-term borrowing rate (%/year)
ABR = Smoothed long-term borrowing rate (%/year)
STOCK = Stock market barometer (Dimensionless)

Desired debt funding rate, DDEBTF, the fraction of external funds that will come from debt, DAF, times the external funding rate, DEXF. DDEBTF also included replacement of retired debt. This "rolls over" debt when it matures. The approach was similar to that discussed earlier for depreciated assets. If no new debt was desired, the current level of debt was maintained.

The debt acquisition fraction, DAF, was a function of four factors. Current borrowing rate compared to the historical borrowing rate was one factor. Desired debt/equity and current debt/equity were

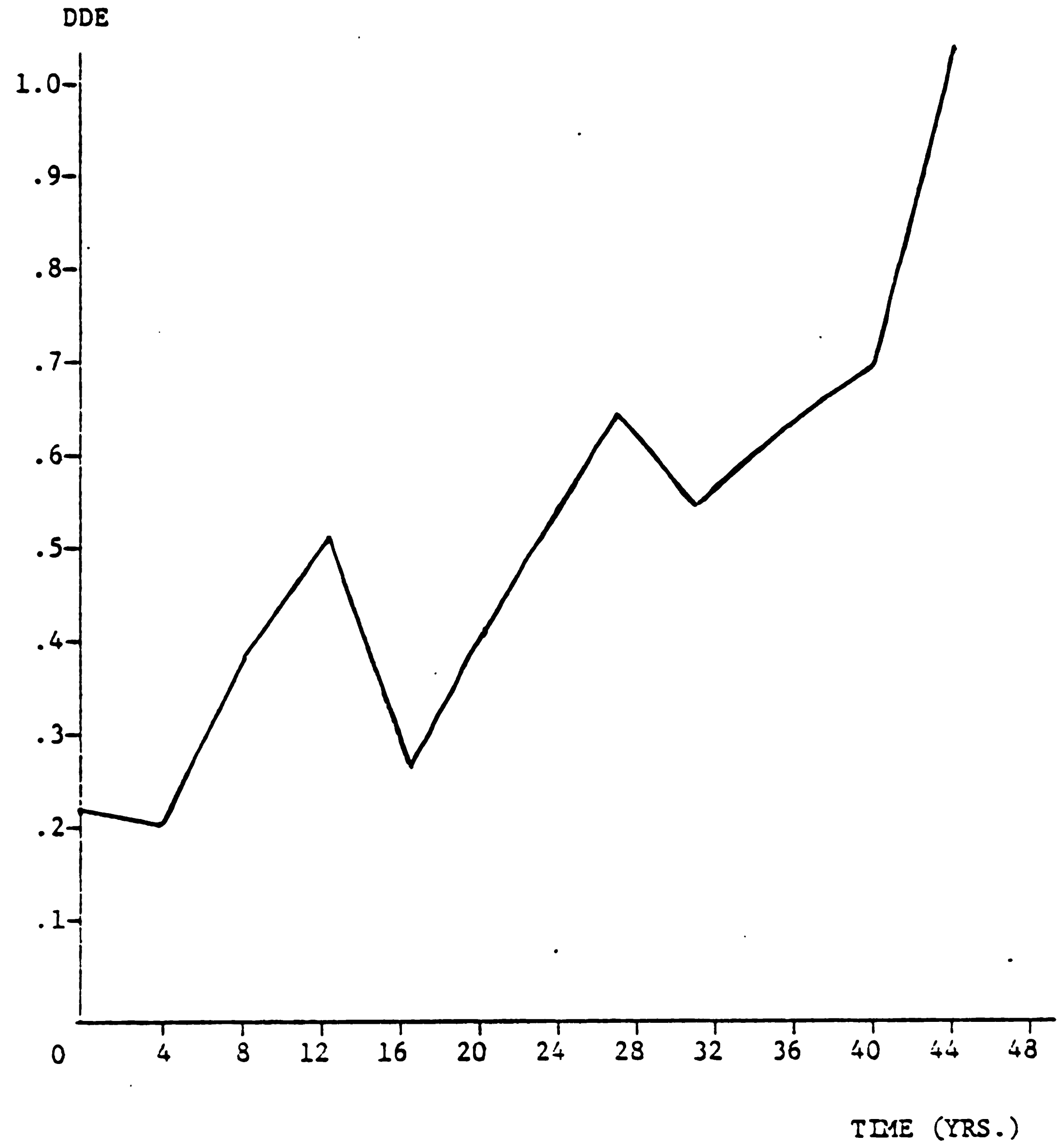


Figure 15: Desired Debt/Equity Ratio

two more factors. The stock market level was a factor that is inversely related to DAF. High market levels on a relative basis made management more receptive to stock issues. DAF was bounded by zero and one.

The debt acquisition multiplier, DAM, represented an accelerator for debt assumption. As the discrepancy between desired and actual debt/equity increased, the DAM was increased. The assumption was that since the debt acquisition fraction was bounded by zero and one the periodic change in debt/equity ratio was also limited. (See Figure 16).

The effect of the borrowing rate on desired debt funding, EBRDD, represented management's reluctance to borrow at higher interest rates. The table function TEBRDD in Figure 17 levels off quickly when the borrowing rate was equal to past rates. This leveling off was a ceteris paribus relationship that management was not as inclined to borrow further as they would at lower rates. Other factors that favored borrowing over the sale of equity securities would prevail.

The effect of stock prices on the desire for debt, ESPDED, is reflected in the table in Figure 18. A neutral market had no effect on the desire for additional debt. The relationship was inverse because equity was the alternate external funding source.

h. Desired Equity Funding

3190=A DEQF.K=(1-DAF.K)*DEXF.K (3190)

where: DEQF = Desired equity funding rate ($/year)
DAF = Debt acquisition fraction (Dimensionless)
DEXF = Desired external funding rate ($/year)

Desired equity funding rate, DEQF, was the part of desired external funding not satisifed by debt.

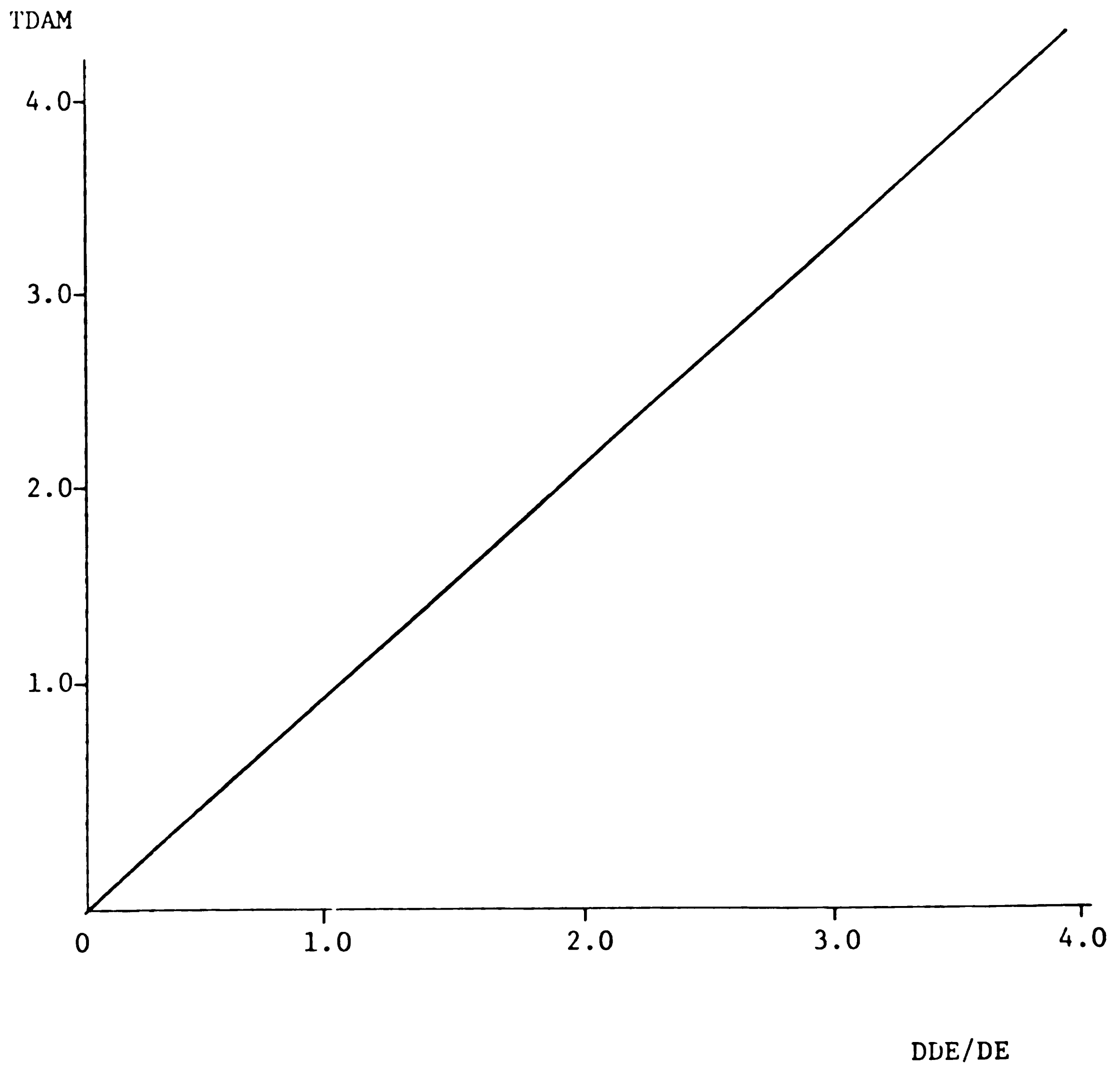


Figure 16: Debt Acquisition Multiplier

Figure 17

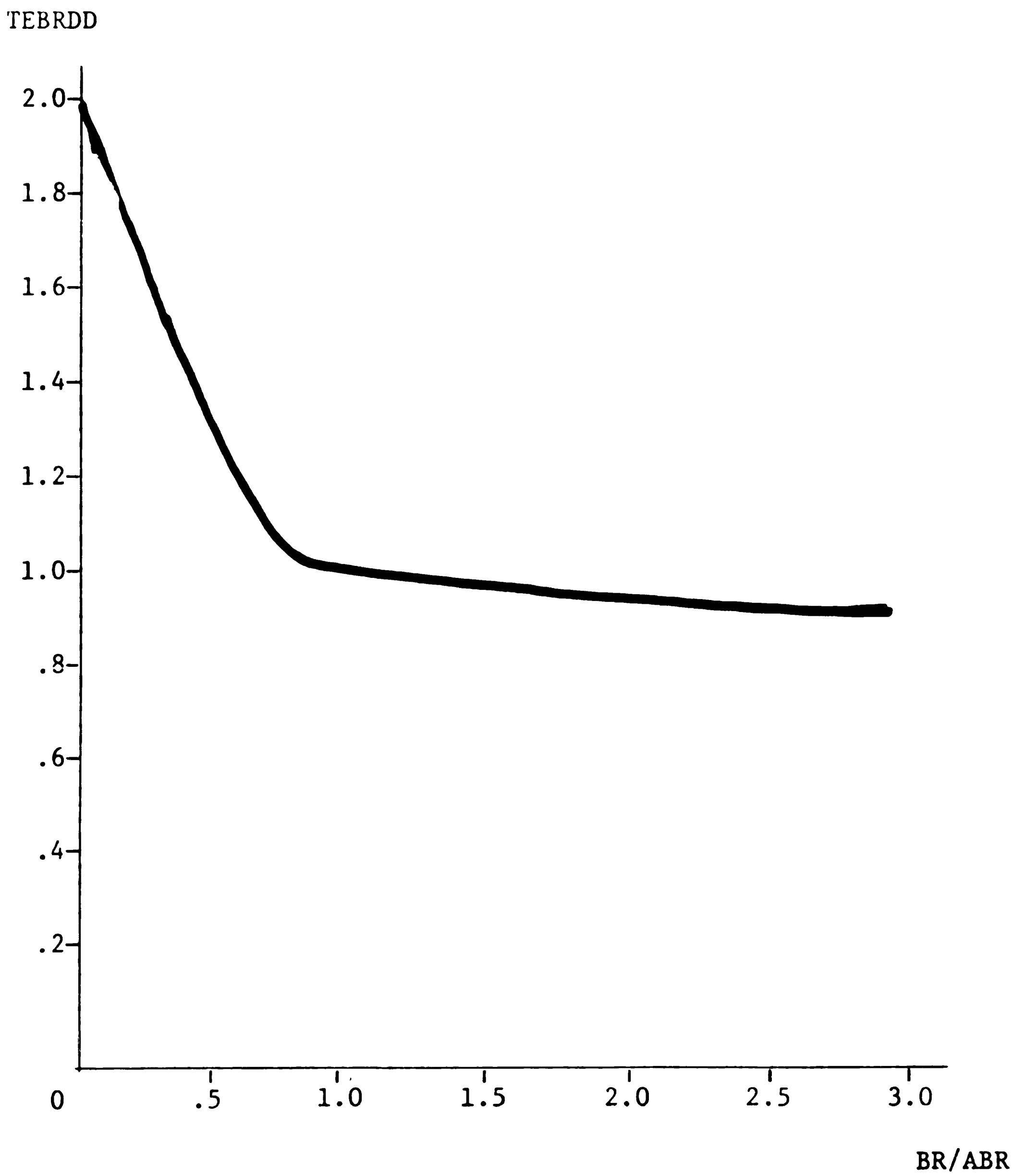


Figure 17: The Effect of Borrowing Rate on Desired Debt

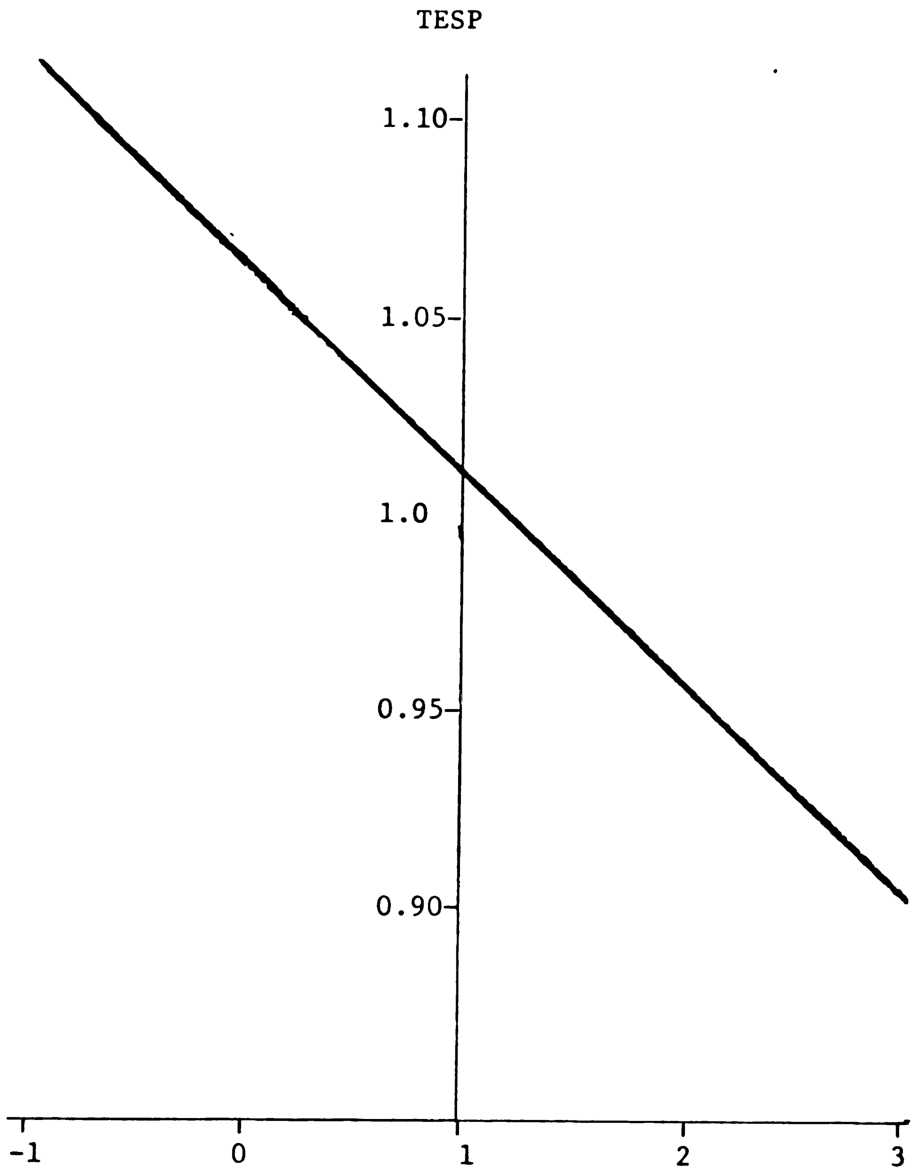


Figure 18: The Effect of Stock Price on Desired Debt

21. Debt Mix

```
A MIX.K=CLIP(1.0,(FINA.K+FUNDS.K)/INVA.K*EIOM.K*      (3230)
ECEXM.K,(FINA.K+)
X FUNDS.K)/INVA.K*EIOM.K*ECEXM.K,1.0)                 (3240)
A EIOM.K=TABHL(TEIOM,INTF.K/PERCIN.K,0,3,.5)          (3250)
T TEIOM=3,1.5,1,1,.8,.5,0                             (3260)
A INTF.K=STR.K/BR.K                                   (3270)
A ECEXM.K=TABHL(TECEXM,CEX.K/NORCEX,0,1.2,.2)         (3280)
T TECEXM=0,.2,.4,.6,.8,1.0,1.2                        (3290)
C NORCEX=80                                           (3300)
```

where:
- MIX = Debt mix of liabilities to total debt (Dimensionless)
- FINA = Non-cash current assets ($)
- FUNDS = Cash ($)
- INVA = Invested a fixed asset ($)
- EIOM = Effect of interest rate fraction on mix (Dimensionless)
- INTF = Interest rate fraction (Dimensionless)
- PERCIN = Perceived interest fraction (Dimensionless)
- STR = Short-term borrowing rate (%/year)
- BR = Long-term borrowing rate (%/year)
- ECEXM = Effect of credit extension on mix (Dimensionless)
- CEX = Credit extension (%)
- NORCEX = Normal credit extension (%)

Debt mix, MIX, was a function of asset mix, interest rates and credit availability. The matching of long-term financing to fixed assets and short-term money to current assets was consistent with current financial theory and management practice.

The effect of interest rate fraction on mix was reflected in a table function, Figure 19. As the interest fraction was consistent with the past, no change in debt mix was sought by management. This explains the flattening of the curve in the mid or operating ranges. Since the fraction was short-term over long-term rate, the desire for more short-term debt was evident at low levels of the interest fraction and vice versa. This table reflected a management preference for short-term funding decisions.

The effect of credit extension or availability on debt mix, ECEXM,

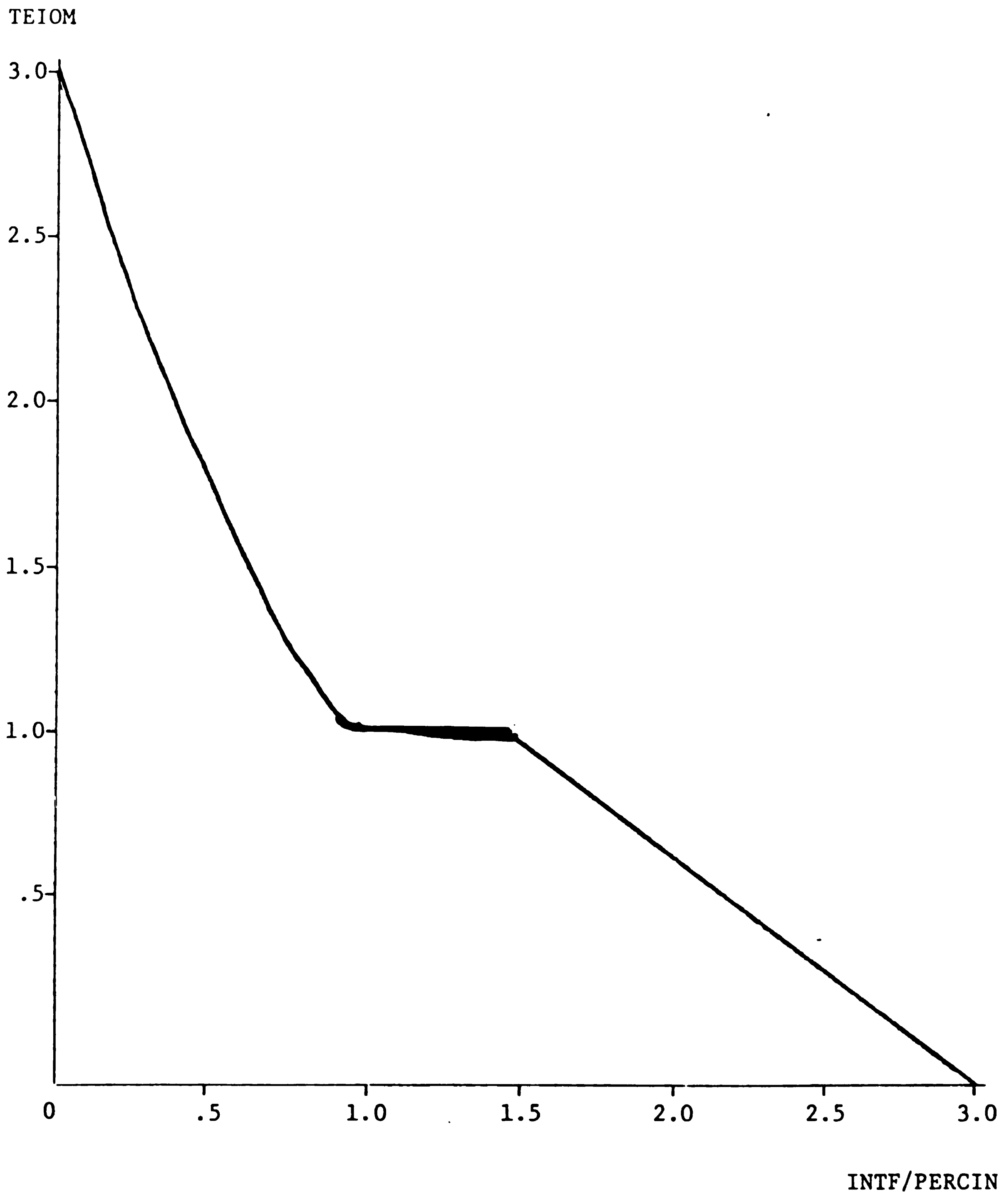


Figure 19: The Effect of Interest Rates on Debt Mix

modeled the dynamics of the desire to use trade payables as a financing source. The availability of credit was the limiting factor for funding from this source. This effect is graphically depicted in Figure 20 as a linear direct relationship. Therefore, use of payables to the limit was a management policy within the model.

22. Switches and Control Cards

The remainder of the DYNAMO statements were a switch for the pink noise generator (statement 3340), DYNAMO control cards and output specifications. The PRINT statements were used for debugging the model.

```
C SWNOI=0                                                   (3340)
NOTE                                                        (3350)
NOTE CONTROL CARDS                                          (3360)
NOTE                                                        (3370)
C DT=.025                                                   (3380)
C LENGTH=0                                                  (3390)
C PLTPER=1.0                                                (3400)
C PRTPER=5.0                                                (3410)
PLOT ROE,ROA,CFROE,CFROA(0,.6)/DIV(0,*)                     (3420)
PLOT INCCOV,CFCOV(0,2)/SDROE,SDROA,CFROED,CFROAD(0,.1)      (3430)
PRINT ROE,ROA,CFROE,CFROA,DIV,INCCOV,CFCOV,SDROE,SDROA      (3440)
PRINT INVA,FINA,FUNDS,EQ,DEBT,NIAT,LIAB,BR,STR              (3450)
PRINT INVRF,IF,CR,FINVR,CIE,CID,CIL,RCF,RE                  (3460)
PRINT TE,TD,DE,CEX,MFIA,MFFA,COV,ALIB,TEX                   (3470)
PRINT NIBT,NIAT,DEPR,CF,GROW,DGROW,DGR,DFUNDS               (3480)
PRINT AFUNDS,MINBAL,DAF,DAM,DDEBTF,DEQF,MIX,ABR             (3490)
RUN                                                         (3500)
```

where: SWNOI = Switch for pink noise (0-off, 1-on)
DT = Time increment (years, approximately 10 days)

D. Causal-Feedback Loops of the Model

Figures 21 through 30 are representations of some of the causal forces in the model. The positive feedback loops were the source of growth and instability in the system and the model. The negative feedback loops modeled the goal seeking behavior of the system. The letters

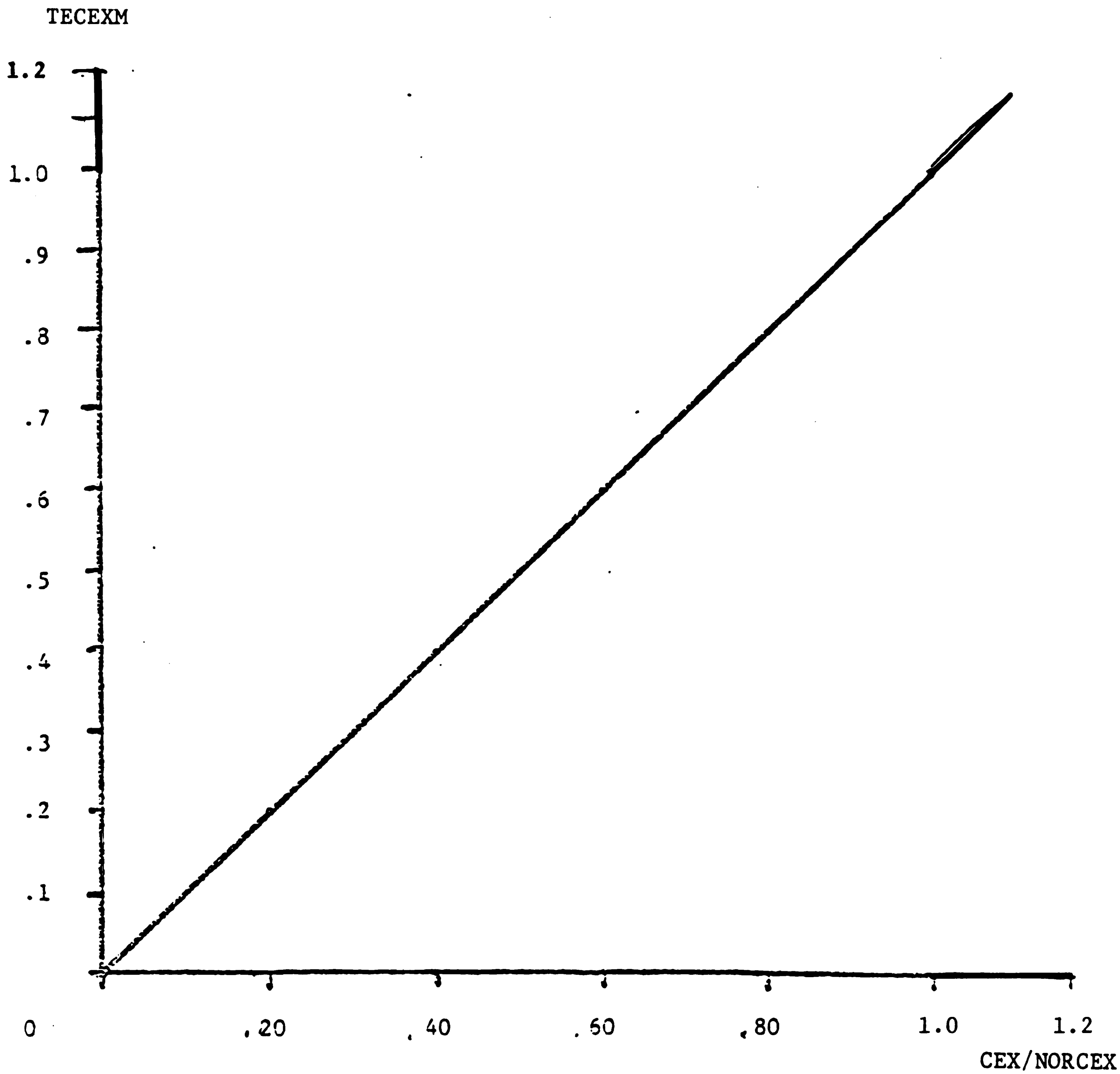


Figure 20: The Effect of Credit Extension on Debt Mix

in parentheses are the DYNAMO variable names used in the model. All relationships are assumed ceteris paribus in the causal-feedback loops.

1. Figure 21 Short-term Interest

Figure A is a positive feedback loop that relates short-term interest rates, interest expense and interest coverage. A positive relationship means that changes in one variable would cause changes in the other in the same direction. Or increasing one; increases the other, decreasing one; decreases the other.

As the short-term interest rate changes, the interest expense of the firm would follow in the same direction. Thus, there is a positive relationship. As interest expense goes up, interest coverage would go down, and the reverse is also true. Thus, there is a negative relationship. As coverage goes up, short-term interest rates go down. Thus, there is a negative relationship. Since an odd number of negative relationships must exist to yield a negative loop, this loop is positive. The short-term rate would tend to grow if this were the only feedback loop.

2. Figure 22 Short-term Interest

Figure B is a negative feedback loop that relates short-term interest rate, debt mix, short-term debt and the debt/equity ratio. As the short-term interest rate increases, the debt mix is reduced to a desire for more long-term debt. Since debt mix is the ratio of short-term to long-term debt, it has a positive effect on liabilities or short-term debt. Liabilities positively effect the debt/equity ratio and the debt/equity ratio positively effects short-term interest

<u>**Figure 21**</u>

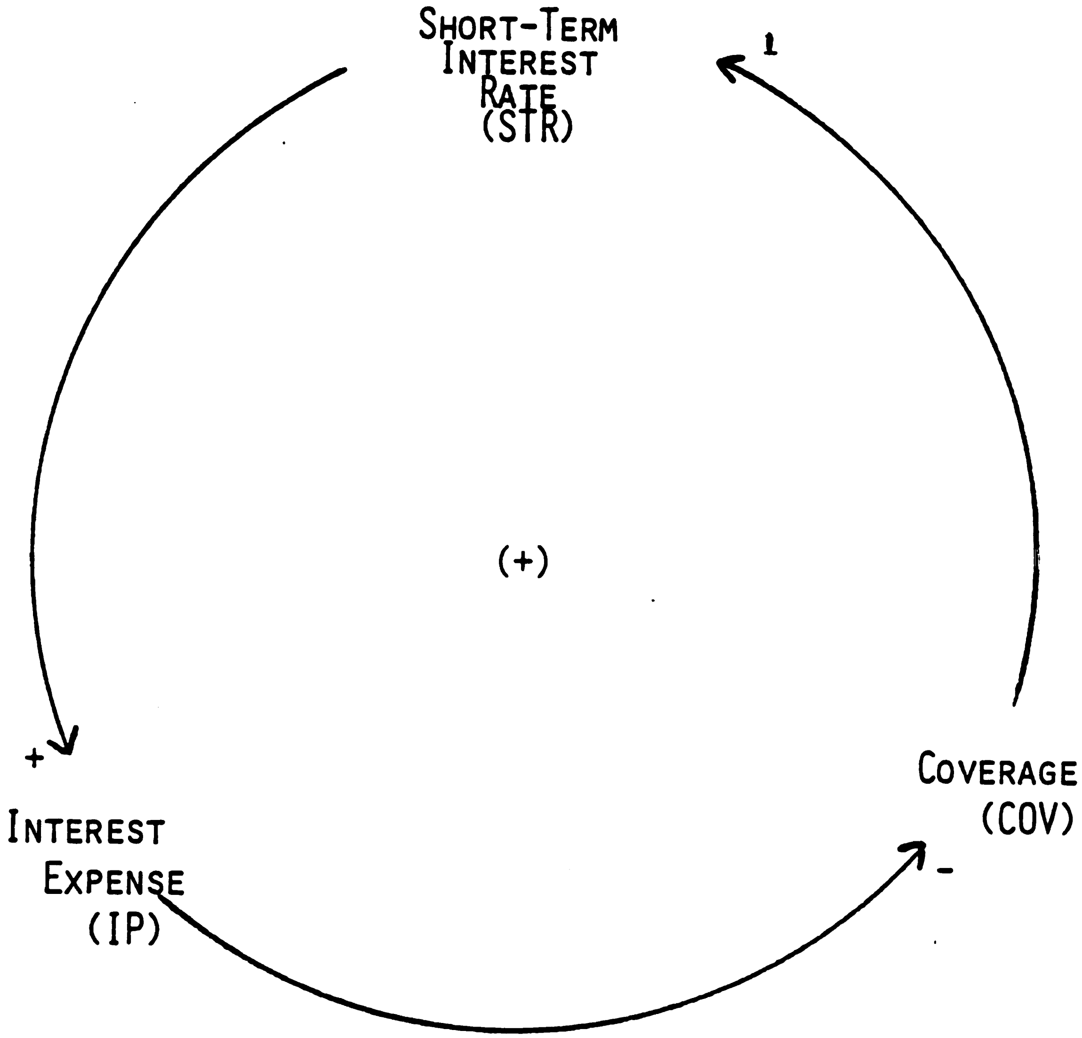
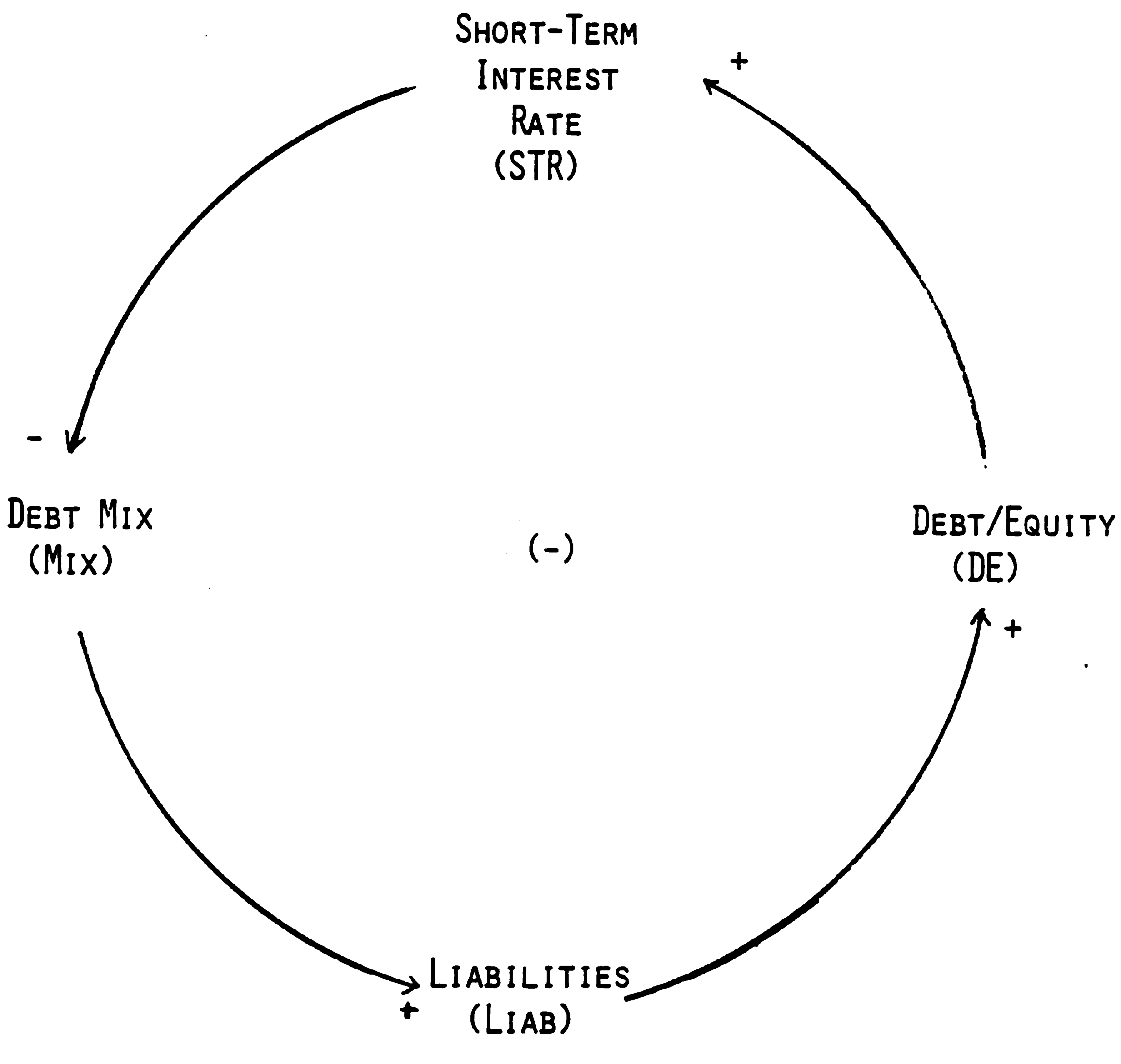

SHORT-TERM
INTEREST
RATE
(STR)
(+)
+
INTEREST
EXPENSE
(IP)
COVERAGE
(COV)
-

Figure 22


SHORT-TERM
INTEREST
RATE
(STR)
+
-
DEBT MIX
(MIX)
(-)
DEBT/EQUITY
(DE)
+
LIABILITIES
(LIAB)
+

rates.

The Figure A loop is positive or destabilizing with regards to short-term interest rates. The Figure B loop is negative or goal seeking with regards to interest rates. The dynamics of the two loops together depend on which loop is dominant. If A dominates, then controlled growth of short-term interest rates would be expected. If B dominates, then the growth would be stifled before it began. In this model, the dominance was difficult to determine because the rates change in different operating modes of the system. Also, empirical data for risk-free rates were inputted and they grew over time.

3. Figure 23 Credit Extension

Figure C is a negative feedback loop on credit extension relative to debt mix, liabilities, and the current ratio. As credit extension is raised by outside suppliers of funds, the debt mix would increase or favor more short-term debt or liabilities. As liabilities increase, the current ratio would fall. The current ratio has a positive effect on credit extension because it is one factor that determines the firm's ability to pay its bills.

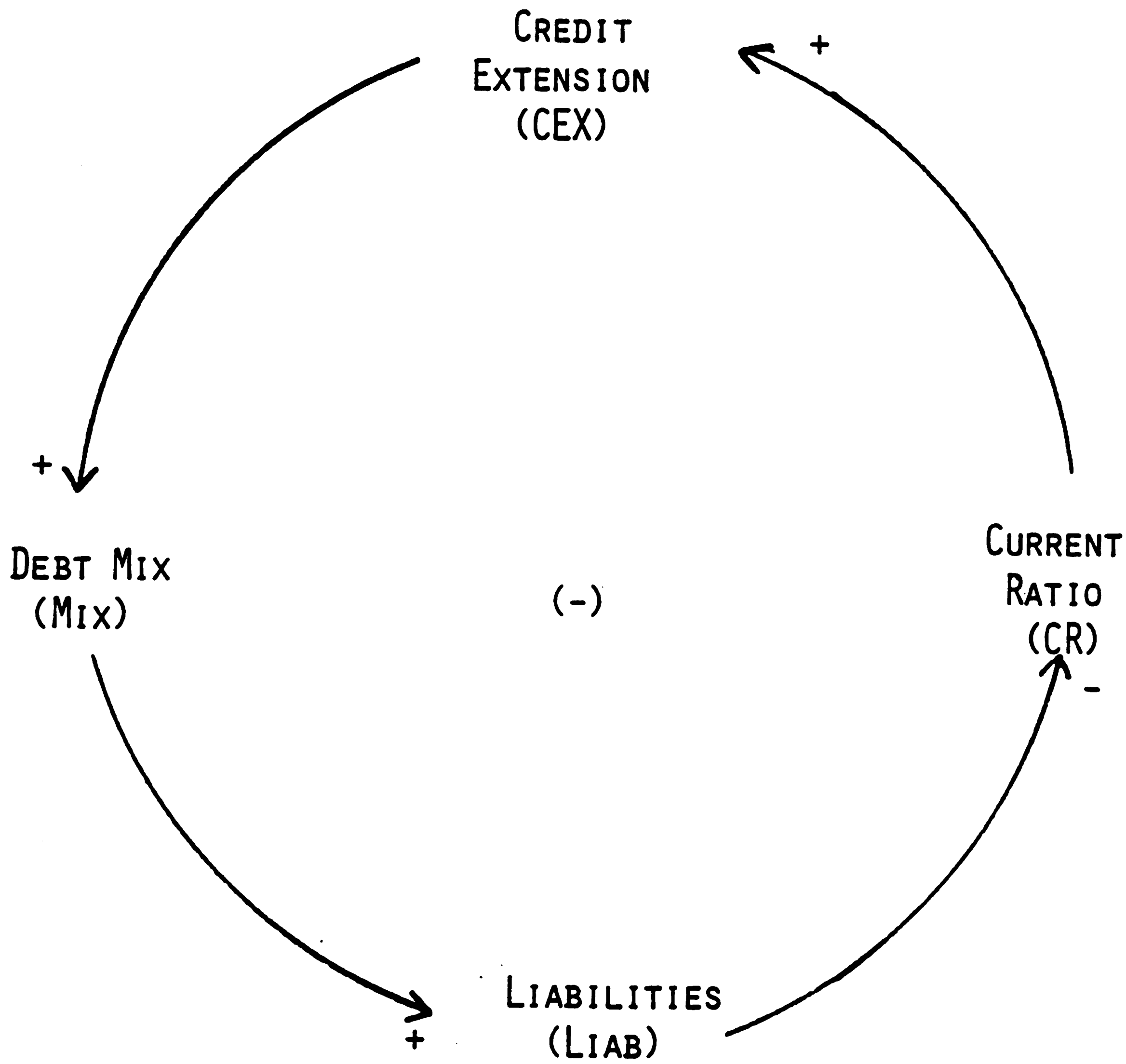
From this loop, credit extension would be expected to be stable. Therefore, growth in interest-free payables would be controlled.

4. Figure 24 Investment Fraction

The investment fraction is a decision variable of the firm. It relates the percentage of funds that will be channeled to fixed assets. Figure D shows a negative feedback loop that tends to stabilize this decision variable.

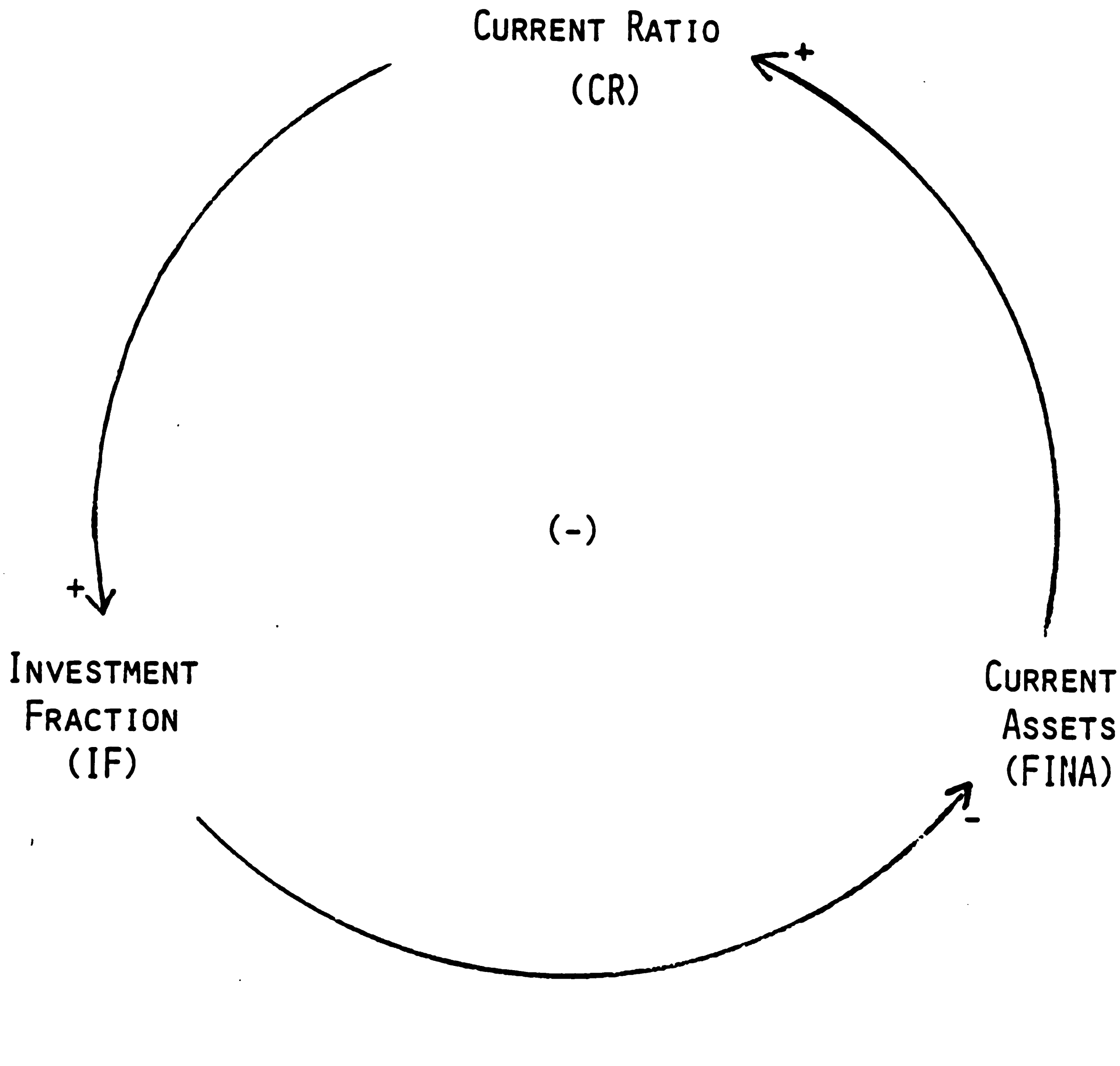
As the investment fraction rises the current asset pool would

Figure 23



CREDIT EXTENSION (CEX)
+
+
DEBT MIX (MIX)
(-)
CURRENT RATIO (CR)
-
LIABILITIES (LIAB)
+

Figure 24


CURRENT RATIO
(CR)
+
(-)
+
INVESTMENT
FRACTION
(IF)
CURRENT
ASSETS
(FINA)
-

decline. The current asset pool directly effects the current ratio. The current ratio directly effects the investment fraction because of the firm's desire for liquidity. If the current ratio were falling, the firm would wish to channel more funds to current assets to support liquidity and therefore the investment fraction would decline. The direction of change in the current ratio and the investment fraction are the same.

5. Figure 25 Short-term Interest

Figure E is similar to Figure B with long-term debt substituted for short-term debt in the loop. This loop also is positive.

6. Figure 26 Long-term Interest or Bond Rate

Figure F is a negative feedback loop of the long-term interest rate or bond rate (BR). The bond rate has a positive effect on the total interest expense of the firm (IP). The interest expense is negatively related to net income before tax (NIBT) and net income after tax (NIAT). Net income after tax directly effects retained earnings which directly effects total equity of the firm.

The Fisher bond premium equation increases with increases in total equity via the equity debt ratio. This bond premium is directly related to the long-term debt or bond rate of the firm. This loop would tend to stabilize bond rates in the system and the model.

7. Figure 27 Long-term Interest or Bond Rate

The explanation for Figure G is similar to Figure F up until net income after taxes. NIAT would have a positive effect on total income (TINC) which would have a positive effect on the standard

Figure 25

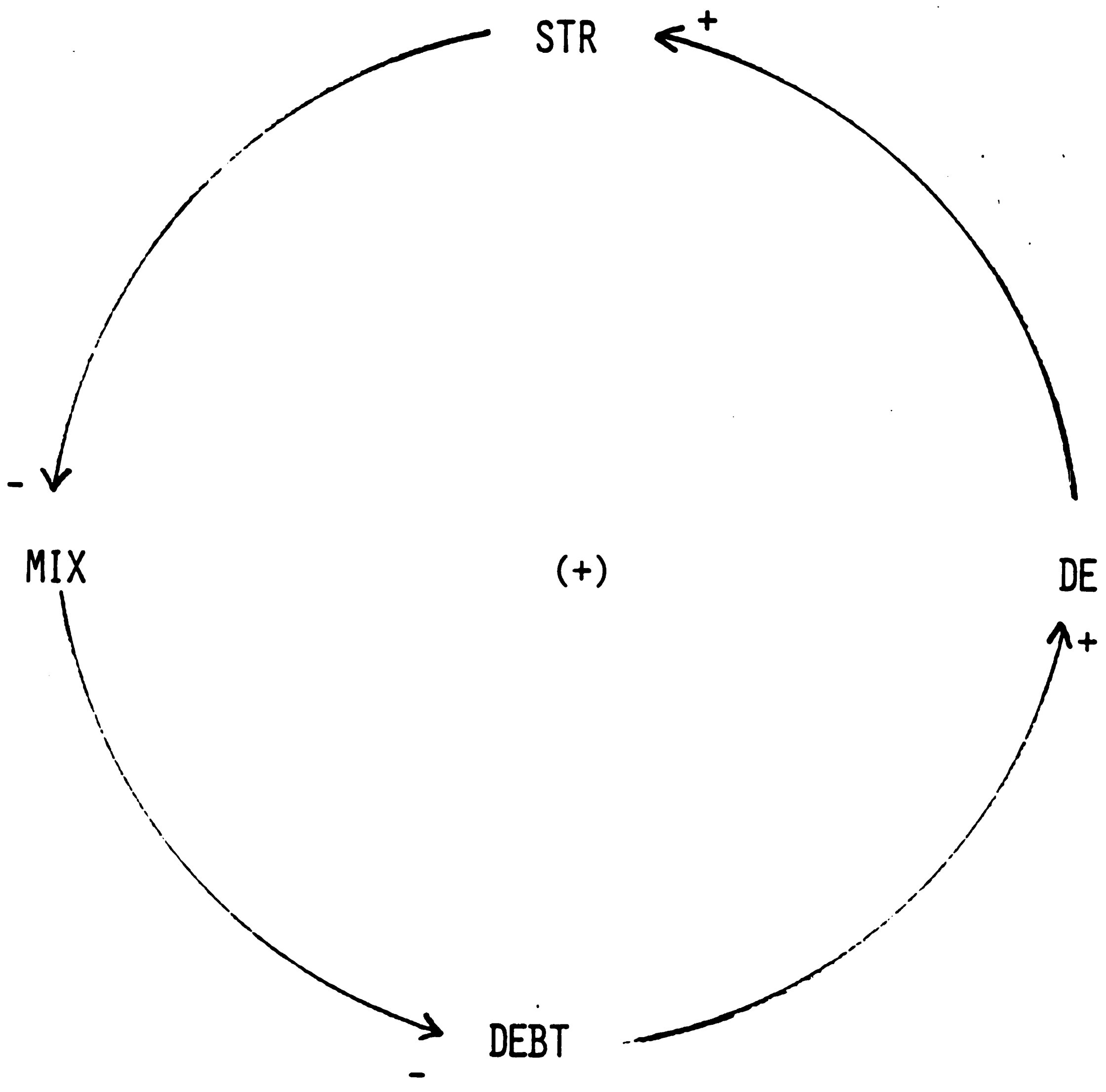
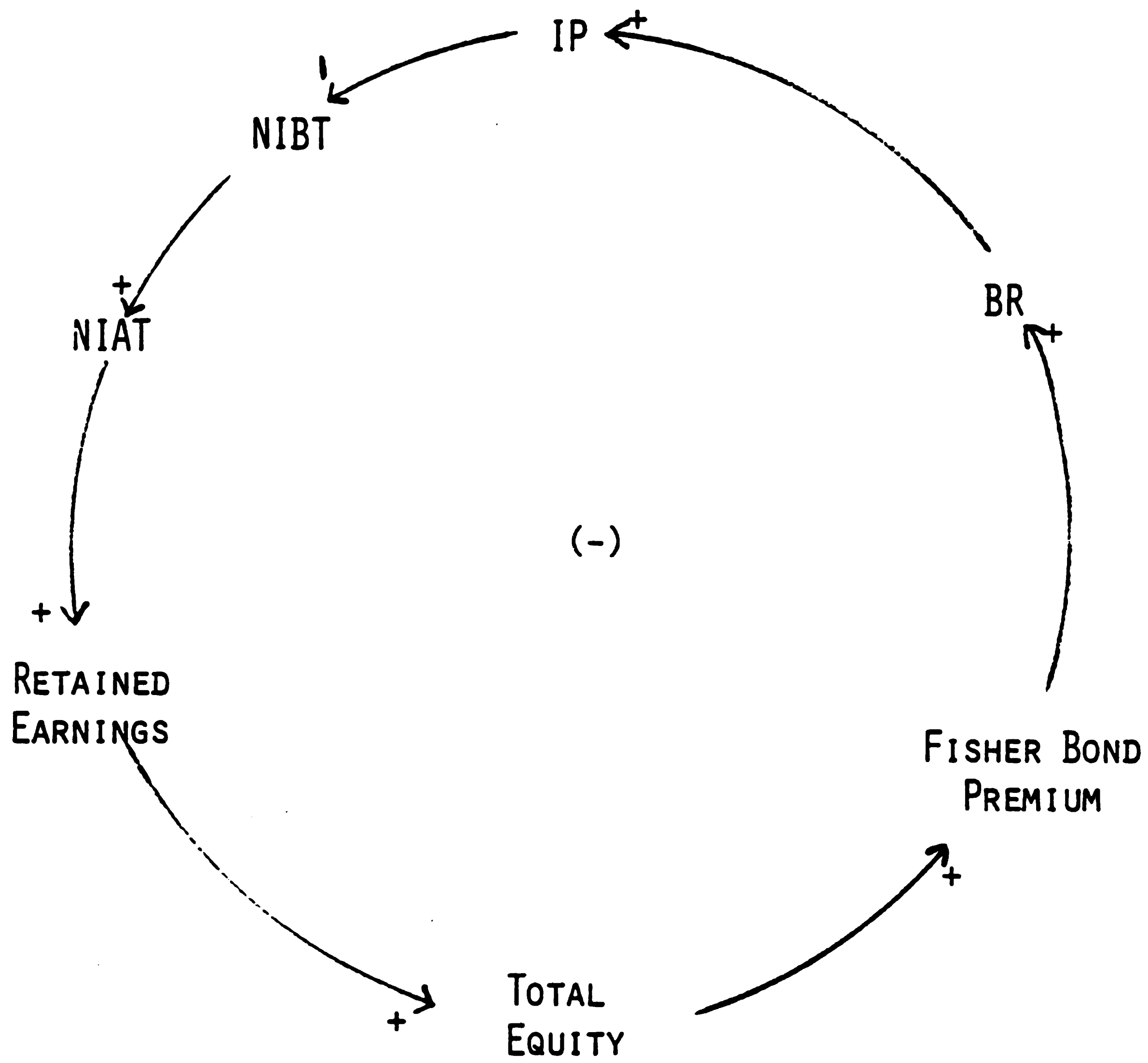
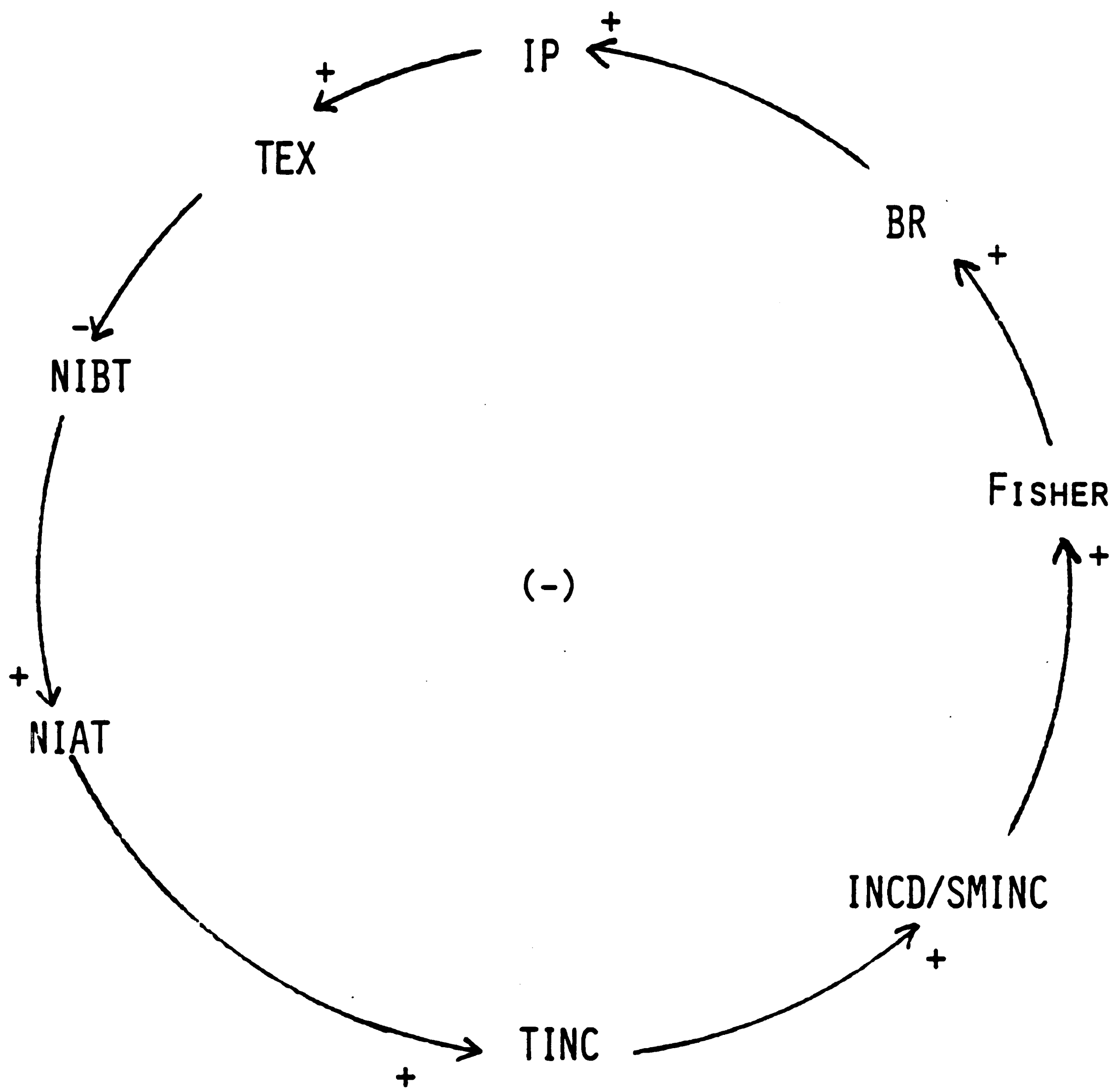


Figure 26


IP
+
'
NIBT
+
NIAT
+
Retained
Earnings
+
Total
Equity
+
Fisher Bond
Premium
+
BR
+
(-)

<u>Figure 27</u>



deviation of income relative to average income. This ratio directly effects the Fisher bond premium which directly relates to the bond rate. The net effect is another negative feedback loop.

8. Figure 28 Dividends

Figure H is a positive feedback loop effecting the absolute dollar value of dividends paid out by the firm. As dividends are increased, the change in funds or cash flow would decline. As the change in funds increases, fixed assets increase through further investment. As fixed assets increase, depreciation expense increases which increases total expense (TEX). Total expense negatively effects net income before and after tax. Net income after tax directly effects the absolute dollar value of dividends paid out. Therefore, dividends would be expected to grow from this loop.

9. Figure 29 Investment Fraction

The investment fraction (IF) of the firm is a decision variable defined in section 4 of this part of Chapter IV. As the investment fraction increases in Figure I, it would have a negative effect on current assets (FINA). As current assets increase, the mix variable would be enhanced which would increase the short-term debt or liability pool. Liabilities have a negative effect on the current ratio (CR) which directly effect the investment fraction. The net effect is a positive feedback loop.

10. Figure 30 Desired Equity

Figure J depicts two feedback loops, one positive; one negative, linked at the management decision variable desired equity (DEQF).

Figure 28

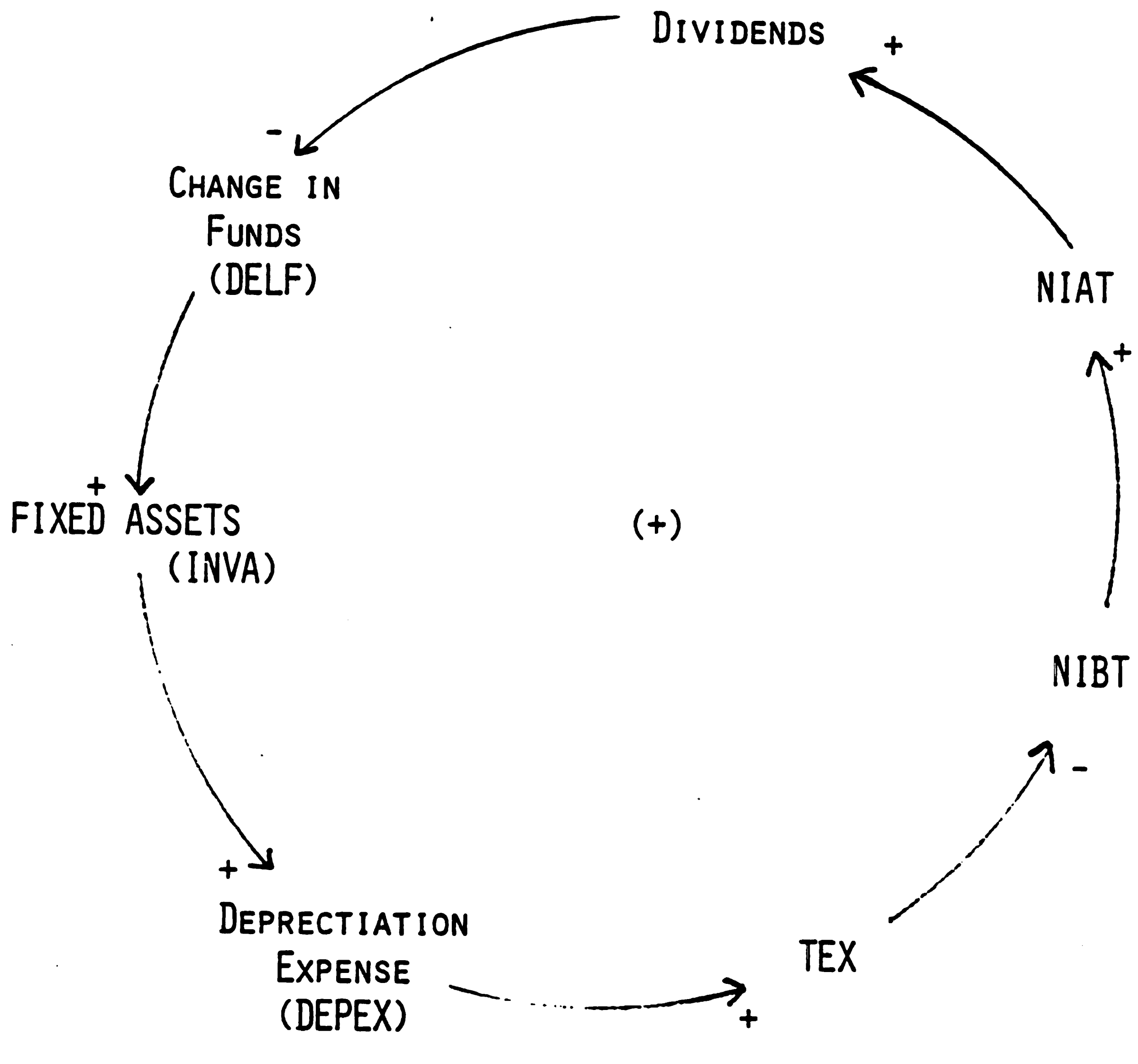

Dividends
+
-
Change in
Funds
(DELF)
NIAT
+
+
FIXED ASSETS
(INVA)
(+)
NIBT
-
+
Depreciation
Expense
(DEPEX)
TEX
+

Figure 29

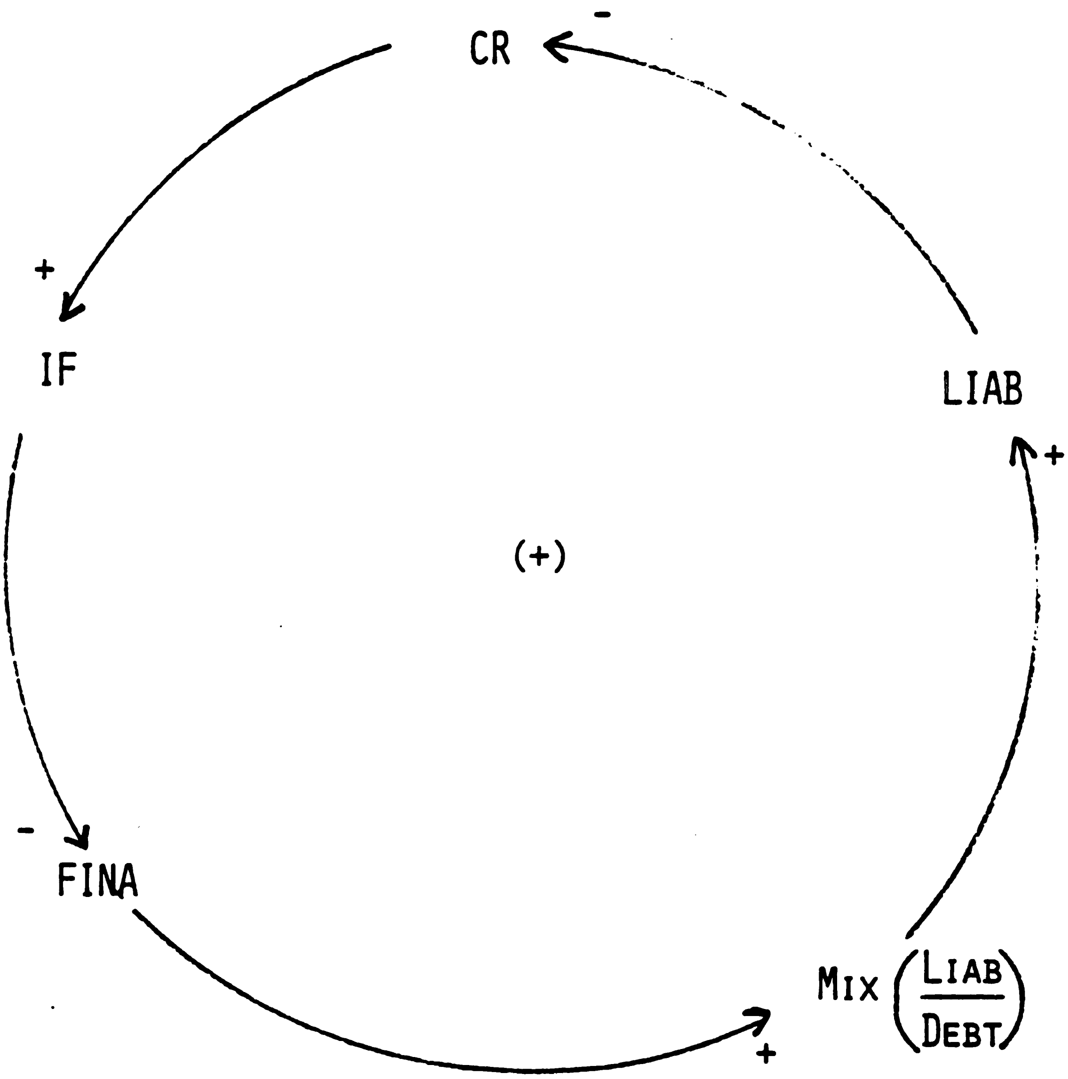
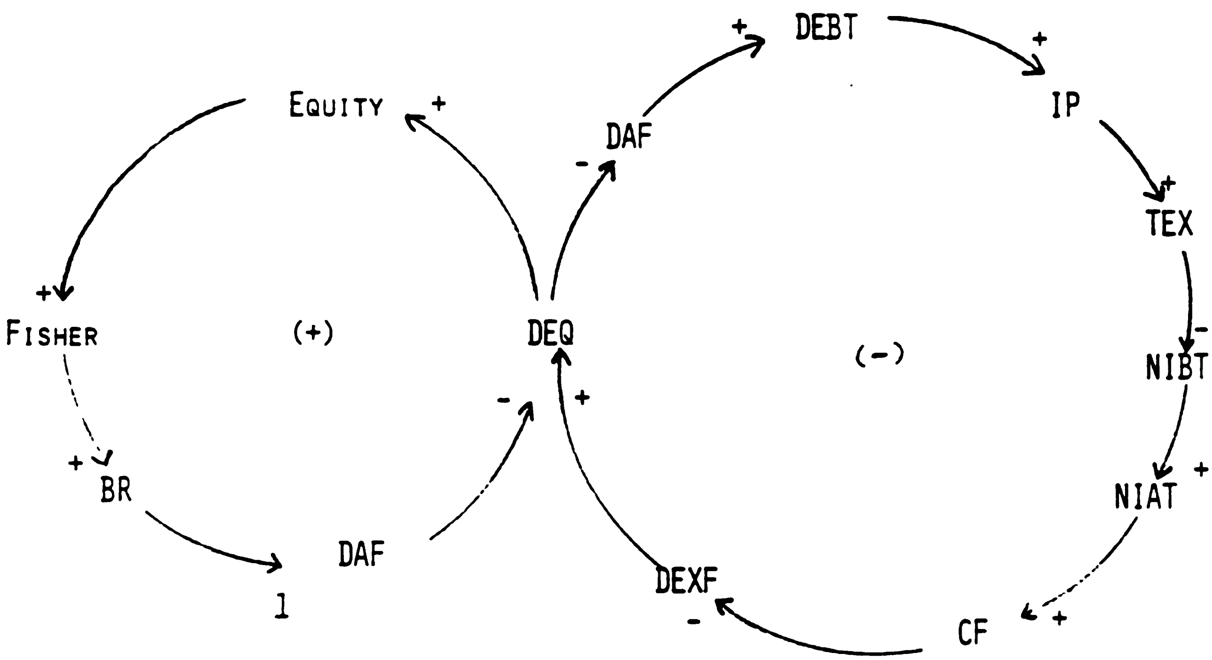


Figure 30



The positive loop shows how equity increases the Fisher bond premium via the equity/debt ratio. In turn, the Fisher increases the bond rate (BR) which would have a negative effect on the debt acquisition fraction (DAF) which means the firm would need more equity. Thus, a positive loop is formed.

The negative feedback loop shows desired equity negatively effects the debt acquisition fraction (DAF). The relationship from DAF to total expense (TEX) is all positive as explained previously. Then, total expense has a negative effect on net income before and after tax. Net income after tax has a direct bearing on cash flow (CF). Cash flow is negatively related to the desire for external funding (DEXF) which has a positive effect on desired equity.

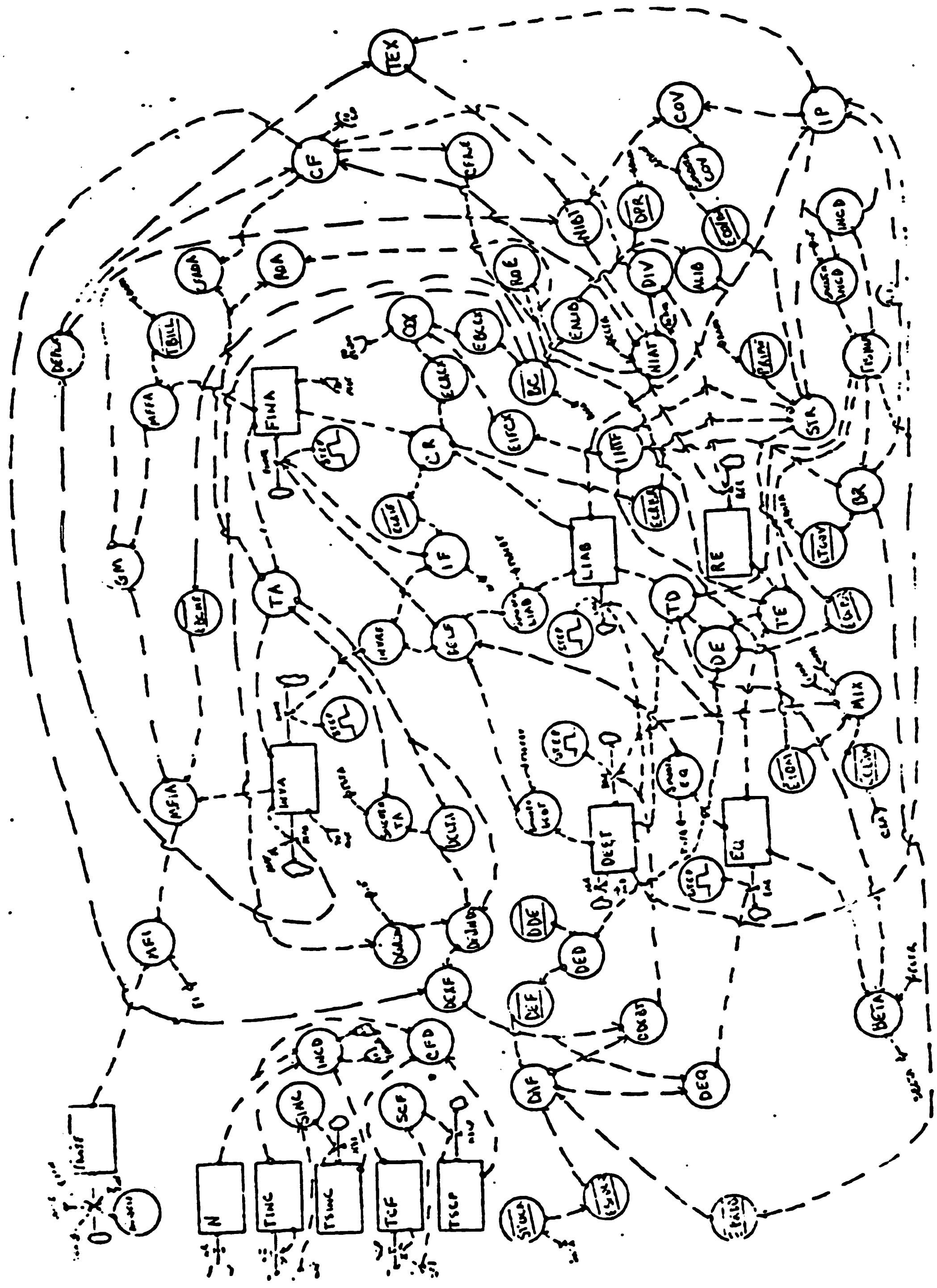
The two loops together will behave according to the dominance of a particular loop. In any case, the system is stable and the desire for equity should be controlled.

E. Block Diagram

The model's block diagram is depicted in Figure 31. It is a graphical representation of the relationships described in parts B and C of this chapter. An explanation of the relationships would be redundant in that it was performed in section B.

Figure 31

Block Diagram



PART II. Simulation Results

CHAPTER V

MODEL VALIDITY

Now that the model description has been concluded in Chapter IV, the process of model validation must be conducted. Validation is defined by Forrester as "the formal processes which leads people to place confidence in a model."[15]

However Greenberger, Crenson and Crissy (1976) point out that, "No model has ever been thoroughly validated.... 'Useful', 'illuminating', or 'inspiring confidence are more apt descriptors applying to models than 'valid'."[16]

Forrester describes the system dynamics model validation process. That process includes justification of the model in three areas. The three areas are suitability, consistency and utility/effectiveness.

The first area, suitability, includes discussions of dimensional consistency, boundary adequacy and parameter and structure insensitivity. Suitability addresses the appropriateness of the model. The appropriateness concerns the task the model was designed to perform or problems it seeks to solve.

Upon passing the first area of validation testing, the model must submit to a set of consistency tests. These tests include face

[15]Forrester, Industrial Dynamics.

[16]Greenberger, Crenson and Crissy, Models in Policy Analysis, p. 1976, pp. 70-71.

validity, parameter values, replication of a reference mode, surprise behavior, extreme conditions and statistical tests. These tests seek to prove the model behaves as the system does in reality.

If the model tests out as suitable and consistent, the validity regarding utility/effectiveness is considered. This third area of validation will be conducted in the concluding chapter of this text. Utility/effectiveness represents the purpose of building the model. Therefore, the appropriate time to discuss this issue is after the study has been completed.

Moreover, the validity of a model continues to be an issue every time it is used. The process of validation encompasses the most current attributes and outputs of the model. As the model is modified or as a new policy intervention is attempted, the question of validity must again be raised. This chapter validates the mdoel in its present state.

A. Suitability

"Is the model suitable for its purposes and the problem it addresses?"[17]

1. Dimensional Consistency

The test for dimensional consistency focused on structural suitability and continued throughout the modeling process. The test included two main thrusts. The first thrust was an equation-by-equation analysis of consistency. The units on the left-hand side of the equation must equal the units on the right-hand side. The dimensions of

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[17] Richardson and Pugh, 1981, Chapter 5, page 1.

the model were consistent on this basis.

The second thrust determined the meaningfulness of the units. The dimensions of rate equations were required to be "units per time." Since accounting values were the underlying basis for the structure of the model, accounting units had to be used. All Balance Sheet items were in "dollars" and Income Statement items in "dollars/year." The dimensions of the model were also consistent on this basis.

2. Boundary Adequacy

In addition to dimensional consistency, structural suitability of the model was based upon boundary adequacy. Boundary adequacy addressed the issue of sufficiency in the scope of the model. The model in this case was designed to address financing policies of the firm. It should therefore be sufficiently large to encompass the financing functions of the firm.

The financing functions of the firm encompassed by the model included securing debt, equity and retained earnings. These were the three major sources of financing for the firm. The debt financing was divided into long- and short-term financing and policy-making concerning their desired mix. The financing functions were adequately represented within the scope of the model.

The representation of the investment function within the model was based upon actual behavior and the policy-making process remained exogenous to the model. This function served only to determine the need for financing. The boundaries would be inadequate to investigate most investment policy issues. Considering the intent and purpose of the model, the boundary was adequate.

The mechanisms that determined the costs of financing, however, were both endogenous and exogenous to the model. The market determined rates were exogenous to the model. Once again, considering the intent and purpose of the model, the boundary was adequate. This was a micro study; not a market study and, thus, the limits of the model were suitable to this end.

3. Parameter Sensitivity

Another measure to be considered under model suitability was parameter sensitivity. In this validation step behavioral suitability was actually tested to determine the sensitivity of the model to parameter value changes. Since not all of the parameters in the model were empirically determined, this was a critical area of suitability.

The computer simulation results of parameter sensitivity can be found in Appendix 9, Sensitivity Analysis Printouts and summarized in Table V-1. The parameters tested were:

TCR - Target current ratio
NLD - Normal length of debt
FI - Normal return from fixed investment
TSTA - Time to smooth total assets
DGFR - Desired growth fraction
BCC - Business conditions constant
TAGR - Time to adjust growth rate
PLH - Planning horizon
TANF - Time to acquire new funds
TTPD - Time to pay dividends
TTPL - Time to pay liabilities
TRINVA - Time to reinvest in fixed assets

The results of these tests conveyed two points for consideration. The first point was the sensitivity of the model's output to varying values of the parameter. The second point was that changes in a parameter's value may also implement a policy change. An example

TABLE V-1

Parameter Sensitivity Test Results

Parameter Changed	Test: Lower Value Used	Test: Higher Value Used
TCR	Slightly more volatile	Slightly damped returns
NLD	No change	No change
FI	Lower values/no behavioral change	Higher values/no behavioral change
TSTA	--------------(n/a)*	No change
DGFR	Collapse year 20	No change
BCC	No change	No change
TAGR	More volatile/higher div & risk	Damped/lower divid & risk
PLH	No change	No change
TANF	No change	No change
TTPD	No change	No change
TTPL	--------------(n/a)*	No change
TRINVA	No change	No change

*(n/a) - not appropriate

might be the firm's target current ratio. In other words, if the firm controls the value of the parameter, would its modification be a worthwhile endeavor. Thus, this section can be perceived as a policy section as well as a suitability validation measure.

It should be noted that it is entirely possible that the model was sensitive to a parameter's values. It is also possible to build confidence in a model showing parameter sensitivities by justifying parameter values. This confidence would center around the desirability of the sensitiveness. Confidence in the model was warranted if the model tended to be insensitive to reasonable changes in parameter values. Therefore, in analyzing the results of parameter sensitivity runs, the question of reasonableness was considered. The test conducted in this study was to halve and double the value of the parameter.

a. Insensitive Parameters

Parameter values which were found insensitive where NLD, TSTA, BCC, PLH, TANF, TTPD, TTPL and TRINVA. The model was considered suitable for these parameters.

b. Sensitive Parameters

Parameters which created model output sensitivity were TCR, FI, DGFR and TAGR. In the case of TCR, target current ratio, the results were expected. With a lower liquidity target the firm's returns became more volatile. The reverse was also true. This was due to movement of funds from current to fixed assets. The returns from the fixed asset investment pool were expected to be higher and subject to greater fluctuations or risk. This sensitivity revealed the model's structure was adequately suitable regarding liquidity. The target current ratio was a policy of the firm.

Changes in values of FI, normal return from fixed assets, did not change the behavioral characteristics of the model's output. The only changes was in the magnitude of returns. This, too, was expected since FI was the basis of the returns to the firm. The absence of behavioral sensitivity was critical. Thus, the model's suitability was not effected by magnitude sensitivity to FI values.

Changes in values of DGFR did however create behavioral model changes. DGFR, desired growth fraction, created model sensitivity when its value was lowered not when it was raised. DGFR was that part of the model which drives the returns or investment results. Growth was a basic objective of the firm over the base period. This sensitivity test result became rather a policy test. The result showed to survive the firm must grow. If the boundaries of the model are expanded to include the investment policy areas, this variable must be replaced by additional model structure.

TAGR, time to adjust the growth rate, sensitivity was not surprising. The results of this sensitivity test reveal behavior that is characteristic of control systems. A control system that reacts to the most recent data will tend to create more volatile results if tracking a volatile system. Therefore, the reasonableness of the value of TAGR should be addressed.

TAGR's value in the model was one year. The firm being modeled used annual plans over the base period and thus TAGR's value was reasonable.

c. Summary

Given the above discussion of the test results, the model appeared to be suitable regarding parameter insensitivity. The limits of the model's boundaries created the growth sensitivity. Otherwise, the model's structure focused on capturing the financing policies of the firm.

4. Structural Sensitivity

Structural sensitivity was considered after parameter sensitivity. Structural sensitivity tests determined whether the model was sensitive to reasonable alternative formulations. It would be anticipated that reasonable structural alternatives would yield similar output modes of behavior. Thus, a suitable model is structurally insensitive.

In the course of this research two model structures were developed. The output from policy-testing of both models was similar. This was not necessarily proof but can be used as evidence of structural insensitivity.

5. Conclusion

Given the discussion above, the model beared consideration as a suitable model. The model has discussed the on-going treatment of dimensional consistency and boundary adequacy. All of these build a case for the acceptance of the model as suitable. The next step in validation became the consistency step.

B. Consistency

"Is the model consistent with the slice of reality it tries to capture."[18]

1. Face Validity

Face validity was the first step in consistency validation. Face validity addressed the reasonableness of the model. On the surface, the model should represent the true system and be a recognizable picture to those who know the true system.

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[18]Richardson and Pugh, 1981, Chapter 5, page 3.

Since the accounting structure of the firm was captured in the model structure, the model exhibited face validity. The components of the Balance Sheet and Income Statement transferred from the system to the model. The financing decision areas of the firm were captured by the model in a familiar state. Therefore, the model had face validity.

2. Parameter Values

After considering face validity, parameter values were evaluated for consistency. Consistency encompasses the recognizability of the parameters to members of the system, the trueness of parameter dimensions and values. The parameters values under consideration are summarized in Table V-2.

Table V-2 shows that all the parameters had system equivalents and were recognizable to the system. The dimensions were the same in both cases. The values were determined by either empirical evidence or management preference. Therefore, parameter value consistency was established.

3. Replication of Reference Mode

A further test of model consistency was replication of reference mode behavior. This test compared the base-run model output to the actual system output values. The base-run output can be found in Appendix 8, Base-Run Output. The observed data of Union Oil Company is part of Appendix 7, Data Tables and Plots.

The plots of the return measures compared favorably. The model output of cash-flow returns and dividends resembled the empirical data best of all the output variables. Peak-to-peak and trough-to-trough

TABLE V-2

Parameter Values

Parameter	System Equivalent	Units	Value
TCR - Target current ratio	Yes - same	Dimensionless	2.5 (p)
NLD - Normal length debt	Yes - debt maturity	Years	20 (e)
FI - Normal return on fixed investment	Yes - gross return	%/year	90 (e)
TSTA - Time to smooth total assets	Yes - monthly report	Years	.08333 (p)
DGFR - Desired growth fraction	Yes - same	Dimensionless	.5 (e)(p)
BCC - Multiplier business conditions	Yes - same	Dimensionless	.1 (p)
TAGR - Time to adjust growth rate	Yes - same	Years	1 (p)
PLH - Planning horizon	Yes - same	Years	1 (p)
TANF - Time to acquire new funds	Yes - financing lead time	Years	.6 (e)
TTPD - Time to pay dividends	Yes - same	Years	.25 (e)
TTPL - Time to pay debt	Yes - same	Years	.08333 (e)
TRINVA - Time to replace assets	Yes - same	Years	.25 (e)

e - empirical, this quantity was measured from data

p - policy, this quantity was determined through management interviews. These values could be modified by the firm if a policy change is desirable.

analysis for all the return measures was close. Peaks matched in periods 1, 8, 12, 16, 29 and 40. Troughs matched in periods 3, 10, 14, 30, 32 and 34.

Income return measures appeared to be more volatile in the system than the model. Since cash-flow measures were preferred in financial analysis, the strength of the model to replicate cash-flow returns enhanced its validity. The model captured dividend behavior due partly to the growth policy of the firm.

The risk measures in the second output and graph exhibited some model problems. The risk macro developed for the model suffered due to the lack of memory in the DYNAMO language. Therefore, risk measures required a start-up period of around ten years. Inferences to risk were restricted to the last thirty years of output. This condition placed upon the analysis enabled the model to be deemed valid for risk measures.

Overall, the model behaved like the system. It replicated the output variables from which conclusions were drawn. The model appeared to be valid under this measure.

4. Surprise Behavior

The next step in consistency validation was the discussion of surprise behavior. When a model exhibits surprise behavior two conclusions are possible: one conclusion reveals a flaw in the model's structure. The other conclusion suggests that under the circumstances the real system would have behaved in the same manner. No surprise behavior was exhibited by the model.

5. Extreme Condition Simulations

As in the case with surprise behavior, the model was expected to behave in a reasonable fashion under extreme conditions. When unreasonable behavior develops, the model needs to be reformulated. The policy tests conducted in this study included extreme conditions. The model did not display unreasonable behavior. Therefore, the model appeared valid regarding this issue.

6. Statistical Tests

The concluding step in consistency validation was statistical testing. The model return output was compared to system return data to reveal a correlation of 0.63. In a test of significance at the .05 level this correlation was found to be statistically significant (See Appendix 7).

Although the results of statistical testing were positive, the statistical data were not the only source of validation. The results of this test built an argument in favor of the model.

7. Summary

The purpose of this section was to determine the consistency of the model. The above discussion revealed a high-level of consistency with the real system.

C. Conclusion

The purpose of this chapter was to provide evidence that the model developed for this research was valid. Validity was defined as a confidence in the model. The confidence encompassed two areas; suitability and consistency. Suitability addressed the purpose of the model. Consistency investigated the realism of the model. In both areas the model fared very well. Confidence in the model had been established.

CHAPTER VI

POLICY INTERVENTIONS

This chapter contains a description of policy test results. The policy testing is broken down into three main categories:

A. Debt policy interventions

B. Dividend policy interventions

C. Debt and dividend combination policy interventions

Under category A, debt/equity ratio policies of 0, 0.5, 1.0, 1.5, 2.0 and 3.0 were implemented. Under category B, dividend payouts of 0, 0.25, 0.5, 0.75 and 1.0 were implemented. Under category C, all possible combinations of A and B were implemented as shown below.

Debt/Equity Ratio	Dividend Payout 0	0.25	0.5	0.75	1.0
0	Test 1	Test 7	Test 13	Test 19	Test 25
0.5	Test 2	Test 8	Test 14	Test 20	Test 26
1.0	Test 3	Test 9	Test 15	Test 21	Test 27
1.5	Test 4	Test 10	Test 16	Test 22	Test 28
2.0	Test 5	Test 11	Test 17	Test 23	Test 29
3.0	Test 6	Test 12	Test 18	Test 24	Test 30

A total of 41 policy interventions were performed. The simulation results of these tests can be found in Appendix 10, Policy Intervention Outputs. The results of these simulation runs were compared to the base-run in order to determine the impact of a given policy. The complete explanation as to why a particular result occurred will be left until Chapter VII.

When describing the output, two factors were involved. First, output variables were examined to see if they behaved as they did in the base-run. This was an evaluation of the plot pattern. Second, the magnitude of the output variable was determined and compared to the base-run levels. Table VI-1 summarizes these results.

TABLE VI-1

SUMMARY OF RESULTS

Policy	Return on Assets	Return on Equity	Total Dividend	Standard Deviation Assets	Standard Deviation Equity
a) Debt Policy					
D/E = 0	+	-	+	0	-
D/E = .5	0* -**	0 +	- -	0 0	0 +
D/E = 1.0	0 0	+ +	- -	+ +	+ +
D/E = 1.5	- -	+ +	- -	+ 0	+ +
D/E = 2.0	- 0	+ +	- -	+ 0	+ +
D/E = 3.0	- 0	+ +	- -	+ 0	+ +
b) Dividend Payout					
Payout = 0	+	+	-	0	0
Payout = 0.25	+ -	+ -	0 +	0 0	0 0
Payout = 0.5	0 -	0 -	+ +	+ +	+ +
Payout = 0.75	- -	- -	0 -	0 -	0 -
Payout = 1.0	- -	- -	- -	- -	- -

Legend

+ Higher than

0 Equal to

- Lower than

*First character compares to the base run.

**Second character compares to the previous run in a particular set of runs.

A. Debt Policy Interventions

Six debt policies were simulated and are discussed in this section. The policies ranged from no debt to debt levels of three times that of equity. These policy interventions were performed by modifying the desired levels of debt/equity and not their actual levels. This allowed for the bending of policy if the need arose although it did not arise for the tests performed in this study.

1. No-debt policy

When the desired debt/equity was set at zero some noticeable and expected changes occurred. First, return on assets and cash-flow return on assets increased. This was due to the elimination of interest expense and the continued profitability of the firm. However, return on equity and cash-flow return on equity were the same. This was due to the fact that less leverage was available for the owners.

The risk measures on assets remained unchanged from the base run. The standard deviation of return on equity declined. The behavior of the risk measures was identical to the base run. The overall risk measures were unchanged.

In all, the firm netted a lower return to the owners at a lower risk level. It also netted a higher return on assets at the same risk level. The profitability of the company carried the firm along, without the assistance of debt, in its growth needs. Dividends were higher but paid to more shareholders.

2. Debt Half of Equity

This policy was close to an average of the base-run policies of the firm. As would be expected the simulation results were very close to those of the base-run. Behaviorally and in magnitude, they were identical with respect to the return and risk measures. The total dividends paid were lower overall.

One possible explanation of the lower dividend is the ending debt/equity values were lower than the base-run. So dividends were lower in the higher profit years due to lower leverage.

It could be considered that this policy was favorable to the base-run policy because of its consistency. However, the level of dividends was lower. Thus, any increase in the firm's market value due to reduced uncertainty would have been offset.

3. Debt Equal to Equity

This policy was close to the ending policy of the base-run. The returns to the owners in this case were higher due to the leverage although return on assets was the same. The total dividend was considerably lower, but that was spread over fewer owners as well due to the leverage effect. The model does not specify dividends per share.

The standard deviation of return on equity was higher and behaved in a less stable manner. The risk measures on assets were also increasing. The overall risk of the firm was higher than the base-run due to leverage.

4. Debt One-and-a-Half Times Equity

The trend that was evident in the previous intervention was continued here. Larger returns to owners, higher risk levels and lower dividends were exhibited. The company was still in a position where it could afford its high interest expense. The return on assets was slightly lower than the base run. The lower dividend was again available to a smaller pool of owners.

The behavior of the return measures was the same but at higher levels. The behavior of the risk measures was noticabely less like the base-run. They were less stable at their higher levels.

5. Debt Twice Equity

Return on assets was still holding its own so the trend continued. Lower dividends for what can be assumed to be fewer owners, higher returns to owners and higher risk levels were all in evidence.

The behavior of the returns continued to remain intact but at still higher levels. The equity return risk behavior was fluctuating more at higher levels. The risk measures on asset return were fairly stable.

The return on equity was not growing as fast as its associated risk measure. It can be assumed that the value of the firm's shares were beginning to feel the downward pressure of higher risks. Dividends were not compensating for this possible reduction in share price.

6. Debt Three Times Equity

This policy seemed to go beyond the break point for the company. Return measures to the owners did not increase from the previous policy intervention. Risk measures continued to rise. The dividend did not change from the previous policy intervention. This meant that everything remained the same while risk increased considerably.

It can be safely assumed that the value of the firm had diminished from the debt/equity level of 2.0. The behavior of the return measures was still about the same. The behavior of the risk measures was noticeably different. Risk was consistently higher.

7. Summary

The model of the company had demonstrated strength to withstand higher debt levels. The debt/equity level of 2 seemed to be the point where leverage advantages no longer outweighed the disadvantages. It appeared that the company fared better than the base-run when it followed a consistent policy especially at the 0.5 and 1.0 debt levels.

The behavioral aspect (exhibiting the same peaks and troughs) of the return measures remained intact throughout. This was due to the fact that the mechanisms determining income were not affected by financing. With the exception of varying interest expense, the return on assets was steady in magnitude. The return on equity increased by leverage effects and then collapsed. Risk behavior and magnitude were changed from the base-run. The dividends available to owners fell with each discrete jump in debt/equity.

B. Dividend Policy Interventions

Five dividend policies were simulated and discussed in this section. The policies ranged from the no-dividend to the all-dividend policy. The policy intervention was performed by setting Desired Dividend Payout, DPR, to the prescribed policy level. Because a desired variable was modified, policy bending was possible if the need arose, i.e. if the company had no money to pay dividends.

1. No-Dividend Policy

When the desired dividend payout was set to zero the model reacted in almost every variable. Initially cash flow return on equity was higher because of the retention of cash. This measure continued to hold its high level through time. All of the other return measures appeared to fare as well.

The standard deviations of return were about the same as the base-run. The other risk measures were also at or near their base-run values. Overall, a higher return was exhibited with equal risk. However, no dividend yield was offered under this policy.

2. Twenty-five Percent Dividend Payout

In this policy intervention the behavior of the model reverted back to the base-run for all variables by not displaying the same growth as above. The returns, however, were slightly higher with higher overall dividends paid. This was probably due to the consistency of the policy and greater retention of earnings overall. The model displayed how extremes were not as attractive. This intervention was more moderate than the previous one.

Asset based risk measures increased. However, the equity based risk measures were unchanged. The fixed dividend payout appeared to stabilize and lower the firm's overall risk.

3. Fifty Percent Dividend Payout

When the dividend payout ratio was pegged at 50% of income, the model behaved similarly to the base-run. Returns reverted back to the same magnitude and behavior as the base-run. Dividends were higher overall, but without a behavioral change. It appeared that the dividend payout was starting to stifle the firm's growth policy.

Risk was now slightly below the level of the base-run. Standard deviation of return was higher. The behavior also was very much the same. Overall, the owners appeared to be better off under this policy than the previous or base-run policies. Returns and risk were the same but dividends increased.

4. Seventy-Five Percent Dividend Payout

In this policy intervention simulation run, the behavioral aspects of the return measures continued to hold to the base-run. The returns, however, were considerably lower. The dividends were lower due to lower income. The lower income was caused by higher financing costs.

The behavior of risk was as in the base run. It was also lower than the base-run by a factor of .25. Thus, the lower returns were matched by lower risk. A result that would be expected.

5. All-Dividend Payout

For this simulation run the entire amount of income was paid out as dividends. The results showed more stable but considerably lower returns. Dividends were higher by a factor of 10.

Risk also was lower overall. The standard deviation of return on equity and the coefficients of variation maintained lower levels throughout. The risk behavior was also more stable. The owners got lower risk and return and much lower total dividends.

6. Summary

The model appeared to be sensitive to dividend payout policy interventions. This was surprising in that external funding was not restricted in the model. A payout of .25 appeared to have improved the firm over the base-run. The increase in payout lowered return and risk but increased dividend yield with diminishing returns.

C. Debt and Dividend Combination Policy Interventions

Thirty combination policy interventions were simulated. Because no theoretical basis for these policies could be identified, the description of their results was performed in Appendix 13. No specific trends were identified and the relative magnitude of change in any one run was rather insignificant.

D. Conclusion

The debt policy and dividend policy interventions results were described in this chapter. The magnitude of the output variable values displayed change albeit not dramatic. The behavioral pattern of the output did not change.

The significance of these results and their relation to theory will be discussed in the concluding chapter.

CHAPTER VII

CONCLUSION

In this chapter the policy intervention results described in Chapter VI are discussed. The discussion compares the results with current theory, tests the results for robustness and describes the contribution of the results to Union Oil's management and others. Further uses of the model and areas for future research were identified and are discussed in this chapter as well.

A. Discussion of Results of Policy Interventions

1. Comparative Analysis with Theory

Although there are several theories regarding the optimal capital structure of the firm including a traditional view and one espoused by Modigliani and Miller, a majority view postulates that there is an optimal structure. This optimum exists due to a trade-off between the tax benefit of debt financing and the costs of financial distress,i.e., bankruptcy and agency costs. The optimum capital structure is one which maximizes the firm's value. Value is determined by a firm's risk and return characteristics. Thus, each firm has a unique optimal capital structure.[19]

The results of the debt/equity policy interventions undertaken in the study were compared to outcomes which would be reasonable if an

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[19]Brealey and Myers (1981), pp. 395-396.

optimum capital structure is assumed to exist for the firm. The use of additional leverage enhanced the value of the firm up to a debt/equity of 2.0. Beyond this point the return to the owners did not increase enough to compensate for the additional assumption of risk. Thus an optimum point was discovered between debt/equity ratios of 2.0 and 3.0.

The literature dealing with dividend theory, on the other hand, does not present a majority view or agreement regarding an appropriate dividend payout ratio. Empirical studies have resulted in conflicting conclusions and little agreement amongst theorists and practitioners. Agreement focuses upon the need for a consistent dividend policy by formulating a target dividend payout ratio. Brealey and Myers [1981] suggest that the target should be sufficiently low to minimize the reliance on external equity.[20]

Dividend policy interventions in the study resulted in small changes in the return and risk output measured at different target payouts. When the payout was set at 0 or 0.25, the returns were slightly higher than the base-run with no difference in risk. The higher payouts netted lower returns and slightly higher risk. Because the changes in the output measures were small, dividend policy did not seem to have a great impact on the firm's value. However, constant and low target payouts outperformed constant and high and variable payouts using the model. This result supported no particular theory and agreed with Brealey and Myers regarding the effect of consistent and low target payouts.

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[20]Ibid., p. 345.

2. Extreme Policy Tests

The results discussed above revealed that this model's output agreed with current theory dealing with debt and dividend policy. Chapter V was devoted to a discussion of model validation before policy test interventions were conducted. The validation process is never complete, however, and additional validation work was done covering policy interventions that fell outside the normal operating range of Union Oil Company. The results of the additional work are discussed below.

Tests outside the normal operating range of the firm revealed departures from the base-run behavior. However, the departures were subtle and slow to develop. Some interesting results were in evidence.

One such result revealed the possible presence of a debt capacity ceiling for the firm. This outcome was exhibited when the debt/equity ratio was increased from 2.0 to 3.0. The marginal increase in returns were substantially lower than the marginal increase in risk. Therefore, if one uses the capital asset pricing model utility function assumptions,[21] the owners of the firm did not benefit from additional leverage.

Another interesting result in the extreme policy range dealt with zero debt. In this case, the opposite of the above was true. The marginal reduction in risk, with no debt, was substantially lower than the marginal reduction in return on equity. Therefore, the owners fared better with some debt versus no debt. This outcome captured the

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[21] See Modigliani and Miller (1958).

Modigliani and Miller supposition of the results of debt financing.[22]

The extreme ranges of dividend policy also resulted in interesting outcomes. In the no-dividend case the returns were higher with no change in risk levels. It was difficult to ascertain whether the returns were high enough to offset the elimination of dividend yield to the owners. The model's behavior appeared to be consistent with corporate practice of retaining earnings for growth purposes.

At the other extreme, a 100 percent dividend payout policy revealed initial higher dividend levels but with the progression of time the overall income and dividend level lagged. The lagged income and dividend levels resulted from delayed investment as the firm waited for funding. The model assumed continuous and dramatic growth requiring substantial financial resources. A firm undergoing such a growth policy would consider it poor financial policy to pay out all of its earnings as dividends.[23] The simulation results were consistent with rational behavior on the part of managers.

When the model was run with growth turned off (Appendix 11, Model Start-Up Runs) the owners received higher overall dividends with the 100 percent payout. It was also concluded that the model exhibited behavior consistent with current financial theory and practice in the extreme ranges.

3. Tests for Policy Robustness

Although the results of the extreme policy tests were consistent with theoretical expectations, tests of policy robustness were

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[22]See Modigliani and Miller (1958).

[23]Weston and Brigham (1978), p. 686.

conducted. Robustness refers to the extent to which a real system can deviate from the assumptions of the model without invalidating policy recommendations based upon it. In system dynamics a policy recommendation is robust only if it remains a viable choice in spite of variations in the model's assumptions.

The model's assumptions under consideration here included the table functions derived by the modeler. The table function slopes were modified at extreme policy values for debt/equity. A table function was flattened by the reductions of the absolute value of a curve's slope coefficient. It was steepened by increasing the absolute value of a curve's slope coefficient. The results of these simulations are summarized in Table VII-1 and can be found in greater detail in Appendix 12.

TABLE VII-1

RESULTS OF TABLE FUNCTION MODIFICATION
WITH EXTREME DEBT POLICIES

	Debt/Equity			
Table	0		3.0	
Function	Flatter	Steeper	Flatter	Steeper
TECRIF	Lower Returns	Higher Returns	Higher Returns	Lower Returns
TEBCCX	No Change	No Change	No Change	No Change
TEIFCX	No Change	No Change	No Change	No Change
TECRCX	No Change	No Change	No Change	No Change
TERBR	No Change	No Change	No Change	No Change
TECOVB	No Change	No Change	No Change	No Change
TEDEBR	No Change	No Change	No Change	Higher Risk
TECRBR	No Change	No Change	No Change	Higher Risk
TEBRDD	No Change	No Change	No Change	No Change
TESP	No Change	No Change	No Change	No Change
TEIOM	No Change	No Change	No Change	No Change
TECEXM	No Change	N/A	No Change	N/A

For a policy of zero debt, the only table function that caused model output sensitivity was TECRIF, the effect of the current ratio on the investment fraction. As the slope of this table was flattened, the returns were lower. When the slope was steepened, the returns were higher. This outcome resulted from the high level of the current ratio with zero debt.

At zero debt, the flatter table function provided a lower investment in fixed assets. Thus, a lower return was exhibited. The steeper slope provided a higher investment in fixed assets and thus the higher return.

Although the cause of this sensitivity can be explained, it does not establish validity for the table function's slope. The flattened table would not be appropriate because the firm would have no mechanism for pursuing its target current ratio. The steeper table would have been appropriate if the firm desired to behave in a riskier manner but the firm did not. Therefore, the slope of the table function used in the model appeared to be realistic.

Because the TECRIF table was sensitive, the debt/equity policy cannot be considered robust regarding TECRIF. Further evidence of this conclusion appeared when a debt/equity policy of 3.0 was attempted. A flatter slope yielded a higher return and a steeper slope a lower return. In this case, the flatter slope was also inappropriate for reasons stated above. The steeper slope would represent a more conservative attitude toward risk. This change in risk attitude is possible but did not reflect the firm's behavior over the base-run period.

Thus, the lack of robustness regarding TECRIF addressed the issue of boundary adequacy of the model. TECRIF captured the investment tendencies of management. Since the model was limited to financing decisions, the investment decision was exogenous. Perhaps policy robustness regarding TECRIF could be established by development of more model structure in the investment area.

The rest of Table VII-1 does, however, reveal policy robustness regarding the other model assumptions. TEDEBR and TECRBR were slightly sensitive at a debt/equity of 3.0. However, this sensitivity was small, one-directional and reflected only in the risk factors. TEDEBR and TECRBR were therefore considered robust. The results of the policy testing were qualified regarding management preferences for risk based on this discussion.

4. Contribution

The contribution of the model and the results obtained from its model runs are discussed in two areas: managers/practitioners and the literature.

a. Contribution to managers/practitioners

The discussion of the model's use to managers/practitioners will focus on the usefulness of the results to Union Oil Company's management. The results indicated that consistent long-term financing policies were better than variant policies. Dividend policy did not appear to be as critical as debt policy although lower dividend payouts maintained lower risk levels. Evidence of a debt ceiling was displayed.

The conclusions drawn above will be useful for future policymaking if the relationships which existed in the past continue into the future. This restriction placed upon the usefulness of the results is common for all empirically based forecast models.

Union Oil management should not use this model as the sole means of analyzing long-term financing policies. This model should be used in conjunction with other models the firm already employs. The use of this model should enhance the policy-making process by providing additional information to the decision-maker.

The model may also make a contribution to managers/practitioners of firms other than Union Oil Company. Models focusing upon long-term financing policy can be built and these models would provide useful insights regarding long-run effects of policy. They also reveal the complexity of interrelationships that occur with any policy decision.

b. Contribution to the literature

In the finance literature an absence of long-term financing, financial planning models was identified. The modeling technique used in this study provides one possible avenue for filling this void.

A further contribution to the finance literature involves the results of the policy testing. The results agreed with the current literature by identifying an optimal capital structure and showing dividend policy to be essentially irrelevant. Using a system dynamics model which was not marked based supported the conclusion drawn from current financial theory based upon market models.

A micro application of system dynamics was developed and exhibited the difficulties encountered in using such an application as was discussed. Such a procedure extended the development of system dynamics financial models since most of those developed earlier modeled macro systems (See Chapter II).

B. Further Uses of the Model

1. Another Firm, Same Issues

The model developed was generic. Union Oil Company's characteristics were used to validate the model. This section provides the reader with the information needed to run the model if another firm is used.

The directions in this section refer to the DYNAMO model listing in Appendix 1. The following statements would need to be changed to model another firm. The appropriate changes would depend on that firm's characteristics and/or accounting data.

240 - the initial fixed asset pool

270 - the depreciation fraction

320 - the effect of the current ratio on the investment fraction

340 - the target current ratio

300 - the investment fraction or mix

400 - the initial current asset pool

470 - the initial level of equity

540 - the initial debt level

560 - the normal length of debt

630 - the initial current liabilities pool

710 - the initial level of cash

1170 - the percentage return on fixed assets before interest and depreciation

1690 - the target interest expense coverage

1770 - the normal fraction of liabilities that are interest bearing

1920 - the effective corporate tax rate every four years

1980 - the dividend payout every four years

2200 - the initial net income to calculate standard deviation

2290 - the initial net cash-flow to calculate standard deviation

2380 - the initial return on equity

2460 - the initial return on assets

2540 - the initial cash-flow return on equity

2620 - the initial cash-flow return on assets

2740 - the initial standard deviation of income

2950 - the desired growth rate

3100 - the desired debt/equity ratio

After the above changes are made, the process of validating the model must be repeated. After validation, policy testing may be conducted. If the basic structure of the model is unchanged, there is no need to perform sensitivity analysis because the work done in this study is transferrable.

2. Further Policy Tests with the Same Model Structure

The present model can be used to perform further policy tests. It could be used to test the same policy areas as this study, but over narrower ranges, or it could test varying policies over the forty-year base period. Another test might include the use of the investment policy variables in the model. The investment function would remain exogenous to the model. Changes in the policy variables would modify expected risk and return of investment and would make possible additional scenarios for analysis. The results of changes in investment, debt/equity and dividend policies could also be investigated.

Some of the policy variables in the model could be modified and tested. They might include debt mix and investment mix policy decisions. Other possibilities would be to test the effects of taxation, changes in debt maturity, and desired growth. Exogenous variables might be modified in anticipation of changes expected in the future. All of these policies are testable without requiring structural changes in the model.

The debt mix decision in the model followed a policy of matching long-term funds to fixed assets and short-term funds to current assets. Changes in this policy might include the elimination and variation in both long-term funding and short-term funding. This policy intervention would be conducted by modifying the equation MIX.K in the model.

The investment mix decision in the model established a minimum current ratio of 2.5. This ratio (TCR) could be changed below and above its current target.

Taxes were modeled in a table function (statement 1920) and reflected past liberal taxation policies towards petroleum companies. Different effective tax-rates can be postulated and used in this table. The effect of such changes on financing needs would be identified.

To examine debt maturity effects, the constant normal length of debt (NLD) should be changed. Desired growth (DGR) can also be modified to reflect changes in management's judgment of the future. Since interest rates remain at high levels today, the interest rate functions might be modified. They are reflected as table functions TPRIME (prime rate) and TLTGOV (long-term government) bond rates.

3. Possible Structure Changes to the Model

All of the above changes can be made without modifying the structure of the model. Other uses of the model would necessitate model structure changes. The model developed represents a beginning for future research in this area.

C. Areas for Further Research

Two difficulties encountered in this research provide areas for further investigation. One weakness of the model concerned the risk measure. The risk macro exhibited a substantial start-up error. Further research should address this issue by developing a more satisfactory method of calculating overall risk. It would appear that DYNAMO may be too restrictive and thus a FORTRAN macro might model this phenomenon better.

The other area of difficulty encountered in this research was the incorporation of exogenous variables. These variables' relative values were critical. This fact necessitated the creation of a perception scale by the modeler. The scale was awkward and judgmental. A better method of tracking business conditions and the stock market could be developed in future research of this type.

D. Summary

The study developed a financial planning model for the firm. This model was behavioral and was not suitable for making point forecasts. The model embodied current financial practice but was not created to test financial theory. The model investigated financing policy decisions but did not optimize those decisions.

The study examined the effects of a particular financing policy or group of policies on the long-run value of the firm. The value of the firm was not calculated because the stock market link was not modeled. The study employed proxy variables for value; accounting return and total risk measures.

The possibilities for future work with the model are considerable. The model should provide useful information to the management of Union Oil. The model provides an example of the intricacies and interrelationships of corporate financial policy and decision making.

APPENDIX 1

DYNAMO MODEL LIST

```
   LIST,100-60^
100=OPT PLT=120
110=NOTE
120=NOTE PINK NOISE GENERATOR
130=NOTE
140=L PKNSE.K=PKNSE.J+(DT/TCN)(SFN*NOISE()+MNSE-PKNSE.J)              PINK AUTOCORRELATED NOISE (DIMLESS)
150=N PKNSE=MNSE                                                      INITIAL PINK NOISE VALUE(DIMLESS)
160=N SFN=SDN*SQRT(24*TCN/DT)                                         STANDARD DEVIATION OF PINK NOISE DISTRIBUTION(DIMLESS)
170=C MNSE=1                                                          INITIAL PINK NOISE VALUE, MEAN(DIMLESS)
180=C SDN=0                                                           STANDARD DEVIATION OF NOISE A SWITCH(DIMLESS)
190=C TCN=40                                                          TIME CONSTANT FOR NOISE(YEARS)
200=NOTE INVESTED ASSETS (FIXED ASSETS)
210=NOTE
220=L INVA.K=INVA.J+(INVR.JK-DEPR.JK)*DT                              INVESTED ASSET POOL ($)
230=N INVA=IINVA                                                      INITIALIZE ASSET POOL ($)
240=C IINVA=300.                                                      SET INITIAL VALUE($)
250=R INVR.KL=INVRF.K+STEP(HGHT,STTM)-STEP(HGHT,STTM2)+DEPF*INVA.K    INVESTMENT RATE ($/YEAR)
260=R DEPR.KL=INVA.K*DEPF                                             DEPRECIATION RATE($/YEAR)
270=C DEPF=.30                                                        DEPRECIATION FRACTION(1/YEAR)
280=A INVRF.K=AFUNDS.K*IF.K                                           INVESTMENT RATE FOR ASSET POOL($/YEAR)
290=A IF.K=NINMIX*ECRIF.K                                             INVESTMENT FRACTION (DIMLESS)
300=C NINMIX=.75                                                      NORMAL INVESTMENT MIX(DIMLESS)
310=A ECRIF.K=TABHL(TECRIF,CR.K/TCR,0,2,.5)                           EFFECT OF CURRENT RATIO ON INVESTMENT MIX(DIMLESS)
320=T TECRIF=0,.75,1.0,1.2,1.33                                       TABLE VALUES FOR CURRENT RATIO EFFECT(DIMLESS)
330=A CR.K=(FINA.K+FUNDS.K)/LIAB.K                                    CURRENT RATIO(DIMLESS)
340=C TCR=2.5                                                         TARGET CURRENT RATIO (DIMLESS)
350=NOTE
360=NOTE FINANCIAL ASSETS (CURRENT ASSETS, NON-CASH)
370=NOTE
380=L FINA.K=FINA.J+FINVR.JK*DT                                       FINANCIAL ASSET POOL ($)
390=N FINA=IFINA                                                      INITIALIZE FINANCIAL ASSETS ($)
400=C IFINA=100                                                       INITIAL FINANCIAL ASSETS ($)
410=R FINVR.KL=(AFUNDS.K*(1-IF))-STEP(FHGHT,STTM)+STEP(FHGHT,STTM2)   FINANCIAL INVESTMENT RATE ($/YEAR)
420=NOTE
430=NOTE EQUITY; COMMON AND PREFERRED
440=NOTE
450=L EQ.K=EQ.J+CIE.JK*DT                                             BOOK VALUE OF EQUITY ($)
460=N EQ=IEQ                                                          INITIALIZE EQUITY BOOK ($)
470=C IEQ=200                                                         INITIAL EQUITY VALUE ($)
480=R CIE.KL=DEQF.K+STEP(EHGHT,STTM)-STEP(EHGHT,STTM2)                CHANGE IN EQUITY ($/YEAR)
490=NOTE
500=NOTE DEBT; LONG-TERM AND LEASES
510=NOTE
520=L DEBT.K=DEBT.J+(CID.JK-DRR.JK)*DT                                BOOK VALUE OF DEBT ($)
530=N DEBT=IDEBT                                                      INITIALIZE DEBT BOOK ($)
540=C IDEBT=130                                                       INITIAL DEBT VALUE ($)
550=R DRR.KL=DEBT.K*(1/NLD)                                           LONG-TERM DEBT RETIREMENT RATE($/YEAR)
560=C NLD=20                                                          NORMAL LENGTH OF LONG-TERM DEBT (YEARS)
570=R CID.KL=(DDEBTF.K*(1-MIX.K))+STEP(DHGHT,STTM)-STEP(DHGHT,STTM2)  CHANGE IN DEBT ($/YEAR)
580=NOTE
590=NOTE SHORT-TERM DEBT
600=NOTE
OK-
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   LIST,610-1100
610=L LIAB.K=LIAB.J+CIL.JK*DT                                           SHORT-TERM DEBT ($)
620=N LIAB=ILIAB                                                        INITIALIZES SHORT-TERM DEBT LEVEL($)
630=C ILIAB=70                                                          INITIAL LIABILITY LEVEL ($)
640=R CIL.KL=DDEBTF.K*MIX.K+STEP(LHGHT,STTM)-STEP(LHGHT,STTM2)         CHANGE IN LIABILITIES ($/YEAR)
650=NOTE
660=NOTE FUNDS (CASH ASSETS)
670=NOTE
680=L FUNDS.K=FUNDS.J+(CIE.JK+CID.JK+CIL.JK-(DRR.JK+INVRF.JK+
690=X FINVR.JK)+RCF.JK)*DT                                              FUNDS($)
700=N FUNDS=IFUNDS                                                      INITIALIZE FUNDS LEVEL($)
710=C IFUNDS=75                                                         INITIAL FUNDS VALUE ($)
720=R RCF.KL=CF.K                                                       RATE OF CASH FLOW FROM OPERATIONS ($/YEAR)
730=NOTE
740=NOTE RETAINED EARNINGS
750=NOTE
760=A RE.K=FUNDS.K+INVA.K+FINA.K-(LIAB.K+DEBT.K+EQ.K)                  ACCUM. RETAINED EARNINGS, BOOK ($)
770=NOTE
780=NOTE DEBT/EQUITY RATIO
790=NOTE
800=A TE.K=EQ.K+RE.K                                                    TOTAL EQUITY ($)
810=A TD.K=DEBT.K+LIAB.K                                                TOTAL DEBT($)
820=A DE.K=TD.K/TE.K                                                    DEBT/EQUITY RATIO (DIMLESS)
830=NOTE
840=NOTE CREDIT EXTENSION
850=NOTE
860=A CEX.K=EBCCX.K*ECRCX.K*EIFCX.K*80                                  CREDIT EXTENSION IN ()
870=A EBCCX.K=TABLE(TEBCCX,BC.K/NBCCFC,-2,2,1.0)                        EFFECT OF BUSINESS CYCLE ON CREDIT(DIMLESS)
880=T TEBCCX=.75,.875,1.0,1.125,1.25
890=A EIFCX.K=TABHL(TEIFCX,INTF.K/PERCIN.K,0,3,.5)                      EFFECT OF INTEREST FRACTION ON CREDIT(DIMLESS)
900=T TEIFCX=1.2,1.1,1,.9,.8,.7,.6
910=A PERCIN.K=SAMPLE(INTF.K,1.0,.1)                                      PERCEIVED INTEREST FRACTION(DIMLESS)
920=A ECRCX.K=TABHL(TECRCX,CR.K/TCR,0,1,.25)                            EFFECT OF CURRENT RATIO ON CREDIT(DIMLESS)
930=T TECRCX=0,.6,.9,1.0,1.0
940=C NBCCFC=1.0                                                        NORMAL CONDITIONS FOR CREDIT EXTENSION(DIMLESS)
950=NOTE
960=NOTE BUSINESS CYCLE
970=NOTE
980=A BC.K=TABLE(TBC,TIME.K,0,44,.25)                                     TABLE TO DISPLAY ECONOMIC  UPS AND DOWNS(DIMLESS)
990=T TBC=-2,-2,-2,-2,-2,-2,-2,-2,1,1,1,1,2,-1,-1,-1,
1000=X -2,1,1,1,2,-1,-1,-1,-1,-1,-2,1,1,1,2,-1,
1010=X -2,1,1,1,1,1,2,1,
1020=X 0,1,1,1,1,1,1,1,2,-1,-1,-1,-2,1,2,-1,
1030=X 0,-1,-1,-1,-2,-2,-2,-2,-2,1,1,1,2,-1,-1,-1,-2,1,1,1,
1040=X 2,-1,-1,-1,-2,1,1,1,2,-1,-1,-1,-2,1,1,1,
1050=X 2,-1,-1,-1,-2,1,1,1,2,-1,-1,-1,-2,1,1,1,1,1,1,1,
1060=X 2,-1,-1,-1,-2,1,2,-1,-2,1,-1,-1,-2,1,2,-1,2,1,1,1,
1070=X -2,-1,-1,-1,1,2,-1,-1,-1,-2,1,1,2,-1,-1,-1,
1080=X -2,1,1,1,1,1,1,1,2,-1,-1,-1,-2,-2,-2,-2,
1090=X -2,1,1,1,2,-1,-2,1,2,2,2,2,1                                      TABLE VALUES 2-PEAKING 1-RISING -1 FALLING -2 BOTTOMING
1100=NOTE
OK-
```

```
   LIBT,1110-1600
1110=NOTE INCOME DETERMINATION/GROSS MARGIN
1120=A GM.K=MFIA.K+MFFA.K                                  GROSS MARGIN ($/YEAR)
1130=NOTE MARGIN FROM FIXEC ASSETS
1140=NOTE
1150=A MFIA.K=INVA.K*(MFI.K+(BC.K/40))                     MARGIN FROM INVESTED OR FIXED ASSETS ($/YEAR)
1160=A MFI.K=FI*(1+SWNOI*PKNSE.K)                          INVESTMENT RETURN FRACTION (1/YEAR)
1170=C FI=.9                                               NORMAL RETURN FROM INVESTED ASSETS(1/YEAR)
1180=NOTE
1190=NOTE MARGIN FROM FINANCIAL ASSETS
1200=NOTE
1210=A MFFA.K=FINA.K*TBILL.K/100                           MARGIN FROM FINANCIAL ASSETS($/YEAR)
1220=NOTE
1230=NOTE INTEREST RATE AND STOCK MARKET DATA
1240=NOTE
1250=A STOCK.K=TABLE(TSTOCK,TIME.K,0,43,.25)              STOCK MARKET BAROMETER S & P 500 INDEX MOVEMENT (DIMLESS)
1260=T TSTOCK=-2,1,-2,1,2,-1,-1,-1,-2,1,1,1,1,2,-1,
1270=X -1,-1,-1,-1,-2,1,2,-1,-2,-1,-1,-2,-1,-1,-1,-2,
1280=X -2,1,-1,-1,1,1,1,1,1,1,1,1,1,1,1,1,
1290=X 2,-1,-1,-1,-1,-1,0,-1,
1300=X -2,1,0,-1,-2,-2,-2,-2,-2,-2,-2,-2,-2,1,1,1,
1310=X 1,1,1,1,1,1,1,1,0,1,1,1,2,-1,-1,-1,
1320=X -1,-1,-2,1,1,1,2,-1,-1,-1,-1,-1,-2,1,1,1,
1330=X 1,1,1,1,1,1,2,-1,
1340=X -2,1,1,1,2,-1,-1,-1,-2,1,1,1,1,1,2,-1,0,
1350=X 1,1,1,2,-1,-1,-1,-2,1,1,1,1,1,2,-1,
1360=X -1,-1,-1,-1,-2,1,1,1,1,1,1,1,2,-1,-1,-1,
1370=X -1,-1,-1,-1,-1,-1,-2,1,1,1,2,1,0                   SAME SCALE AS BUSINESS CYCLE DATA (DIMLESS)
1380=A LTGOV.K=TABLE(TLTGOV,TIME.K,0,43,1)                 LONG-TERM GOVERNMENT BOND RATE()
1390=T TLTGOV=3,2.8,2.8,2.8,2.6,2.4,2.2,2,2.5,2.5,2.5,2.3,2.1,2.2,2.4,
1400=X 2.2,2.2,2.5,2.7,3,2.7,2.9,3.1,3.5,3.4,4.2,4.1,3.9,4,4,
1410=X 4.3,4.3,4.8,5,5.5,6.4,7,6.3,6.1,7.1,8.1,8.4,8.1,8.1    ACTUAL INTEREST RATES FOR THE YEAR()
1420=A TBILL.K=TABLE(TTBILL,TIME.K,0,43,1)                 TREASURY BILL RATES ()
1430=T TTBILL=.2,.2,.2,.3,0,0,0,.1,.3,.4,.3,.3,.4,.5,.8,1.1,1.2,
1440=X 1.5,1.7,1.8,.9,1.6,2.5,3.1,1.5,3,2.7,2.1,2.7,3.1,3.5,3.9,4.8,
1450=X 4.2,5.2,6.6,6.5,4.4,3.8,6.9,8,5.8,5.1,5.1              ACTUAL ANNUAL TBILL RATES()
1460=A PRIME.K=TABLE(TPRIME,TIME.K,0,43,1)                 PRIME RATE OF INTEREST()
1470=T TPRIME=1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,1.5,
1480=X 1.8,2,2,2,2.8,3,3.25,3,3,4,4.5,4,5,4.5,4.5,4.5,4.5,4.5,4.5,
1490=X 6,5.5,6.5,8.5,7,5.5,6,9.5,7.5,7.5,7.5                  ACTUAL PRIME RATES ANNUAL()
1500=NOTE
1510=NOTE INCOME / EXPENSES
1520=NOTE
1530=NOTE INTEREST EXPENSE
1540=NOTE
1550=A IP.K=ABR.K*DEBT.K+STR.K*ALIB.K                      INTEREST EXPENSE FOR PERIOD ($/YEAR)
1560=L ABR.K=ABR.J+(DT/(DEBT.J/(CID.JK-DRR.JK)))(BR.J-ABR.J)   SMOOTH BORROWING RATE (1/YEAR)
1570=N ABR=IBR                                             INITIALIZES THE LONG-TERM BORROWING RATE
1580=C IBR=.03
1590=A BR.K=(LTGOV.K/100)*ERBR.K*EDEBR.K*ECOVBR.K         LONG-TERM BORROWING OR BOND RATE(1/YEAR)
1600=A ERBR.K=TABHL(TERBR,INCD.K/SMINCD.K,0,3,1)          THE EFFECT OF RISK ON THE BORROWING RATE(DIMLESS)
OK-
```

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   LIST,1610-2100
1610=T TERBR=.9,1,1.1,1.2
1620=A STR.K=(PRIME.K/100)*ECOVBR.K*EDEBR.K*ECRBR.K          SHORT-TERM INTEREST RATE(1/YEAR)
1630=A ECOVBR.K=TABHL(TECOVB,SCOV.K/MINCOV,-5,1,1)           EFFECT OF COVERAGE ON BORROWING RATE(DIMLESS)
1640=T TECOVB=2/1.9/1.8/1.5/1.3/1.2/1.0                      TABLE TO DETERMINE COVERAGE EFFECT (DIMLESS)
1650=N ECOVBR=1.0                                            INITIALIZES EFFECT OF COVERAGE ON B. RATE(DIMLESS)
1660=A SCOV.K=SMOOTH(COV.K,TSCOV)                            SMOOTH COVERAGE, 1ST ORDER INFO DELAY (DIMLESS)
1670=A COV.K=(NIBT.K+IP.K)/IP.K                              INTEREST EXPENSE COVERAGE(DIMLESS)
1680=C TSCOV=.25                                             DELAY TIME FOR COVERAGE (YEARS) TO BE DISSEMINATED
1690=C MINCOV=2.0                                            MINIMUM ACCEPTABLE COVERAGE(DIMLESS)
1700=A EDEBR.K=TABHL(TEDEBR,DE.K/MINDE,0,6,1)                EFFECT OF DEBT/EQUITY ON BORROWING RATE(DIMLESS)
1710=T TEDEBR=0.9/1.0/1.2/1.4/1.6/1.8/2.0                    TABLE TO DETERMINE DEBT/EQUITY EFFECT (DIMLESS)
1720=C MINDE=.5                                              MINIMUM DEBT/EQUITY FOR EFFECT ON INTEREST(DIMLESS)
1730=A ECRBR.K=TABHL(TECRBR,CR.K/TCR,0,1,.25)                EFFECTOF CURRENT RATIO ON S.T.BORROWING RATE(DIMLESS)
1740=T TECRBR=5,2.5,1.5,1.1,1.0
1750=A ALIB.K=NFRIBL*LIAB.K*EALIB.K                          AMOUNT OF LIABILITIES THAT ARE INTEREST BEARING($)
1760=A EALIB.K=1.0-BC/10                                     EFFECT BUS. CYC. ON AMT. OF INTER. BEAR'G LIAB. (DIMLESS
1770=C NFRIBL=.5                                             NORMAL FRACTION OF LIAB. INTEREST BEARING (DIMLESS)
1780=NOTE
1790=NOTE TOTAL EXPENSE
1800=NOTE
1810=NOTE
1820=NOTE DEPRECIATION EXPENSE
1830=NOTE
1840=A TEX.K=DEPR.JK+IP.K                                    TOTAL EXPENSE ($/YEAR)
1850=NOTE
1860=NOTE INCOME DETERMINATION
1870=NOTE
1880=A NIBT.K=GM.K-TEX.K+IFAI.K                               NET INCOME BEFORE TAXES ($/YEAR)
1890=A IFAI.K=NORMRN(MEAN,STDV)                              INCOME FROM ADDITIONAL INVESTMENT($/YEAR)
1900=A NIAT.K=NIBT.K-ECTR.K*NIBT.K                           NET INCOME AFTER TAX ($/YEAR)
1910=A ECTR.K=TABLE(TECTR,TIME.K,0,44,4)                      EFFECTIVE CORPORATE TAX RATE(DIMLESS)
1920=T TECTR=.07/.3/.18/.24/.15/.04/.1/.25/.11/.21/.3/.45
1930=NOTE
1940=NOTE DIVIDEND PAYMENT
1950=NOTE
1960=A DIV.K=MAX(NIAT.K*DPR.K,0)                             DIVIDEND PAYMENT ($/YEAR)
1970=A DPR.K=TABLE(TDPR,TIME.K,0,44,4)                        DIVIDEND PAYOUT RATE (DIMLESS)
1980=T TDPR=.7,.9,.75,.5,.35,.4,.48,.4,.4,.6,.35,.3          TABLE VALUES OF DIVIDEND PAYOUT RATES(DIMLESS)
1990=NOTE
2000=NOTE CASH FLOW
2010=NOTE
2020=A CF.K=NIAT.K+DEPR.JK-DIV.K                             CASH FLOW FROM INCOME ($/YEAR)
2030=NOTE
2040=NOTE RETURN MEASURES
2050=NOTE
2060=A ROA.K=NIAT.K/TA.K                                     RETURN ON TOTAL ASSETS (1/YEAR)
2070=A CFROA.K=CF.K/TA.K                                     CASH FLOW RETURN ON ASSETS (1/YEAR)
2080=A TA.K=INVA.K+FINA.K+FUNDS.K                            TOTAL ASSETS ($)
2090=A ROE.K=NIAT.K/TE.K                                     RETURN ON EQUITY (1/YEAR)
2100=A CFROE.K=CF.K/TE.K                                     CASH FLOW RETURN ON EQUITY (1/YEAR)
OK-
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   LIST,2110-2600
2110=NOTE
2120=NOTE RISK MEASURES
2130=NOTE
2140=NOTE STANDARD DEVIATION OF INCOME
2150=NOTE
2160=A INCD.K=(SQRT(N*TSINC.K-TINC.K**2))/N            STANDARD DEVIATION OF INCOME($ PER YEAR)
2170=C N=20                                            SAMPLE SIZE, TWENTY QUARTERS IN FIVE YEARS
2180=A TSINC.K=N*DELAY3(SNIAT.K*SNIAT.K,5)             TOTAL SQUARED INCOME($ PER YEAR)**2
2190=A SNIAT.K=SAMPLE(NIAT.K,.25,INIAT)                SAMPLE OF INCOME MEASURES PER QUARTER($ PER YEAR)
2200=C INIAT=80.306                                    INITIAL INCOME($ PER YEAR)
2210=A TINC.K=N*EVINC.K                                TOTAL INCOME ($ PER YEAR)
2220=A EVINC.K=DELAY3(SNIAT.K,5)                       EXPECTED VALUE OF INCOME($ PER YEAR)
2230=NOTE
2240=NOTE STANDARD DEVIATION OF CASH FLOW
2250=NOTE
2260=A CFD.K=(SQRT(N*TSCF.K-TCF.K**2))/N               STANDARD DEVIATION OF CASH FLOW($ PER YEAR)
2270=A TSCF.K=N*DELAY3(SCF.K*SCF.K,5)                  TOTAL SQUARED CASH FLOW($ PER YEAR)**2
2280=A SCF.K=SAMPLE(CF.K,.25,ICF)                      SAMPLE OF QUARTERLY CASH FLOWS($ PER YEAR)
2290=C ICF=114.09                                       INITIAL CASH FLOW($ PER YEAR)
2300=A TCF.K=N*EVCF.K                                  TOTAL CASH FLOW($ PER YEAR)
2310=A EVCF.K=DELAY3(SCF.K,5)                          EXPECTED VALUE OF CASH FLOW($ PER YEAR)
2320=NOTE
2330=NOTE STANDARD DEVIATION OF RETURN ON EQUITY
2340=NOTE
2350=A SDROE.K=(SQRT(N*TSROE.K-TROE.K**2))/N           STANDARD DEVIATION OF RETURN ON EQUITY(PER YEAR)
2360=A TSROE.K=N*DELAY3(SROE.K*SROE.K,5)               TOTAL SQUARED ROE(PER YEAR)**2
2370=A SROE.K=SAMPLE(ROE.K,.25,IROE)                   SAMPLE OF QUARTERLY ROE'S(PER YEAR)
2380=C IROE=.29?02                                     INITIAL ROE(PER YEAR)
2390=A TROE.K=N*DELAY3(SROE.K,5)                       TOTAL ROE (PER YEAR)
2400=NOTE
2410=NOTE STANDARD DEVIATION OF RETURN ON ASSETS
2420=NOTE
2430=A SDROA.K=(SQRT(N*TSROA.K-TROA.K**2))/N           STANDARD DEVIATION OF ROA (PER YEAR)
2440=A TSROA.K=N*DELAY3(SROA.K*SROA.K,5)               TOTAL SQUARED ROA (PER YEAR)**2
2450=A SROA.K=SAMPLE(ROA.K,.25,IROA)                   SAMPLE OF QUARTERLY ROA'S (PER YEAR)
2460=C IROA=.16907                                     INITIAL ROA (PER YEAR)
2470=A TROA.K=N*DELAY3(SROA.K,5)                       TOTAL ROA (PERYEAR)
2480=NOTE
2490=NOTE STANDARD DEVIATION OF CASH FLOW ROE
2500=NOTE
2510=A CFROED.K=(SQRT(N*TSCROE.K-TCFROE.K**2))/N       STANDARD DEVIATION OF CASH FLOW ROE (PER YEAR)
2520=A TSCROE.K=N*DELAY3(SCFROE.K*SCFROE.K,5)          TOTAL SQUARED CASHFLOW (PER YEAR)**2
2530=A SCFROE.K=SAMPLE(CFROE.K,.25,ICFROE)             SAMPLE OF QUARTERLY CFROE'S(PER YEAR)
2540=C ICFROE=.41488                                   INITIAL CFROE (PER YEAR)
2550=A TCFROE.K=N*DELAY3(SCFROE.K,5)                   TOTAL CFROE (PER YEAR)
2560=NOTE
2570=NOTE STANDARD DEVIATION OF CASH FLOW ROA
2580=NOTE
2590=A CFROAD.K=(SQRT(N*TSCROA.K-TCFROA.K**2))/N       STANDARD DEVIATION OF CASH FLOW ROA (PER YEAR)
2600=A TSCROA.K=N*DELAY3(SCFROA.K*SCFROA.K,5)          TOTAL SQUARED CFROA (PER YEAR)**2
OK-
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   LIST,2610-3100
2610=A SCFROA.K=SAMPLE(CFROA.K,.25,ICFROA)            SAMPLE OF QUARTERLY CFROA'S (PER YEAR)
2620=C ICFROA=.24019                                  INITIAL CASH FLOW ROA (PER YEAR)
2630=A TCFROA.K=N*DELAY3(SCFROA.K,5)                  TOTAL CASH FLOW ROA (PER YEAR)
2640=NOTE
2650=NOTE COEFFICIENTS OF VARIATION
2660=NOTE
2670=S INCCOV.K=INCD.K/EVINC.K                        COEFFICIENT OF VARIATION OF INCOME (DIMLESS)
2680=S CFCOV.K=CFD.K/EVCF.K                           COEFFICIENT OF VARIATION OF CASH FLOW (DIMLESS)
2690=NOTE
2700=NOTE MOVING AVERAGE OF STANDARD DEVIATION OF INCOME
2710=NOTE
2720=A SMINCD.K=DELAY3(SINCD.K,5)                     MOVING AVERAGE OF STANDARD DEVIATION OF INCOME($/YEAR)
2730=A SINCD.K=SAMPLE(INCD.K,.25,IINCD)               SAMPLE OF QUARTERLY INCOME DEVIATIONS($/YEAR)
2740=C IINCD=0.000001                                  INITIAL STANDARD DEVIATION OF INCOME ($ PER YEAR)
2750=NOTE
2760=NOTE INVESTMENT DECISION VARIABLES
2770=NOTE
2780=C MEAN=0                                         NEW INVESTMENT EXPECTED NIBT($/YEAR)
2790=C STDV=0                                         STANDARD DEVIATION OF NEW INVESTMENT($/YEAR)
2800=C HGHT=0                                         TOTAL INVESTMENT($)
2810=C FHGHT=0                                        CURRENT ASSETS USED TO FUND INVESTMENT($)MILLIONS
2820=C DHGHT=0                                        DEBT SOLD TO FUND INVESTMENT($)MILLIONS
2830=C LHGHT=0                                        LIABILITY ASSUMED TO FUND INVEST($)
2840=C EHGHT=0                                        EQUITY SOLD TO FUND INVESTMENT($)MILLIONS
2850=C STTM=0                                         TIME WHEN INVESTMENT IS SCHEDULED FOR(YEAR)
2860=C STTM2=0                                        TIME TO END INVESTMENT(YR)
2870=NOTE
2880=NOTE
2890=NOTE DESIRED FUNDING
2900=NOTE
2910=A SMTA.K=SMOOTH(TA.K,TSTA)                       SMOOTH TOTAL ASSETS TO ACCUMULATE ($)
2920=C TSTA=.083333                                   TIME TO SMOOTH TOTTAL ASSETS (YEARS)
2930=A GROW.K=TA.K-SMTA.K                            GROWTH IN TOTAL ASSETS ($)
2940=A DGROW.K=DGFR*TA.K+DGRFBC.K*TA.K                  DESIRED GROWTH($)
2950=C DGFR=.5                                        DESIRED GROWTH FRACTION (DIMLESS)
2960=A DGRFBC.K=BCC*BC.K                               DESIRED FROM BUSINESS CYCLE (DIMLESS)
2970=C BCC=.1
2980=A DGR.K=(DGROW.K-GROW.K)/TAGR                    DESIRED GROWTH RATE ($/YEAR)
2990=C TAGR=1.0                                       TIME TO ADJUST GROWTH RATE (YEARS)
3000=A DFUNDS.K=DGR.K*PLH                             DESIRED FUNDS ($)
3010=C PLH=1.0                                        PLANNING HORIZON (YEARS)
3020=A DEXF.K=(DFUNDS.K-AFUNDS.K)/TANF                DESIRED EXTERNAL FUNDING RATE($ PER YEAR)
3030=C TANF=.60                                       TIME TO ACQUIRE NEW FUNDS(YEARS)
3040=A AFUNDS.K=FUNDS.K-MINBAL.K                      AVAILABLE FUNDS FOR INVESTMENT ($)
3050=A MINBAL.K=DIV.K*TTPD+DRR.JK*TTPL+DEPF*INVA.K*TRINVA  MINIMUM BALANCE OF FUNDS NEEDED FOR OBLIGATIONS($)
3060=C TTPD=.25                                       TIME TO PAY DIVIDENDS(YEARS)
3070=C TTPL=.083333                                   TIME TO PAY LIAB. & DEBT (YEARS)
3080=C TRINVA=.25                                     TIME TO REPLACE INVESTED ASSETS(YEARS)
3090=A DDE.K=TABLE(TDDE,TIME.K,0,44,4)                 DESIRED DEBT/EQUITY (DIMLESS)
3100=T TDDE=.22,.2,.37,.48,.3,.41,.54,.63,.53,.59,.68,.96   TABLE VALUES OF DESIRED DEBT/EQUITY LEVELS(DIMLESS)
OK-
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   LIST,3110-3600
3110=A DAF.K=MIN(DAM.K*EBRDD.K*ESPDED.K*DE.K,1)                          DEBT ACQUISITION  FRACTION (DIMLESS)
3120=A DAM.K=TABXT(TDAM,DDE.K/DE.K,0,4,1)                                  DEBT ACQUISITION MULTIPLIER FROM DDE(DIMLESS)
3130=T TDAM=0,1,2,3,4
3140=A EBRDD.K=TABHL(TEBRDD,BR.K/ABR.K,0,3,.5)                             EFFECT OF THE BORROWING RATE ON DESIRED DEBT(DIMLESS)
3150=T TEBRDD=2,1.5,1.0,0.95,0.90,0.85,0.85
3160=A ESPDED.K=TABLE(TESP,STOCK.K+1,-1,3,1)                               EFFECT OF STOCK MARKET ON DESIRED DEBT(DIMLESS)
3170=T TESP=1.1,1.05,1,.95,.9
3180=A DDEBTF.K=DAF.K*DEXF.K+DEBT.K*(1/NLD)                                 DESIRED DEBT FUNDING ($/YEAR)
3190=A DEQF.K=(1-DAF.K)*DEXF.K                                               DESIRED EQUITY FUNDING ($/YEAR)
3200=NOTE
3210=NOTE DEBT MIX
3220=NOTE
3230=A MIX.K=CLIP(1.0,(FINA.K+FUNDS.K)/INVA.K*EIOM.K*ECEXM.K,(FINA.K+
3240=X FUNDS.K)/INVA.K*EIOM.K*ECEXM.K,1.0)                                 DEBT MIX OF DESIRED LIABILITY(DIMLESS)
3250=A EIOM.K=TABHL(TEIOM,INTF.K/PERCIN.K,0,3,.5)                          EFFECT OF INTEREST RATES ON DEBT MIX(DIMLESS)
3260=T TEIOM=3,1.5,1,1,.8,.5,0
3270=A INTF.K=STR.K/BR.K                                                   INTEREST RATE FRACTION(DIMLESS)
3280=A ECEXM.K=TABHL(TECEXM,CEX.K/NORCEX,0,1.2,.2)                         EFFECT OF CREDIT EXTENSION ON DEBT MIX(DIMLESS)
3290=T TECEXM=0,.2,.4,.6,.8,1.0,1.2
3300=C NORCEX=80                                                           NORMAL CREDIT EXTENSION(PERCENT)
3310=NOTE
3320=NOTE SWITCHES
3330=NOTE
3340=C SWNOI=0                                                             SWITCH ON NOISE;OFF=0 ON=1
3350=NOTE
3360=NOTE CONTROL CARDS
3370=NOTE
3380=C DT=.025                                                             APPROXIMATELY TEN DAYS (YEARS)
3390=C LENGTH=0
3400=C PLTPER=1.0
3410=C PRTPER=5.0
3420=PLOT ROE,ROA,CFROE,CFROA(0,.6)/DIV(0,*)
3430=PLOT INCCOV,CFCOV(0,2)/SDROE,SDROA,CFROED,CFROAD(0,.1)
3440=PRINT ROE,ROA,CFROE,CFROA,DIV,INCCOV,CFCOV,SDROE,SDROA
3450=PRINT INVA,FINA,FUNDS,EQ,DEBT,NIAT,LIAB,BR,STR
3460=PRINT INVRF,IF,CR,FINVR,CIE,CID,CIL,RCF,RE
3470=PRINT TE,TD,DE,CEX,MFIA,MFFA,COV,ALIB,TEX
3480=PRINT NIBT,NIAT,DEPR,CF,GROW,DGROW,DGR,DFUNDS
3490=PRINT AFUNDS,MINBAL,DAF,DAM,DDEBTF,DEQF,MIX,ABR
3500=RUN
OK-
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APPENDIX 2

LIST OF LEVEL VARIABLES

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   LOSS/L/(1)
140=L  PKNSE.K=PKNSE.J+(DT/TCN)(SFN*NOISE()+MNSE-PKNSE.J)         PINK AUTOCORRELATED NOISE (DIMLESS)
220=L  INVA.K=INVA.J+(INVR.JK-DEPR.JK)*DT                         INVESTED ASSET POOL ($)
380=L  FINA.K=FINA.J+FINVR.JK*DT                                  FINANCIAL ASSET POOL ($)
450=L  EQ.K=EQ.J+CIE.JK*DT                                        BOOK VALUE OF EQUITY ($)
520=L  DEBT.K=DEBT.J+(CID.JK-DRR.JK)*DT                           BOOK VALUE OF DEBT ($)
610=L  LIAB.K=LIAB.J+CIL.JK*DT                                    SHORT-TERM DEBT ($)
680=L  FUNDS.K=FUNDS.J+(CIE.JK+CID.JK+CIL.JK-(DRR.JK+INVRF.JK+
1560=L  ABR.K=ABR.J+(DT/(DEBT.J/(CID.JK-DRR.JK)))(BR.J-ABR.J)      SMOOTH BORROWING RATE (1/YEAR)
OK-
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APPENDIX 3

LIST OF RATE VARIABLES

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   LIST/R/(1)
250=R INVR.KL=INVRF.K+STEP(HGHT,STTM)-STEP(HGHT,STTM2)+DEPF*INVA.K         INVESTMENT RATE ($/YEAR)
260=R DEPR.KL=INVA.K*DEPF                                                  DEPRECIATION RATE($/YEAR)
410=R FINVR.KL=(AFUNDS.K*(1-IF))-STEP(FHGHT,STTM)+STEP(FHGHT,STTM2)        FINANCIAL INVESTMENT RATE ($/YEAR)
480=R CIE.KL=DEQF.K+STEP(EHGHT,STTM)-STEP(EHGHT,STTM2)                     CHANGE IN EQUITY ($/YEAR)
550=R DRR.KL=DEBT.K*(1/NLD)                                                LONG-TERM DEBT RETIREMENT RATE($/YEAR)
570=R CID.KL=(DDEBTF.K*(1-MIX.K))+STEP(DHGHT,STTM)-STEP(DHGHT,STTM2)       CHANGE IN DEBT ($/YEAR)
640=R CIL.KL=DDEBTF.K*MIX.K+STEP(LHGHT,STTM)-STEP(LHGHT,STTM2)            CHANGE IN LIABILITIES ($/YEAR)
720=R RCF.KL=CF.K                                                          RATE OF CASH FLOW FROM OPERATIONS ($/YEAR)
3500=RUN
OK-
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APPENDIX 4

LIST OF AUXILIARY VARIABLES

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LIST/A/(1)
280=A  INVRF.K=AFUNDS.K*IF.K                                  INVESTMENT RATE FOR ASSET POOL($/YEAR)
290=A  IF.K=NINMIX*ECRIF.K                                    INVESTMENT FRACTION (DIMLESS)
310=A  ECRIF.K=TABHL(TECRIF,CR.K/TCR,0,2,.5)                  EFFECT OF CURRENT RATIO ON INVESTMENT MIX(DIMLESS)
330=A  CR.K=(FINA.K+FUNDS.K)/LIAB.K                           CURRENT RATIO(DIMLESS)
760=A  RE.K=FUNDS.K+INVA.K+FINA.K-(LIAB.K+DEBT.K+EQ.K)        ACCUM. RETAINED EARNINGS, BOOK ($)
800=A  TE.K=EQ.K+RE.K                                         TOTAL EQUITY ($)
810=A  TD.K=DEBT.K+LIAB.K                                     TOTAL DEBT($)
820=A  DE.K=TD.K/TE.K                                         DEBT/EQUITY RATIO (DIMLESS)
860=A  CEX.K=EBCCX.K*ECRCX.K*EIFCX.K*80                       CREDIT EXTENSION IN ()
870=A  EBCCX.K=TABLE(TEBCCX,BC.K/NBCCFC,-2,2,1.0)             EFFECT OF BUSINESS CYCLE ON CREDIT(DIMLESS)
890=A  EIFCX.K=TABHL(TEIFCX,INTF.K/PERCIN.K,0,3,.5)           EFFECT OF INTEREST FRACTION ON CREDIT(DIMLESS)
910=A  PERCIN.K=SAMPLE(INTF.K,1.0,.1)                           PERCEIVED INTEREST FRACTION(DIMLESS)
920=A  ECRCX.K=TABHL(TECRCX,CR.K/TCR,0,1,.25)                 EFFECT OF CURRENT RATIO ON CREDIT(DIMLESS)
980=A  BC.K=TABLE(TBC,TIME.K,0,44,.25)                          TABLE TO DISPLAY ECONOMIC  UPS AND DOWNS(DIMLESS)
1120=A GM.K=MFIA.K+MFFA.K                                      GROSS MARGIN ($/YEAR)
1150=A MFIA.K=INVA.K*(MFI.K+(BC.K/40))                         MARGIN FROM INVESTED OR FIXED ASSETS ($/YEAR)
1160=A MFI.K=FI*(1+SWNOI*PKNSE.K)                              INVESTMENT RETURN FRACTION (1/YEAR)
1210=A MFFA.K=FINA.K*TBILL.K/100                               MARGIN FROM FINANCIAL ASSETS($/YEAR)
1250=A STOCK.K=TABLE(TSTOCK,TIME.K,0,43,.25)                  STOCK MARKET BAROMETER S & P 500 INDEX MOVEMENT (DIMLESS)
1380=A LTGOV.K=TABLE(TLTGOV,TIME.K,0,43,1)                     LONG-TERM GOVERNMENT BOND RATE()
1420=A TBILL.K=TABLE(TTBILL,TIME.K,0,43,1)                     TREASURY BILL RATES ()
1460=A PRIME.K=TABLE(TPRIME,TIME.K,0,43,1)                     PRIME RATE OF INTEREST()
1550=A IP.K=ABR.K*DEBT.K+STR.K*ALIB.K                          INTEREST EXPENSE FOR PERIOD ($/YEAR)
1590=A BR.K=(LTGOV.K/100)*ERBR.K*EDEBR.K*ECOVBR.K             LONG-TERM BORROWING OR BOND RATE(1/YEAR)
1600=A ERBR.K=TABHL(TERBR,INCD.K/SMINCD.K,0,3,1)               THE EFFECT OF RISK ON THE BORROWING RATE(DIMLESS)
1620=A STR.K=(PRIME.K/100)*ECOVBR.K*EDEBR.K*ECRBR.K            SHORT-TERM INTEREST RATE(1/YEAR)
1630=A ECOVBR.K=TABHL(TECOVB,SCOV.K/MINCOV,-5,1,1)             EFFECT OF COVERAGE ON BORROWING RATE(DIMLESS)
1660=A SCOV.K=SMOOTH(COV.K,TSCOV)                              SMOOTH COVERAGE, 1ST ORDER INFO DELAY (DIMLESS)
1670=A COV.K=(NIBT.K+IP.K)/IP.K                                INTEREST EXPENSE COVERAGE(DIMLESS)
1700=A EDEBR.K=TABHL(TEDEBR,DE.K/MINDE,0,6,1)                  EFFECT OF DEBT/EQUITY ON BORROWING RATE(DIMLESS)
1730=A ECRBR.K=TABHL(TECRBR,CR.K/TCR,0,1,.25)                  EFFECTOF CURRENT RATIO ON S.T.BORROWING RATE(DIMLESS)
1750=A ALIB.K=NFRIBL*LIAB.K*EALIB.K                            AMOUNT OF LIABILITIES THAT ARE INTEREST BEARING($)
1760=A EALIB.K=1.0-BC/10                                       EFFECT BUS. CYC. ON AMT. OF INTER. BEAR'G LIAB. (DIMLESS
1840=A TEX.K=DEPR.JK+IP.K                                      TOTAL EXPENSE ($/YEAR)
1880=A NIBT.K=GM.K-TEX.K+IFAI.K                                 NET INCOME BEFORE TAXES ($/YEAR)
1890=A IFAI.K=NORMRN(MEAN,STDV)                                INCOME FROM ADDITIONAL INVESTMENT($/YEAR)
1900=A NIAT.K=NIBT.K-ECTR.K*NIBT.K                             NET INCOME AFTER TAX ($/YEAR)
1910=A ECTR.K=TABLE(TECTR,TIME.K,0,44,4)                        EFFECTIVE CORPORATE TAX RATE(DIMLESS)
1960=A DIV.K=MAX(NIAT.K*DPR.K,0)                               DIVIDEND PAYMENT ($/YEAR)
1970=A DPR.K=TABLE(TDPR,TIME.K,0,44,4)                          DIVIDEND PAYOUT RATE (DIMLESS)
2020=A CF.K=NIAT.K+DEPR.JK-DIV.K                               CASH FLOW FROM INCOME ($/YEAR)
2060=A ROA.K=NIAT.K/TA.K                                       RETURN ON TOTAL ASSETS (1/YEAR)
2070=A CFROA.K=CF.K/TA.K                                       CASH FLOW RETURN ON ASSETS (1/YEAR)
2080=A TA.K=INVA.K+FINA.K+FUNDS.K                              TOTAL ASSETS ($)
2090=A ROE.K=NIAT.K/TE.K                                       RETURN ON EQUITY (1/YEAR)
2100=A CFROE.K=CF.K/TE.K                                       CASH FLOW RETURN ON EQUITY (1/YEAR)
2160=A INCD.K=(SQRT(N*TSINC.K-TINC.K**2))/N                    STANDARD DEVIATION OF INCOME($ PER YEAR)
2180=A TSINC.K=N*DELAY3(SNIAT.K*SNIAT.K,5)                     TOTAL SQUARED INCOME($ PER YEAR)**2
2190=A SNIAT.K=SAMPLE(NIAT.K,.25,INIAT)                        SAMPLE OF INCOME MEASURES PER QUARTER($ PER YEAR)
2210=A TINC.K=N*EVINC.K                                        TOTAL INCOME ($ PER YEAR)
2220=A EVINC.K=DELAY3(SNIAT.K,5)                               EXPECTED VALUE OF INCOME($ PER YEAR)
2260=A CFD.K=(SQRT(N*TSCF.K-TCF.K**2))/N                       STANDARD DEVIATION OF CASH FLOW($ PER YEAR)
2270=A TSCF.K=N*DELAY3(SCF.K*SCF.K,5)                          TOTAL SQUARED CASH FLOW($ PER YEAR)**2
2280=A SCF.K=SAMPLE(CF.K,.25,ICF)                              SAMPLE OF QUARTERLY CASH FLOWS($ PER YEAR)
2300=A TCF.K=N*EVCF.K                                          TOTAL CASH FLOW($ PER YEAR)
2310=A EVCF.K=DELAY3(SCF.K,5)                                  EXPECTED VALUE OF CASH FLOW($ PER YEAR)
2350=A SDROE.K=(SQRT(N*TSROE.K-TROE.K**2))/N                   STANDARD DEVIATION OF RETURN ON EQUITY(PER YEAR)
2360=A TSROE.K=N*DELAY3(SROE.K*SROE.K,5)                       TOTAL SQUARED ROE(PER YEAR)**2
2370=A SROE.K=SAMPLE(ROE.K,.25,IROE)                           SAMPLE OF QUARTERLY ROE'S(PER YEAR)
2390=A TROE.K=N*DELAY3(SROE.K,5)                               TOTAL ROE (PER YEAR)
2430=A SDROA.K=(SQRT(N*TSROA.K-TROA.K**2))/N                   STANDARD DEVIATION OF ROA (PER YEAR)
2440=A TSROA.K=N*DELAY3(SROA.K*SROA.K,5)                       TOTAL SQUARED ROA (PER YEAR)**2
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2450=A SROA.K=SAMPLE(ROA.K,.25,IROA)                          SAMPLE OF QUARTERLY ROA'S (PER YEAR)
2470=A TROA.K=N*DELAY3(SROA.K,5)                              TOTAL ROA (PERYEAR)
2510=A CFROED.K=(SQRT(N*TSCROE.K-TCFROE.K**2))/N              STANDARD DEVIATION OF CASH FLOW ROE (PER YEAR)
2520=A TSCROE.K=N*DELAY3(SCFROE.K*SCFROE.K,5)                 TOTAL SQUARED CASHFLOW (PER YEAR)**2
2530=A SCFROE.K=SAMPLE(CFROE.K,.25,ICFROE)                    SAMPLE OF QUARTERLY CFROE'S(PER YEAR)
2550=A TCFROE.K=N*DELAY3(SCFROE.K,5)                          TOTAL CFROE (PER YEAR)
2590=A CFROAD.K=(SQRT(N*TSCROA.K-TCFROA.K**2))/N              STANDARD DEVIATION OF CASH FLOW ROA (PER YEAR)
2600=A TSCROA.K=N*DELAY3(SCFROA.K*SCFROA.K,5)                 TOTAL SQUARED CFROA (PER YEAR)**2
2610=A SCFROA.K=SAMPLE(CFROA.K,.25,ICFROA)                    SAMPLE OF QUARTERLY CFROA'S (PER YEAR)
2630=A TCFROA.K=N*DELAY3(SCFROA.K,5)                          TOTAL CASH FLOW ROA (PER YEAR)
2720=A SMINCD.K=DELAY3(SINCD.K,5)                             MOVING AVERAGE OF STANDARD DEVIATION OF INCOME($/YEAR)
2730=A SINCD.K=SAMPLE(INCD.K,.25,IINCD)                       SAMPLE OF QUARTERLY INCOME DEVIATIONS($/YEAR)
2910=A SMTA.K=SMOOTH(TA.K,TSTA)                               SMOOTH TOTAL ASSETS TO ACCUMULATE ($)
2930=A GROW.K=TA.K-SMTA.K                                    GROWTH IN TOTAL ASSETS ($)
2940=A DGROW.K=DGFR*TA.K+DGRFBC.K*TA.K                          DESIRED GROWTH($)
2960=A DGRFBC.K=BCC*BC.K                                        DESIRED FROM BUSINESS CYCLE (DIMLESS)
2980=A DGR.K=(DGROW.K-GROW.K)/TAGR                             DESIRED GROWTH RATE ($/YEAR)
3000=A DFUNDS.K=DGR.K*PLH                                     DESIRED FUNDS ($)
3020=A DEXF.K=(DFUNDS.K-AFUNDS.K)/TANF                        DESIRED EXTERNAL FUNDING RATE($ PER YEAR)
3040=A AFUNDS.K=FUNDS.K-MINBAL.K                              AVAILABLE FUNDS FOR INVESTMENT ($)
3050=A MINBAL.K=DIV.K*TTPD+DRR.JK*TTPL+DEPF*INVA.K*TRINVA    MINIMUM BALANCE OF FUNDS NEEDED FOR OBLIGATIONS($)
3090=A DDE.K=TABLE(TDDE,TIME.K,0,44,4)                          DESIRED DEBT/EQUITY (DIMLESS)
3110=A DAF.K=MIN(DAM.K*EBRDD.K*ESPDED.K*DE.K,1)              DEBT ACQUISITION  FRACTION (DIMLESS)
3120=A DAM.K=TABXT(TDAM,DDE.K/DE.K,0,4,1)                     DEBT ACQUISITION MULTIPLIER FROM DDE(DIMLESS)
3140=A EBRDD.K=TABHL(TEBRDD,BR.K/ABR.K,0,3,.5)                EFFECT OF THE BORROWING RATE ON DESIRED DEBT(DIMLESS)
3160=A ESPDED.K=TABLE(TESP,STOCK.K+1,-1,3,1)                  EFFECT OF STOCK MARKET ON DESIRED DEBT(DIMLESS)
3180=A DDEBTF.K=DAF.K*DEXF.K+DEBT.K*(1/NLD)                    DESIRED DEBT FUNDING ($/YEAR)
3190=A DEQF.K=(1-DAF.K)*DEXF.K                                  DESIRED EQUITY FUNDING ($/YEAR)
3230=A MIX.K=CLIP(1.0,(FINA.K+FUNDS.K)/INVA.K*EIOM.K*ECEXM.K,(FINA.K+
3250=A EIOM.K=TABHL(TEIOM,INTF.K/PERCIN.K,0,3,.5)             EFFECT OF INTEREST RATES ON DEBT MIX(DIMLESS)
3270=A INTF.K=STR.K/BR.K                                      INTEREST RATE FRACTION(DIMLESS)
3280=A ECEXM.K=TABHL(TECEXM,CEX.K/NORCEX,0,1.2,.2)            EFFECT OF CREDIT EXTENSION ON DEBT MIX(DIMLESS)
OK-
```

APPENDIX 5

CASUAL-FEEDBACK LOOPS

Figure A

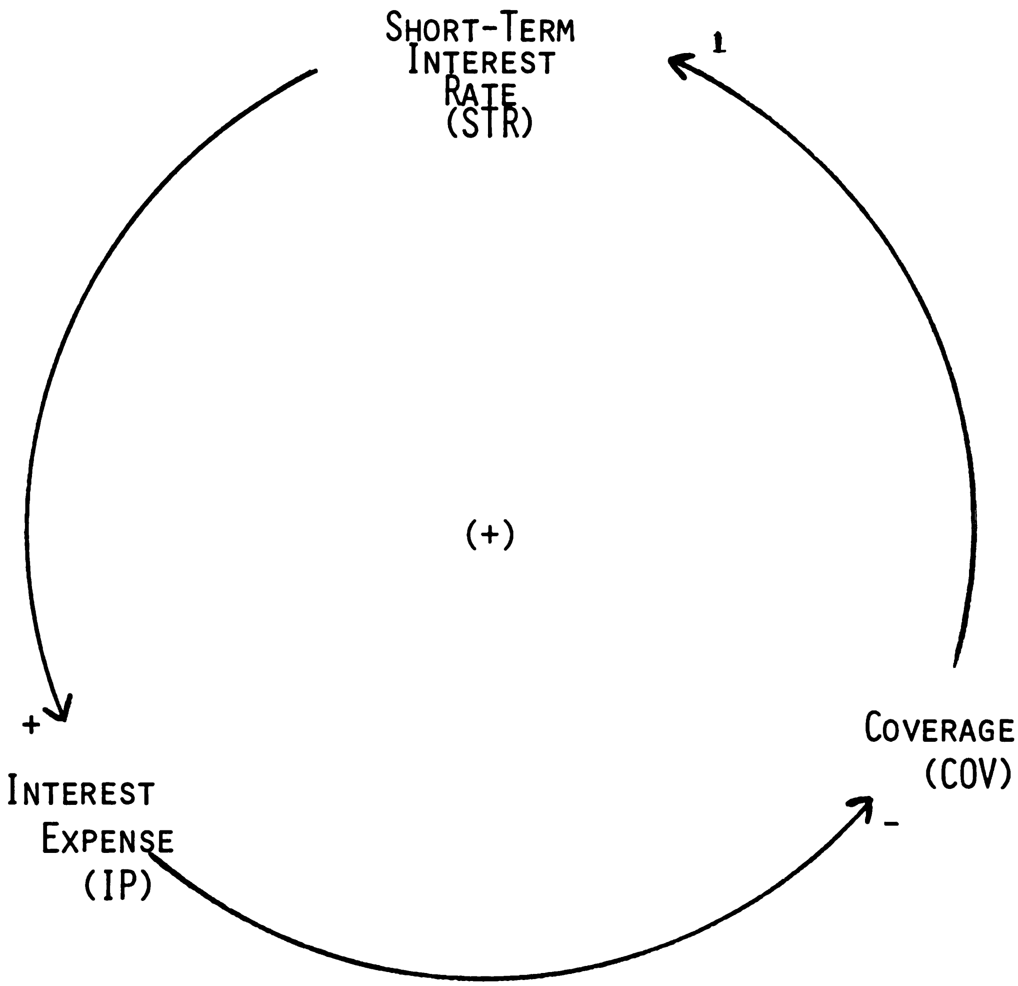

SHORT-TERM INTEREST RATE (STR)
1
(+)
+
INTEREST EXPENSE (IP)
COVERAGE (COV)
-

Figure B

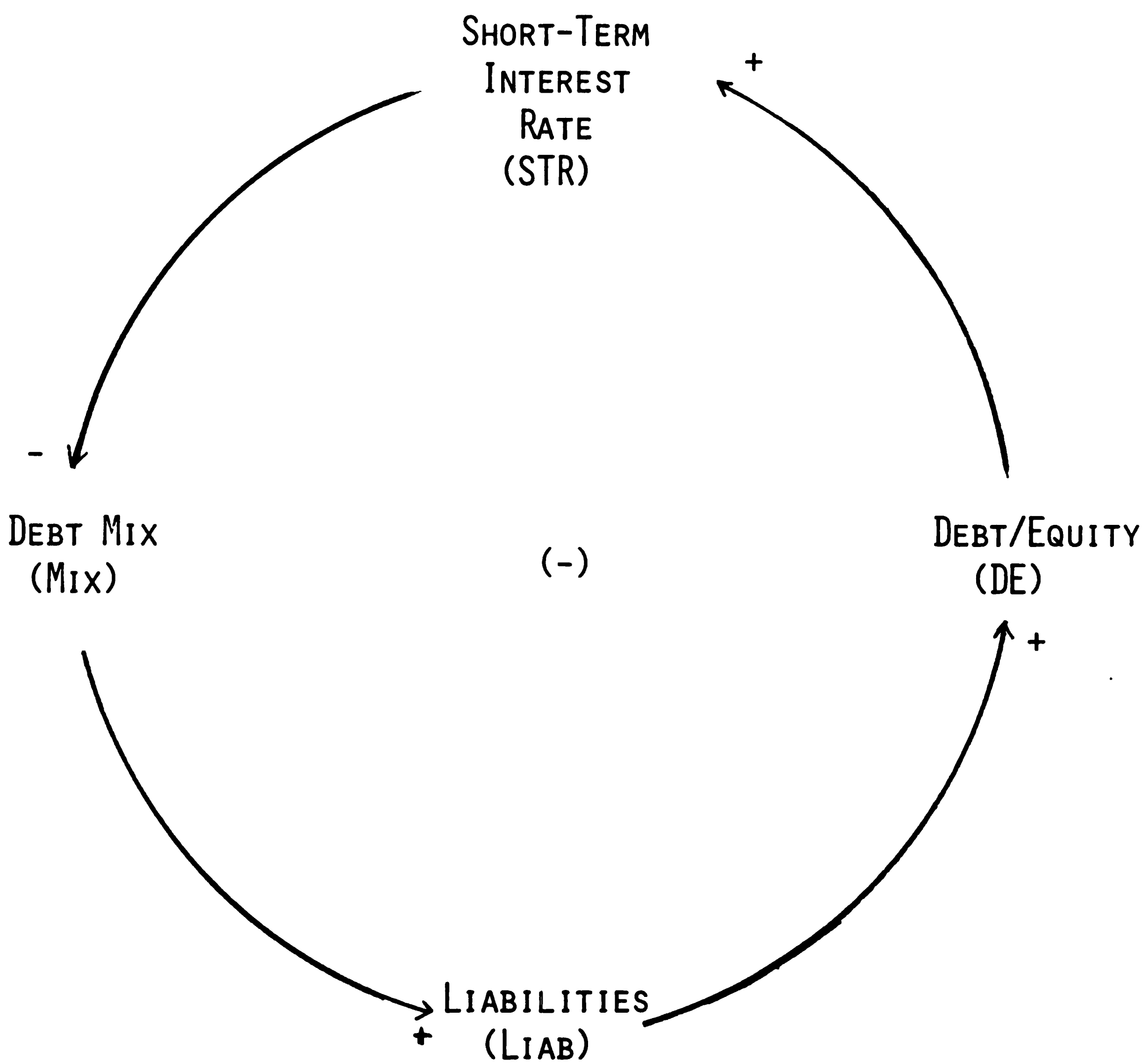

SHORT-TERM
INTEREST
RATE
(STR)
+
-
DEBT MIX
(MIX)
(-)
DEBT/EQUITY
(DE)
+
LIABILITIES
(LIAB)
+

Figure C

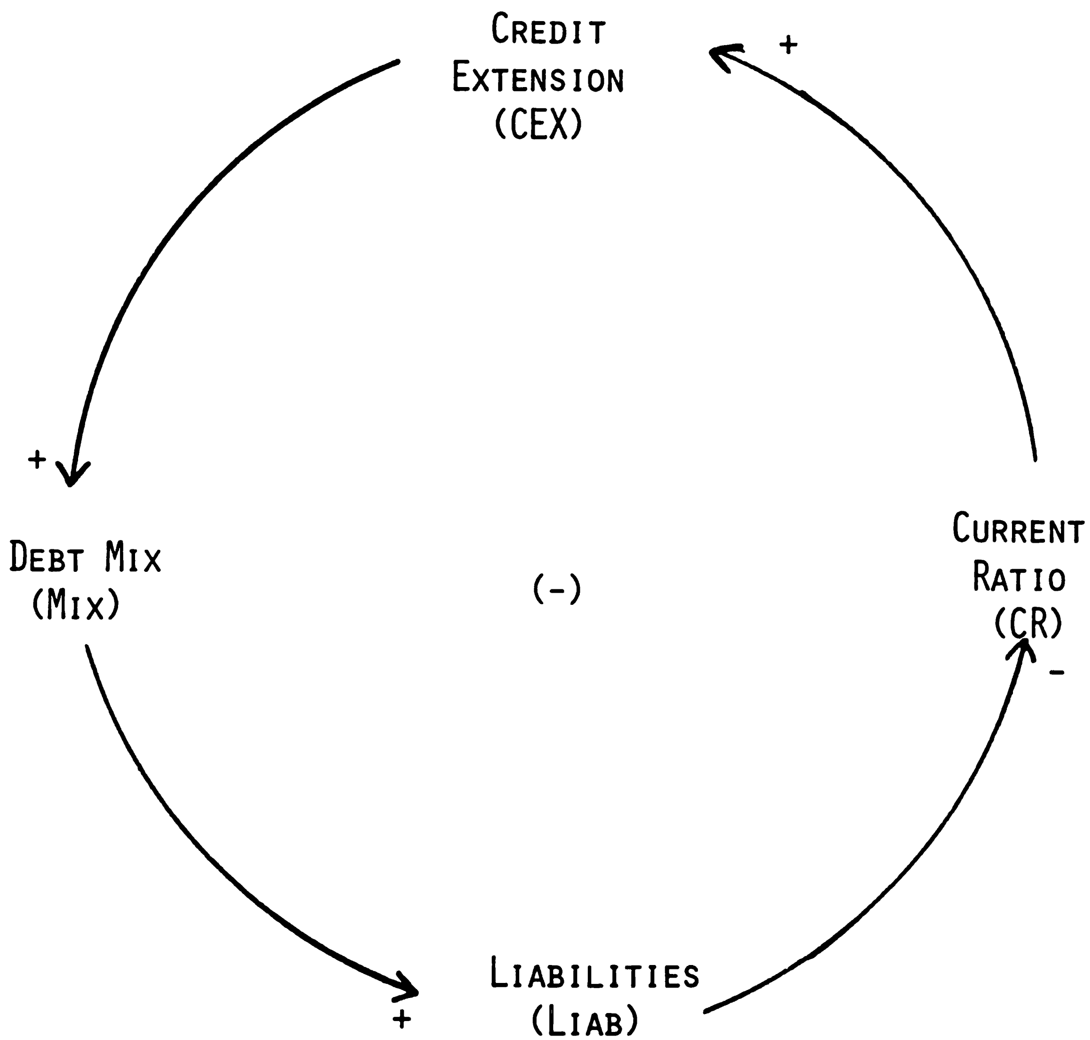
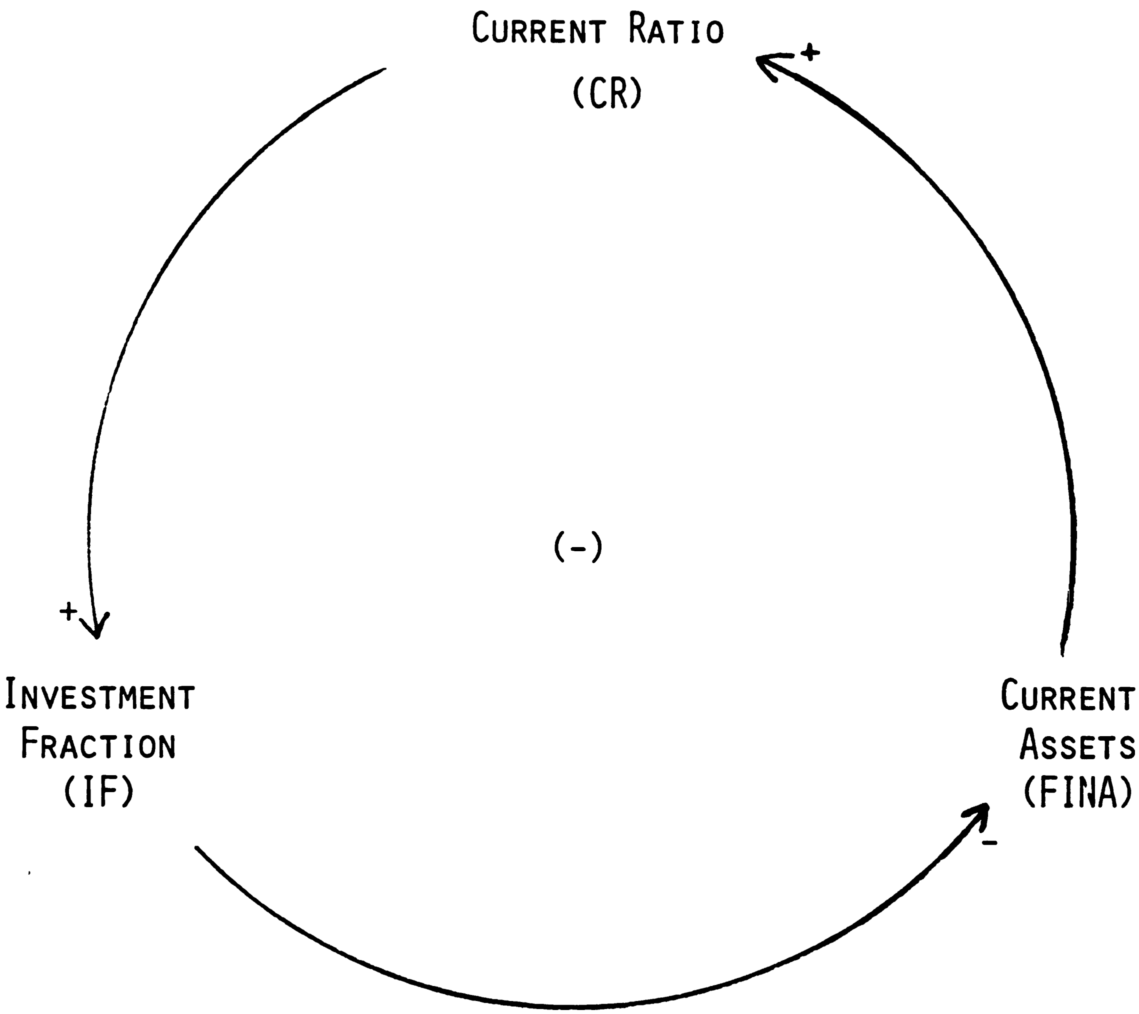

CREDIT
EXTENSION
(CEX)
+
+
DEBT MIX
(MIX)
(-)
CURRENT
RATIO
(CR)
-
+
LIABILITIES
(LIAB)

Figure D


CURRENT RATIO
(CR)
+
(-)
+
INVESTMENT
FRACTION
(IF)
CURRENT
ASSETS
(FINA)
-

<u>Figure E</u>

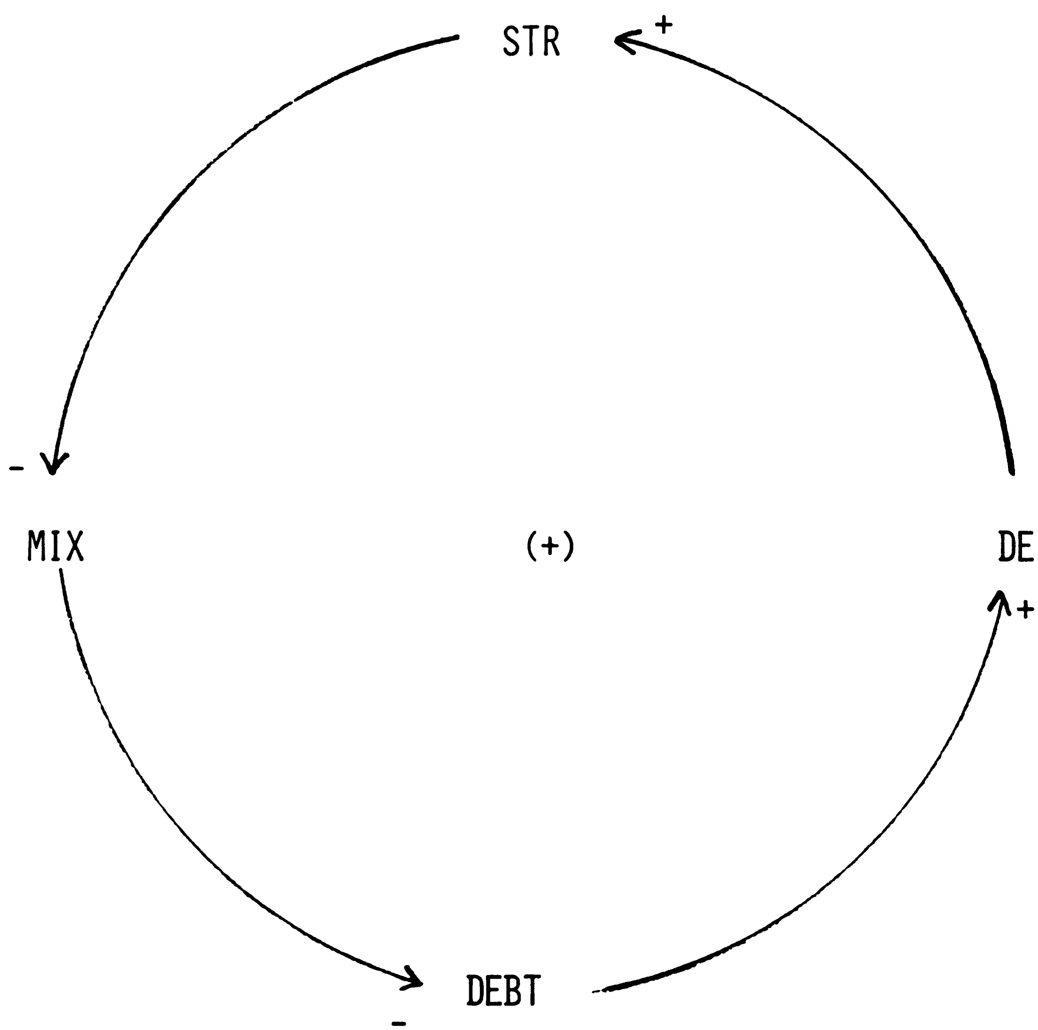


Figure F

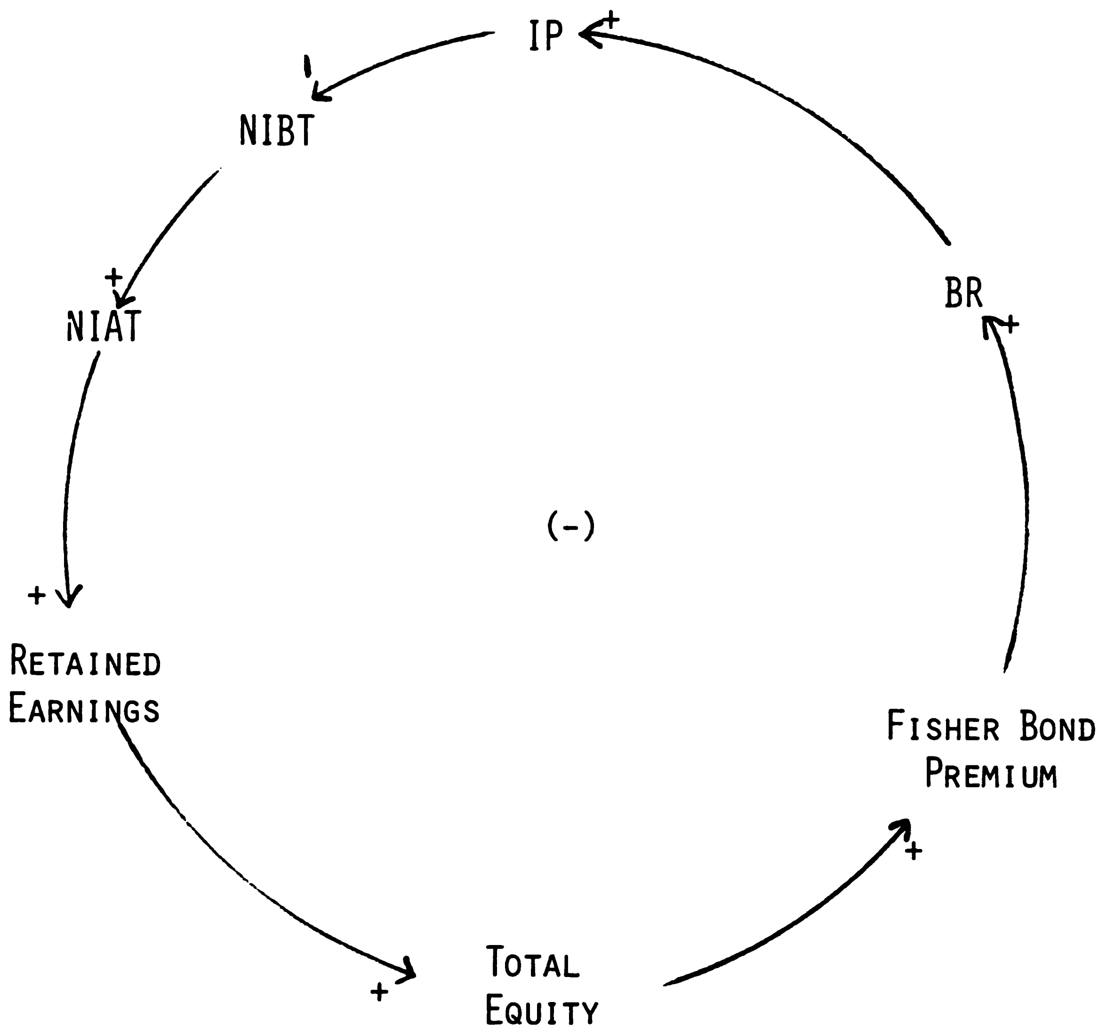

IP
+
'
NIBT
+
NIAT
+
Retained
Earnings
+
Total
Equity
+
Fisher Bond
Premium
+
BR
+
(-)

Figure G

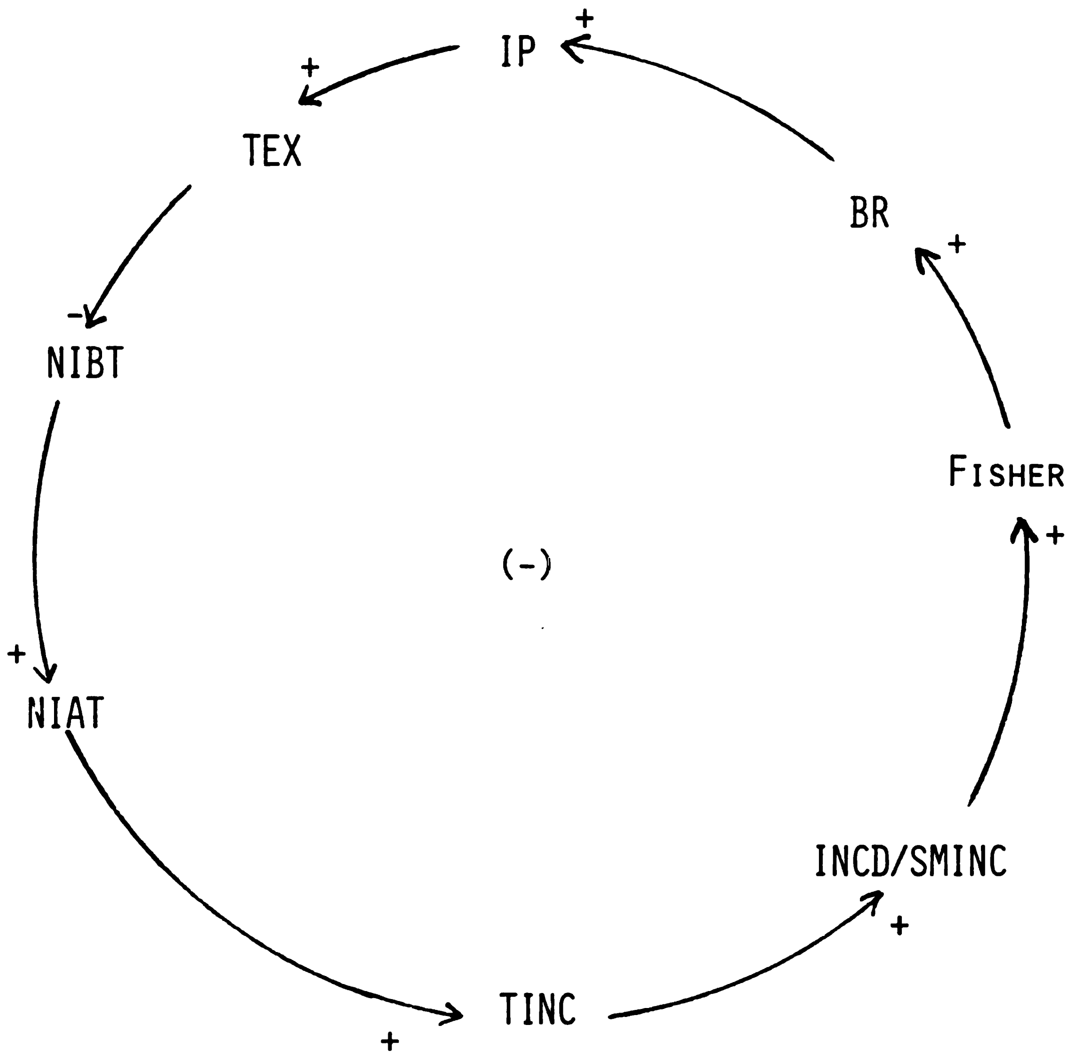


Figure H

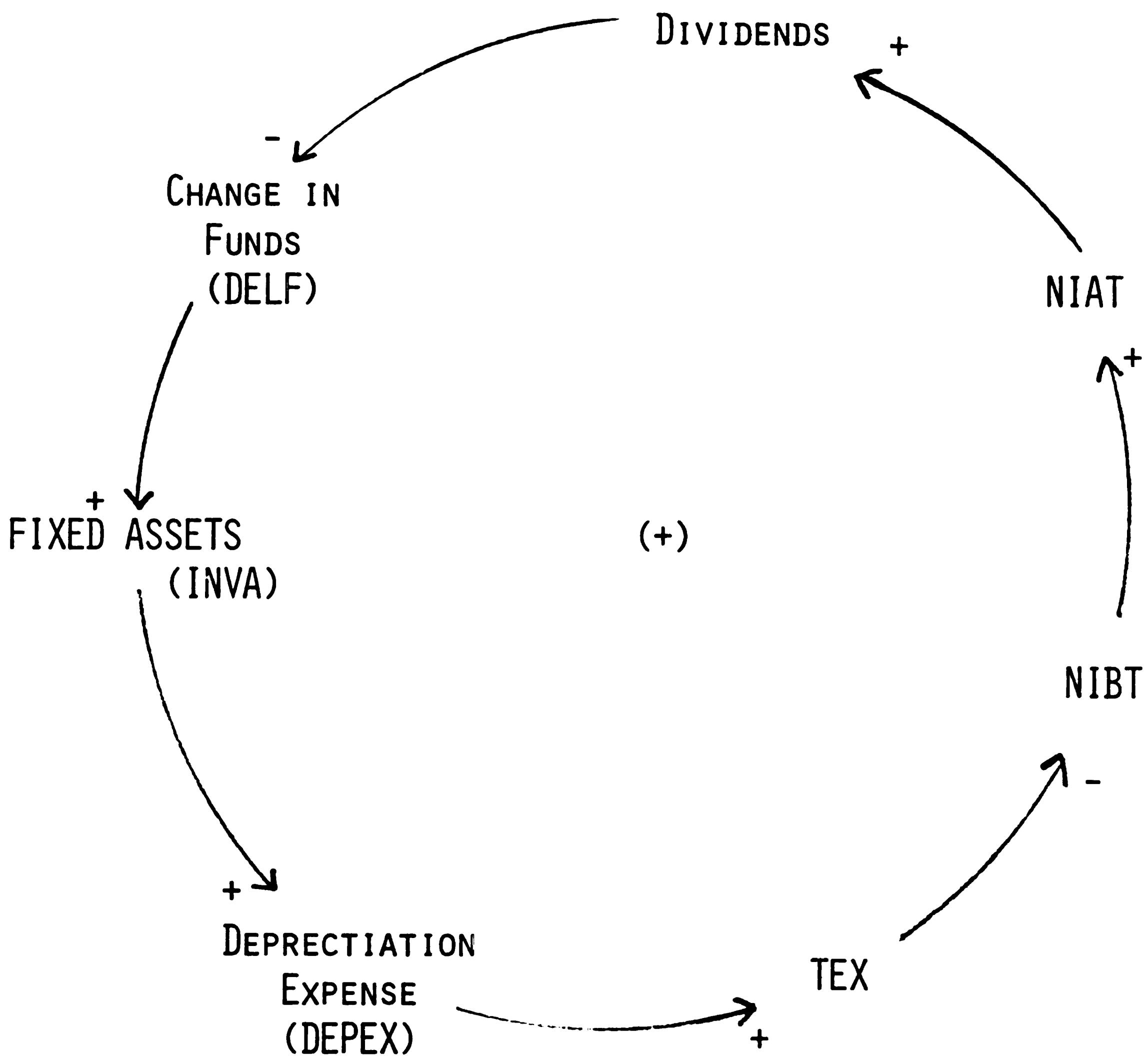

Dividends
+
-
Change in
Funds
(DELF)
NIAT
+
+
FIXED ASSETS
(INVA)
(+)
NIBT
-
+
Depreciation
Expense
(DEPEX)
TEX
+

Figure I

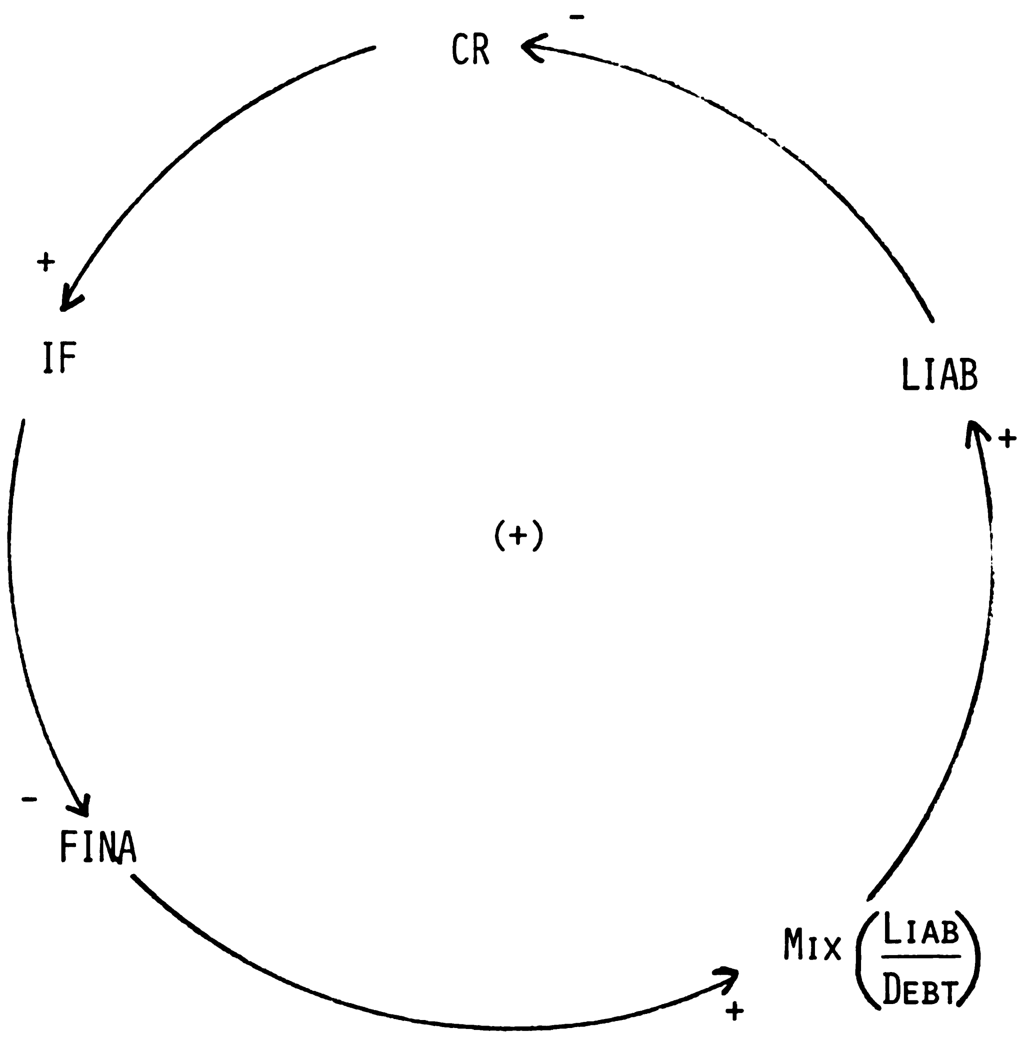
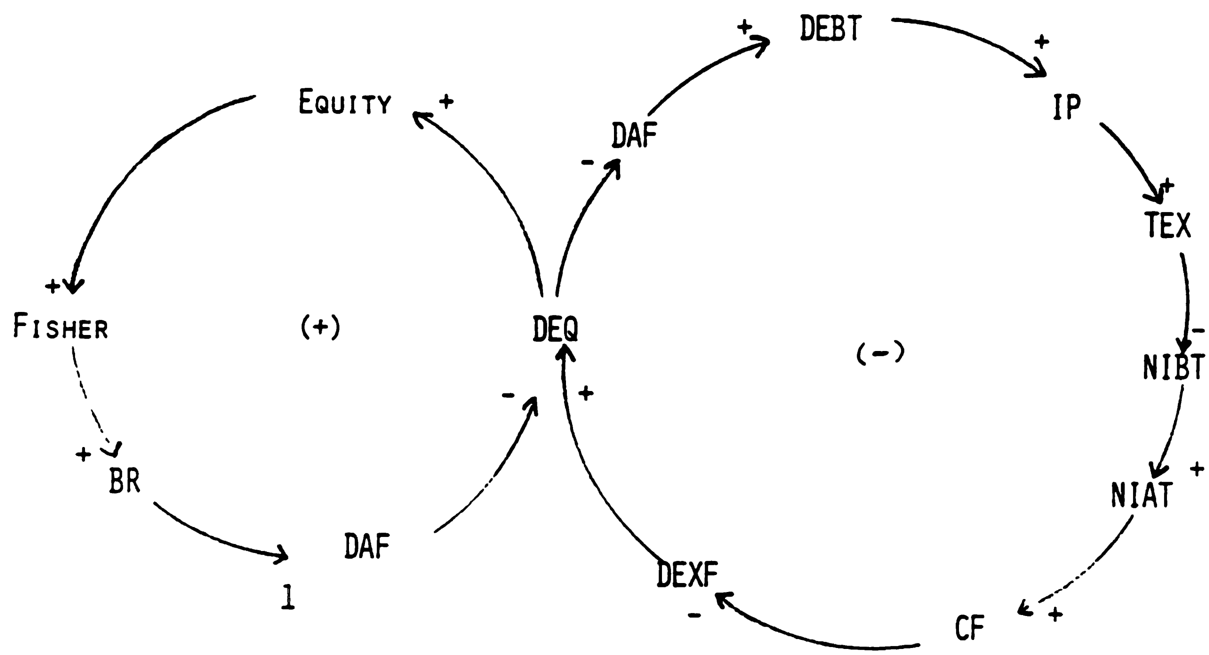
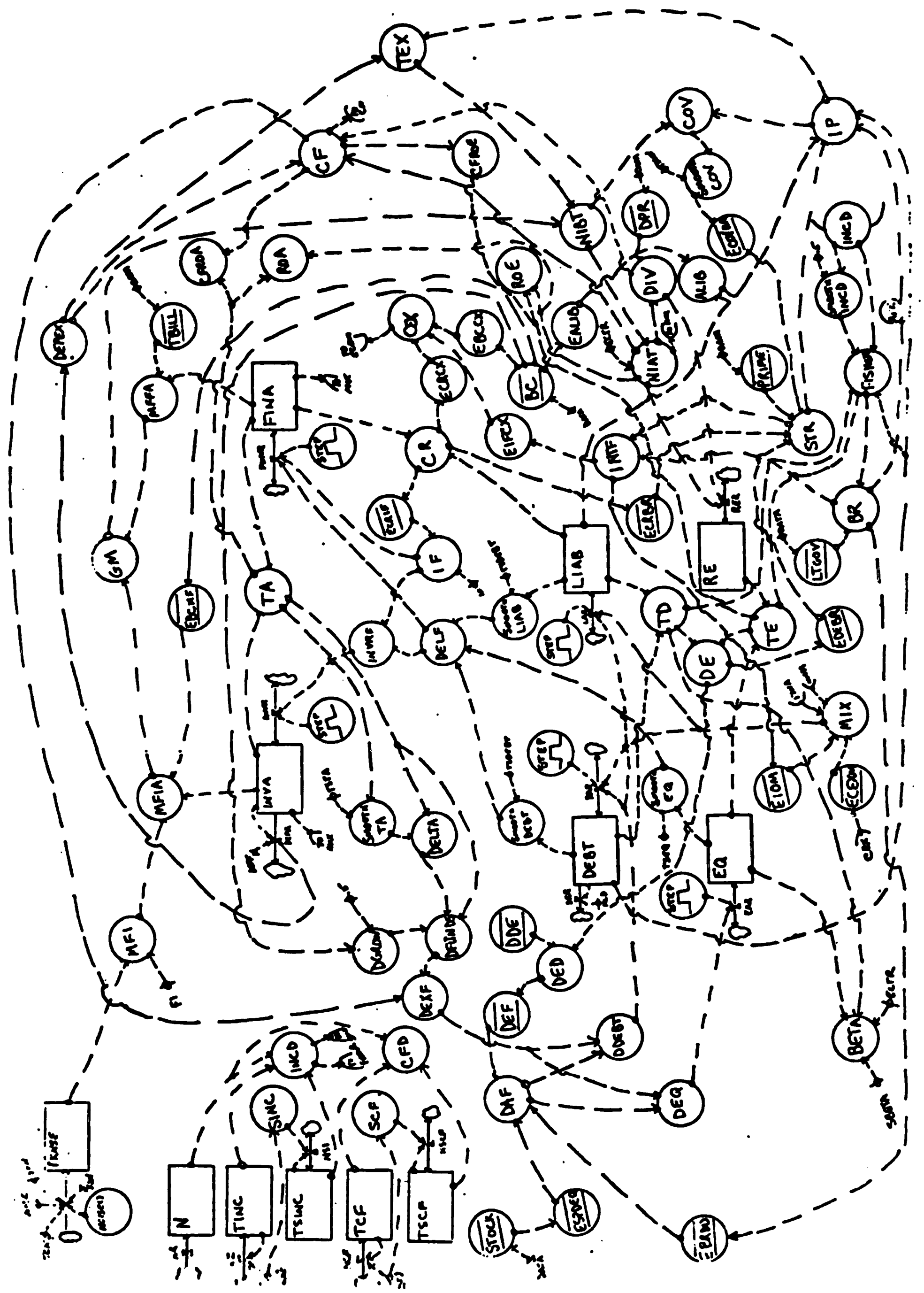


Figure J



APPENDIX 6

DYNAMO FLOW DIAGRAM


TEX
CF
IP
COV
NIBT
DIV
ROE
ROA
GM
TA
CR
IF
LIAB
RE
DEBT
EQ
STR
BR
MIX
DE
TD
TE
BETA
DEQ
DAF
DEKF
MFI
MFIA
FINA
INVA
N
TINC
TSINC
TCF
TSCF

APPENDIX 7

DATA TABLES

Year	Shares Outstanding	Share Price	Interest Expense	Inc. Before Tax
1977	41,766,000	54.2656	78,111,000	605,939,000
1976	38,374,000	50.0781	67,940,000	567,784,000
1975	38,811,000	41.5	58,957,000	470,854,000
1974	33,282,000	38.6875	42,954,000	488,603,000
1973	31,444,000	39.9844	41,405,000	260,770,000
1972	28,372,000	34.6875	40,636,000	183,443,000
1971	28,363,000	35.8125	38,363,000	161,907,000
1970	28,318,000	31.6875	45,646,000	153,761,000
1969	28,117,000	49.0	39,348,000	154,192,000
1968	27,896,000	59.875	27,271,000	176,232,000
1967	27,662,000	55.75	18,986,000	172,966,000
1966	27,596,000	52.5	19,122,000	151,014,000
1965	27,187,000	44.375	18,468,000	119,845,000
1964	28,901,000	35.75	15,830,000	87,563,624
1963	9,406,000	71.75	7,048,142	74,327,732
1962	9,143,000	56.5	7,065,614	59,425,733
1961	8,920,000	55.75	6,583,147	34,835,524
1960	8,710,000	40.0625	5,620,463	40,078,451
1959	8,532,000	46.9375	5,706,606	30,615,409
1958	7,872,000	47.5	5,973,341	24,448,695
1957	7,717,000	52.0625	6,020,073	40,035,525
1956	7,700,000	58.8125	6,628,388	37,264,630
1955	7,332,000	52.25	3,853,843	31,459,509
1954	6,659,000	48.875	2,723,738	42,487,920
1943	5,809,397	40.78	3,362,591	46,849,602

Year	Shares Outstanding	Share Price	Interest Expense	Inc. Before Tax
1952	5,266,270	40.625	2,892,888	32,379,759
1951	5,266,270	38.0625	2,180.291	41,295,971
1950	5,266,270		2,202,688	22,577,547
1949	5,266,270		1,703,961	22,456,946
1948	4,666,270		1,550,513	37,493,147
1947	4,666,270		1,153,654	22,510,860
1946	4,666,270		1,137,500	11,954,523
1945	4,666,270		1,405,411	10,801,123
1944	4,666,270		1,277,945	11,582,994
1943	4,666,270		1,295,619	10,469,199
1942	4,666,270		1,451,244	8,237,329
1941	4,666,270		1,374,150	7,700,732
1940	4,666,270		1,382,099	4,945,557
1939			1,173,259	
1938			836,148	
1937			887,657	
1936			916,343	
1935			1,063,140	
1934				
1933				
1932				

Year	Total Debt	Long Term Debt	Equity	Total Assets	Dividends
1977	2,287,063,000	1,024,513,000	2,437,453,000	4,724,516,000	97,461,000
1976	2,165,021,000	937,774,000	2,188,408,000	4,353,429,000	88,725,000
1975	1,856,683,000	732,365,000	1,919,441,000	3,776,124,000	80,553,000
1974	1,536,004,000	647,962,000	1,922,646,000	3,458,650.000	80,406,000
1973	1,194,021,000	564,164,000	1,714,664,000	2,908,685,000	70,874,000
1972	1,091,262,000	578,267,000	1,605,000,000	2,696,262,000	69,462,000
1971	1,012,286,000	546,015,000	1,552,484,000	2,564,770,000	69,454,000
1970	1,008,070,000	556,450,000	1,506,803,000	2,514,873,000	69,417,000
1969	1,015,074,000	494,095,000	1,461,340,000	2,476,414,000	68,004,000
1968	918,883,000	499,969,000	1,375,287,000	2,294,170,000	63,844,000
1967	735,951,000	360,273,000	1,290,195,000	2,026,146,000	62,435,000
1966	704,008,000	362,324,000	1,195,462,000	1,899,470,000	58,153,000
1965	668,741,000	380,947,000	1,089,775,000	1,758,516,000	49,800,000
1964	556,496,000	293,399,000	1,126,022,000	1,682,518,000	26,156,533
1963	294,149,588	164,276,000	559,192,412	853,342,000	19,297,000
1962	279,554,295	167,969,000	520,271,705	799,826,000	20,144,000
1961	268,819,511	173,200,000	492,649,489	761,469,000	17,463,000
1960	262,233,976	176,570,000	471,703,024	733,937,000	14,942,000
1959	255,180,370	180,716,322	451,985,630	707,166,000	8,197,000
1958	258,662,188	184,069,439	425,895,812	684,558,000	10,494,994
1957	261,839,507	187,050,036	411,371,493	673,212,000	18,515,713
1956	259,699,432	189,864,723	391,005,568	650,705,000	18,261,315
1955	192,695,278	135,782,286	353,784,722	546,480,000	16,273,000
1954	148,097,071	93,996,735	363,140,929	511,238,000	15,766,000
1953	166,791,247	122,111,274	309,255,753	476,047,000	11,690,000

Year	Total Debt	Long Term Debt	Equity	Total Assets	Dividends
1952	140,015,800	118,203,207	274,974,404	414,990,204	10,532,590
1951	106,548,243	84,906,540	259,269,292	365,817,535	10,532,540
1950	101,698,424	79,400,000	243,669,880	345,368,304	10,532,540
1949	90,010,795	79,700,000	238,104,711	336,115,506	10,799,108
1948	64,528,368	54,400,000	211,104,202	275,632,570	10,382,451
1947	58,170,740	54,600,000	191,131,006	249,301,746	5,599,524
1946	51,977,677	40,000,000	178,757,170	230,734,847	4,666,270
1945	49,408,818	40,000,000	174,556,417	223,965,235	4,666,270
1944	77,560,059	53,700,000	148,905,516	226,465,575	4,666,270
1943	66,363,018	42,554,000	144,182,156	210,545,174	4,666,270
1942	65,350,939	43,639,000	140,905,578	206,256,517	4,666,270
1941	52,033,327	37,480,000	140,497,345	192,530,672	4,666,270
1940	48,529,913	37,958,500	138,940,019	187,469,932	4,666,270
1939	47,999,479	38,018,500	139,066,921	187,066,400	4,899,584
1938	26,383,537	18,018,500	139,609,828	165,993,365	5,599,524
1937	27,167,799	18,026,500	138,347,994	165,515,793	6,465,338
1936	27,695,079	20,326,500	125,520,049	153,215,128	4,386,070
1935	27,884,707	21,526,500	123,772,721	151,657,428	4,386,070
1934	27,128,209	21,489,500	123,565,973	150,694,182	4,386,070
1933	79,903,492	26,687,000	109,651,750	189,555,242	4,386,070
1932	88,040,344	31,609,145	109,651,750	197,692,094	5,263,284

Year	Inc. After Tax	Fixed Assets	Depreciation
1977	334,239,000	2,967,298,000	3,242,500,000
1976	285,784,000	2,651,674,000	2,977,200,000
1975	232,754,000	2,333,535,000	2,561,379,000
1974	288,003,000	2,086,091,000	2,349,281,000
1973	180,170,000	1,854,811,000	2,051,839,000
1972	121,943,000	1,764,433,000	1,936,458,000
1971	114,707,000	1,743,793,000	1,824,466,000
1970	114,461,000	1,757,307,000	1,692,138,000
1969	153,230,000	1,749,618,000	1,596,019,000
1968	151,232,000	1,558,229,000	1,480,319,000
1967	144,963,000	1,313,188,000	1,346,084,000
1966	142,240,000	1,260,934,000	1,278,546,000
1965	119,200,000	1,193,774,000	1,202,005,000
1964	67,063,240	1,150,747,000	690,481,507
1963	53,928,000	538,479,053	651,075,182
1962	45,920,733	502,113,338	615,941,589
1961	36,935,524	481,002,682	583,399,612
1960	34,478,451	482,761,006	561,254,976
1959	27,515,409	449,204,701	533,062,401
1958	24,998,695	431,657,431	494,328,358
1957	38,235,535	429,572,306	459,728,702
1956	34,240,878	400,766,077	425,088,178
1955	30,522,963	379,741,538	387,664,350
1954	35,887,920	712,342,783	353,505,861
1953	38,099,603	654,023,268	331,339,362

Year	Inc. After Tax	Fixed Assets	Depreciation
1952	27,579,759	618,975,457	313,538,296
1951	27,295,971	574,164,032	293,497,267
1950	17,177,547	525,535,200	271,034,240
1949	20,356,946	503,631,629	254,259,360
1948	31,293,147	429,027,228	234,525,287
1947	18,910,860	398,076,970	219,669,471
1946	9,804,523	376,576,128	200,753,687
1945	9,201,123	354,845,423	200,207,504
1944	8,932,994	348,418,024	179,818,510
1943	7,269,199	310,863,859	165,901,373
9142	5,537,329	292,421,850	158,528,392
1941	6,239,232	280,166,416	149,894,510
1940	4,606,790	269,563,227	149,302,296
1939	5,846,241	261,569,129	145,032,269
1938	6,862,758	254,961,701	139,169,124
1937	12,061,332	246,426,813	134,252,021
1936	6,133,398	235,746,443	127,890,082
1935	5,038,286	231,842,873	123,299,339
1934	2,902,733	225,685,706	117,729,696
1933	1,954,279	312,027,038	172,288,358
1932	3,211,084	311,329,214	166,448,125

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