An Integrated Approach to Financial Management

by

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AN INTEGRATED APPROACH TO FINANCIAL MANAGEMENT

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Economics

(ABSTRACT)

The various components of financial structure management are usually discussed in isolation with little concern for the other components. A unified model of financial structure management bridging these components has not yet been developed. This dissertation seeks to establish such an underpinning by combining Miller and Orr's cash management model with contemporary corporate finance theory, and is able to address a wide range of questions while retaining a comprehensible format. I simulate the proposed strategy to show the consequences of implementation, and to provide hypotheses about the behavior of financial variables characterizing the firm as a result of implementing this strategy.
Acknowledgement

I am eternally in debt to all those who assisted me in the writing of this dissertation. Special thanks go to my committee members; particularly Dr. Hans Haller, Dr. Catherine Eckel, and Dr. Daniel Orr. I am also very grateful for the Lord's blessing and the help and encouragement of Helen and Chloe Foster.
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Chapter One
Problem Description and Objectives

The common first response to a complex issue is to "divide and conquer": break the issue down into several smaller problems which can be separately considered. This is usually the best first step because it is rarely possible to comprehend the whole before understanding the parts. On the other hand, understanding the parts does not necessarily answer the original issue - unless one knows how to put the partial solutions back together again.

It has worked this way in corporate finance. A partial listing of the subtopics include dividend policy, debt policy, capital structure management, capital budgeting, cash management, and short-term financial management. The process of combining separate answers related to the various subtopics into sensible composite decisions is called financial planning.

Successful integration requires an understanding of the relationships which exists between the various financial accounts. Analyzing the separate management of one component cannot provide insight into total financial management. Numerous models deal with the separate components in a secular manner, but very few examine their interrelationship. To do so requires a proper vantage.
An examination centering on one small part of financial management, such as commercial paper, is too concentrated to understand the avenues between the various components. The same problem occurs from a traditional capital structure vantage. A more compromising approach is required; one that captures the important relationships between the various financial components, yet retains a comprehensible solution. The framework to be presented attempts to accomplish this task.

It has evolved after considerable effort to find the appropriate level of aggregation for a useful planning tool. The model decomposes the firm to capture reality and important distinctions, yet there is sufficient aggregation to allow the financial manager (or the student of corporate finance) to see the "forest from the trees" in an organization as complex as the modern corporation. All of the usual components are incorporated and the framework is formulated in such a general fashion that it could be used as a foundation for more detailed models of corporate financial planning.

The following criteria typify a financial planning model which can be utilized by the financial manager:

1. The model should be flexible enough to meet current uses and easily expandable to meet future demands.

2. It should be realistic enough so as not to suffer
from the complaint that it is an "ivory tower" tool which fails to catch the realities of life.

3. It should provide a "step forward." That is, it should either improve upon existing techniques or make it easier to perform what is currently being done.

4. It should provide a conduit between cash management and the areas of long-term financial structure.

5. It should forecast when the corporation will require more capital; how much capital it will require; and the implications of alternative financing strategies and dividend policies for earnings per share and taxes.

6. It should inform the user of the effect of alternative policies on the likelihood of bankruptcy.

7. Finally, it should be formulated within a framework which is comprehensible to the ultimate user.

The last requirement is where this dissertation makes its greatest contribution. Other models provide the financial manager with a more detailed and complete format. However, many times this is at the expense of clarity.

The objective to optimize (minimize) is the net present cost of financial management where this is given a
very general interpretation.\textsuperscript{1} It includes all of the usual expenses as well as a number of less obvious ones. Examples of the former are lost interest on idle cash balances and the issue expense of long-term securities. An example of the latter is increased taxes due to a suboptimal maturity structure - an expense usually not considered in the literature.

A principal shortcoming of the model is that a analytic solution is difficult to obtain. However, a solution is obtainable by simulation. This allows management to quantify the effects of a large number of alternative policies and decisions quickly. This encourages the performance of sensitivity analysis so that management can determine which variables will be most critical in determining the future performance of the firm.

The dissertation is structured as follows. Chapter two gives a very general discussion of previous research on working capital management, capital structure management, and maturity structure management. The main purpose of this discussion is to place the dissertation within the literature - a more detailed recounting of previous research would fill volumes.

The principal working capital models considered are

\textsuperscript{1} The minimum expense is not zero since there are transaction costs and/or lost interest on idle cash balances - regardless of the chosen strategy.
based on inventory theory; Baumol's (1952) and Miller and Orr's (1966) models figure prominently since they are the keystones for much of what follows.

Capital structure models of two competing lines of analysis are examined: static tradeoff models and those based on a capital source pecking order. The former views the firm's observed capital structure as a conscious effort to balance competing incentives for debt and equity use. One period models with no transaction costs are the norm. Under the latter approach the firm has ordered preferences for capital sources: first reliance is on retention and then outside debt - outside equity is used only as a last resort. The justification for exhibiting both model types is that in bridging the gap between short-term and long-term financial management a reconciliation of the two competing approaches was accomplished.

The third section of chapter two examines the management of a firm's maturity structure. The cost of short-term versus long-term debt sources plays an important role in the attempted integration. The final section presents previous attempts to integrate the three components. Most involve the ad-hoc "paste work" of partial models without an unifying theme. Two or more

secular models are superimposed and presented as a unified theory. One model which does not have this deficiency is Orr's three asset model (1971). It is discussed in detail.

Chapter three provides a description of the model. The chapter commences with a presentation of the firm's balance sheet as it will be utilized throughout the remainder of this dissertation. The structure is somewhat unusual, but has its roots in the previous research of Taggart (1977). The unorthodox aggregation provides an ideal framework for the discussion of total financial management.

The interrelationship between day-to-day net cash flow and financial structure is examined next; section two shows how movement in the firm's financial structure depends on the day-to-day net cash flow, and section three shows how net cash flows are dependent on the firm's choice of financial structure. A general presentation of the costs associated with the management of the financial structure follows. The final section lists and explains the difficulties associated with an analytic solution.

A simulation study of the model is displayed in chapter four. It begins with a description of the balance sheet, costs, and cash flows of a fictitious firm. A flow chart of the computer simulation is presented and the optimum selection of control parameters is then obtained.
Chapter five performs a sensitivity analysis. The usual techniques of comparative statics are found partially infeasible, partially too complex. An alternative, pragmatic approach is proposed. But, because of limited computer funds, it was implemented only for a simpler model: the two-asset Economic Order Quantity (EOQ) control system of Miller and Orr (1966).

Chapter six summarizes the results and compares them to those obtained from existing financial structure models. There is also a discussion of the limitations and shortcomings of the present framework. The last section provides a listing of areas of potentially fruitful research.

The presentation is set within the structure of a large publicly owned corporation. However, other ownership structures are possible with slight amendment.
Chapter Two
Literature Review

The various partial models of financial structure management are usually discussed under one of three traditional subheadings: working capital, capital structure, and maturity structure management. The first three sections review each of these. The lack of integration is apparent. Early attempts to integrate the three components are shown in section D. Orr's three asset model (1971) is used in subsequent analysis and discussed in detail.

A. Working Capital Management

There are two types of working capital accounts: short-term assets and short-term liabilities. Principal short-term assets include cash, marketable securities, accounts receivable, and inventories. Table 2.1 exhibits short-term assets as a percentage of total (short-term and long-term) assets for seven broad industrial categories. Two points stand out: the large magnitudes and the wide interindustry variation. Short-term assets comprise 48 percent of assets for all industries and range from a low of 27 percent in agriculture to a high of 70 percent in manufacturing. A firm must adjust its short-term asset accounts in
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response to its particular environment.

First consider cash balances. The corporation has four motives for holding cash. The first three are the same reasons that an individual holds cash: to conduct day-to-day transactions, for speculative reasons, and as a precaution against emergencies. The fourth reason relates strictly to the holding of cash balances at commercial banks. Banks provide a number of services to the firm and many times require that the firm maintain "compensating balances" in exchange for these services.¹

The amount of noncash short-term assets that the firm holds depends on the nature of the industry, seasonal fluctuations, business cycles, and other factors. A public utility requires a large amount of fixed assets and receives an almost continuous stream of cash from its bill-paying customers. Only a small short-term financial asset position is required.

A firm in a seasonal business finds not only that short-term financial securities fluctuate in volume from one season to the next, but their composition also changes. Similar changes are found over the course of the business cycle.

The principal short-term non-cash assets are: accounts receivable, marketable securities, and

¹ Compensating balances are usually around twenty percent of outstanding debt.
inventories. Accounts receivable are debts owed the firm by customers for the firm's goods or services sold in the ordinary course of business. In the United States most ordinary business sales are credit sales and most firms have substantial investments in receivables. Penalty for late payment is substantial and most are paid just prior to expiration. Terms of these purchase contracts and their use tend to be standardized within an industry.

Marketable securities are financial instruments issued by governments and firms which are market traded and easily converted into cash. They come in many forms. The most common are Treasury bills, Treasury notes, long-term government bonds, negotiable certificates of deposit (CDs), commercial paper, money market mutual funds, and other firms' long-term debt equity securities. All these have two things in common: they can be liquidated quickly and with little cost.

Inventories are another short-term asset carried by firms. For wholesalers and retailers the only inventories are finished goods. Manufacturers also have work-in-progress and raw materials inventories. All prevent costly shutdowns or production variation.

Like short-term assets, short-term liabilities are a conglomeration of many items. Some of the most common are accounts payable, accrued payments, commercial bank
loans, and commercial paper. All are financial in nature. Accounts payable are outstanding obligations to other firms for goods and services received. Firms usually pay these accounts promptly since prolonging the payment period often leads to the loss of substantial price discounts. Accrued payments are outstanding obligations to providers of services; examples include employee wages, insurance expense, and taxes due. Payment is due at an agreed upon time and failure to pay involves substantial costs.

Firms that require frequent short-term bank loans generally ask their banks for lines of credit which allow the firm to borrow at any time up to an established dollar limit. They represent the simplest and most common way to obtain short-term financial credit. Such loans may be secured and come in two varieties: note obligations and installment loans. Most are not formal commitments and the bank usually reserves the right to refuse additional credit if there is significant financial deterioration. If the borrower requires an unconditional guarantee an additional standby fee is charged. A line of credit usually extends for a year.\(^2\)

Commercial paper is unsecured short-term debt issued by large corporations with maturities of one to
nine months.³ Commercial paper is limited to large corporations and is generally substantially cheaper (by one to two percent) than bank loans.⁴ Nevertheless, in their borrowing activity few firms bypass the banking system entirely because of the additional financial services provided.

A.1 Baumol's Model

The best known working capital problem is the choice between cash and marketable securities. Various quantitative models have been developed for determining the optimal division. The most popular is based on inventory control theory and first applied to cash management by Baumol (1952).⁵

In its simplest form the model incorporates

1. a known constant cash flow drain rate of $m per day,

2. the requirement that all demands for payment are filled immediately,

3. a lumpy cost of transfer from assets (marketable securities) into cash, denoted by θ, and

4. an opportunity cost of holding cash, denoted by v, equal to the interest foregone on the interest-

³ Loans with maturities of over 270 days require Security and Exchange registration, an expensive proposition.

⁴ There are approximately one hundred corporations with established commercial paper markets.

⁵ This exposition closely follows Orr (1971).
earning asset.

Baumol's model calls for the sale of $M$ worth of securities every $M/m$ days. Receipts from the sale are obtained immediately and interest rates are considered known and constant. Figure 2.1 displays cash balances over time and reveals the familiar saw-tooth pattern often associated with inventory models.

The firm's objective is to minimize average daily operating costs:

$$c = \theta m/M + vM/2.$$  (2.1)

The quantity $m/M$ is the frequency of transfer into cash and $M/2$ is average cash balance. Optimization with respect to $M$ reveals the optimal transfer size:

$$M^* = (2\theta m/v)^{1/2},$$  (2.2)

the familiar square root formula. Subsequent research by Tobin (1956) established that this policy form is optimal for the assumed environment.

Almost immediately after its introduction the model came under heavy fire. Much of the criticism centered around the money demand elasticities implicit in the formula. The interest rate and velocity elasticities were of the wrong size; they were $1/2$ with respect to $m$, the transactions variable and $-1/2$ with respect to $v$, the interest rate. Early empirical tests, primarily Friedman (1959), uncovered larger elasticities for both

---

6 Thus, the model is nonstochastic.
Figure 2.1
Deterministic Model of Cash Balances
velocity and interest; in the neighborhood of 1.8 and zero respectively.

Patinkin (1956) felt that the problem resulted from the nonstochastic and always negative cash flows. His model drops these assumptions and relies heavily on a combinatorial analysis developed by Dvoretzky. Formally, he allowed cash flows to occur and costs to be incurred throughout the time intervals \([t, t+1), [t+1, t+2), \ldots\). However, cash management decisions were only permitted at times \(t, t+1, t+2, \ldots\).

During each time interval \(2N\) transactions of size \(m\) occur; \(N\) are payments, \(N\) are receipts. At the end of each interval the net cash flow is zero. However, the order of the receipts and expenditures is random and shortages and surpluses do occur. As in Baumol's model the cash manager minimizes the average daily cost.

A.2 Miller and Orr's Extension

While moving in the right direction, Patinkin's model was still unsatisfactory. In particular, the specification of budget periods during which receipts and expenditures net out to zero, a maximum of a single shortage per period, and no intraperiod control were unduly restrictive. Miller and Orr (1966) dropped these restrictions and introduced technical simplifications to permit cleaner solutions.
They developed the cash management policy illustrated in figure 2.2. The firm sets control limits such that when cash balances reach an upper limit, h, the cash balance is reduced by purchase of short-term assets. When cash hits the lower limit, zero, a transfer into cash is triggered; short-term assets are sold. Both corrective transfers return the cash balance to the same level, the common return point, z. As long as cash balances stay between zero and h, no corrective purchase or sale of securities is called for.

As in Baumol's model, it is assumed that the firm operates in a two asset environment: cash and short-term marketable securities. Cash earns no interest, and the securities have a nonstochastic daily yield of v. Transfer between assets take place instantaneously at a cost of θ dollars per transfer, regardless of size and direction.

Cash flows are stochastic and behave as if generated by a sequence of independent Bernoulli trials. In a small fraction (1/t) of the working day (e.g., an hour) cash balances increase by m dollars with probability p and decrease by m dollars with probability q=1-p.7

Given this cash management policy and the

7 The p=q=.5 case offers the cleanest mathematics although the nonzero drift case has also been solved, Orr (1971).
Figure 2.2
Stochastic Model of Cash Management
assumptions listed above, the steady state expected cost per day of managing the firm's cash balance can be expressed as:

\[ E(C) = \Theta P(T) + \psi E(M), \]

(2.3)

where \( P(T) \) is the steady-state probability of a portfolio transfer and \( E(M) \) is the average level of cash balances. The firm's objective is to minimize (2.3) by optimal choice of policy parameters \( z \) and \( h \).

To obtain these optimal values it is necessary to characterize the steady state probability distribution for the level of cash balances. Once found, it is a small step to calculate \( P(T) \) and \( E(M) \) for substitution into equation (2.3). A common and ingenious method to solve for the occupancy probability distribution, developed for sequential sampling, is to write the transition rules as a difference equation and a set of boundary conditions. The transition relations for the zero drift case are

\[
\begin{align*}
    P_{t+1}(x) &= .5(P_t([x-1]) + P_t([x+1])) \text{ for } 0 \leq x \leq z \text{ and } z \leq x \leq h, \\
    P_{t+1}(z) &= .5(P_t([z-1]) + P_t([z+1]) + P_t(m) + P_t([h-1])), \\
    P_{t+1}(m) &= .5P_t(2m), \text{ and} \\
    P_{t+1}([h-1]) &= .5P_t([h-2]),
\end{align*}
\]

(2.4)

where \( P_k(j) \) denotes the probability that the cash balance is precisely \$j at time \( k \). Note that the entire finite set of possible values for cash balance levels
(0,m,2m,3m,...,z,...h) is specified in (2.4). With no loss of generality m is normalized to unity.

The ability to employ difference equations as a solution technique depends critically on the equivalency of jump sizes in the upper and lower directions. If this criterion is not met, alternative and messy solution techniques are required.\textsuperscript{8}

Difference equations are obtained by looking at the steady state probabilities (as $t$ approaches infinity):

$$P_x = .5(P_{x-1} + P_{x+1}) \text{ for } 0 \leq x \leq h \text{ and } x \neq z,$$

(2.5a)

and

$$P_z = .5(P_{z-1} + P_{z+1} + P_1 + P_{h-1}) \text{ (2.5b)}$$

with two boundary conditions

$$P_0 = 0 \text{ and } P_h = 0.$$

(2.6a, 2.6b)

The following probability restriction also holds:

$$\sum_{x=0}^{h} P_x = 1 \text{ (2.7)}$$

This is a second order difference equation (2.5a) with four boundary conditions (2.5b, 2.6a, 2.6b, and 2.7). This over specification offers problems which are

\textsuperscript{8} It is still possible to use difference equation mathematics (possibly of higher order than two) if the ratio

$$\frac{\text{size of larger jump}}{\text{size of smaller jump}}$$

is a non-negative integer.
cleverly solved by the partition of the state space to get the desired quantities.\(^9\)

The steady state distribution is

\[ P_x = \frac{2x}{z} \quad \text{for } 0 \leq x < z, \quad \text{and} \]

\[ P_x = \frac{2(h-x)}{h(h-z)} \quad \text{for } z \leq x \leq h. \quad (2.8) \]

This is a triangular distribution with mode \(z\), the return point, and average cash balance

\[ E(M) = \frac{h+z}{3}. \quad (2.9) \]

The probability of a transfer on any given day is then found by

\[ P(T) = \frac{t}{2} P_1 + \frac{t}{2} P_{h-1} = \frac{t}{z(h-z)}. \quad (2.10) \]

The logic is that on half of the occasions when the system finds itself at \(x=1\) or at \(x=h-1\) the cash balance hits the limit zero or \(h\) on the next move.

Substitution of (2.9) and (2.10) into the cost function (2.3) allows the formalization of the optimization problem:

\[
\begin{align*}
\min_{Z,h} E(C) &= \frac{(9t)}{zZ} + \frac{[vm(Z+2z)]}{3}, \\
\end{align*}
\]

where \(Z=(h-z)\). Standard optimization techniques yield

\[ z^* = \left(\frac{30t}{4vm}\right)^{1/3}, \quad \text{and} \quad (2.12) \]

\[ h^* = 3z^*. \quad (2.13) \]

To obtain the optimal control parameters in single dollar units, instead of transaction units, multiply

\[ 9 \text{ See Miller and Orr (1966).} \]
Equation (2.12) by m to obtain
\[ z^* = \left[ \frac{3\sigma^2}{4v} \right]^{1/3}, \tag{2.14} \]
where \( \sigma^2 = m^2 t \) is the daily cash flow variance.

Substitution of the optimal control parameters into (2.9) gives
\[ M^* = \left[ \frac{4}{3} \right] \left[ \frac{3\sigma^2}{4v} \right]^{1/3}. \tag{2.15} \]
The partial with respect to \( \theta \) and \( v \) give the comparative static relations:
\[ \frac{\delta M^*}{\delta \theta} > 0 \quad \text{and} \quad \frac{\delta M^*}{\delta v} < 0, \quad (2.16) \]
as in Baumol's original work.

There are two interesting results of this analysis. First, the return point is always below the midpoint of the range of permissible cash balances; for a given value of \( h \) the transaction cost component of cash management is symmetrically U shaped and the opportunity cost of lost interest is monotonically increasing throughout its range. This implies fewer security sales of larger size than security purchases. Secondly, the ratio between \( z \) and \( h \) remains at one to three regardless of the values of \( \theta/v \). Changes in the cost parameters just shrink or expand the system without any change in the ratio of \( z \) to \( h \).
A.3 Other Extensions

Miller and Orr's two-asset model has been extended in many directions. Weitzman (1968) argues that the transaction costs of security purchases are different from security sales and incorporates this into his generalization. Eppen and Fama (1969) find that if the transfer cost is strictly proportional to the transfer size, the optimal policy specifies a range [U,D] over which the cash balance drifts freely. When either control limit, U or D, is passed, a control action is signalled and a transfer is made that is large enough to restore the expected cash balance to the nearest control limit.

Frenkel and Jovanovic (1980) examine the continuous time version. They assume that changes in money holdings are stochastic and characterized by

$$dM(t) = -\mu dt + \sigma dW(t) \quad M(0) = M_0 \quad \mu \geq 0 \quad (2.17)$$

where $M(t)$ is cash balance at time $t$ and $W(t)$ is a Standard Wiener process which is normally distributed with mean zero and variance $t$. They consider only the single boundary problem due to computational difficulties in obtaining closed form solutions for the more general two boundary case. Additionally, instead of minimizing steady state costs they minimize net present value.

Miller and Orr's model is generalized to the three
asset case by Orr (1971). This extension is discussed in section D of the present chapter. First, however, contemporary capital structure theory is reviewed.

B. Capital Structure

As the firm moves from short-term to long-term financing it will encounter fundamental differences in the procedures and costs of obtaining capital. Major sources of outside long-term capital are common stock, long-term debt, preferred stock, warrants, and convertible bonds. The most important are common stock and long-term debt. These two securities account for over 98 percent of the long-term financing requirements of United States corporations. Preferred stocks, issued primarily by regulated industries (public utilities), account for much of the remaining two percent. Common stock and bonds are the only two long-term securities discussed here.

Additions to the equity account are obtained in two ways: externally and internally. The former involves the sale of new common stock, identical to existing shares, to either current stockholders or outside investors. Internal equity capital is generated by retention of the firm's earnings. Long-term debt is obtained by the issue of additional debt.

For a given level of debt and other sources of
outside capital, stockholders' contribution to the capital account is determined by the payout ratio--dividends divided by total net income. If the ratio is low current stockholders are a relatively important capital source and the firm does not have to go through the expense of frequent equity issue. This is a substantial saving, as will be shown.

The relative importance of the various capital sources is shown in table 2.2. Three points should be noted. First, retained earnings are, by far, the most important source of funds. Secondly, outside debt is much more utilized than outside equity. And, lastly, firms show greater reliance on long-term debt sources than short-term debt sources.

B.1 Modigliani and Miller's Model

Modigliani and Miller (1958 and 1963) are generally considered the originators of contemporary capital structure theory. In 1963 they wrote the seminal paper on corporate valuation and capital structure. They assumed that

(a) capital markets are frictionless,

(b) both individuals and firms can borrow and lend at the risk free rate,

(c) bankruptcy costs are zero,

(d) firms issue only two types of claims: risk free debt and (risky) equity,
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<td>Retained Earnings¹⁰</td>
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<td>70</td>
<td>63</td>
<td>56</td>
<td>55</td>
<td>53</td>
<td>43</td>
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<td>57</td>
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<td>5</td>
<td>7</td>
<td>2</td>
<td>5</td>
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<td>Net Long-Term Debt</td>
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<td>14</td>
<td>19</td>
<td>20</td>
<td>27</td>
<td>23</td>
<td>27</td>
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<td>21</td>
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<td>8</td>
<td>6</td>
<td>17</td>
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<td>11</td>
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<td>Net Accounts Payable</td>
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<td>10</td>
<td>11</td>
<td>15</td>
<td>7</td>
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<td>11</td>
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¹⁰ Retained earnings also include depreciation.
(e) each firm is a member of an equal risk class of firms,\(^{11}\)

(f) corporate taxes are the only form of government levy, and

(g) interest expenses are tax deductible (only) at the corporate level.

Many of these assumptions have been dropped in later analysis. The three crucial assumptions are no bankruptcy costs, no personal taxes, and equal borrowing rates (Stiglitz, 1973).

By an arbitrage proof based on the "undoing" at the personal level of suboptimal behavior by managers at the corporate level they show that the value of the levered firm \((V^L = S^L + B^L\), the sum of the market values of equity and debt) is equal to the value of an unleveraged firm, \(V^U\), plus the present value of the tax shield provided by debt, \(t_c B\):

\[
v^L = v^U + t_c B, \tag{2.18}
\]

where \(t_c\) is the average (and marginal) tax rate.\(^{12}\)

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\(^{11}\) Two firms are a member of the same risk class if Pearson's correlation coefficient of their respective net operating incomes (earnings before interest and taxes, EBIT) is unity; perfectly, linearly related.

\(^{12}\) If the value of the leveraged firm is greater than \(v^U + t_c B\) then individuals owning shares of the leveraged firm can sell their shares and use a combination of personal borrowing and unleveraged share purchase to obtain exactly the same return at a lower price. This arbitrage continues until the equality is met. If the value of the leveraged firm is less than \(v^U + t_c B\) the shareholders of the unleveraged firm can sell
This is the single most important result in the theory of corporate finance obtained in the last 25 years. It says that in the absence of market imperfections a firm's market value is maximized by one hundred percent debt finance. If corporate taxes are zero or if interest payments at the corporate level lose their special tax deduction then the value of the firm is independent of the type of financing:

$$v^L = v^U,$$  \hspace{1cm} (2.19)

Modigliani and Miller's earlier result (1958).

Since (2.18) goes against both intuition and empirical evidence, later researchers attempted to reconcile the disparity between the large predicted leverage values (close to 100 percent) and those observed (ten to fifty percent). Their attempts have followed two distinct avenues: a static tradeoff approach, and a pecking order approach. In the static tradeoff framework the firm determines a target debt-to-equity ratio which is instantaneously and costlessly obtained. Under the pecking order framework the firm has no well-defined optimum leverage ratio, but has a

their shares and use a combination of personal lending and the purchase of leveraged shares to obtain the exact save returns at a lower price. Again, this arbitrage continues until the equality holds. For a more detailed exposition of Modigliani and Miller's Proposition One see their 1963 article.

13 Or very close to it.
preference for internal versus external funds and for outside debt over outside equity issue.

B.2 Static Tradeoff Models

In the static tradeoff models the firm manipulates its liability and equity structure to maximize firm value. Corrections to suboptimal structure are usually instantaneous and costless. They come under three, not necessarily mutually exclusive, classifications: bankruptcy cost models, contracting cost models, and personal tax models. Since adjustments are instantaneous and costless these models are usually one period and do not usually differentiate retained earnings (dividend policy) and stock issue or differentiate long-term and short-term debt issue.

B.2.a Bankruptcy Cost Models

In the simplest form of the bankruptcy cost model the firm balances the tax incentive of debt use with the increasing probability of bankruptcy. Examples include Baxter (1967), Kraus and Litzenberger (1973), Scott (1976), and Kim (1978). According to this theory, tax deductible interest payments provide a positive incentive for corporate leverage. However, the increased use of leverage increases the probability of bankruptcy with its attendant cost which, in turn,
provides a negative incentive for leverage. These two costs are balanced at the margin to give an interior optimum capital structure. More general versions allow additional positive and negative incentives for the use of debt, such as investment tax credits and depreciation expense tax-shields (DeAngelo and Masulis, 1980).

B.2.b Contracting Cost Models

Other static tradeoff models are based on (agency and information) contracting costs. The firm is viewed as a contractual arrangement among several classes of claimants, one of which may be the firm's management. If the firm's management operates in the shareholders' best interests most such models rely on information asymmetries (e.g., Ross, 1977), or security holder (bond versus stock) conflict (Fama and Miller, 1972). Ross finds that capital market transactions signal the firm's intentions and convey information to the market. Fama and Miller show that firms undertake an investment policy with too much risk to maximize firm value if leverage is

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14 There is a long standing controversy concerning the size of the bankruptcy cost; Altman (1984) provides a summary. Estimates range from a low of one percent of total assets a few months prior to the declaration of bankruptcy to a high of over thirty percent.

15 An interior capital structure is one which is neither one hundred percent debt nor one hundred percent equity.
large enough to make bankruptcy possible.

Other models cut the umbilical cord which connects managers and stockholders and allow them to have divergent interests. The minimization of agency costs of debt and equity lead to an interior capital structure. Jensen and Meckling (1976) show that the marginal agency cost of equity decreases with leverage.

B.2c An Integration of Corporate and Personal Taxes

The third type of static tradeoff model attributes the failure of firms to pursue maximum leverage policies to the existence of differential tax treatment of personal income from stock and bonds and the manner in which this tax structure interacts with the (personal and corporate) tax deductibility of interest payments. According to this view there are some investors for whom the favorable tax treatment of returns from stock (relative to returns from corporate bonds) at the personal level more than offsets the favorable tax treatment of interest payments at the corporate level in such a way that these investors would prefer to hold the shares of firms that follow less than maximum leverage policies.16

Arguments to this effect have been put forth by

16 The 1987 Tax Act may alter this advantage.
Farrar and Selwyn (1967) and Stiglitz (1973). They found three reasons why debt is not as attractive as originally thought: (1) Increased leverage means that less of the total returns can be taken as capital gains which have a lower personal tax rate than interest payments, (2) Capital gains are taxed upon realization rather than upon accruals, and (3) Personal borrowing is a substitute for corporate borrowing and personal interest payments are also tax deductible.¹⁷

Miller (1977) and Feldstein, Green, and Sheshinski (1978) construct their integration in a macroeconomic equilibrium context. Miller found that there exists an optimum aggregate leverage ratio for all firms, but that any given firm is indifferent between debt and equity. Feldstein et al. centered their concern on the effect that inflation has on the personal and corporate tax system. They found that firms react to increased inflation by increasing leverage.

B.3 Pecking Order Models

The static tradeoff models can be contrasted to a competing version of the story based on a financing source pecking order. A firm has lexicographic preferences for its capital sources, financing its

¹⁷ Again, the 1987 Tax Act may mitigate these advantages.
operations according to the following order:

1. Firms' first choice as a source of funds is the retention of earnings.

2. If retained earnings are inadequate, the firm first draws down its cash balance and then its marketable securities portfolio to prevent dividend variability. If retained earnings permit, the firm first pays off debt or invests in short-term assets (cash or marketable securities).

3. If additional finance is required the firm issues securities in order of decreasing safety. They start with debt, then possibly hybrid securities such as convertible bonds, and only after that do they issue new equity.18

Each firm's observed debt ratio reflects its past requirements for financial resources. That is, one must examine the financial history of any particular firm in order to understand its current capital structure.

18 This is not in concordance with the observance of firms simultaneously paying dividends and issuing debt.
B.3.a Donaldson's Sample Survey

The pecking order hypothesis dates back at least to Donaldson (1961). In his 1961 study of corporate financing policies he observed that "management strongly favored internal generation as a source of new funds even to the exclusion of external funds except for occasional unavoidable bulges in the need for funds" (p. 67). Furthermore, these bulges were not generally met by cutting dividends; reducing the "customary cash dividend payment ... was unthinkable to most managers except as a defensive measure in a period of extreme financial distress" (p. 70). If external financing was required the managers rarely thought of stock issue. He found that a large majority had not had an outside equity issue in twenty years and had no plans for one in the foreseeable future.

A criticism of this approach is that it lacks any theoretical basis in optimal choice. High reliance on internal funds and low reliance on outside stock issue are observed and then presented as an explanation. Later researchers attempted to formalize the model.

B.3.b King's Formalization

King (1974) integrates personal and corporate taxes on a period by period basis in a risk free world to establish a pecking order. He found that if desired
capital is smaller than retained earnings then internal finance should be used. If internal earnings are not adequate the firm then issues outside debt.

This is very similar to some versions of the static tradeoff model, most notably Stiglitz (1973). However, an important conceptual difference exists. King took a myopic view in which the firm utilized the cheapest form of capital on a period by period basis. Stiglitz had a grander view; he argued that the firm should maintain a high retention rate to ensure low reliance on outside capital. In the course of integrating short-term and long-term financial management this dissertation bridges the gap between these two researchers.

Regardless of the theoretical merits of pecking order models, they do well at explaining the data. Although one can doubtlessly find many counterexamples, such as firms issuing stock when they "could" issue debt, the aggregate data show a heavy reliance on internal finance and debt issue. For all non-financial corporations over the decade 1973-1982, internally generated cash covered, on average, 62 percent of total capital generated. The bulk (over ninety-five percent) of required external financing was borrowed.19

19 Board of Governors of the Federal Reserve System, Division of Research and Statistics, Flow of Funds Account.
C. Maturity Structure

A firm's maturity structure is the distribution of its liabilities among the various maturities. There is a great deal of discretion in its selection. Three examples are shown in figure 2.3. Maturity structure "B" exhibits equal reliance on short-term and long-term debt. Maturity structure "A" shows heavy reliance on long-term debt and maturity structure "C" shows heavy reliance on short-term debt.

Before one can understand how a firm decides upon an optimal maturity structure the concepts of term-structure and duration must be introduced. The term-structure is the relationship between yield-to-maturity and time-to-maturity for equal (default) risk debt instruments at a particular point in time.20

The term-structure is drawn for debt instruments of equal default risk. Default risk is not the only type of risk and total risk is not necessarily homogeneous across securities with equal default risk. In particular, unexpected changes in the level of future interest rates causes the market value of bonds to change, and exposure to this risk is depends on the

\[ \text{NPV} = \sum_{t=0}^{T} \frac{C(t)}{(1+r)^t} - \text{Price} = 0, \]

where \( C(t) \) is cash flow at time \( t \).

\[ ^{20} \text{The yield to maturity, } r, \text{ is usually defined as that rate such that the net present value is equal to zero,} \]

\[ \text{NPV} = \sum_{t=0}^{T} \frac{C(t)}{(1+r)^t} - \text{Price} = 0, \]
Figure 2.3
Three Maturity Structures
maturity of the debt instrument.

Figure 2.4 displays the term-structure for United States Treasury securities at two different points in time, March 1976 and August 1981. The lower of the two curves illustrates what has tended to be called the 'normal' relationship where yield to maturity rises at a decreasing rate. This structure has dominated for the post war era. In recent years, however, the normal relationship has been frequently disturbed to the extent that short-term rates have been significantly above long-term yields, generating a downward sloping term-structure. This has been particularly true when interest rates were at historically high levels.21

Three "classical" theories have been put forth to explain the profile of the term-structure: the unbiased expectation hypothesis, the market segmentation hypothesis, and the liquidity premium hypothesis. The unbiased expectation hypothesis was first postulated by Irving Fisher (1896) and further developed by Lutz (1940). Under this hypothesis the forward rates implied by the term-structure are unbiased estimates of future spot rates.22 This hypothesis must be rejected except

21 That is, if interest rates were above those prevailing over the previous ten years.

22 The forward rates, $r_i$'s, are defined as

$$P(t) = \Pi_{i=1}^{t}(1+r_i), \quad t=1,2,3,...,$$
Figure 2.4

Two Term-Structures
in environments of perfect certainty since it shows a total disregard for the price vulnerability of bonds of different maturities due to interest rate fluctuations. For example, if the term-structure experiences a parallel downward shift the percentage price increase of long-term bonds is greater than that of short-term bonds. The empirical observation that short-term interest rates exhibit greater volatility than long-term interest rates further confuses the issue.

The second theory of term-structure determination was originally formulated by Walker (1954) and later refined by Modigliani and Sutch (1966). Under the "market segmentation hypothesis" there is little or no substitution between assets of different maturity since investors have specialized "habitats" which determine their preferences for bonds of a particular maturity. In Walker's formulation the preference loyalties are so strong as to create distinct markets. In Modigliani and Sutch's formulation investors are "tempted out of their natural habitats by the lure of higher expected returns" (p. 182).

Both hypothesize that the individual investor has a n-period habitat if the funds are not required for n periods. Consider pension funds. Their wealth

\[ P(t) \]

where \( P(t) \) is the current price of a \( t \) period discount bond.
disbursements are far in the future; therefore, they have a preference for long-term securities. Local supply and demand for funds at specific maturities define the term-structure as well as offering an explanation of why implied forward and expected future rates may differ.23

The third theory is based on the liquidity premium hypothesis. It was first formulated by Hicks (1939). He observed that for single and parallel shifts in the term-structure the percentage price change is greater for long-term bonds than short-term bonds, a phenomenon mentioned above. If term-structure alterations are constrained to parallel shifts then price risk is larger for long-term bonds than for short-term bonds and long-term lenders are compensated for this additional risk exposure by larger coupons. This "liquidity premium" gives the term-structure its "normal" upward slope. No explanation is offered for downward sloping term-structures.

In formalizing his hypothesis Hicks also developed a time measure of the vulnerability of debt security prices to parallel shifts in the term structure.24 The

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23 An updated version of the hypothesis is provided by Hirshleifer (1970).

24 Working independently, Macaulay (1938) derives a slightly different time measure of price volatility.
maturity (i.e., the final payment date) of bonds provides one potential measure, but most debt instruments consist of a number of payments at different points in time. Maturity is not an appropriate time measure of price change exposure for these (coupon) bonds. Therefore, Hicks developed the alternative time measure of "duration." It is the weighted average

$$D = \frac{\sum_{t=1}^{T} tC(t)P(t)}{\sum_{t=1}^{T} C(t)P(t)},$$  \hspace{1cm} (2.20)

where $C(t)$ is the stream of coupons and principal repayment and $P(t)$ is the present value of one dollar to be received at time $t$. This measure correctly ranks bonds in term of their price variability to parallel shifts in term-structure. \hspace{1cm} 25

The trouble with this and similar measures is that they severely restrict the type of term-structure alterations. \hspace{1cm} 26 Ingersoll, Skelton, and Weil (1978) demonstrate that $D$ is a valid risk measure only for parallel (i.e., shape preserving) shifts in the entire yield curve. A superior measure would allow term-structures to change in shape and location. \hspace{1cm} 27

\hspace{1cm} 25 An additional advantage is that the duration of a portfolio is the weighted average of its individual securities.

\hspace{1cm} 26 See Bierwag (1977).

\hspace{1cm} 27 For example, if the spot rate of interest (or any particular forward rate) changes singularly then the price of a bond with a long duration will not necessarily be affected proportionally more than a bond
Cox, Ingersoll, and Ross (1978, 1981, 1985a, and 1985b) wrote a series of articles considering these more general alterations in the term-structure utilizing recent advances in contingent claims and valuation theory.\textsuperscript{28} They let the equilibrium yield-to-maturity on a pure discount bond of maturity $T$ be

$$R(t,T) = \left(1/(T-t)\right) \sum_{i=0}^{T-t} \left[ E_t [r_{t+i}] + h(t,T) \right]$$  \hspace{1cm} (2.21)

where $h(t,T)$ captures the effects of any (positive or negative) liquidity premium. A common method to acquire the required expectations is:\textsuperscript{29}

$$E[r_{t+1}] = w_0 \mu + \sum_{i=0}^{\infty} w_i r_{t+1-i}.$$  \hspace{1cm} (2.22)

Recursive substitution of conditional expectation permits a re-expression of the yields in (2.22) as a linear function of observable past rates\textsuperscript{30}

\[ \text{of short duration since the yield-to-maturity of the short duration bond may change by more; see Cox, Ingersoll, and Ross (1978) for a more complete discussion.} \]

\[ \text{\textsuperscript{28} The presentation here only reviews one small part of their analysis. Their formulation was much broader in scope and more general in application.} \]

\[ \text{\textsuperscript{29} Dobson, Sutch, and Vanderford (1976) survey a large body of literature which relies on this formulation.} \]

\[ \text{\textsuperscript{30} Typically, strong regularity conditions are imposed on the set of weights $w_i$'s and they are usually assumed to be constant over time. In addition the constant term $x_0$ is often set to zero. For stationarity of the model it is required that $w_0$ not equal 0, $\Sigma w_i=1$, and $\Sigma w_i^2<\infty$.} \]
\[ R(t, T) = x_0(T-t) + \sum_{i=0}^{\infty} \omega_i(T-t)r_{t+i} - i. \] (2.23)

By changing the forecast weights in (2.22) one can obtain a wide variety of shapes for the yield curve for the same interest rate history and most can be easily studied due to the linear structure of (2.23).

Within a general equilibrium framework Cox et al. were able to use this characterization to derive a closed form solution for term-structure. They do this by equating the prices of all bonds with the same expected yield (expected coupon plus expected capital gain) and variance. Their model provides realistic term-structures. The yield curve is rising for low spot rates and falling for high spot rates, the volatility of interest rates decreases with maturity, and a liquidity premium imparts a positive bias to forward rates as estimators of future spot rates.\(^{31}\)

Although Cox, Ingersoll, and Ross feel that their measure of duration permits greater generality in the types of term-structure alterations allowed versus the earlier model of Hicks, this is a matter of contention. Every alteration in term-structure can be decomposed into two parts: a transitory change representing a

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\(^{31}\) In addition, they develop a stochastic duration measure for price sensitivity to changes in the current spot rate, the only independent state variable within their Markov framework.
temporary displacement and a permanent change representing a change in regime. Cox et al. consider only the first types and Hicks only the latter. A superior measure would allow both. Nevertheless, when compared to the alternative time measure of bond price volatility (i.e., maturity), duration, in any form, is superior and used throughout the remainder of this dissertation unless otherwise stated.\footnote{Because of its superior properties, term-structures usually show the relationship between yield-to-maturity and \textit{duration} (not maturity as in figure [2.3]).}

Now that the concepts of term-structure and duration have been introduced the past research on the selection of an optimum maturity structure can be presented. Under the "classical" theory of maturity structure selection, the firm matches the duration of assets (which produce cash inflows) and liabilities (which produce cash outflows); see Redington (1952) and Wallas (1959). For example, the firm finances plant and equipment with long-term debt and inventories by rolling over short-term debt.

The motivation for this hypothesis goes as follows. The firm faces two types of risk in its planning process. The first is that at some date in the future, its asset and liability streams will be different from those expected. This risk component is momentarily
ignored in order to concentrate on the second. The second kind of risk is present when the general level of discount rates can change. Wealth is the difference between the present values of the agent's asset and liability streams, and if assets and liabilities have different durations changes in the discount rate can affect these values differently. Most attempts to minimize this exposure have allowed only single and parallel shifts in the term-structure.

Grove (1966 and 1974) re-examines the classical approach, takes a closer look at the second moment of interest rates, and analyzes the maturity structure problem in terms of its effect on the mean and variance of net worth. He finds that a hedging policy, matching the duration of assets and liabilities, does minimize the variance of net worth, but seems to him "to be far too narrow and mechanical to survive serious examination. Attitudes toward risk, tastes in wealth, and expectations play no role in it and ... are left unexplained" (p. 46; Grove 1966). He shows that for a given expected change of interest rates on the part of management, expected net worth can be increased by departing from the hedged position. The cost of this increase in expected returns is an increase in the variance of net worth.

Morris (1976) took a fresh and innovative approach
to the selection of an optimum maturity structure by exploring the consequence of the risk associated with alternative debt maturity policies: the effect of debt maturity upon the variance of net income. In doing so he provides a partial integration of working capital management (the variance of cash flows) and liability management (the selection of the firm's maturity structure).

He finds that if interest rates and the firm's net operating income (earnings before interest and taxes, EBIT) are positively correlated, then increased reliance on short-term debt causes a reduction in the volatility of residual income. Thus, even though a policy of financing with a sequence of short-term loans increases the risk of the future interest expense, it can, under certain conditions, decrease the risk of net income by decreasing its variance. In depressed economic conditions the interest rates and net operating income may tend to decrease simultaneously, and the increased reliance on short-term debt causes interest costs to decrease with net operating income. This mitigates the decline in net income. The opposite is true for periods of prosperity where the increase in net income is limited by the increased interest expense.

This completes a (albeit lengthy) review of the precursors required for an understanding of the model
presented in chapter three. Previous attempts to integrate the various components are considered next.

D. A Unified Approach to Financial Management

The attempted unification of the various components of financial management has taken three distinct approaches. Under the first the firm's financial structure is viewed as a network solvable by a programming solution. Under the second, various empirical regularities between balance sheet items are observed and presented in conjunction with simple adjustment mechanisms as a unified approach to financial management. The problem with these two approaches is that they "paste together" various partial models without an unifying theme. The third approach does not have this deficiency. It is an extension by Orr (1971) of Miller and Orr's (1966) firm cash management model to the case of three assets.

D.1 A Programming Approach

The financial manager's short-run portfolio problem was first modeled as a linear programming problem by Robichek, Teichroew, and Jones (1965). It was later generalized by Mao (1968), Orgler (1969), and Pogue and Bussard (1972) to include unequal time periods, stochastic parameters, and additional constraints.
Myers and Pogue (1974) further extend this technique to include total financial management. They argued that the investment, financing, dividend, and working capital options require simultaneous solution, and employed integer programming to optimize the entire system. Principal constraints were a debt limit and a "sources equal uses" restriction. Additional constraints restricted liquidity, investment choices, and dividend policy. The valuation model used to price leverage was Modigliani and Miller's 1963 result. The optimized objective function was the net worth of the firm's original stockholders.

The problem with this approach is that the linear programming framework quickly becomes very large and unwieldy, making interpretation difficult. Many of the earlier studies, which restricted discussion to short-term management, often faced difficulty in interpretation. Orgler (1970) estimated that 300 to 500 constraints, 2,000 to 5,000 variables, and large amounts of input data are required for moderate sized short-term models. The addition of long-term management decisions further exacerbates the problem. The use of this approach limited the financial manager to a number crunching technocrat.

\[ v^L = v^U + tC \]

That is, \( v^L = v^U + t_C \).
D.2 Empirical Regularities

A second attempt to integrate the various components of financial management is based on empirical observation. Various econometric models utilizing accounting identities and ad-hoc variable selection procedures have found statistically significant regularities among the various items of a firm's balance sheet and its environment; examples include Spies (1974), Jaffee (1971), Bosworth (1971), Taub (1975), and Taggart (1977). Most rely heavily on the fundamental accounting identity. This "uses equals sources" identity requires that all capital invested or distributed be accounted for.

Spies (1974) partitions the capital budget into five components: dividends, short-term investment, gross long-term investment, debt finance, and equity finance. The former three are outflows and the latter two are inflows. Optimal levels of the various financial structure components are postulated to be a function of a set of exogenous variables; a partial list includes earnings before interest and taxes (EBIT), bond rating, and the dividend-price ratio. The aggregation and averaging of cross-sectional with time series data were used to establish "optimal" values.

A partial adjustment model was used to explain the adjustment speed of the various components to their
optimal values. Due to the limitation on funds (i.e., the accounting identity) the adjustment speeds of the various accounts depend on the spread between the other components and their optimal values. Significant interactions were found and the author concluded that the various components cannot be studied separately. Studies by Jaffee (1971) and Bosworth (1971) confirm this conclusion.

While all three of these researchers recognized that the sources equals uses identity imposes constraints on the coefficients of the equations, none allow for the possibility that balance sheet interrelationships may enter through the error terms. Taggart (1977) recognizes this and corrects for the problem by a technique developed by Zellner (1962) which exploits these cross-correlations to achieve more efficient estimates.

Balance sheet measures have also found themselves on the "right-hand side" of the regression equation. A study by Marsh (1982) and earlier studies by Baxter and Cragg (1970) and Martin and Scott (1974) have looked at the explanatory power of various balance sheet components in the selection of a firm's capital structure. Baxter and Cragg found that firms raising

---

34 Shocks which affect one of the adjustment equations should influence the other equations, resulting in correlations among the error terms.
large sums relative to asset size favored debt. Martin and Scott employ an alternative statistical technique and found that firms with a high proportion of fixed assets had a larger propensity for debt issue. Marsh used British data and obtained similar results as well as establishing the significance of solvency levels in the determination of capital structure. A shortcoming with all of these attempts is that they rely heavily on empirical regularities and very little on economic theory. The same cannot be said of the third approach.

D.3 Orr's Three Asset Model

Miller and Orr's (1966) model of cash management examined a firm's choice between two assets: cash and short-term marketable securities. Orr (1971) extended this to three assets. The three assets consists of cash and two revenue-producing assets: marketable short-term financial securities and physical assets. When the firm has an excess of cash its first recourse is to increase the firm's holding of marketable securities (shorts). If such holdings are already in excess the firm then purchases physical capital. When the firm has a cash deficiency the situation is reversed. However, instead of selling their physical assets the firm issues additional securities (debt) since the transaction costs involved in the sale of physical assets make such
transfers prohibitively expensive. Both physical investment and debt issue are called 'longs'.

Cash balances and marketable securities for a given moment of time are denoted by $x_t$ and $X_t$ respectively. The upper limit and return point for cash are respectively $h$ and $z$. The corresponding points for shorts are $H$ and $Z$ respectively. Both accounts have lower limits of zero.

The firm follows an inventory control approach to financial management. The policy employed is as follows:

(a) If $x=h$ and transfer of $h-z$ would place the shorts account above its upper limit of $H$ the firm purchases $(h-z)+(X-Z)$ worth of physical equipment. Cash balances and the shorts account are lowered to $z$ and $Z$ respectively.

(b) If $x=h$ and a transfer of $h-z$ would not place the shorts account above $H$ then the firm increases short balances by $h-z$ and lowers the cash position to $z$.

(c) If $0<x<h$ no corrective action is taken.

(d) If $x=0$ and a transfer of $z$ from shorts would not lower the balance below $0$ the firm sells $z$ worth of shorts and increases cash balances to $z$.

(e) If $x=0$ and a transfer of $z$ from shorts would lower the balance below $0$ the firm issues additional long-term securities.

A graphical representation is provided in figure 2.5.

The interrelationship between the two accounts is
Figure 2.5

The Three Asset Control Policy
evident.

The simplest case assumes that transfer costs into and out of both shorts and longs do not depend upon direction, the interest rates attainable on shorts is constant ($v_S$), and the corresponding rate of return on longs is $v_L$.\textsuperscript{35} Cash flows are structured, and the cash account is regulated in the same manner as in the two-asset model. Therefore, many of the conclusions concerning cash balances remain true. In particular, two results still hold. The mean cash balance remains

$$E(x) = \frac{h+z}{3}, \quad (2.24)$$

and the probability of a transfer in any given time period still is

$$\text{Probability of Transfer} = \sigma^2(z(h-z))^{-1}. \quad (2.25)$$

These hold true regardless of the $h$ and $z$ selected except that $h$ is restricted to be no less than $z$ and both are non-negative.

However, there is a major difference between the three-asset and two-asset models with regard to the selection of the optimal cash control parameters. The effect on total costs of the selection of $h$ and $z$ for

\textsuperscript{35} The assumption of nondirectional transfer costs is particularly troubling for the long-term assets. It has been removed for the two asset case by Weitzman (1968). Orr (1971) removes this assumption for the three asset case.
the three-asset case is farther-reaching since the structure and costs of the movements in shorts depend on the values assigned to h and z. Nevertheless, the per-period variance of transfers between cash and shorts is the same as the per period variance of cash flows, $\sigma^2$, even though such transfers are not evenly spaced.

Since the variances are homogeneous, the expected first passage time for the shorts from Z, the short-term account return point, to either zero (the lower trigger point) or H (the upper trigger point) is $((H-Z)Z)/\sigma^2$, and the steady-state probability of a transfer is

$$[(H-Z)Z]^{-1}\sigma^2.$$  \hspace{1cm} (2.26)

Consequently, the frequency of transfers involving long-term assets is determined entirely by the values assigned to H and Z, the policy control parameters of shorts, and is independent of h and z, the policy control parameters of the cash account.

The dependency of the mean of shorts, $E(X)$, on h and z is more difficult to establish, but can be shown to be quite small. This is accomplished by establishing steady-state relations in a method analogous to the two-asset model presented in section A. Additionally, the mean of shorts is approximately $(H+Z)/3$ with equality if the cash-short transaction are Bernoullian:

$$E(X) = (H + Z)/3.$$ \hspace{1cm} (2.27)
The approximation is quite accurate, particularly for H to Z ratios of one-third to one-half.

In summary, there are three important conclusions of the extended model. First, the selection of h and z do not appreciably effect the mean of shorts or the probability of short-long transactions and, therefore, the management of cash balances and shorts can be done separately. Secondly, the per period variance of shorts is equal to \( \sigma^2 \), the per period variance of cash balances and, therefore, the probability of short-long transfer is \([ (H-Z)Z ]^{-1} \sigma^2 \). And finally, the mean of shorts is very close to \( (H-Z)/3 \). Both of these latter two results are equivalent to the results obtained if cash-short transactions were Bernoullian.

With these results the expected steady-state cost for the three-asset model in terms of the control parameters is easily obtained:

\[
E(C) = \frac{v_L(h+z)}{3} + \frac{\theta_S \sigma^2}{(h-z)} + \frac{(v_L - v_S)(H+Z)}{3} + \frac{\theta_L \sigma^2}{(H-Z)} \tag{2.28}
\]

where \( \theta_S \) and \( \theta_L \) are the (fixed) transfer costs of cash-short and short-long transactions respectively.

Standard optimization techniques yield the optimal control values:

\[
h^* = 3z^* \quad \quad z^* = \left[ \frac{(3\theta_S \sigma^2)}{4v_L} \right]^{1/3} \tag{2.29a}
\]

---

36 Therefore, the optimal ratio of h to z remains at three for the zero drift case.
If $\theta_S \leq \theta_L$ and $v_L \geq v_S$, as cursory empirical examination suggests, the optimal cash-short transfer cost is of smaller size and higher frequency than short-long transfers.

The case where the short-long transfers are not symmetric is also discussed by Orr (1971). If the transaction cost of physical investment is larger than the purchase cost of the long-term debt he finds that the optimal ratio of $H$ to $Z$ is larger than three, its value when the two expenses are equal.

The concepts introduced in the first three sections of this chapter represent the major areas of corporate finance. In order to present an integrated model of corporate finance it is necessary to incorporate all of these areas into a single framework. This is done in chapter three in a manner superior to the three methods just presented. The integration uses the Orr (1971) three asset model as the glue to hold everything together. However, unlike his model the firm is able to choose from a number of alternatives for a solvency surplus and solvency deficiency. This allows the areas of the first three sections to enter into the discussion.

\[
H^* = 3Z^* \quad \quad Z^* = \frac{[3\theta_L \sigma^2]}{[4(v_L-v_S)]^{1/3}}. \tag{2.29b}
\]
Chapter Three
A Model of Financial Management

This chapter describes the proposed model. It commences with a presentation of the somewhat unconventional framework in which the firm is examined. Attention is then turned towards the interaction between day-to-day net cash flows and financial structure. Section B examines the effect of financial structure on day-to-day net cash flow. Section C looks at the conduit from the opposite vantage; the effect of spillover from liquid accounts to long-term financial management. Section D discusses the costs associated with financial management. The final section, E, examines the difficulties associated with an analytical solution.

A. A Framework for Financial Management Analysis

A typical firm's balance sheet with its standard classification scheme is shown in table 3.1. This format is too cumbersome for examining the interrelationship between short-term and long-term financial management. A leaner framework is required. This section formulates such a framework. To accomplish this a novel discrimination scheme partially developed
Table 3.1: An Example Balance Sheet ($000)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities and Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Assets</strong></td>
<td><strong>Current Liabilities</strong></td>
</tr>
<tr>
<td>Cash</td>
<td>Accounts Payable $322</td>
</tr>
<tr>
<td>$ 363</td>
<td>Notes Payable 60</td>
</tr>
<tr>
<td>Accounts Receivable</td>
<td>Commercial Paper 50</td>
</tr>
<tr>
<td>503</td>
<td>Bank Loans 50</td>
</tr>
<tr>
<td>Inventories</td>
<td>Accruals 148</td>
</tr>
<tr>
<td>289</td>
<td></td>
</tr>
<tr>
<td>Marketable Securities</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td></td>
</tr>
<tr>
<td><strong>Total Current Assets</strong></td>
<td><strong>Total Liabilities</strong></td>
</tr>
<tr>
<td>1223</td>
<td>1550</td>
</tr>
<tr>
<td><strong>Fixed Assets</strong></td>
<td></td>
</tr>
<tr>
<td>Land and Buildings</td>
<td>Long-Term Debt 1042</td>
</tr>
<tr>
<td>1728</td>
<td></td>
</tr>
<tr>
<td>Machinery &amp; Equipment</td>
<td>Total Liabilities 1550</td>
</tr>
<tr>
<td>466</td>
<td></td>
</tr>
<tr>
<td>Vehicles</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>Stockholder's Investment 489</td>
</tr>
<tr>
<td>Other</td>
<td>Retained Earnings 1538</td>
</tr>
<tr>
<td>102</td>
<td></td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td><strong>Total</strong> 3577</td>
</tr>
<tr>
<td>3577</td>
<td></td>
</tr>
</tbody>
</table>
by Taggart (1977) is used.

The left hand side of the balance sheet is divided into three categories. The first is called "cash"; it consists of currency and checking accounts and is denoted by $x_t$. This asset is used in all transactions and cannot become negative. The second category includes most financial assets and is called "short-term assets". In order for an asset to be an element of this group, the firm must be prepared to utilize it in day-to-day financial management. It includes only marketable securities, excluding those held for strategic purposes. For example, if a firm holds shares of a certain company for a potential takeover attempt, as in Norfolk and Southern's ownership of Piedmont's common stock, these are not counted as short-term assets. Government and other corporations' debt securities are always considered short-term assets since they involve no voting rights.

Noticeably absent from this category are inventories and accounts receivable. These are usually considered short-term assets since they are held for a short time and are highly liquid. In the present model they are not included in this category because the assets are not held for financial management purposes. If the firm has a cash deficiency, it does not liquidate these accounts except in cases of severe financial
distress. These two assets as well as the fixed assets are aggregated and called "productive assets" since they are necessary to carry on production.

On the right side of the balance sheet similar aggregations are necessary. The composite which is usually called "short-term liabilities" is partitioned into two groups: "short-term liabilities" and "productive liabilities". The first group contains liabilities used in financial management and include commercial bank loans and commercial paper issued by the firm. When there is a cash deficiency a firm often issues one of these liabilities as an alternative to the sale of financial assets. The second category includes accounts payable, taxes, and accrued wages. A firm rarely utilizes these liabilities as a solution to a cash deficiency except in cases of severe financial distress.

Long-term capital sources are reduced to two categories: equity and long-term debt. Equity is assumed to consist entirely of common stock, and long-term debt entirely of consols.¹ By permitting additional categories of securities, little is gained in the way of results and much is lost in exposition. The same balance sheet after partial aggregation is shown in

¹ Prior references (table 2.2) established that long-term debt and common stock account for the vast majority of long-term capital funds.
A firm's balance sheet is further simplified in two additional ways without the destruction of important distinctions. First, instead of having both short-term assets and (negative) short-term liabilities as measures of liquidity they are combined to give a single measure. The firm's "short-term position" is defined as short-term assets minus short-term liabilities and is a measure of the non-cash liquidity position.\(^2\) It is denoted by \(X_t\). Intuitively, this is appealing; if a firm has a cash shortage it can either decrease short-term assets (e.g., sell a Treasury bill) or increase short-term liabilities (e.g., issue commercial paper). Both have the same effect on the firm's short-term position and are close substitutes.

The final aggregation combines productive assets and (negative) productive liabilities and is called "net productive assets". It is assumed to be exogenous since physical investment is assumed to be fixed in order to center attention on the financial aspects of the firm. The net cash flows associated with this stream, revenue, is taken to be a stationary Markov process whose distribution is later characterized. The stochastic nature of this stream is the reason the firm's financial

\(^2\) Observed short-term position are sometimes negative.
Table 3.2: An Example of an Aggregated Balance Sheet ($000)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities and Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>Short-Term Liabilities $160</td>
</tr>
<tr>
<td>Short-Term Assets</td>
<td>Productive Liabilities 348</td>
</tr>
<tr>
<td>Productive Assets</td>
<td>Consols 1042</td>
</tr>
<tr>
<td></td>
<td>Common Stock 2027</td>
</tr>
<tr>
<td>Total Assets $3577</td>
<td>Total $3577</td>
</tr>
</tbody>
</table>
structure is always in a state of stochastic flux. The balance sheet in its final form is shown in table 3.3.

B. The Effect of Financial Structure on Net Cash Flows

When a firm alters its financial structure the nature of its day-to-day net cash flows is altered. This dependency is rarely considered in cash management models. Such deletion masks some important consequences.

Cash flows at time t are of three types: net cash flows from productive operations ($\beta_t$), net cash flows from short-term financial operations ($U_t$), and cash flows from long-term financial operations ($\epsilon_t$). A short discussion of each gives the discrimination scheme precision.

Recall the definition of the "net productive assets" provided in section A. Since physical investment is assumed constant the stochastic net cash flow emanating from this account at time t, $\beta_t$, is exogenous.3

Cash flow from short-term financial operations at

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3 Thus, the firm has a given stock of physical capital as well as a fixed trade credit policy, wage payment policy, and inventory policy. Although all of these areas are important they are outside the realm of this dissertation.
Table 3.3: A Parsimonious Balance Sheet ($000)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liability and Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>$ 363</td>
</tr>
<tr>
<td>Short-term Position</td>
<td>-92</td>
</tr>
<tr>
<td>Net Productive Assets</td>
<td>3146</td>
</tr>
<tr>
<td></td>
<td>Consols</td>
</tr>
<tr>
<td></td>
<td>$ 1042</td>
</tr>
<tr>
<td></td>
<td>Common Stock</td>
</tr>
<tr>
<td></td>
<td>2027</td>
</tr>
<tr>
<td>Total</td>
<td>$ 3069</td>
</tr>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>$ 3069</td>
</tr>
</tbody>
</table>
time $t$, $U_t$, is the net interest income derived from the firm's short-term position. This is the net cash flow derived from the firm's position in short-term financial assets and short-term financial liabilities. It can be negative (i.e., the firm is a net short-term borrower) or positive and is calculated by

$$U_t = X_{t-1}i(t-1, st)$$

where $i(t, st)$ is the short-term interest rate for period $t$. The short-term interest rate is stochastic for the simulation performed in chapter four.

Cash flow from long-term financial management at time $t$, $\epsilon_t$, is the sum of two components: dividend payments to stockholders and interest payments to

Net cash flow from short-term financial operations is positive for credit companies and other financial institutions. The distinction between short-term financial assets and productive investments disappears for these firms.

The short-term interest rate is a weighted average of the interest rates of the various short-term financial securities which compose it. However, in this dissertation the short-term interest rate is not assumed to vary with the composition of the short-term account, only with its aggregate net level. A more general model would allow for this dependency.

The effect of the interest deductibility on the corporate tax bill can be included with slight amendment

$$U_t = (1-t_c)(X_{t-1})i(t-1, st)$$

where $t_c$ is the (constant) marginal corporate tax rate. This can be given one of two interpretations. The first is that a sinking fund is established to pay taxes and that contributions to the account are decreased with short-term debt issue. The second is that taxes are paid daily.
holders of the firm's long-term debt. It is always nonpositive and calculated by

$$\epsilon_t = -d_t - D_{t-1}i(t-1, l_t), \quad (3.2)$$

where $d_t \geq 0$ is the total dividend paid at time $t$, $D_t \geq 0$ is the market value of long-term debt carried during period $t$, and $i(t, l_t)$ is the interest rate for long-term debt for period $t$. All long-term debt is assumed to have originally sold at par.

The sum of the three cash flows is the firm's "wealth retention stream" and is denoted by

$$\alpha_t = \beta_t + U_t + \epsilon_t. \quad (3.3)$$

It is stochastic since cash flows from productive operations and interest rates are stochastic. If the expected value of the wealth retention stream is positive the firm is expected to accumulate wealth in the form of short-term funds. If the expected value is negative the reverse is true; the firm is expected to increase its reliance on short-term debt and lower its stock of short-term financial assets.

Thus, the short-term position can be thought of as an inventory account for stored financial wealth. The existence of such an account allows the firm to avoid frequent and expensive transactions in the long-term market. Long-term transactions do occur, but on an

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7 The long-term interest rate is a weighted average of the interest rates on the various issues of consols.
infrequent basis.

The firm's financial structure not only affects the mean of the firm's day-to-day net cash flow, but also its variance. If the firm has a large short-term position (negative or positive), the firm has a high percentage of days for which an usually large cash flow is obtained. For example, if the firm is relying heavily on short-term debt then it will often have days for which it has to pay back the principal on short-term bank loans and commercial paper. If instead, the firm has a large amount of short-term financial assets then the firm will often have days for which it receives back the principal on its Treasury bills, government bonds, and its commercial papers of other firms. Both extreme positions make the management of cash balances more difficult due to increased variance.\(^8\) The next section examines the dependency of financial structure on the day-to-day net cash flow in more depth.

C. The Effect of Net Cash Flows on Financial Structure

The avenue between day-to-day net cash flows and a firm's long-term financial structure runs both ways.

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\(^8\) This effect should dominate the effect suggested by Morris (1976) which was discussed chapter two. This may be one reason that he did not find that firms with high positive correlations between short-term interest rates and net operating income made increased use of short-term debt.
Section B discussed the effect of financial structure on the day-to-day net cash flow. This section discusses the mirror image; the spillover effect of net cash flows on the firm's financial structure. This is another area which has received surprisingly scant treatment in the literature.

First consider the situation where a firm has a solvency deficiency (that is, it has very few marketable securities and has used up most of its lines of credit). If the stock of physical investment is fixed the firm has three alternatives for remaining solvent: debt issue, equity issue, and the initiation of a policy of decreased dividends. The effect of each on present and future cash flows are different. Direct cash flows are those emanating immediately from the policy decision. There are four types:

(a) issue proceeds,
(b) dividend payments to new shares,
(c) interest payments to new bonds, and
(d) changes in total retention due to dividend changes.

Direct cash flows for equal size alternatives are shown in figure 3.1. Debt and equity issues are of equal size if gross proceeds are identical. An equivalent size

\footnote{If the investment decision is endogenous then the firm could sell some of its physical assets, an alternative with large transaction costs.}
Figure 3.1

Direct Cash Flows for Alternative Policy Decisions:
(A) Debt Issue, (B) Equity Issue, and (C) Dividend Decrease
dividend reduction is one for which the net present value of the dividend reduction is equal to the gross proceeds of the security (debt or equity) issue.

Debt and equity issue result in the immediate inflow of proceeds and the periodic payment of additional interest and dividends respectively. Dividend reduction decreases future dividends.

Since the investment decision is exogenously determined, any increase in retained funds is used to increase the short-term position. For example, if the firm decides upon a long-term large debt issue the proceeds of the issue are not left idle - they are used to purchase marketable securities and pay off short-term loans. Both actions increase the short-term position.

Therefore, long-term debt issue substitutes long-term debt (consols) for short-term debt and does not necessarily affect the firm's total debt-to-equity ratio. Equity issue has a different consequence; it immediately substitutes equity for short-term liability. Finally, dividend reduction slowly increases the equity account while slowly decreasing the amount of short-term liabilities (i.e., increases the short-term position) relative to the case when no action is taken.

Now, consider the effect of the alternative policy decisions on the mean day-to-day net cash flow and expected drift of the short-term position. Both are
increased if the firm issues equity and expected dividend payments are less than the expected costs of servicing short-term debt. The reverse is true if dividend yield is greater than expected short-term interest rates. Similarly, new issues of long-term debt decrease the net day-to-day net cash flow and the expected drift of the short-term position if the current long-term interest rate is greater than the expected short-term rates. Again, the opposite is true if the current long-term interest rate is less than the expected short-term rate. Lastly, dividend reduction increases expected net day-to-day cash flow and the expected drift of the short-term position.

Figure 3.2 displays the short-term position time path for the three alternatives when

\[ E(\text{dividend yield}) \leq E[\text{i}(t,\text{st})] \leq \text{i}(t,\text{lt}), \quad (3.4) \]

the initial drift is zero, and the initial short-term position is zero. For both debt and equity issue there is an immediate increase in the short-term position. However, expected drifts following the two issues are of different sign. The issue of long-term debt lowers the expected drift of the short-term position since the issue replaces short-term debt with a security which increases the expected drift. The issue of equity
Figure 3.2

Effect on Short-Term Position of Alternative Policy Decisions: (A) Debt Issue, (B) Equity Issue, and (C) Dividend Decrease
raises total retention since the amount required to service the dividends on the new shares is less than the expected short-term interest payment which it replaced. A decrease in dividends has no immediate effect, but increases the size of future retention giving the short-term position its upward slope.\textsuperscript{10}

The results for a solvency surplus are reversed. There are three alternatives: equity repurchase, debt repurchase and the initiation of a policy of increased dividends. The effect on the drift of the short-term position under condition (3.4) are shown in figure 3.3. Dividend increases and equity repurchases both decrease future total retention and debt repurchase increases

\textsuperscript{10} There are empirical implications of this proposition. If policy decisions provide information to the market about managers' future net income projections then the change in stock price should be different for the three alternatives. Both the issue of equity and dividend reduction should increase expected retention and inform the market that poor income prospects are the cause of such action (if condition 3.4 is satisfied.) The issue of long-term debt decreases expected retention and informs the market that net income prospects are so favorable as to warrant this additional purge of net operating income (earnings before interest and taxes). This would indicate that the firm's stock price should increase on days when it announces long-term debt issues. If condition (3.4) is not satisfied then different consequences should occur. For example, when long-term interest rates are below the expected short-term rate, then the stock price should decrease when long-term debt is issued. See the January-February issue of The Journal of Financial Economics for a number of empirical articles concerning the empirical measurement of these events.
Figure 3.3

Effect on Short-Term Position of Alternative Policy Decisions:
(A) Debt Repurchase, (B) Equity Repurchase, and (C) Dividend Increase
retention relative to inaction.\textsuperscript{11}

D. Costs of Financial Management

The objective function to be optimized (minimized) is the cost of financial management. This section lists and discusses the various components of total cost. It is convenient to do this in three sub-sections. The first discusses the costs associated with the management of the firm's cash balance: cash shortage costs, cash surplus costs, and the costs of maintaining a cash management system. The second sub-section discusses the costs associated with the management of the firm's long-term accounts; the issue and repurchase expense of long-term securities and the cost of dividend alterations. The third sub-section considers expenses which do not fit neatly into either short-term or long-term financial management, but include parts of both.

D.1 Cost of Working Capital Management

Even with the most carefully constructed cash budgets the firm will have occasional shortfall in its cash holdings. These shortfalls impose certain costs on the firm. One of the most obvious is the transaction cost associated with raising cash. If the firm sells

\textsuperscript{11} Both dividend increases and equity repurchases should increase stock price and debt repurchase should decrease stock price under condition (3.4). This is established by using the same logic as above.
some of its liquid assets (e.g., Treasury bills) transfer taxes and commission fees are paid. If instead, the firm decides to borrow (e.g., issue some commercial paper), there are initiation costs for the arrangement of the loan.  

On the other hand, the firm incurs costs if it has excessively large cash balance. Too much idle cash means the firm has missed opportunities to invest those funds, if only temporarily, at a positive rate of interest. The following example illustrates the magnitudes involved. In 1983 Kaiser Aluminum had a year ending cash balance of $25 million. The prevailing interest rate was approximately 12 percent. If it is assumed, albeit crudely, that the ending balance was the yearly average then idle cash cost the firm nearly $3 million in foregone interest.

In addition to the cash shortage and surplus cost, there are costs associated with the establishment and operation of the cash management staff and activities. These costs are generally fixed for given cash

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12 There are also costs associated with a deterioration of the firm's credit rating. As shortfalls increase in severity and frequency, banks will start charging more for loans, and the cost of short-term funds rises. Less readily quantified aspects of a deteriorated credit standing are also present: suppliers might stop extending credit, some may demand cash on delivery, and others may refuse to deal with the firm.

management system and are mainly accounted for by salaries, book keeping expenses, and the storage and handling costs of securities.

The monitoring expense is well controlled if the cash management system allows low-level managers control the day-to-day operations. This requires a low level of technical sophistication in order to give low-level managers decision making control. The system is of little practical use if it requires the instincts, experience, and expense of a Swiss currency speculator to operate.

The selection of a cash management system is based on the criterion of minimizing the total cost of cash management; the sum of shortage, surplus, and administrative cost. Shortage costs and surplus costs are positively and negatively related to average cash balance respectively. Administrative costs are composed mainly of fixed costs and do not vary substantially with average cash balance. An example of a commonly used system which performs well at minimizing total cost is based on inventory theory. It was discussed in chapter two.

D.2 The Cost of Long-Term Financial Management

Now consider the costs associated with long-term financial management. There are two types: issue
expense and repurchase expense. Each is discussed in turn.

D.2a Issue Expense

Some of the nonunderwriting cost associated with long-term security issue is the result of Securities and Exchange Commission's (SEC) regulations. The SEC requires the prior registration of all securities offered to the public.\textsuperscript{14} The registration process is designed to ensure full disclosure of all relevant information.

Nearly all large firms use outside investment bankers to underwrite their long-term securities. The investment banker is in the business of channeling funds from lenders to borrowers. Put simply, the investment bankers are wholesalers of securities. They purchase the securities from the firm at one price and plan to sell them at a higher price. The spread between the purchase price and sales price is their primary source of income.\textsuperscript{15}

\textsuperscript{14} There are exemptions from this regulation. However, all long-term securities, as that term is understood in this dissertation, are not exempt and must follow the registration process. Examples of exempt securities are commercial paper (a maturity of less than 270 days), government securities, and securities of charitable organizations.

\textsuperscript{15} There is a strong sense of brand name loyalty in the investment banking. A company will deal with only one investment banker at a time and rarely changes. The investment banking firm usually has a representative in close contact with a firm's Board of Directors.
The first step toward a security issue is the initiation of face-to-face contact between firm's management and an underwriter executive. In this initial meeting the two representatives discuss the broader aspects of the security issue such as type of security, expected market demand, and desired size and timing of the issue. The two parties also agree on a tentative net price to the issuer. The underwriter is usually willing to pay a few dollars below what she believes to be the market price of the securities.

The investment banker usually organizes a syndicate to help underwrite the security issue and then signs a formal agreement with the firm. Once signed, the firm must register the proposed offering with the SEC. The application is accompanied by a preliminary prospectus. This prospectus (also known as a red herring because of the required red lettering warning that it is a preliminary and not a final prospectus) is examined by SEC lawyers to verify full disclosure of all relevant information.

Included in the preliminary prospectus are a short history of the issuer, a statement of intended use, recent financial statements, a summary of the risks associated with the firm's operations, personnel profiles of the firm's top management, recent prices of
outstanding securities, a list of major customers and their importance, and a copy of major contracts. Estimated floatation expenses of the security issue are also included, but this is an understatement since management's opportunity cost is not included.

If the issue does not sell out at the planned retail price the price is lowered and the underwriter syndicate's revenue falls. The risk of low resale price can be considerable. In 1979 Salomon Brothers, an investment banker, had agreed to purchase $500 million of IBM long-term debt. The next day the Federal Reserve announced a new monetary policy and interest rates substantially increased. The value of the securities which they had agreed to buy had lost a great deal of value. Nevertheless, they contracted at the previous price and had to accept the loss. Wisely, they had hedged their investment with interest rate futures contracts and did not lose the full value of the price drop.

The total expense to the issuing firm of long-term security issue is the sum of three costs: expenses and fees directly paid by the firm (direct issue expense), managerial expense, and marketing expense. Direct issue expense is composed of the various costs (largely legal, accounting, and printing) paid directly by the firm. Most are incurred in compliance of SEC registration
requirements. Management expense is the implicit cost of the drain on management's time and energy. Marketing cost include the underwriter's spread and potential noncash benefits to the underwriter. Taken together, these three costs are labeled flotation cost. Each is discussed in turn.

1. Direct Issue Expense

Legal and paralegal expenses are considerable. Outside counsel may charge between $20,000 and $80,000, depending on the complexity of the deal and required hours. Curiously, the legal bills may be less for larger companies. There are economies of scale in legal services; many tasks do not have to cover as extensive an area or time period since much of the work has been done in connection with previous offers. Underwriter's counsels are paid out of the underwriter's spread.

SEC regulations are demanding and even printing costs have run up bills in excess of $100,000. Filing fees are another area of expense. The SEC charges a filing fee of one-fiftieth of one percent (.02 percent) of the maximum offering price of the securities and the National Association of Security Dealers (NASD), an intraindustry watchdog organization, charges fees of $100 plus one-hundredth of one percent (.01 percent) of the maximum offering price, subject to a maximum of $5,000. Total direct issue expenses range from $50,000
to $500,000.

2. Management Expense

Management expense is the most difficult of the costs to estimate. The other costs (direct and marketing) are available from the SEC registration prospectus or stock market data sources and are relatively accurate. No attempt is made to estimate managerial expenses, but a few casual observations give an indication of their magnitude. First, corporate financial officials consider capital structure determination to be of great importance to financial management. Both theoretical and practitioner-oriented textbooks of financial management contain large sections devoted to capital structure selection. Scott and Johnson's (1982) sample survey of financial officers support this contention.

A second indication of large managerial cost is obtained from observing an issue's time table. Even for routine issues, obtaining long-term funds is a long procedure. The typical issue takes approximately four months from its inception to collection of proceeds. Some issues require security holder consent which can further delay the process. For example, many corporate charters contain clauses on the total number of shares permitted. If management desires an additional amount a
stockholders' meeting and consent are required.\textsuperscript{16}

3. Marketing Expense

Marketing expense consists of two parts: underwriter's spread and direct payments to the underwriter. The underwriter's spread represents a cost since purchase price is below the terminal price of the security. The principal determinants of underwriter spread are firm size, issue size, security type, unsystematic risk, prevailing market uncertainty and market yield.

There is a negative association between size (market value of assets) and underwriter spread since larger companies are more closely scrutinized and have established markets for their securities (Smith, 1986). Also, for a given size firm, economies of scale are present; West (1967) and Tallman and Melicher (1976) have found a strong negative association between underwriter spread and issue size.

Examination of SEC files show that underwriter spreads on an equity issue can be as much as four times the spread on a debt issue of comparable size. Christenson (1965) has found that the unsystematic risk of a security and underwriter spread have a positive association due to the increased chance of price change.

\textsuperscript{16} For a very good chronological example of a security issue see Wasserstein (1978).
Finally, Ederington (1974 and 1984) and others have established a positive association between an index of market uncertainty and underwriter spread for similar reasons.

Aside from their spreads, the underwriters sometimes ask for cash reimbursement for all of their direct costs and almost always get the costs of their work involved in fulfilling state registration requirements, including qualification fees and legal expenses. In addition, the underwriter may seek first refusal rights on future security issues.

4. Total Flotation Expense

Tables 3.4 and 3.5 show the average underwriting commission and direct issue cost for stock and debt issues respectively. Cursory observation reveals two points. First, it is much cheaper to issue debt than equity for all issue sizes; both direct issue costs and underwriter costs are less for debt issues. Secondly, a very large part of floatation costs is fixed.
Table 3.4: Issue Cost as a Percent of Proceed for Registered Issues of Common Stock During 1971-1975; General Underwritten Cash Offers

<table>
<thead>
<tr>
<th>Issue Size, Million of Dollars</th>
<th>Underwriter's Compensation, Percent</th>
<th>Other Expense, Percent</th>
<th>Total Cost, Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50 to 0.99</td>
<td>7.0</td>
<td>6.8</td>
<td>13.7</td>
</tr>
<tr>
<td>1.00 to 1.99</td>
<td>10.4</td>
<td>4.9</td>
<td>15.3</td>
</tr>
<tr>
<td>2.00 to 4.99</td>
<td>6.6</td>
<td>2.9</td>
<td>9.5</td>
</tr>
<tr>
<td>5.00 to 9.99</td>
<td>5.5</td>
<td>1.5</td>
<td>7.0</td>
</tr>
<tr>
<td>10.00 to 19.99</td>
<td>4.8</td>
<td>0.7</td>
<td>5.6</td>
</tr>
<tr>
<td>20.00 to 49.99</td>
<td>4.3</td>
<td>0.4</td>
<td>4.7</td>
</tr>
<tr>
<td>50.00 to 99.99</td>
<td>4.0</td>
<td>0.2</td>
<td>4.2</td>
</tr>
<tr>
<td>100.00 to 500.00</td>
<td>3.8</td>
<td>0.1</td>
<td>4.0</td>
</tr>
<tr>
<td>Average</td>
<td>5.0</td>
<td>1.2</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Table 3.5: Issue Costs as a Percent of Proceed for Registered Issues of Long-Term Debt

<table>
<thead>
<tr>
<th>Issue Size, Million of Dollars</th>
<th>Underwriter's Compensation, Percent</th>
<th>Other Expense, Percent</th>
<th>Total Cost, Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 0.50</td>
<td>13.6</td>
<td>6.2</td>
<td>18.8</td>
</tr>
<tr>
<td>0.50 to 0.99</td>
<td>7.7</td>
<td>5.2</td>
<td>12.7</td>
</tr>
<tr>
<td>1.00 to 1.99</td>
<td>6.4</td>
<td>3.0</td>
<td>9.4</td>
</tr>
<tr>
<td>2.00 to 4.99</td>
<td>4.6</td>
<td>1.7</td>
<td>6.3</td>
</tr>
<tr>
<td>5.00 to 9.99</td>
<td>1.6</td>
<td>0.9</td>
<td>2.5</td>
</tr>
<tr>
<td>10.00 to 19.99</td>
<td>1.2</td>
<td>0.6</td>
<td>1.9</td>
</tr>
<tr>
<td>20.00 to 49.99</td>
<td>1.1</td>
<td>0.4</td>
<td>1.5</td>
</tr>
<tr>
<td>50.00 and Above</td>
<td>0.8</td>
<td>0.3</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Issue costs may absorb 15 percent of a $1 million underwritten stock issue but only four percent of a $500 million issue. Floatation costs for comparable size debt issues are ten and one percent respectively. Note, managerial expense is not included in either of these expositions.

The 'issue cost' of dividend reduction is defined differently. It is the decrease in stock price resulting from the announcement of the dividend reduction. Donaldson's (1961) conversation with financial managers suggest large magnitudes and recent empirical work, listed by Myers (1984), confirm this suspicion. Possible reasons for its existence are agency, information, and tax consequences. Its magnitude is exogenously determined and assumed known by all market participants.

D.2b Repurchase Expense

Now consider the repurchase expense incurred when the firms has a solvency surplus. There are three policy alternatives: the repurchase of debt, the repurchase of equity, or the initiation of a policy of increased dividends. The expense of each is discussed in turn.

A firm can repurchase its own debt in one of two ways. It can recall an entire debt issue or purchase
bonds on the open market. The recall option is only available if the outstanding debt has a call provision. This provision gives the firm the right to purchase the entire debt issue, usually after five years, at an agreed upon price. The call price is usually par plus a penalty premium for early recall. In over ninety-eight percent of debt recalls the firm issues new debt at a lower coupon rate immediately prior to the recall, usually within one month (Johnson and Klien, 1974). These authors also found that management's principal motivation was a desire to decrease interest expense. Since the timing of debt recall is determined by interest rate levels (past, present, and expected future) and not out of a desire to lower the solvency surplus, this transaction is not discussed further.17

The purchase of debt on the open market, the second method of debt repurchase, does not require the purchase of an entire issue. Instead, the firm acts in the same manner as any outside investor. It goes to the long-term credit market and purchases the debt at the prevailing market price. A brokerage commission is typically paid.18

17 A good review of past research is provided by Emory and Lewellen (1984).

18 Many times there are bond covenants which forbid the partial repurchase of debt issues since all bondholders are not treated equally.
A firm may also repurchase its own common stock. United States tax law prohibits the acquisition of treasury stock (corporate ownership of its own shares) unless motivated by a desire to obtain an alternative capital structure. The reason for the prohibition is that personal taxes paid on share repurchases are less than those paid on dividends since the former are taxed as capital gains and the latter as ordinary income.19 Since the capital gain tax rates are typically less than those on ordinary dividend income the Internal Revenue Service (IRS) discourages such behavior. Like debt and equity issue the repurchase of debt or equity is assumed to convey no information to the market.

The actual volume of stock repurchases is a matter of dispute. Analyzing changes in balance sheets for the years 1926-1977 Ciccolo and Baum (1985) find that as a percentage of aggregate stock issues, share repurchases have stayed relatively constant over the sample period at about thirty percent. Since stock issues are themselves relatively small in magnitude this indicates a minimal importance. Other studies, however, give a different impression. In a discussion of data from the middle 1970's, Brealy and Myers (1984) found that "share

19 The 1987 tax bill changed this, however, there is a good chance that this provision will be repealed based on public comments made by both Democratic and Republican leaders.
repurchases swelled to about a fifth of the value of dividend payments".

This trend must be continuing for Asquith and Mullins (1986) find that in 1984 "New York Stock Exchange companies ... [paid out] $77 billion through repurchases of common stock versus $68 billion in cash dividends". This represents an increase of over 500 percent. Much of this increase is undoubtedly accounted for by the large leveraged buy outs. Nevertheless, firm repurchases of their own shares are increasing in frequency and magnitude.

The third and final method which a firm uses to purge excess solvency is through the initiation of a policy of increased dividends. The definition of issue cost is different from the two previous methods. It is the price change of common stock on the announcement date; it is usually a negative cost (i.e., a positive price change). Its significance has been empirically observed by many researchers; Myers (1984) provides a recent listing.

D.3 Additional Costs

This subsection considers various costs which do not neatly fit into either of the two former headings. They involve both short-term and long-term financial management. There are two types: tax costs and
bankruptcy costs. Each is discussed in turn.

D.3a Tax Cost

Tax cost at time \( t \), \( TX_t \), is the corporate and personal taxes paid at time \( t \). It is the cost component which dominates contemporary thought on capital structure determination. Corporate and/or personal taxes are used as a keystone upon which to build most popular models. The variation of frameworks, perspectives, and conclusions of these popular models are great, yet all have two things in common: (a) they recognize that the tax deductibility of interest at the corporate level gives a positive incentive for leverage, and (b) they do not differentiate between short-term and long-term debt. Taxes paid at time \( t \) are

\[
TX_t = t_c[\beta_t + i(t-1,st)X_t - i(t-1,lt)D_t].
\]

(3.5)

That is, taxes paid at time \( t \) are a certain percentage of the total of revenue minus interest expense.

---

20 See Appendix A.

D.3b Bankruptcy Costs

Bankruptcy cost at time $t$, $BC_t$, is the sum of the expenses associated with a bankruptcy. It is the sum of three components: (1) direct bankruptcy costs (legal, accounting, filing and other administrative costs of bankruptcy); (2) indirect bankruptcy costs (reduced profits from lost sales that a firm can be expected to suffer due to significant bankruptcy potential); and (3) lost tax credits which the firm would have received had it not gone bankrupt.

There is much disagreement as to the magnitude of their sum. Values range from a low of one percent to a high of seventy percent of total assets measured prior to financial distress. Important references include Kim (1978), Altman (1984), and Stanley and Girth (1971). The firm pays these expenses only in the event of bankruptcy.

E. Difficulty of Analytic Solution

This section discusses three possible solution techniques for determining the financial strategy which minimizes the total cost of financial management. The three techniques are based on (a) a discrete time Markov process, (b) a continuous time Gaussian process, and (c) a simulation analysis. The former two allow analytic solution; however to obtain it is difficult or
impossible. The latter one does not offer an analytical solution but guarantees an answer; however not necessarily an optimal one. Each is briefly discussed.

If the two stochastic components, cash flows from productive assets and interest rates, are characterized by Markov processes then a rich area of technical capability can be employed. The mathematical framework for analyzing the cash flows from productive operations were derived by Orr (1971) and the mathematics for interest rates can be easily incorporated. The principal disadvantages are that the results are dependent on the Markov assumption and a solution is technically difficult.

The second analytic technique assumes that the cash flow from productive operations and interest rates are continuous time Gaussian processes. An important special case is the Wiener process which arises as a mathematical model for the physical phenomenon known as Brownian motion.

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22 The exact nature of the stochastic processes are made explicit in chapter four.

23 A Markov process is a process with the property that, given the value of $X_t$, the value of $X_s$, $s>t$, does not depend on the values of $X_u$, $u<t$; that is, the probability of any particular future behavior of the process, when its present state is known exactly, is not altered by additional knowledge concerning it past behavior.

24 The Brownian motion is an example of a continuous time, continuous state space Markov process.
Much of the secular analysis for this framework has also already been developed. Frenkel and Jovanovic (1980) derived the results for the one-sided cash management problem of Baumol (1952); Cox, Ingersoll, and Ross (1978, 1981, and 1985b) derived the term-structure framework. The principal problem with this technique is that the technical analysis becomes very difficult. Frenkel and Jovanovic were unable to solve even the two-boundary, two-asset problem of Miller and Orr (1967). The generalization to the extended three asset model exacerbates the difficulties.

Simulation is the third technique. It evaluates the merits of alternative courses of action through experimentation performed on a mathematical model representing the actual decision-making situation. A simulation study starts with the construction of a mathematical model designed to capture the essence of the relevant features of the real world, thereby revealing the functional relationships among the variables being investigated.

The mathematical model serves as a medium of statistical experimentation. This is what distinguishes simulation from analytic optimization. It would be ideal to derive analytical solutions from the mathematical models. Unfortunately, this is sometimes impossible since a problem may be so complex that either
it has no analytical solution or it has an analytical solution which is too costly to derive or implement.

Chorafas (1965) has outlined three steps involved in planning and conducting a simulation study:

(a) mathematical model construction,
(b) experimentation performed on the mathematical model, and
(c) evaluation of the experimental findings.

In addition, there is usually a feedback loop which utilizes knowledge, insight, and appreciation acquired on the initial run.

This solution technique has been used in financial models since at least 1965 by such large corporations as General Electric, Dow Chemical, and Sun Oil. It was initially felt that the financial models were the easiest of the corporate models to simulate. Naylor (1968) felt that "a corporate financial model is nothing more than a mathematical statement of a firm's accounting and financial identities. All that is required to build a corporate financial model is for one of the company's accountants or financial analysts to be able to describe and explain ... the financial ratios required to run the firm" (p. 28).

The main advantage of simulation is that it always provides a solution to the applied problem - although not necessarily an optimal one. Its principal
disadvantages are that it lacks elegance and may mask important results which closed form solutions would reveal. It should be utilized only if analytic difficulties of the problem make a derived solution impossible.
Chapter Four
Simulation Study

This chapter presents a simulation study of the management strategy proposed in chapter three. It is performed within the context of a fictitious firm and any future application must amend the present formulation to incorporate any special considerations associated with the particular firm under study. The chapter's principal objectives were to demonstrate the manner and ease of implementation, and to estimate various expenses.

A firm's financial structure at any moment in time is identified by five quantities:

(a) cash balance \( (x) \)
(b) short-term position \( (X) \)
(c) long-term debt level \( (D) \)
(d) long-term interest payment \( (\text{INTPAY}) \)
(e) dividend payment \( (\text{DIVPAY}) \)

and one stochastic process which represents cash flows from productive operations. The original \( (t=0) \) level of the five quantities are discussed in section A. Section B gives the characterization of cash flows from productive operations and the characterization of interest rates (term-structure). Section C presents estimates of the required cost parameters. Section D
explicitly sets out the control parameters and the cost function and determines the former which optimize (minimize) the latter. The final section, E, summarizes the results.

A. Financial Structure

The aggregate balance sheet for U.S. corporations is published annually by the Federal Reserve in its Flow of Funds Report. Table 4.1 presents the aggregate balance sheet for manufacturing corporations for 1984. Division of all quantities by 10,000 yields a balance sheet which approximates an average publicly owned corporation. Comparison with the balance sheets of individual corporations indicate that such a firm would be in the 300-400 range of the Fortune 500.

This "representative balance sheet" was reformulated as described in chapter three. The final balance sheet is displayed in table 4.2. The three stock variables describing the firm's original financial structure (x, X, and D) appear on the reformulated balance sheet. The other stock variable shown in table 4.2, net productive assets, is exogenous and not considered further.\(^1\)

The income statement for the aggregate of United States manufacturing corporations is also published in

\(^1\) See chapter three, section A.
Table 4.1: Aggregate Balance Sheet for the U.S. Manufacturing Corporations for 1984 (millions of dollars)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities and Net Worth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>Short-Term Debt $113,345</td>
</tr>
<tr>
<td>Short-Term</td>
<td>Trade Accounts $156,541</td>
</tr>
<tr>
<td>Financial Investment</td>
<td>Taxes $31,664</td>
</tr>
<tr>
<td>Trade Accounts</td>
<td>Other $186,825</td>
</tr>
<tr>
<td>Inventories</td>
<td>Long-Term Debt $360,951</td>
</tr>
<tr>
<td>Net Property</td>
<td>Equity $906,297</td>
</tr>
<tr>
<td>All Other</td>
<td>Liability &amp; Equity 1,755,534</td>
</tr>
<tr>
<td>Total Assets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,755,534</td>
</tr>
</tbody>
</table>
Table 4.2: Initial Financial Structure (millions of dollars)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities and Net Worth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>$4.6429</td>
</tr>
<tr>
<td>Short-Term Position</td>
<td>-5.2754</td>
</tr>
<tr>
<td>Net Productive Assets</td>
<td>127.3484</td>
</tr>
<tr>
<td>Total</td>
<td>126.7159</td>
</tr>
<tr>
<td></td>
<td>Long-Term Debt $36.0952</td>
</tr>
<tr>
<td></td>
<td>Equity 90.6297</td>
</tr>
<tr>
<td></td>
<td>Total 126.7159</td>
</tr>
</tbody>
</table>
the Flow of Funds Report and the two flow quantities DIVPAY and INTPAY are found in a similar manner. The respective aggregate annual dividend and long-term interest payments (divided by 10,000) are $3.3884 million and $3.1689 million. Since dividends and (long-term) interest payments are paid quarterly and biannually the payment period cash flows are $.8461 \left(\frac{3.3884}{4}\right) and $1.58445 \left(\frac{3.1689}{2}\right)$ million respectively.

B. Characterization of Cash Flows from Productive Operations and Interest Rates

The sixth and final defining parameter of the firm is the distribution of cash flows from productive operations. Although taken to be exogenous, it is necessary to specify its day-to-day pattern of movement; a two-parameter Gaussian distribution is assumed.\(^2\) Its distribution was estimated from a 180 day time series of net cash flows of the Union Tank Car Corporation (1966-1967). If the underlying risk of the economy has not drastically altered in the last twenty years the specification should be representative.\(^3\) The estimated mean and variance were calculated, corrected for inflation, and scaled to obtain the mean and variance of

\(^2\) Therefore, the mean and variance are sufficient for identification.

\(^3\) A more recent series was not obtainable. A sensitivity analysis is discussed in chapter five.
the idealized firm. The expected net daily cash flow from productive operations is $30,115 and its daily variance is $5.23 \times 10^{12}.^4$

Now consider the characterization of interest rates (term-structure). Since it has been assumed that there are only two types of debt instruments (one-period discount bonds and consols) the term-structure is described by two interest rates: a short-term rate and a long-term rate. The present simulation assumes that these two rates are described by a two-dimensional Gaussian distribution.\(^5\) The mean ($\mu$), variance ($\sigma^2$), and correlation coefficient ($\Omega$) of short-term and long-term interest rates are

\[
\begin{align*}
\mu_S &= .07 \\
\mu_L &= .08, \\
\sigma^2_S &= .0012 \\
\sigma^2_L &= .0006, \quad \text{and} \\
\Omega &= .95. \quad (4.1)
\end{align*}
\]

This gives a "normally behaved" term-structure.\(^6\)

---

4 The model presented in chapter three suggests that the mean day-to-day net cash flow (not cash flow from productive operation) should be zero since this allows the firm to avoid expensive transactions in the long-term accounts. Orr (1971) has found this to be true for net cash flow of a large unnamed corporation.

5 This "mean revision characterization" is in keeping with recent empirical work by Fama and Bliss (1987).

6 The phrase "normally behaved term-structure" is prevalent in the literature (e.g., Cox, Ingersoll, and Ross, 1981). A normally behaved term structure has short-term rates with a lower mean than long-term rates, short-term rates with a larger variance than long-term rates, and a positive correlation between the two rates.
C. Estimates of Cost Parameters

The cost of various expenses must also be estimated. These are assumed common to all firms unless otherwise stated. It is necessary to estimate the following ten expenses:

(a) cash-to-short transaction,
(b) short-to-cash transaction,
(c) debt issue,
(d) equity issue,
(e) dividend reduction,
(f) dividend increase,
(g) debt repurchase,
(h) equity repurchase,
(i) bankruptcy,
(j) rollover of short-term debt, and
(k) taxes.

Estimates of each are presented in turn. Much of the preliminary analysis was given in chapter three.

The cost of transactions involving cash and shorts is assumed to be fixed and non-directional. That is, the costs of cash-short transfers do not depend on size and the costs of a cash-to-short transfer and a short-to-cash are equal. The two assumptions permit clearer exposition.

The nature of payment transfers has greatly changed in the past twenty years due to the development of the
Electronic Fund Transfer (EFT). This device permits the use of wire rather than paper to request banks to give some of the depositor's funds to someone else, or to deposit them to his credit in his bank account. Not only is it faster, but it is cheaper. However, although these costs have decreased there are still fees associated with cash-short transfers. For example, brokerage costs are incurred if the firm purchases Treasury bills. A one million dollar purchase with a $500 brokerage fee represents a .05 percent commission - a plausible estimate.

The estimated costs of debt and equity issue were obtained from Smith (1977) and previously discussed in detail. Both are assumed linear and were estimated by ordinary least squares using aggregated data. Although the estimates are inefficient, the data was readily obtained and precise estimates were expected. The intercept and slope parameter are shown in equation 4.2:

\[
\begin{align*}
\text{Issue Cost} \text{ of Long-} & = 150,000 + .008(\text{Issue Size}), \text{ and} \\
\text{Term Debt} & \\
\text{Issue Cost} \text{ of } & = 480,000 + .025(\text{Issue Size}), \\
\text{Equity} & \\
\end{align*}
\]

where all quantities are measured in dollars. The cost of debt issue is less than equity issue for all issue sizes.

The cost of dividend reductions and dividend
increases are difficult to estimate. It is well established that stock prices rise when dividend increases are announced and stock prices fall when dividend decreases are announced, Myers (1984). The reason(s) for these price changes are less well established, several current beliefs were listed in chapter three.

Estimates of the price changes were obtained from Charest (1978). He found one time excess returns of six percent above the normal yearly return for dividend increases and excess returns of negative thirteen percent for dividend decreases. Multiplication of the average annual dividend by the excess returns gave a transaction cost of negative $203,634 (3.3844x.06) for dividend increases. Similar calculations for dividend decreases gave transaction costs of (positive) $ 439,972 (3.3844x.13). 7

It is unfortunate that Charest's and other empirical studies do not examine how this cost varies with the size of the dividend change. It is suspected that the price change would show a positive association with the size of the dividend change.

Accurate estimates of the transaction costs of debt

7 As previously indicated, the "informational" effects of other transactions are assumed zero. See Asquith and Mullins (1986) for more information on this topic.
and equity repurchases are also difficult to obtain.\(^8\)

This is further complicated by fact that these expenses are dependent on the firm's recent financial history. For example, if a firm has recently repurchased some of its equity, the Internal Revenue Service (IRS) may provide strong opposition to any further share repurchase, even if a firm with an identical financial structure is offered no opposition. Such an obstacle can significantly increase the cost of share repurchase. The same can be said of restrictive covenants on bonds.\(^9\)

If the IRS or bond covenants do not prevent security repurchase the costs of these two transactions are relatively small; brokerage fees of less than two percent are expected. The general form is again assumed linear

\[
\text{Cost of Security Repurchase} = a + b(R), \quad (4.3)
\]

where \(a\) is dependent on recent financial history and \(R\) is repurchase size in dollars. The intercept is initially set at zero and the proportional cost is set at one percent for debt repurchases and two percent for equity repurchases. These are educated guesses since this author is aware of no empirical study from which to

---

\(^8\) This author was unable to find a single empirical estimate of their costs.

\(^9\) The distinction between debt repurchases and debt recall was highlighted in chapter three.
obtain more accurate estimates.

The cost of maintaining credit accessibility (turnover cost) is assumed to be two percent. An accurate estimate is difficult to obtain because of the unique contract relations which firms have with their various potential lenders and creditors: banks, holders of commercial paper, and institutional investors. It is suspected that the opportunity cost of management's time and brokerage costs figure strongly in this expense.

The cost of bankruptcy is a matter of dispute (see chapter three). Although no estimate can claim consensus, a magnitude of five percent of assets prior to the financial difficulty is between the ranges prescribed by Warner (1977) (one to five percent) and Altman (1984) (eleven to seventeen percent), the two most significant empirical studies of bankruptcy costs. Since the assets of the idealized firm have a value of $175 million this gives an estimated bankruptcy cost of $8.75 million (.05x1.75x10^{12}). Although on the low side of the estimated bankruptcy costs found in the literature (see Altman, 1984), the order of magnitude is much larger than any other transaction.

The firm also views taxes as an expense. They can be mitigated by the proper use of (short-term and long-term) debt since interest payments are tax deductible at the corporate level. The firm determines and allows for
taxes on a daily (single period) basis. This could be interpreted in two ways. The first is that the firm pays taxes daily. The second is that the firm sets up a special account where it accumulates funds in the form of short-term assets for expected taxes which are periodically paid (every ninety days).\textsuperscript{10} The marginal (and average) tax rate is assumed constant at 24 percent of net income.\textsuperscript{11} The tax on period t's income is

\[ .24(CFPO_t + X_{tL} - D_{tL}), \] (4.5)

where CFPO is the net cash flow from productive operations. If (4.5) is negative the firm receives a rebate under the first interpretation and lowers the tax account under the second.

This completes the presentation of the initial estimates of the costs of financial management. Some are highly suspect and are reconsidered in chapter five when a sensitivity analysis is performed.

There are three additional parameters required to run the simulation. They are:

(a) the size of dividend increases,

(b) the size of dividend decreases, and

\textsuperscript{10} The second interpretation is preferred by this author.

\textsuperscript{11} The effect of the depreciation tax shields and investment tax credits are assumed constant since the investment policy is fixed and are incorporated into the cash flow from productive operations stream. The 24 percent figure is obtained from aggregate income and aggregate tax data.
(c) the upper limit on allowable debt.
The first two are both set at twenty percent of current dividends.\(^\text{12}\) The upper limit on debt sets a cap on the amount of total (long-term plus short-term) debt. If total debt is below the exogenously set limit and the firm has a solvency deficiency it issues long-term debt; if total debt is above the limit the firm decreases dividends. If the latter occurs and the firm has no current dividends the firm is declared bankrupt. For the present simulation the limit is set equal to fifty-seven percent of the book value of assets. That is, the bankruptcy limit is equal to $100,000,000 (= $1,755,534 \times .57)$. Again, these three estimates are little more than educated guesses due to the lack of empirical information.\(^\text{13}\)

\(^{12}\) A more general analysis would allow these two parameters to be endogenous. This would require information on how price changes are related to the size and direction of unexpected dividend changes.

\(^{13}\) The actual program used to run the simulation was written in BASIC and presented in appendix B.
D. Cost Minimization

The cost in period $t$ of operating a firm's financial structure is

$$\text{Cost of Financial Management} = B(\text{debt issue})_t C(\text{debt issue})$$

$$+ B(\text{equity issue})_t C(\text{equity issue})$$

$$+ B(\text{dividend reduction})_t C(\text{dividend reduction})$$

$$+ B(\text{debt repurchase})_t C(\text{debt repurchase})$$

$$+ B(\text{equity repurchase})_t C(\text{equity repurchase})$$

$$+ B(\text{dividend increase})_t C(\text{dividend increase})$$

$$+ B(i_g>i_L)_t X_t (i_g-i_L)$$

$$+ B(i_L>i_g)_t D_t (i_L-i_g)$$

$$+ B(\text{bankruptcy})_t C(\text{bankruptcy})$$

$$+ \text{Taxes}$$

$$+ C(\text{short-term debt issue}) \mid X_t \mid$$

$$+ B(\text{cash-to-short transfer})_t C(\text{cash-to-short})$$

$$+ B(\text{short-to-cash transfer})_t C(\text{short-to-cash})$$

$$+ B(i_L>i_g)_t i_L X_t$$

$$+ B(i_g>i_L)_t i_g X_t, \quad (4.6)$$

where the $B()$'s are binary functions with a value of one if the event occurs and a value of zero otherwise, and the $C()$'s are their respective costs.

This unwieldy equation incorporates all of the cost elements usually associated with financial management. For example, if transaction costs are zero, the costs of cash management are zero, and short-term and long-term
interest rates are constant, and equal the cost function becomes

\[
\text{Cost of Financial Management} = B(\text{bankruptcy})_t C(\text{bankruptcy}) + \text{Tax Costs.}\quad (4.7)
\]

This bankruptcy-tax cost tradeoff model was discussed in chapter two.

Similarly, if the firm just considers cash management and if interest rates are assumed equal, the cost function becomes

\[
\text{Cost of Financial Management} = B(\text{cash-to-short transfer})_t C_t(\text{cash-to-short}) + B(\text{short-to-cash transfer})_t C_t(\text{short-to-cash}) + X_t i. \quad (4.8)
\]

This cost function is minimized by balancing interest expense and expected transactions costs at the margin. It was also discussed in chapter two.

Finally, if the firm considers only the maturity structure problem the cost function becomes

\[
\text{Cost of Financial Management} = B(i_s>i_L)_t X_t(i_s-i_L) + B(i_L>i_s)_t D_t(i_L-i_s) + C(\text{short-term debt issue})|X_t| + B(\text{debt issue})_t C(\text{debt issue})_t; \quad (4.9)
\]

the sum of the cost of borrowing short-term when short-term rates are larger than long-term rates, the cost of borrowing long-term when the short-term rates are larger than the short-term rates, and issue expense of short-
term and long-term debt respectively. Thus, cost function (4.6) is a very general expression of the costs of financial structure management. It integrates the separate components of financial management into a single objective function. The strengths and weaknesses of this unified approach is discussed later.

Once the cost function has been specified the next question is which cost to minimize: the steady state cost or the net present value. Because of the large magnitude of some of the expenses and the infrequency of their occurrence it is necessary to minimize the more cumbersome net present value rather than the steady state cost.

This is justified as follows. Within many frameworks, including the present, the firm (eventually) goes bankrupt with probability one. However, if firm "A" has a conditional expected time before bankruptcy of two years and firm "B" has a conditional expected time before bankruptcy of twenty years these firms will clearly not be priced identically, even if the steady state probability of bankruptcy is the same for both firms. The difference of the two ranking schemes can be established quantitatively by the substitution of large fixed transaction costs into the net present value models of Frenkel and Jovanovic (1980), Trippi and Lewin
There are six control parameters which the firm uses to define its financial management policy:

(a) cash upper limit (h),
(b) cash return point (z),
(c) short-term position upper limit (H0),
(d) short-term position return point (ZSTP),
(e) short-term position lower limit (H₀), and
(f) total (short-term and long-term) debt upper limit (DBUPLMT).

The first two are an upper boundary and return point for cash balances. The cash lower boundary is set at max[0,−.2*(STP)]. The next three control parameters (H₀, ZSTP, H₀) control the level of the short-term position: its upper boundary, common return point, and lower boundary respectively. The final control parameter is the lower boundary on total (short-term and long-term) debt: DBUPLMT. If long-term debt is above DBUPLMT the firm repurchases its long-term debt in the case of a solvency surplus; if long-term debt is below DBUPLMT the firm increases dividends.

---

14 The more correct method is to minimize the net present value. However, for some areas the results are nearly identical. This justifies the use of the more tractable steady state cost for certain secular models of financial management.

15 The twenty percent figure represents a minimum compensating balance, Appel (1986).
For every control parameter combination the following quantities are calculated for a simulation with a time span of ten years (T=3650):

(a) number of no financial transaction days,
(b) number and discounted cost of STP decreases,
(c) number and discounted cost of STP increases,
(d) number and discounted cost of debt issues,
(e) number and discounted cost of debt repurchases,
(f) number and discounted cost of dividend increases,
(g) number and discounted cost of dividend decreases,
(h) number and discounted cost of bankruptcies,
(i) discounted cost of borrowing short-term when $i_S > i_L$,
(j) discounted cost of borrowing long-term when $i_L > i_S$,
(k) discounted cost of rolling over the short-term accounts, and
(l) discounted cost of taxes.

A grid search is used to determine the optimal combination of control parameters. The two cash control parameters, ZCASH and HCASH, are set at seven and three levels respectively. The four long-term control parameters ($H^0$, ZSTP, $H_o$, and DBUPLMT) are set at two levels each. This gives 336 (7x3x2^4) separate permutations. The examined levels of each are shown in table 4.3. A search with a larger range and higher resolution was desired but computer fund limitations
Table 4.3: Various Levels of Control Variables

<table>
<thead>
<tr>
<th>ZCASH</th>
<th>HCASH</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) $500,000</td>
<td>2*ZCASH</td>
</tr>
<tr>
<td>(2) 1,000,000</td>
<td>3*ZCASH</td>
</tr>
<tr>
<td>(3) 2,000,000</td>
<td>4*ZCASH</td>
</tr>
<tr>
<td>(4) 3,000,000</td>
<td></td>
</tr>
<tr>
<td>(5) 6,000,000</td>
<td></td>
</tr>
<tr>
<td>(6) 12,000,000</td>
<td></td>
</tr>
<tr>
<td>(7) 24,000,000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HSTPUP</th>
<th>ZSTP</th>
<th>HSTPDO</th>
<th>DBUPLMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) $7,500,000</td>
<td>$-2,500,000</td>
<td>$-32,500,000</td>
<td>$47,500,000</td>
</tr>
<tr>
<td>(2) 17,500,000</td>
<td>$-12,500,000</td>
<td>$-22,500,000</td>
<td>57,500,000</td>
</tr>
</tbody>
</table>
required frugality.\textsuperscript{16}

An example of the results obtained from a single simulation are shown in table 4.4 for a representative selection of control parameters.\textsuperscript{17} The first section of the output lists the control parameter combination, the second section partitions daily cash flows, the third section partitions average daily costs, the forth section lists the number of various transactions, and the fifth section displays the total discounted costs of the separate expenses. These results not only allow one to obtain the cost minimizing combination, but also gives a very clear picture of the mechanics and costs of financial management - a great assistance to the financial manager. A discussion of the output follows a determination of the cost minimizing permutation.

The five permutations which minimize and maximize total cost are listed in tables 4.5 and 4.6 respectively. The cost minimizing permutation is:

\textsuperscript{16} Selected permutations were run over a wider range. These suggested that the optimal tuning parameters are in this range.

\textsuperscript{17} The entire set of results are obtainable from the author.
Table 4.4: A Representative Output

Section A (Control parameter combination)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H_{CASH}</td>
<td>$6,000,000</td>
</tr>
<tr>
<td>Z_{CASH}</td>
<td>$3,000,000</td>
</tr>
<tr>
<td>H_{O}</td>
<td>$7,500,000</td>
</tr>
<tr>
<td>Z_{STP}</td>
<td>$-12,500,000</td>
</tr>
<tr>
<td>H_{O}</td>
<td>$-32,500,000</td>
</tr>
<tr>
<td>D_{BUPLMT}</td>
<td>$47,500,000</td>
</tr>
</tbody>
</table>

Section B (Partition of average daily cash flows)

| Cash flow from productive operations | $30,115 |
| Roll over expense                   | -627    |
| Transaction expense of cash-short transfers | -148 |
| Taxes                               | -3,516  |
| Interest on short-term position     | -1,928  |
| Interest on long-term debt          | -14,439 |
| Dividends                           | -9,272  |
| Issue expense                       | -170    |
| Repurchase expense                  | 0       |

Section C (Partition of average daily costs)

| Opportunity cost of cash balances  | $724    |
| Cost of maturity management        | 1,619   |
| Cost of cash-short transactions    | 148     |
| Cost of short-term debt rollover   | 627     |
| Taxes                              | 3,516   |
| Issue cost of debt                 | 170     |
| Bankruptcy                         | 0       |
| Dividend decreases                 | 0       |
| Dividend increases                 | 0       |

Section D (Listing of transactions)

<table>
<thead>
<tr>
<th>Transaction Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of debt issues</td>
<td>2</td>
</tr>
<tr>
<td>Number of bankruptcies</td>
<td>0</td>
</tr>
<tr>
<td>Number of dividend decreases</td>
<td>0</td>
</tr>
<tr>
<td>Number of no transaction days</td>
<td>2,563</td>
</tr>
<tr>
<td>Number of short-to-cash transfers</td>
<td>1,004</td>
</tr>
<tr>
<td>Number of cash-to-short transfers</td>
<td>81</td>
</tr>
<tr>
<td>Number of dividend increases</td>
<td>0</td>
</tr>
<tr>
<td>Number of debt repurchases</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4.4: A Representative Output (Continued)

<table>
<thead>
<tr>
<th>Section E (Partition of total expenses)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost of cash-to-short transfers</td>
<td>$343,730</td>
</tr>
<tr>
<td>Total cost of short-to-cash transfers</td>
<td>28,081</td>
</tr>
<tr>
<td>Opportunity cost of cash holdings</td>
<td>1,844,957</td>
</tr>
<tr>
<td>Total cost of cash management</td>
<td>2,216,779</td>
</tr>
<tr>
<td>Cost of rollover</td>
<td>1,798,040</td>
</tr>
<tr>
<td>Cost of maturity structure management</td>
<td>4,310,032</td>
</tr>
<tr>
<td>Cost of debt issue</td>
<td>484,361</td>
</tr>
<tr>
<td>Cost of bankruptcies</td>
<td>0</td>
</tr>
<tr>
<td>Cost of dividend decreases</td>
<td>0</td>
</tr>
<tr>
<td>Cost of dividend increases</td>
<td>0</td>
</tr>
<tr>
<td>Cost of debt repurchase</td>
<td>0</td>
</tr>
<tr>
<td>Cost of taxes</td>
<td>9,443,660</td>
</tr>
<tr>
<td>Total cost of financial management</td>
<td>18,036,253</td>
</tr>
</tbody>
</table>
Table 4.5: The Five Combinations which Minimize Total Cost

<table>
<thead>
<tr>
<th>Rank</th>
<th>Combination A B C D E F</th>
<th>Cost $10^7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 2 2 1 1 1</td>
<td>1.748047</td>
</tr>
<tr>
<td>2</td>
<td>2 1 2 1 1 1</td>
<td>1.749226</td>
</tr>
<tr>
<td>3</td>
<td>1 3 2 1 1 1</td>
<td>1.749163</td>
</tr>
<tr>
<td>4</td>
<td>1 3 2 1 1 2</td>
<td>1.749163</td>
</tr>
<tr>
<td>5</td>
<td>1 2 2 1 1 1</td>
<td>1.758408</td>
</tr>
</tbody>
</table>

The combination number refers to table (4.3)

- A is HCASH
- B is ZCASH
- C is H
- D is ZSTP
- E is H
- F is DBUPLMT
Table 4.6: The Five Combinations which Maximize Costs

<table>
<thead>
<tr>
<th>Rank</th>
<th>Combination</th>
<th>Cost (10^7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7 3 1 2 1 2</td>
<td>3.119254</td>
</tr>
<tr>
<td>2</td>
<td>7 3 1 2 1 1</td>
<td>3.119254</td>
</tr>
<tr>
<td>3</td>
<td>7 3 1 1 1 1</td>
<td>3.019489</td>
</tr>
<tr>
<td>4</td>
<td>7 3 1 1 1 2</td>
<td>3.019489</td>
</tr>
<tr>
<td>5</td>
<td>7 2 1 1 1 1</td>
<td>3.012236</td>
</tr>
</tbody>
</table>

The combination number refers to table (4.3).

A is HCASH
B is ZCASH
C is Ho
D is ZSTP
E is Ho
F is DBUPLMT
ZCASH = $1,000,000
HCASH = $3,000,000  (=3xZCASH)
H₀ = $17,500,000
ZSTP = -$12,500,000
H₀ = -$32,500,000
DBUPLMT = $47,500,000.  (4.10)
The cost maximizing permutation is:
ZCASH = $24,000,000
HCASH = $96,000,000  (=4xHCASH)
H₀ = $7,500,000
ZSTP = -$12,500,000
H₀ = -$32,500,000
DBUPLMT = $57,500,000.  (4.11)

Note the disparity in the cash control parameters.
Their complete outputs are jointly shown in table 4.7.
The cost minimizing combination avoids the large cash holding and large number of long-term transactions so prevalent in the more expensive costly-outcomes found in table 4.6.

Table (4.7) clearly demonstrates the difference between the two polar cases. The primary difference is that the policy without an effective cash control strategy (the cost maximizing selection) is very expensive in terms of lost interest on cash balances. This increased expense is (slightly) mitigated by the
Table 4.7: Cost Minimizing and Maximizing Output

<table>
<thead>
<tr>
<th>Section A (Control combination)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCASH = 3*ZCASH</td>
<td>4*ZCASH</td>
<td></td>
</tr>
<tr>
<td>ZCASH = 1,000,000</td>
<td>24,000,000</td>
<td></td>
</tr>
<tr>
<td>H^O = 17,500,000</td>
<td>7,500,000</td>
<td></td>
</tr>
<tr>
<td>ZSTP = -12,500,000</td>
<td>-12,500,000</td>
<td></td>
</tr>
<tr>
<td>H = -32,500,000</td>
<td>-32,500,000</td>
<td></td>
</tr>
<tr>
<td>DBUPLMT = 47,500,000</td>
<td>57,500,000</td>
<td></td>
</tr>
</tbody>
</table>

Section B (Partition of average daily cash flows)

| Cash flow from productive operations | $30,115 | $30,115 |
| Roll over expense                  | - 537   | - 1,579 |
| Cost of cash-short transfer        | - 294   | <1      |
| Taxes                             | - 3,730 | - 2,287 |
| Interest on short-term position    | - 1,469 | - 5,361 |
| Interest on long-term debt         | - 13,994| -17,518 |
| Dividends                         | - 9,272 | - 8,518 |
| Issue expense                      | - 256   | - 84    |
| Repurchase expense                 | - 82    | 0       |

Section C (Partition of average daily costs)

| Opportunity cost of cash          | $ 263   | $ 6,158 |
| Cost of maturity management       | 773      | 2,217    |
| Cost of cash-short transactions   | 294      | <1       |
| Cost of short-term debt rollover   | 537      | 1,579    |
| Taxes                             | 3,707    | 2,287    |
| Issue cost                        | 164      | 84       |
| Bankruptcy                        | 0        | 0        |
| Dividend decreases                | 0        | 120      |
| Dividend increases                | 0        | 0        |
| Repurchase cost                   | 82       | 0        |

Section D (Listing of transactions)

<p>| Number of debt issues             | 3        | 1        |
| Number of bankruptcies            | 0        | 0        |
| Number of dividend decrease       | 0        | 1        |
| Number of no transaction days     | 1,497    | 3,645    |
| Number of short-to-cash transfer  | 2,026    | 3        |
| Number of cash-to-short transfer  | 125      | 2        |
| Number of dividend increase       | 0        | 0        |
| Number of debt repurchases        | 1        | 0        |</p>
<table>
<thead>
<tr>
<th>Section E (Partition of total expenses)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost of cash-to-short transfers</td>
<td>$735,650</td>
<td>$1,920</td>
</tr>
<tr>
<td>Total cost of short-to-cash transfers</td>
<td>43,559</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Opportunity cost of cash holdings</td>
<td>671,826</td>
<td>14,870,130</td>
</tr>
<tr>
<td>Total cost of cash management</td>
<td>1,451,035</td>
<td>14,872,052</td>
</tr>
<tr>
<td>Rollover cost</td>
<td>1,297,39</td>
<td>3,924,214</td>
</tr>
<tr>
<td>Taxes</td>
<td>9,757,552</td>
<td>6,415,301</td>
</tr>
<tr>
<td>Cost of maturity structure management</td>
<td>4,268,221</td>
<td>5,329,005</td>
</tr>
<tr>
<td>Cost of debt issue</td>
<td>579,003</td>
<td>393,172</td>
</tr>
<tr>
<td>Cost of bankruptcies</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cost of dividend decreases</td>
<td>0</td>
<td>259,090</td>
</tr>
<tr>
<td>Cost of dividend increases</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cost of debt repurchase</td>
<td>127,223</td>
<td>0</td>
</tr>
<tr>
<td>Total cost of financial management</td>
<td>17,480,471</td>
<td>31,192,544</td>
</tr>
</tbody>
</table>
lower taxes due to the lost interest income. The rankings of the various expenses for the cost minimizing strategy are:

(i) tax expense (2),
(ii) maturity structure interest expense (3),
(iii) rollover expense (4),
(iv) cash-short transfer expense (6),
(v) lost interest of cash holding expense (1),
(vi) security issue expense (5),
(vii) security repurchase expense (8),
(viii) dividend alteration expense (7), and
(ix) the cost of bankruptcies (9).

The number in parenthesis is the rank for the maximum cost alternative. The differences are due mainly to the cash control expenses.

For the cost minimizing selection the largest expense, by far, was taxes. This supports its predominant place in the theory of finance. Next largest was the interest expense of maturity structure management - an area given surprisingly scant treatment in the literature. Its effect would have been even more substantial if the slope of the term-structure was larger than the one percent assumed here. The cost of issuing short-term debt (rollover cost) is another large

18 The firm did not go bankrupt for either polar case and, therefore had bankruptcy costs of zero.
expense often ignored. At the other end of the list is the surprisingly small expenses of security issue and repurchase. They represented less than 3.5 percent of total costs.

It should be noted that the most expensive strategy does not have a bankruptcy while less expensive permutations (not shown) do have this expensive event. The reason for this surprising occurrence is that if the firm maintains large cash balances it rarely reaches an upper bound on the STP account and, therefore, never lowers the mean of the net retention stream (or short-term asset account) through dividend increases or security repurchase. This again emphasizes the great potential expense of ignoring cash management when addressing capital structure problems.

Another interesting result of this procedure is that it allows one to compare the selection of the cost minimizing cash parameters under two criteria: total cost of financial management (cost function 4.6) and cost of cash management (cost function 4.7). The former was just performed, the latter was performed in an analogous manner. The results are quite disparate. The two rankings were tested for homogeneity by the nonparametric Spearman's correlation test. A statistically significant difference was found.19

19 A p-value of .032 was found.
An analogous disparity is found in the costs of long-term financial management. An examination using an analysis of covariance design was performed using total cost as the dependent variable, the cash control parameters as the covariates and the sixteen \((2^4)\) permutations of the long-term parameters as the treatment effects. The results are shown in table 4.8. They indicate that the cost of total financial management are strongly dependent on the cash control parameters.

The nonparametric test and the analysis of covariance results conclusively demonstrate that the two components of financial management, short-term and long-term, should not be secularly optimized and pasted together. The interaction and feedback between the two components runs deeply in both directions making such a luxury prohibitively expensive.

Since the cost of running the simulations imposed a binding constraint on this exposition it was felt important to examine the speed with which the various policies approached their final ranking. This was done for a select group of policies. In particular, the cost of the two least expensive and two most expensive parameter combination were recorded after one, two, three, ..., nine, and ten years.

These are shown in tables 4.9 and 4.10 for the two
Table 4.8: Analysis of Covariance Results

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>412.679</td>
<td>.000</td>
</tr>
<tr>
<td>ZCASH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCASH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-Term</td>
<td>15</td>
<td>16.667</td>
<td>.002</td>
</tr>
<tr>
<td>Error (Within)</td>
<td>318</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>335</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>First least expensive alternative</td>
<td>Second least expensive alternative</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>----------------------------------</td>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost ($10^6$)</td>
<td>Percent</td>
<td>Cost ($10^6$)</td>
</tr>
<tr>
<td>1</td>
<td>2.469135</td>
<td>14.1</td>
<td>2.473289</td>
</tr>
<tr>
<td>2</td>
<td>4.680681</td>
<td>26.8</td>
<td>4.711935</td>
</tr>
<tr>
<td>3</td>
<td>7.106009</td>
<td>40.7</td>
<td>7.158157</td>
</tr>
<tr>
<td>4</td>
<td>9.021807</td>
<td>51.6</td>
<td>9.065451</td>
</tr>
<tr>
<td>5</td>
<td>10.75281</td>
<td>61.5</td>
<td>10.78383</td>
</tr>
<tr>
<td>6</td>
<td>12.54655</td>
<td>71.8</td>
<td>12.36951</td>
</tr>
<tr>
<td>7</td>
<td>13.99455</td>
<td>80.1</td>
<td>14.15329</td>
</tr>
<tr>
<td>8</td>
<td>15.21746</td>
<td>87.1</td>
<td>15.47551</td>
</tr>
<tr>
<td>9</td>
<td>16.39888</td>
<td>93.8</td>
<td>16.64122</td>
</tr>
<tr>
<td>10</td>
<td>17.48047</td>
<td>100.0</td>
<td>17.49226</td>
</tr>
</tbody>
</table>
Table 4.10: Cost Profile for Cost Maximizing combinations

<table>
<thead>
<tr>
<th>Year</th>
<th>First least expensive alternative</th>
<th>Second least expensive alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost ($10^6)</td>
<td>Percent</td>
</tr>
<tr>
<td>1</td>
<td>4.042453</td>
<td>13.0</td>
</tr>
<tr>
<td>2</td>
<td>8.061331</td>
<td>25.4</td>
</tr>
<tr>
<td>3</td>
<td>11.10273</td>
<td>35.6</td>
</tr>
<tr>
<td>4</td>
<td>14.87516</td>
<td>47.8</td>
</tr>
<tr>
<td>5</td>
<td>17.77205</td>
<td>57.0</td>
</tr>
<tr>
<td>6</td>
<td>19.96730</td>
<td>64.0</td>
</tr>
<tr>
<td>7</td>
<td>22.44535</td>
<td>72.0</td>
</tr>
<tr>
<td>8</td>
<td>25.43724</td>
<td>81.5</td>
</tr>
<tr>
<td>9</td>
<td>28.43669</td>
<td>91.1</td>
</tr>
<tr>
<td>10</td>
<td>31.19254</td>
<td>100.0</td>
</tr>
</tbody>
</table>
least expensive and two most expensive parameter combinations respectively.\(^{20}\) Columns two and four list the total cost of financial management incurred up to the respective year. Columns three and five list these costs as a percentage of the final (ten year) cost.

Table 4.9 indicates that for the two cost minimizing parameter combinations that over fifty percent of the final cost is incurred by year four. Additionally, the cost minimizing combination is less expensive than the second best combination every year of the ten year study period. These results indicate that it might be possible to reduce the run length from the current ten years to four years for the cost minimization selection problem. For the cost maximizing combinations the results are more complex.

Since the total cost of financial management for the two most expensive combinations were identical for each year of the ten year study period and the cost of the third and forth most expensive combinations were identical for each year of the ten year study period table 4.10 actually shows the cost profile for the first (and second) most expensive combination and the third (and fourth) most expensive combination. The reason that these two pairs are identical is that the only

\(^{20}\) Recall that the discount rate is the mean of the long-term interest rates.
difference in the parameter combinations is the upper limit on debt which is not binding for either of the two combination pairs.

The speed of convergence for the cost maximizing combinations also tend to be slower than for the cost minimizing combinations. After four years both of the cost minimizing combinations had converged to more than fifty percent of their terminal values; for the two cost maximizing combinations the percent of total cost incurred after four years was 47.8 percent and 43.7 percent. The principal reason for this slow rate of convergence is that the firm takes a number of years to build up the large cash balances (and large interest opportunity cost) which figure so prominently in these cost maximizing combinations. In addition, table 4.10 shows that the cost the more expensive combination is not more expensive than the next most expensive combination for each of the ten years under study as the cost minimizing combinations were. These results indicate that the firm must be careful in shortening the simulation lengths for the more expensive parameter combinations.

E. Summary

This chapter presented a simulation study of management strategy proposed in chapter three within the
context of a fictitious firm. Application to a working firm would have been preferred, but most firms are reluctant to release the required information. Since the cost function was very general it offered the advantage of an integrated format, but only at the cost of mathematical complexity - and thus the simulation. The output is general in scope and includes many important summary statistics which the financial manager can use to understand the various alternatives. The results established that the secular optimization of short-term or long-term components can lead to erroneous results, the major thesis of this dissertation. The next chapter examines the sensitivity of the results to the parameter estimates.
Chapter Four found the control parameters which minimized the cost of financial management for a specific environment. However, it says nothing of the robustness of these results to the (sometimes suspect) cost estimates. The present chapter addresses this issue. Section A defines sensitivity analysis and section B reviews some of the standard techniques. Section C examines the reason these cannot be utilized for the current problem. The final section, D, offers an alternative, pragmatic approach and reflects on its merits.

A. Introduction

Many important problems in economic analysis are expressible as constrained optimization problems; examples include consumer choice, production, and growth theories. Most impose a set of exogenous parameters (outside environment) on the problem and select the endogenous parameters which optimize an explicit objective function. The study of the responsiveness of this optimal selection to changes in the environment is
termed sensitivity analysis.¹

B. Classical Techniques

The usual textbook procedure for sensitivity analysis is to differentiate the first order conditions used in optimization (if they exist) with respect to the changed exogenous parameters.²

Although the above method is conceptually straightforward it often burdens the user with the harassment of Hessians and bordered Hessians. Anderson and Takayama (1979) develop a method which lightens this burden. Additionally, they alleviate four deficiencies of the local approach:

(1) They do not assume that the objective function or the constraint functions are differentiable with respect to the choice variables.

(2) Their formulas are global in the sense that displacements from the original point need not be infinitesimally small - they allow for discrete jumps in the shift parameters.

¹ In the economic literature it is also called comparative statics for static systems and comparative dynamics for dynamic systems. In the theory of differential equations, the term "stability analysis" prevails.

² Even if the first order conditions exist, they may not be differentiable; see Silberberg (1978).
(3) They do not restrict the problem to a unique solution. This implies that the choice variables are not necessarily a single valued, differentiable function of the shift parameters.

(4) They do not assume that the constraint is binding at the optimum.

Brock (1969) examines the sensitivity analysis of a different kind of problem: optimization in a one-sector discrete time neoclassical growth model. If there is no population growth and no depreciation of capital stock the standard setup requires

\[ x_{t+1} + k_{t+1} - k_t = f(k_t) \]  

where \( x_t \) is the per capita consumption in period \( t \), \( k_t \) is the per capita capital stock in period \( t \), and \( f() \) is the per capita production function. Brock and Takayama (1986) considers the effect on the optimal path for two types of changes: a change in the terminal stock and a change in the time horizon.

C. Application to Simulation Solution Methods

These techniques for examining the sensitivity of

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3 See Samuelson (1967).

4 The usual restrictions are imposed on \( f() \):
   (1) \( 0 < f'(k) < \infty \),
   (2) \( f(0) = 0 \), and
   (3) \( f''(k) \leq 0 \) for all \( k < \infty \).
the endogenously determined parameters to changes in the environment do not lend themselves easily to problems solved by simulation. The first, and most common, method commences its analysis from the first order conditions. Nothing analogous exists in the simulation approach. Other technique relies on the concavity of the objective function in the exogenous parameter. This is difficult to establish for the complicated mathematical frameworks often associated with problems solved by simulation techniques.

The problem specific techniques (e.g., Brock, 1969) lacks robustness. Analogous analysis could potentially be developed for more complex problems. However, this seems to be an extremely difficult, if not impossible, task. Therefore, a pragmatic way of sensitivity analysis for problems solved by simulation techniques is proposed.

D. Sensitivity Analysis for Simulation Techniques

The usual method of sensitivity analysis for problems solved with simulation solution techniques is to change the exogenous parameters and rerun the simulation to obtain a (possibly new) optimal selection of endogenous parameters. The ease with which this is performed for simple problems is a positive attribute of simulation analysis. However, there are times when the
simulation is too expensive (complex or lengthy) for this comparative method. Such is the case for the simulation performed earlier in this thesis.

For illustrative purposes, reconsider the two-asset EOQ control system of Miller and Orr (1966). The firm selected the endogenous parameters $z$ (the return point) and $h$ (the upper boundary) which minimized total cost for a given environment (set of exogenous parameters). For clarity of presentation suppose that $h$ is fixed; this leaves a single control variable $z$ ($0 \leq z \leq h$). Additionally, suppose that the firm minimizes the net present cost instead of the steady state cost in order to strengthen the analogy with the large simulation performed in chapter four. The usual simulation solution technique determines the total cost of cash management for various values of $z$ for the assumed (imposed) environment. The results for a arbitrarily selected environment are shown in figure 5.1. The cost minimizing selection is $z^*$. The exogenous parameters describing the environment for this simplified two asset case are:

1. the mean and variance of the net cash flow stream,
2. the time horizon,
3. the cost parameters (cost of a transfer and interest [discount] rate), and
Figure 5.1
Simulation Results for Two-Asset Case
(4) the particular sequence of random numbers. The last of these requires a word of explanation. The sequence of random numbers used to determine the net cash flow stream is one of many possible alternatives; other sequences may lead to an alternative selection of $z^*$. Each of the four parameters are examined in turn.

The distribution of net cash flows was assumed to be normal and, thus, sufficiently described by its mean and variance. The effect of altering either parameter can have a substantial effect on the optimal selection. This can be seen as follows. The simulation was performed and the cost of maintaining a cash system was recorded under a constant exogenous environment except that the mean and variance of net cash flows were altered. The results are shown in figures 5.2 and 5.3 respectively. The cost minimizing selection displays substantial variation as the distribution changes. As expected, the optimal choice of return point is lowered as the mean of the net cash flow stream is increased. The affect of changing the variance is less easily deciphered.

The total cost also changes as the time horizon, $T$, is altered. However, this does not necessarily mean

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Identical runs were used for the simulation performed in chapter four.
Figure 5.2

The Effects of a Changing Mean
Figure 5.3

The Effects of a Changing Variance
that the optimal selection, \( z^* \), changes. Simulations were run in the same environment for time horizons of 100, 200, 300, 500, 2000, and 5000 periods. The results are shown in figure (5.4). They indicate that after some fairly short period of time, around three hundred time periods, the optimal selection shows little change. This is true even though the total cost still demonstrates substantial change.

The effect on the selection of \( z^* \) of changing the cost parameters can be done in a similar manner. For a given distribution and time horizon the two cost parameters (transfer cost and interest rate) give a series of cost curves (cost versus \( z \) relationships). These are shown in figure 5.5.

The last exogenous parameter is the "roll of the dice". When altered, the total cost of financial management is changed. Figure 5.6 shows an abridged version of the possible paths that a particular run of the simulation can take through the chance nodes. Let the particular run which actually occurred be represented by the permutation \((U,U,U)\). If the effect of a small change in the "roll of the dice" is minimal then slightly altered runs should give similar cost. Suppose that instead of sequence \((U,U,U)\) the randomly chosen permutation was \((U,U,D)\). That is, the runs are identical until the third (and final) chance node. If
Figure 5.4

The Effects of a Changing Time Horizon
Figure 5.5
The Effects of Changing the Cost Parameters
Figure 5.6

A Simplified Representation Highlighting Chance
the effect of chance is small, the cost difference between runs \((U,U,U)\) and \((U,U,D)\) should be negligible. Similar logic indicates that the cost difference between permutations \((U,U,U)\) and \((D,U,U)\) should also be negligible. This would indicate (through transitivity) that the costs of permutations \((U,U,D)\) and \((D,U,U)\) are approximately the same. Such logic could be extended to show that if the effect of chance is small enough, then all the paths should have approximately the same cost. If this were the case, a single run would be representative of the average run and multiple runs would be unnecessary.

To test if this is true for the two-asset EOQ model example of this section multiple runs were performed for a number of exogenous-endogenous combinations. Little or no differences were found. A particular example of the homogeneity is shown in table 5.1. The closeness of these costs indicates that a single run is representative \((T=1000)\).

The extensions of these results to the simulation problem performed earlier would be time consuming and expensive. However, the process is straightforward. Instead of a single endogenous variable, as in this simplified example, there are six \((z, h, H^0, ZSTP, H_0,\) and \(DBUPLMT)\) and instead of four exogenous parameters there are thirteen:
Table 5.1: Effect of Different Permutations

<table>
<thead>
<tr>
<th>Run</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$14,739</td>
</tr>
<tr>
<td>1</td>
<td>14,695</td>
</tr>
<tr>
<td>2</td>
<td>14,456</td>
</tr>
<tr>
<td>3</td>
<td>14,902</td>
</tr>
<tr>
<td>4</td>
<td>14,678</td>
</tr>
<tr>
<td>5</td>
<td>14,834</td>
</tr>
<tr>
<td>6</td>
<td>14,971</td>
</tr>
<tr>
<td>7</td>
<td>14,334</td>
</tr>
<tr>
<td>8</td>
<td>14,274</td>
</tr>
<tr>
<td>9</td>
<td>14,845</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
(1) cost of debt issue,  
(2) cost of dividend reduction,  
(3) benefit of dividend increase,  
(4) cost of debt repurchase,  
(5) tax rate,  
(6) distribution of cash flow,  
(7) distribution of interest rates,  
(8) chance,  
(9) bankruptcy limit on debt,  
(10) time horizon,  
(11) size of dividend increase,  
(12) size of dividend decrease, and  
(13) cost of bankruptcy.

In summary, a simulation program is nothing but a very simple algorithm which comes up with a numerical solution. The numerical solution, as a rule, differs from the exact theoretical solution and can be improved. One can always investigate the responsiveness of the numerical solution to a higher refinement of the simulation algorithm, say to a smaller width between the scrutinized values of \( z \).

The pragmatic approach taken here to rerun the simulation with different exogenous parameters and/or a modified program certainly generates valuable data to evaluate the numerical outcomes of the simulation procedure. But, without a good theoretical backup, discontinuities and, as a consequence, a substantial suboptimality of the simulation solution may remain undiscovered by this pragmatic approach.
Chapter Six

Conclusion

A. Summary

First consider the results not obtained. No major new theoretical discovery was made; all the concepts discussed are easily found elsewhere. No conclusion is drawn as to whether firms should issue more or less debt - only that a fictitious firm should issue long-term debt or change its dividend policy if some continually changing boundary is crossed. Nothing is said of the investment decision; it is taken to be exogenous. The question of whether dividends should be distributed in lieu of capital gains remains unanswered.¹ What is presented, however, is a method of developing a financial planning model with some positive social utility based on a reinterpretation of financial structure and the costs associated with its management.

The firm's financial structure is transformed from its usual (accounting) format to one which is clean and flexible, yet which retains the important distinctions.²

¹ However, the distinction between dividends and capital gains is made clearer.

² The financial economist has for too long subordinated himself to work within the balance sheet confines prescribed by the accountant. This has hampered any progress towards an integrated model of financial management.
The cost function explicitly presented in chapter four incorporates all the expenses which are commonly minimized separately to determine cash, short-term, and long-term financial structure. These two changes offer a number of advantages over current models.

B. Improvements on Existing Frameworks

Most financial policy models attempting to explain total financial structure suffer from one of two deficiencies: they are either ivory tower exercises with little thought to implementation or mechanical number crunchers which are optimized without a sense of understanding. Examples of models suffering from the first defect usually assume an environment of frictionless markets, some theoretical studies of minor departures from market perfection notwithstanding. This dissertation empirically examines the impact of certain market imperfections (e.g., transaction costs and the possibility of bankruptcy) on the cost of financial management. It is hoped that this will make the insight of the financial economist more accessible to the financial manager.

Models suffering from the second deficiency are exemplified by the programming models briefly discussed in chapter two. These were popular in the 1960s and
early 70s and have recently lapsed into disuse.\textsuperscript{3} The present model is a compromise; the present formulation is easily explained, but must employ the computer to obtain a solution.

This allows a number of advantages over the programming approach. First, it allows the financial manager the use of a tool which can be understood; a massive programming framework awakes the skeptical financial manager.

Not only is the framework easily understood, but the simulation results presented in chapter four are in a clear and highly informative format. The daily cash flows and costs are each partitioned into their respective components which allows the user an appreciation of the results. Instead of just determining that policy A is less expensive than policy B, the reasons for the difference are clearly presented.

That these informative results are obtained at such low labor cost is another advantage. The cost of initiating the system is quite small, the cost of upkeep is even smaller. Most of the parameters required to run the simulation are reusable and are required to be updated only on a periodic basis. Additionally, much of the data necessary for the simulation is already being

\textsuperscript{3} There has been little work in reestablishing this quest along another route since that time.
collected. 4

Another way in which the present framework is superior to the programming paradigm is that it does not require the ad hoc selection of constraints. For example, certain programming models ask the financial manager to input into the software program a minimum coverage ratio. 5 The shadow price of the constraint is infinite and the model offers no help in its selection. 6 This is like putting the buggy before the horse. The proposed framework does not have these zero-one constraints. Instead, there are gradually changing probabilities of expensive events - a more appealing presentation. Additionally, the present framework can quickly be altered to satisfy any peculiarities which management deems important. That the actual simulation was written in BASIC only strengthens this result. 7

The present framework is very general in scope and can act as underpinning for a more complete integration. Such an integration is clearly required as established

4 That data which is not being currently collected should also be useful for less extensive studies.

5 A coverage ratio is (expected) net income over (expected) interest payments.

6 Some of the more advanced programming models allow for a sensitivity analysis. However, this only multiplies the problem of interpretation mentioned earlier.

7 This simple computer language is expensive in another way; the cost of running a simulation.
by the simulation performed in chapter four. The secular optimization of single components is convenient and more easily accomplished; however, it can be very expensive. The cost of total financial management had a range of $1.7 \times 10^7$ (the financial strategy which minimized the total cost of financial management) to $3.1 \times 10^7$ (the financial strategy which maximized the total cost of financial management). Much of this disparity was due to cash control parameters. The dependency also works in the other direction.  

The present framework also allows the academic theorist to obtain a feeling for the practical consequences of his results. The framework within which most of their studies are performed does not easily allow for such inquiry. Researchers working on capital structure theory will be glad to find support for what they always presumed – taxes make a significant contribution to the analysis. Additionally, the (relatively) small issue costs of debt and equity issue and repurchase do support their exclusion when considering the long-term debt-equity target objective. Their assumption of equal short-term and long-term interest rates is less satisfactory; the results

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8 For example, if the firm issues long-term debt (substitutes long-term debt for short-term debt) this affects the mean daily cash flow. In more refined versions the variance would also be effected. This was discussed in chapter three.
indicate that the cost associated with the interest rate differential is not small and should be given more attention.

Another result discovered in the course of this research is the importance of differentiating between equity issue and dividend decreases for reasons other than personal taxes - the only contemporary motive for discrimination. The issuance of new equity produces an immediate inflow of funds (increase the in short-term position) and the periodic payment of dividends in lieu of short-term interest payments. The ramifications of the distinction are severe, both in the short run and the long run. Analogous statements can be made for the replacement of short-term debt with long-term debt (i.e., a debt issue), and debt and equity repurchases (replacement of long-term commitments with a depletion of short-term assets).

The dependency between financial structure and dividend policy was also made explicit. Few models examining the choice between a bird in the hand (dividends) versus two in the bush (capital gains) consider where the retained funds are invested. If all profitable physical investments have been made, the firm uses the excess funds to increase the short-term position account. This affects the corporate tax liability, probability of bankruptcy, and the timing of
future policy changes - all expensive considerations.

The reader should not get the impression that the present framework is a godsend. Serious problems which are not easily handled remain. One is the limitation of debt to two maturities. Most corporations have maturity structures which include bonds of many maturities. Another weak assumption is that of fixed dividend changes - corporations change their dividends by various amounts. 9 Personal taxes, a favorite with financial economists, have also been ignored. An analysis based on expenses net of personal tax is superior to the present formulation. The investment decision has similarly been ignored. To correct these deficiencies is expensive in terms of clarity - the principal attribute of the current framework over the earlier programming models.

An unexpected result of this study was the highlighting of theoretical and empirical topics for which the profession lacks knowledge. Examples include the repurchase cost of debt and equity, the measure of association between size of dividend changes and stock price changes, and the lack of agreement on the size of bankruptcy costs. This exposure clearly demonstrates that financial economists have left to perform a lot of

9 The framework does, however, provide a format for analyzing the consequences of different size changes.
theoretical inquiring and empirical measurement. These are discussed in next.

C. Future Areas of Inquiry

Researchers of corporate finance have accumulated a wealth of empirical and theoretical knowledge over the course of the last twenty-five years. However, the implementation of these results has been minimal due, at least in part, to the failure of the academic profession to build a bridge between the worlds of the theorist and the corporate manager. The framework presented in this dissertation has purported to lay the ground work for such a bridge. Consider some of its immediate consequences.

The recording of financial information on computer tapes has provided a data set whose potential has barely been scratched. Empirical studies which might prove fruitful are many. One concerns the effect of long-term debt issue on stock price. If there is an information effect of debt issue it should result in stock price changes. The empirical consensus is that debt issue has little or no effect on stock price.\(^\text{10}\) This may be due to the current method of measuring price change. The presented model predicts that stock prices should

\(^{10}\) The January-February 1986 issue of the *Journal of Financial Economics* contains numerous articles on this subject.
increase when a long-term debt issue is announced, if long-term rates are larger than expected short-term interest rates. The opposite should occur if the opposite situation prevails. By not differentiating the two environments, as currently done, it is possible that the net result is little or no effect on stock price - the current consensus.

Another potential empirical study concerns dividend changes. With the wealth of information available on dividend alterations it is rather surprising that our current state of knowledge still aggregates all dividend changes into a single event. It is suspected that the larger the increase or decrease the more effect the dividend change should have on stock price. However, without an empirical verification this remains speculation.

The framework also lends itself nicely to the study of predicting bankruptcy. Since the late 1960s there has been considerable interest among researchers in the development and estimation of models for classifying and predicting business failures. The two most influential works are Beaver (1967) and Altman (1968). Beaver partitioned firms into two groups (ex post): those which went bankrupt and those which did not. He then performed an univariate analysis whereby each of the various explanatory measures or ratios were separately
analyzed and an optimal discrimination point obtained. Altman performs a multivariate discriminant analysis along the same lines. Variables of importance were statistically selected in both studies.\textsuperscript{11} The current models offers an alternative framework.\textsuperscript{12}

Another empirical study which might prove elucidating is the cross-sectional and temporal exhibition of financial structure within the context of the reformulated format. Other researchers have found no intra-industry and significant inter-industry differences in capital structure.\textsuperscript{13} Similar differences are found for other financial measures. It would be interesting to make an analogous comparison of the entire financial structure instead of single measures. One way of performing this is through multivariate analysis of variance (MANOVA), the multidimensional extension of univariate analysis of variance (ANOVA) - the method often employed for the univariate studies.

Another deficient area of knowledge exposed is the cost of debt and equity repurchase. One possible reason for this neglect is the complications caused by Internal

\textsuperscript{11} The variables included (a) working capital/total assets, (b) EBIT/total assets, (c) debt/equity, and (d) total sales/assets.

\textsuperscript{12} An analogous paragraph could be written for the takeover and target firms of mergers.

\textsuperscript{13} See chapter two for a brief discussion.
Revenue Service and bond covenant constraints. This is not a justifiable excuse. A possible commencement point is an informal discussion analogous to Donaldson's (1961) study of capital structure, Shad's (1969) study of mergers, and Lintner's (1956) general discussion of dividends. It will be more difficult to build a formal model of such behavior, but the potential benefits are great - particularly in light of the highly volatile market for corporate control.

Changes in price levels and their effects on taxes also have important implications for the relationships between the financial components of the firm. Nevertheless, the subject has been ignored in this dissertation. Its omission is justified by the steady state approach taken; the macroeconomic environment was assumed to follow a stationary stochastic process. As long as the long-term inflation rate remains stable the emission does not alter the framework. A comparative static examination of the differences in optimal financial management in environments with two different long-term inflation rates may provide clues to its effect on financial structure.

An integrated explanation of corporate financial behavior in response to business cycles has always been difficult. Most studies have been little more than empirical observations. The current framework may prove
useful in explaining the cyclical change in financial structure associated with the business cycle.

A more refined version of the current framework could also lead to fruitful results. One possible extension is the generalization of the three stochastic processes (cash flows from productive operations, and short-term and long-term interest rates) into a three dimensional normal distribution instead of univariate and bivariate distribution respectively. Various studies (e.g., Mikkelson [1985]) have found that there is a positive association between interest rates and cash flows from productive operations and examined the consequences of this relationship.\textsuperscript{14} The extension to a three dimensional distribution would allow the further study of these consequences.

Another possible extension would utilize the recent work of Cox, Ingersoll, and Ross (1985a) describing the behavior of term-structure. The current formulation assumed a serially independent term-structure. Cox et al. developed a general equilibrium model of term-structure which results in a term-structure with a partial adjustment mechanism. The consequences of this adoption could be severe.

The framework can also be generalized to include an endogenously chosen net productive asset account. This

\textsuperscript{14} See Morris (1974).
could provide a conduit between the real and financial aspects of the firm just as the current framework provided such a conduit between short-term and long-term financial management. To accomplish this extension it would be necessary to address the thorny issue of the cost of capital - an area intentionally ignored in the present discussion. A problem with this extension is that it would greatly add to the complexity of the results, an undesirable consequence.
Appendix A

There are at least two additional costs which should be considered in a more general version of this model: the cost of an unhedged position and the cost of bankruptcy risk. These are not discussed within the context of main body of the text since they are not considered in the simulation presented in chapter four.

Cost of an Unhedged Position

If a firm has an unhedged position then, by definition, the duration of its assets and liabilities are unequal. Such a position leaves the firm's equity (and debt) vulnerable to price changes and even to bankruptcy due to unexpected shifts in discount rates. Consider the following example. Suppose the duration of the firm's assets is less than the duration of its liabilities and that the firm currently has a positive equity value of \( \varepsilon \) (marginally greater than zero). Any downward movement in the discount rate, ceteris paribus, increases the market value of both assets and liabilities. However, since the duration of liabilities is greater that of assets the firm then has a negative (zero) equity value.

Bondholders recognize this bankruptcy vulnerability for unhedged firms and demand a higher interest rate in compensation. The cost of this
vulnerability is the increased interest payments to newly issued short-term and long-term debt. It is calculated by

$$H_C(t) = H_C^S\left(\frac{X_t}{D_t - X_t}\right)\left(-X_t\right) + H_C^L\left(\frac{X_t}{D_t - X_t}\right)D_t^\ast,$$

where $H_C^S( )$ and $H_C^L( )$ are the increased interest expense due to an unhedged position for newly issued short-term and long-term debt respectively, and $D_t^\ast$ is the long-term debt issued at time $t$. It is suspected that the effect of this risk is minimal except in environments with highly volatile inflation (interest) rates.

This hypothesis also implies that the current interest rate must be considered when defining the bankruptcy condition for unhedged firms. One level of interest rates may allow the firm to retain a positive equity value while another would impose bankruptcy. This condition is never mentioned when considering the bankruptcy condition. Whether Penn-Central and other bankruptcies would not have occurred given a more favorable maturity structure is not known.

An empirical implication of this hypothesis is that there should be more bankruptcies when discount rates are at historically high or low levels. This author feels that the former holds, but is unsure of the latter.
Cost of Bankruptcy Risk

For a given level of interest rates the possibility of the firm being unable to meet its interest obligations due to low earnings increases with leverage. Since the long-run investment level is fixed, leverage can be measured by total debt \((D-X)\). Lenders are aware of the dependency and demand higher interest rates in compensation. The cost in period \(t\) of this increased compensation is

\[
DC_t = DC^S(D_t-X_t)(-X_t) + DC^L(D_t-X_t)D^*_t,
\]

where \(DC^S(\cdot)\) and \(DC^L(\cdot)\) are the increased interest expenses due to low capitalization for short-term and long-term debt respectively.

If the bondholders are risk neutral this increased interest expense is equal to the expected value of the bankruptcy costs discussed in the main text which is the usual definition of bankruptcy cost. It is paid only if the firm declares bankruptcy. The present definition is different. The "risk of bankruptcy" cost is paid every period, even if the firm does not declare bankruptcy.
Appendix B

An abridged version of the program used to perform the simulation:

000060 REM THIS SECTION SETS THE INITIAL PARAMETER VALUES
000070 LET TIMESSPAN = 3650
000080 LET ZCASH = 1000000
000090 LET HCASH = 4*ZCASH
000110 LET MEANCFPO = 30115
000120 LET VARCFPO = 5230000000000
000130 LET STDCFPO = SQR(VARCFPO)
000140 LET MEANSINT = .07
000150 LET VARSINT = .0012
000170 LET MEANLINT = .08
000180 LET VARLINT = .0006
000190 LET STDLINT = SQR(VARLINT)
000200 LET TRANCS = 500
000210 LET TRANSC = TRANCS
000220 LET RRAW = MEANLINT
000230 LET R = ((1+RRAW)**(1/360))-1
000240 LET BR = ((1+RRAW)**(1/2))-1
000250 LET DIVUP = 211525
000260 LET DIVCUT = 211525
000270 LET RCDV = -203694
000280 LET ICDV = 439972
000290 LET ICDBI = 150000
000300 LET ICDBS = .008
000310 LET ICEI = 480000
000320 LET IICES = .025
000330 LET DIVPAY = 846100
000340 LET INTPAY = 1584500
000350 LET DEBT = 36000000
000360 LET STP = -52750000
000370 LET CASH = 4600000
000380 LET BKCT = 8750000
000390 LET BKLMT = 100000000
000400 LET D = .02*(1/360)
000410 LET N = 1
000420 LET NINT = 42
000430 LET NDIV = 13
000480 LET RCDB = .01*(HSTP-ZSTP)
000490 LET RCE = .02*((HSTPUP-ZSTP)
000500 LET ICEB = ICDBI + ICDBS*((ZSTP-HSTP)+ZCASH)
000510 LET ICE = ICEI + IICES*((ZSTP-HSTP)+ZCASH)
000520 LET CFPO1 = INT(100*RND(N**3)+1)
000530 LET SINT1 = INT(100*RND(N**2)+1)
000540 LET LINT1 = INT(100*RND(N**2)+1)
000561 REM THIS SECTION CONVERTS A UNIFORM DISTRIBUTION TO
000580 A NORMAL DISTRIBUTION FOR CASH FLOW FROM PRODUCTIVE
OPERATIONS (CFPO2)

REM THIS SECTION CONVERTS A UNIFORM DISTRIBUTION TO A NORMAL DISTRIBUTION FOR SHORT-TERM INTEREST RATES (SINT2)

REM THIS SECTION CONVERTS A UNIFORM DISTRIBUTION TO A NORMAL DISTRIBUTION FOR LONG-TERM INTEREST RATES (LINT2)

LET CFPO3 = MEAN CFPO + STDCFPO*CFPO2
LET SINT3 = MEAN SINT + STD SINT*SINT2
LET LINT3 = MEAN LINT + STD LINT*LINT2
LET DSINT = ((1+SINT3)**(1/360))-1
LET DLINT = ((1+LINT3)**(1/360))-1

LET DIVPAY = DIVPAY + NEWDIV

REM THIS SECTION IS A DIVIDEND DAY COUNTER

NDIV = NDIV + 1
IF NDIV < 90 THEN 3970
IF NDIV = 90 THEN 3990
LET DIVDUM = 0
GOTO 4020

LET DIVDUM = 1
LET NDIV = 0
GOTO 4020

LET DPT = DIVDUM*DIVPAY

REM THIS SECTION IS A LONG-TERM INTEREST DAY COUNTER

LET INTPAY = INTPAY + NEWINT
LET NINT = NINT + 1
IF NINT < 180 THEN 4080
IF NINT = 180 THEN 4100
LET INTDUM = 0
GOTO 4120

LET INTDUM = 1
LET NINT = 0
LET IPT = INTPAY*INTDUM
LET STPA = ABS(STP)

REM THIS SECTION DETERMINES THE NEW CASH LEVEL

IF MEANCFPO < 0 THEN 4220
IF MEANCFPO + DSINT3*STP - R*DEBT > 0 THEN 4170
IF MEANCFPO + DSINT3*STP - R*DEBT < 0 THEN 4220

LET CAST1 = CASH + CFPO3 - IPT - DPT - (CN6+CN7+CN8)*TRANCS
LET CASHT2 = -(CN1+CN3+CN5)*TRANSC-D*STPA+DSINT*STP
LET CASHT3 = -.24*(MEANCFPO+DSINT*STP-R*DEBT)
LET CASHT = CASHT1 + CASHT2 + CASHT3
GOTO 4270

LET CASHT1 = CASH + CFPO3 - IPT - DPT - (CN6+CN7+CN8)*TRANCS
LET CASHT2 = -(CN1+CN3+CN5)*TRANSC-D*STPA+DSINT*STP
LET CASHT3 = 0
LET CASHT = CASHT1+CASHT2+CASHT3
GOTO 4270

LET CASH = CASHT
REM THIS SECTION DECIDES THE DAILY ACTION TAKEN
IF CASH < .2*(-STP) THEN 4320
IF CASH <= 0 THEN 4320
IF CASH < HCASH THEN 5840
IF CASH => HCASH THEN 5190
IF STP < HSTPDO THEN 4340
IF STP => HSTPDO THEN 5010
IF (DEBT-STP) => BKLMT THEN 4360
IF (DEBT-STP) < BKLMT THEN 4380
IF DIVPAY <= 0 THEN 4380
IF DIVPAY > 0 THEN 4590
IF (NNDIV-N) > -90 THEN 5010
LET NNDIV = N
REM THIS SECTION MEASURES THE COST OF BANKRUPTCY
LET NCASE2 = NCASE2 + 1
LET BKCTT = ((1+R)**(-N))*BKCT
LET BKCTTT = BKCTTT + BKCTT
LET TRANCST = 0
LET TRANSCT = 0
LET DEBT = 0
LET NEWINT = -INTPAY
LET NEWDIV = -DIVPAY
LET STP = ZSTP
LET CASH = ZCASH
LET CN1=0
LET CN2=1
LET CN3=0
LET CN4=0
LET CN5=0
LET CN6=0
LET CN7=0
LET CN8=0
GOTO 6020
IF (NNDIV-N) > -90 THEN 5010
LET NNDIV = N
REM THIS SECTION MEASURES THE COST OF DIVIDEND DECREASES
LET NCASE3 = NCASE3 + 1
LET ICDVT = ((1+R)**(-N))*ICDV
LET ICDVTT = ICDVTT + ICDVT
LET TRANSCT = ((1+R)**(-N))*TRANSCT
LET TRANSCTT = TRANSCTT + TRANSCT
LET DEBT = DEBT
LET NEWINT = 0
LET NEWDIV = -DIVCUT
LET CASH = ZCASH
LET STP = STP
LET CN1=0
LET CN2=0
LET CN3=1
LET CN4=0
LET CN5=0
LET CN6=0
LET CN7=0
LET CN8=0
GOTO 6020
REM THIS SECTION MEASURES THE COST OF DEBT ISSUE
LET NCASE1 = NCASE1 + 1
LET ICDBT = ((1+R)**(-N))*ICDB
LET ICDBTT = ICDBTT + ICDBT
LET TRANSCT = ((1+R)**(-N))*TRANSC
LET TRANSCCT = TRANSCTT + TRANSCT
LET TRANCST = 0
LET DEBT = DEBT + ((ZSTP-STP)+ZCASH))
LET NEWINT = BR*((ZSTP-STP)+ZCASH)
LET NEWDIV = 0
LET CASH = ZCASH
LET STP = ZSTP
LET CN1=1
LET CN2=0
LET CN3=0
LET CN4=0
LET CN5=0
LET CN6=0
LET CN7=0
LET CN8=0
GOTO 6020
REM THIS SECTION MEASURES THE COST OF SHORT SALES
LET NCASE5 = NCASE5 + 1
LET TRANSCT = ((1+R)**(-N))*TRANSC
LET TRANSCCT = TRANSCTT + TRANSCT
LET TRANCST = 0
LET DEBT = DEBT
LET NEWINT = 0
LET NEWDIV = 0
LET STP = STP - (ZCASH-CASH)
LET CASH = ZCASH
LET CN1=0
LET CN2=0
LET CN3=0
LET CN4=0
LET CN5=1
LET CN6=0
LET CN7=0
LET CN8=0
GOTO 6020
IF STP <= HSTPUP THEN 5210
IF STP > HSTPUP THEN 5390
REM THIS SECTION MEASURES THE COST OF SHORT PURCHASES
LET NCASE6 = NCASE6 + 1
LET TRANCST = ((1+R)**(-N))*TRANCS
LET TRANSCSTT = TRANSCSTT + TRAN CST
005240 LET TRANSCT = 0
005250 LET DEBT = DEBT
005260 LET NEWINT = 0
005270 LET NEWDIV = 0
005280 LET STP = STP + (CASH-ZCASH)
005290 LET CASH = ZCASH
005300 LET CN1=0
005310 LET CN2=0
005320 LET CN3=0
005330 LET CN4=0
005340 LET CN5=0
005350 LET CN6=1
005360 LET CN7=0
005370 LET CN8=0
005380 GOTO 6020
005390 IF (DEBT-STP) <= DBUPLMT THEN 5410
005400 IF (DEBT - STP) > DBUPLMT THEN 5630
005410 IF (NNDIV-N) > -90 THEN 5210
005420 LET NNDIV = N
005425 REM THIS SECTION MEASURES THE COST OF DIVIDEND INCREASES
005430 LET NCASE7 = NCASE7 + 1
005440 LET RCDVT = ((1+R)**(-N))*RCDV
005450 LET RCVDVT = RCDBTT + RCDVT
005460 LET TRANCST = ((1+R)**(-N))*TRANCS
005470 LET TRANCSTT = TRANCSTT + TRANCST
005480 LET TRANCT = 0
005490 LET DEBT = DEBT
005500 LET NEWINT = 0
005510 LET NEWDIV = DIVUP
005520 LET CASH = ZCASH
005530 LET STP = STP
005540 LET CN1=0
005550 LET CN2=0
005560 LET CN3=0
005570 LET CN4=0
005580 LET CN5=0
005590 LET CN6=0
005600 LET CN7=1
005610 LET CN8=0
005620 GOTO 6020
005625 REM THIS SECTION MEASURES THE COST OF DEBT REPURCHASE
005630 LET NCASE8 = NCASE8 + 1
005640 LET RCDBT = ((1+R)**(-N))*RCDB
005650 LET RCDBTT = RCDBTT + RCDBT
005660 LET TRANCST = ((1+R)**(-N))*TRANCS
005670 LET TRANCSTT = TRANCSTT + TRANCST
005680 LET TRANCT = 0
005690 LET DEBT = DEBT - ((STP-ZSTP) + (CASH-ACASH))
005700 LET NEWINT=0
005710 LET NEWDIV = 0
LET NEWDIV = 0
LET CASH = ZCASH
LET STP = ZSTP
LET CN1 = 0
LET CN2 = 0
LET CN3 = 0
LET CN4 = 0
LET CN5 = 0
LET CN6 = 0
LET CN7 = 0
LET CN8 = 1
GOTO 6020

REM THIS SECTION MEASURES THE COST OF INCIDENTAL EXPENSES
LET NCASE4 = NCASE4 + 1
LET TRANCST = 0
LET TRANSCT = 0
LET CASH = CASH
LET DEBT = DEBT
LET NEWINT = 0
LET NEWDIV = 0
LET STP = STP
LET CASH = CASH
LET CN1 = 0
LET CN2 = 0
LET CN3 = 0
LET CN4 = 1
LET CN5 = 0
LET CN6 = 0
LET CN7 = 0
LET CN8 = 0
GOTO 6020

REM THIS SECTION MEASURES THE COST OF SHORT TURNOVER
LET CDSTP = D*STPA
LET CDSTPT = ((1+R)**(-N))*CDSTP
LET CDSTPTT = CDSTPTT + CDSTPT

REM THIS SECTION MEASURES THE COST OF MATURITY MANAGEMENT
IF SINT3 < LINT3 THEN 6080
IF SINT3 > LINT3 THEN 6120
LET CMATSIL = (DLINT-DSINT)*DEBT
LET CMATSILT = CMATSIL*((1+R)**(-N))
LET CMATSILTT = CMATSILTT + CMATSILT
GOTO 6150

LET CMATSIL = (DSINT-DLINT)*STP*(-1)
LET CMATSILT = CMATSIL*((1+R)**(-N))
LET CMATSILTT = CMATSILTT + CMATSILT

REM THIS SECTION MEASURES THE INTEREST COST OF CASH HOLDINGS
IF SINT3 < LINT3 THEN 6170
IF SINT3 > LINT3 THEN 6210
LET CMATCS = CASH*DLINT
LET CMATCS*(1+R)**(-N))
LET CMATCSTT = CMATCSTT + CMATCST
GOTO 6250
LET CMATCS = CASH*DSINT
LET CMATCST = CMATCS*(1+R)**(-N))
LET CMATCSTT = CMATCSTT + CMATCST
LET AVGTRAN = AVGTRAN +
(1/TIMESPAN)*(C5+C6)*TRANCS
IF MEANCFPO < 0 THEN 6400
IF MEANCFPO+DSINT*STP-DLINT*DEBT>0 THEN 6350
IF MEANCFPO+DSINT*STP-DLINT*DEBT<=0 THEN 6400
REM THIS SECTION MEASURES THE COST OF TAXES
LET AVGTAX=AVGTAX+(1/TIMESPAN)*(MEANCFPO+DSINT*STP-DLINT*DEBT)*.24
LET CTAX = .24*(MEANCFPO+DSINT*STP-DLINT*DEBT)
LET CTAXT = ((1+R)**(-N))*CTAX
LET CTAXTT = CTAXTT + CTAXT
GOTO 6450
LET AVGTAX=AVGTAX
LET CTAX = 0
LET CTAXT = ((1+R)**(-N))*CTAX
LET CTAXTT = CTAXTT + CTAXT
GOTO 6450
REM THIS SECTION MEASURES THE DAILY COST OF MANAGEMENT
IF MEANCFPO < 0 THEN 6620
IF MEANCFPO - DLINT*DEBT + DSINT*STP > 0 THEN 6550
IF MEANCFPO - DLINT*DEBT + DSINT*STP < 0 THEN 6220
LET CFMT1 = (CN6+CN8)*TRANCS + (CN1+CN5)*TRANSC +
(CN2)*BKCT
LET CFMT2 = (CN1)*ICDB + (CN3)*ICDV + (CN0)*ICE +
(CN8)*RCDB
LET CFMT3 = (CN7)*RCDB + (CN9)*RCE +
(CN1+CN5)*TRANSC + CMATCS
LET CFMT4 = .24*(MEANCFPO-DLINT*DEBT+DSINT*STP) +
CMATSL
LET CFMT = CFMT1 + CFMT2 + CFMT3 + CFMT4
REM THIS SECTION MEASURES THE PRESENT VALUE OF MANAGEMENT
LET CASHCFMT = (CN6+CN8)*TRANCS + (CN1+CN5)*TRANSC +
CMATCS
GOTO 6680
LET CFMT1 = (CN6+CN8)*TRANCS +
(CN1+CN5)*TRANSC+(CN2)*BKCT
LET CFMT2 = (CN1)*ICDB + (CN3)*ICDB + (CN0)*ICE +
(CN8)*RCDB
LET CFMT3 = (CN7)*RCDB + (CN10)*RCE +
(CN1+CN5)*TRANSC + CMATCS
LET CFMT4 = CMATSL
LET CFMT = CFMT1 + CFMT2 + CFMT3 + CFMT4
LET CASHCFMT = (CN6+CN8)*TRANCS+(CN1+CN5)*TRANSC +
CMATCS
006680 LET CFMTT = ((1+R)**(-N))*CFMT
006690 LET CASHCFMTT = ((1+R)**(-N))*CASHCFMT
006700 LET CFMTTTT = CFMOTT + CFMTT
006710 LET CASHCFMTTT = CASHCFMOTT + CASHCFMTT
006720 LET N = N + 1
006720 IF N < TIMESSPAN THEN 840
006730 IF N > TIMESSPAN THEN 6750
006735 REM THIS SECTION CONTAINED THE VARIOUS PRINT STATEMENTS
008580 END
BIBLIOGRAPHY


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