A MICROCOMPUTER-BASED APPLICATION OF A CASH DECISION MODEL FOR SMALL BUSINESSES

by

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Thesis submitted to the Graduate Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Industrial Engineering and Operations Research

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March, 1982
Blacksburg, Virginia

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(ABSTRACT)

Cash decision-making involves the simultaneous consideration of financing and investment opportunities over a short-term planning horizon. Decision variables include timing, amount, and source of cash transactions. Decisions can be made regarding these variables such that the worth of the firm (i.e. outstanding investments less financing) at the end of the planning horizon is maximized.

Because cash decision-making is often of critical importance to small business, this study focuses directly on the small business environment. Alternatives available to the small business are limited, as are the resources to evaluate alternatives. This study takes these factors into account by building a cash decision model which is specifically tailored to the small business, and implementing this model on a low-cost, high-powered microcomputer.

The model itself is formulated as a linear program with a simple procedure included for handling noncontinuous variables. The model makes use of input generators for ease of implementation. A practical example problem is provided to illustrate the workings of the model.

ACKNOWLEDGEMENTS

I wish to express my most sincere thanks to my committee members whose various perspectives contributed to the overall development of this study. Dr. Tanchoco served as a true adviser by instilling motivation and entrusting faith in me. His philosophies in approaching problems within and beyond the scope of this study will long be remembered. Dr. Ghare, in his capacity as Director of the Productivity Evaluation Center, provided the funding for this study. His interesting sidelines and general views richly supplemented my classroom instruction. Dr. Davis extended encouragement and kindness throughout my graduate program. His concern for the well-being of others has inspired me on many an occasion. Dr. Agee taught me much by his day-to-day example. His genuine interest in whatever came his way was backed by a fortitude to complete what needed to be done. Together these individuals formed a committee which I feel fortunate to have served.

I wish also to express thanks to my friend and colleague for offering considerable guidance and support throughout this study. Finally, I wish to thank my father and mother, six sisters and brother for having played a major role in shaping my life and for offering love and care unending.

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Chapter I

INTRODUCTION

The economic system in a highly capitalistic society is often perceived as being monopolized by giant corporations with profits in the millions. And yet, in the United States, 97% of the approximately 13 million business organizations can be legitimately classified as small [33]. Even so, many people argue that the contribution of small business to a nation's economy is insignificant and unimportant. The fact is that small businesses account for close to one-half of the goods, services, and employment generated by the U.S. private sector [16].

Despite their relative influence in terms of both numbers and contribution, small businesses are particularly vulnerable to failure. Dun and Bradstreet, Inc., in a study of business failures [34], estimate that each year more than one third of all new businesses declare bankruptcy. In addition, they report that by an overwhelming percentage, mismanagement is the primary cause of business failure. The Small Business Administration confirms this report with an estimate that 9 out of 10 business failures are due to poor management [35].

There are many functional areas within the realm of management, and the previously noted business studies do not specifically relate failures to these various functions. However, it can safely be claimed that weaknesses in any management area cannot be overcome without the use of sound financial strategies. It is the purpose of this study, therefore, to develop a tool for the financial management of a small business.

Scope of Study

"Small business" means different things to different persons. For instance, the Small Business Administration, the Senate Small Business Committee, the Department of Commerce, and the Securities and Exchange Commission all have varying and often conflicting definitions of small business. These definitions are based upon such criteria as number employed, sales volume, capital investment, and competitive position.

For purposes of this study, the term small refers to characteristics of a firm other than size. These characteristics are: 1) area of operations, and 2) management control. With regard to area of operations, small business refers to an organization which is both independent and localized in nature. With regard to management control, small business refers to an organization whose activities are directly managed by its owners.

The above characteristics are particularly relevant to this study. The independent nature of the small business creates a critical need for sound financial management. Unlike their large counterparts, small businesses cannot absorb management failures by distributing these failures over a broad organization. Thus, the impact of managerial errors and oversights is heightened in a small business. Furthermore, the financial resources necessary to recover from mistakes are severely restricted by the localized operations of the small firm.

The owner-manager aspect of small business also causes difficulties in the sphere of financial management. An owner-manager of a small firm is seldom a financial specialist and, unfortunately, he cannot afford to hire the highly trained personnel found in large corporations. Therefore, the small business posesses limited expertise in developing financial policies. In addition, the owner-manager of a small firm is charged with the responsibility of handling all functions of the firm. As a result, little time exists for properly administering financial procedures.

The characteristics which define small business give rise to limited time, limited financial knowledge, and limited resources. These factors must be considered in creating a tool for small business financial management.

This study focuses attention on these factors by developing a model specifically tailored to the small business environment and implementing the model on a microcomputer.

Problem Statement

Sound financial management must serve to further the goals of a firm. Small businesses tend to hold highly personalized and widely divergent goals. It cannot be assumed, as is usually the case in solving business problems, that profit maximization is the foremost of these goals. Oftentimes the small firm is willing to forego income in favor of such other motives as creative pursuit, personal freedom, or retention of family control. In spite of these differing business motives, all firms do face a common immediate objective: maintaining the cash flow for daily operations of the business. The ideal situation is to provide sufficient but not excessive cash in the most economical manner. It is the cash aspect of small business financial management which this study specifically addresses.

Importance of Study

A cash decision-making model for small businesses offers several desirable results. First, and most importantly, small firms can increase their management effectiveness and, consequently, reduce business failures. Also, a formal cash management procedure can facilitate the acquisition of financial resources. And finally, goods or services provided by small businesses can be realized at a lower cost.

Neglect in cash management forces a firm to be pressured into hasty, ad hoc decisions. In a world of inflation, tight monetary policy, and high interest rates, the result of such rash decision-making can be disastrous. Hence, there exists a vital need for a systematic cash decision-making program. The frequency with which cash decisions must be made increases this need.

Organization of Study

The study proceeds as follows. First, a general overview of the system within which cash decisions are made is presented. The system description is followed by a review of the relevant literature.

The study then focuses on the cash decision itself. Alternative decision possibilities are discussed. A model for choosing among alternatives is then presented, along with a discussion of solution and implementation procedures. Next the model is applied to a realistic example problem. Lastly, conclusions and comments are given.

Chapter II

A CASH MANAGEMENT SYSTEM

The objective of the following discussion is to present a consolidated view of a cash management system. The traditional management functions of planning, decision-making, and control will form the framework for discussion.

The Planning Function

The primary purpose of planning is to provide information; the basic tool in planning is the budget. Cash budgeting, then, is a planning device which provides information on a firm's cash flows. With the cash budget as a guide, the firm can make rational decisions regarding cash transactions.

The first step in the construction of a cash budget is selection of a format. The two most widely used formats in cash budgeting are termed "receipts & disbursements" and "adjusted net income". Receipts & disbursements is a type of format which allows construction of the cash budget directly from operating data. The firm's activities are traced through each cash-related account and the various accounts are then grouped into two major categories, receipts and disbursements. This format provides a very detailed record of cash flows.

Adjusted net income is an alternative format which allows indirect construction of the cash budget. The format begins with the firm's net income account. This account is converted into a cash flow by making certain adjustments. The adjustments take into consideration various delay factors which result from the accrual basis of income determination, as well as non-cash factors such as depreciation. The adjusted net income format lacks detail in summarizing cash flows; however, it is often helpful when the cash budget is to be incorporated as part of the overall master budget of the firm.

Selection of the budgeting format is most strongly influenced by the length of the planning horizon and its division into periods. The selection of planning periods is, in turn, influenced by the nature of the cash flow patterns. Stable cash flow patterns permit longer planning periods which more readily lend themselvs to the adjusted net income approach. That is, the projection and distribution of net income becomes more meaningful for longer periods than for shorter ones. Volatile cash flows require shorter planning periods for which an estimate of net income is somewhat trivial. Hence, the direct receipts & disbursements method is more appropriate for short planning periods.

Once the format of the cash budget is chosen, the individual variables which are to be included must be specified. To a large extent the format itself indicates which variables are to be included. Yet there remains a need to combine certain variables into major classifications. By so doing, the overall budgeting effort is minimized, and those factors of greatest importance are highlighted. In specifying appropriate variables, the emphasis is placed on the activity of individual accounts. Those accounts with relatively small activity can be combined; whereas the most active accounts should be separated in order to maintain control.

The discussion thus far has concentrated on the cash budgeting framework within which the information is to be placed. The final step involves the actual forecasting of the variable amounts. There are three general techniques to cash forecasting. Direct forecasts rely on experience and judgment in estimating variable amounts. Ratio forecasts are based on fixed relationships of one variable to another variable, or one variable to the sum of several variables. Quantitative forecasts are based on analytical projections of past data into the future.

The cash forecasting techniques most often used today are direct estimating and ratio analysis [3]. It is common practice to select the important variables and estimate these directly. In order to reduce bias in the forecast, estimates are prudently gathered from several sources within the firm. These estimated variables form the basis for measurement of other variables via the ratio method. That is, historical ratios are applied to each of the remaining variables in order to determine the forecast amounts.

Under these two methods, the longer the forecast the more uncertain the conditions and, consequently, the less reliable the estimates. More accurate estimates can be obtained from quantitative forecasting techniques; yet their implementation in cash budgeting has been slow [3]. This is due largely to the fact that greater accuracy has historically been unnecessary in cash budgeting. Penalties for inaccuracy have been minimal because of low interest rates. This is obviously not true today. Accelerating interest rates and tight monetary policies now demand greater precision in cash budgeting. Consequently, future attention in cash budgeting is likely to be directed toward quantitative forecasting techniques. Time series techniques may be used to identify trend, seasonal, and cyclical patterns in the forecast variables. Regression techniques may be used to consider relationships which exist between variables, and to statistically determine the level of forecasting accuracy.

Recognition of the importance of accuracy in cash budgeting has led to a further development; namely, simulation. Information in cash budgeting provides nothing more than a most-likely estimate of cash flow variables. Simulation is a tool which can incorporate into cash planning both the most-likely cash budget estimates and an associated margin of error. By simulating under various business conditions, the firm can acquire greater insight for cash planning.

The Decision-Making Function

Given cash planning information in the form of a budget, the firm faces a twofold decision-making task. The first decision involves the financing of cash shortages; the second involves the investment of excess cash. The decisions must be considered simultaneously since cash shortages can be financed through the sale of investments and excess cash can be used to reduce financing obligations. Each decision-making activity involves specification of feasible alternatives and selection among these alternatives.

In specifying and selecting alternatives, it is important to consider the scope of the cash decision-making activity. That is, cash decisions are of a short-term nature. Longer term financial decisions such as mergers and acquisitions, issues of stocks and bonds, and dividend distributions clearly affect cash management. However, these long-term financial decisions are not made simultaneously with cash decisions. For example, a merger decision will clearly affect cash flows but it is not likely to be considered simultaneously with a decision of whether to invest excess cash in a 13-week Treasury Bill. Similarly, an issuance of stocks will not be viewed in the same way as an obligation for a 90-day bank note. The differences in magnitude and timing, and the consequent differences in commitment and risk, result in separate approaches to these decisions. Once long-term decisions have been made, their effects on cash management must be taken into consideration through effective handling of the resulting cash flows. That is, the outcome of long-term decisions serve as input to the cash decision-making problem.

The determination of a short-term planning horizon is subjective. The accounting definition limits the short run to a period of one year. In practice, the length of the short-term horizon may be substantially less than one year. The choice of a specific horizon should be based on the particular characteristics of the firm.

Determination of an appropriate planning horizon leads to another time-related aspect of cash management. This is the problem of dividing the planning horizon into a number of decision-making periods. In determining the number of periods, advantages and disadvantages must be weighed. That is, a large number of periods increases both the complexity of the problem and the required detail of the planning information. A smaller number of periods reduces the detail and complexity and, consequently, the cost. However, a small number of periods also reduces the effectiveness of the decision-making activity.

The previous discussion of planning horizon and periods is particularly relevant to cash management. This is due to the fact that cash decisions of one period affect and are affected by decisions of subsequent periods. An approach to decision-making must therefore be able to cope with the multi-period nature of the cash problem.

The objective of cash decision-making is to select the best financing and investment alternatives from a specified set. The decision-making activity is based on the cash planning information of the budget. An element of uncertainty exists here. Uncertainty is associated not only with the planning information but also with the projection of costs and returns for the various alternatives. It can be argued that the nature of the cash problem alleviates some of the concern over uncertaintly. That is, the timing and magnitude of the cash decision impose relatively small commitment on the part of the firm and, consequently, impose relatively small risk. However, the uncertainty aspect of the cash problem cannot be ignored in making decisions.

The decision-making function of cash management is the central focus of this study. Thus, the decision-making function will be discussed in greater detail in subsequent chapters.

The Control Function

The objective of cash control is threefold: speed up cash inflows, delay cash outflows, and economize on cash holdings. Each of these aspects will be discussed in turn.

Two basic techniques have been utilized to speed up cash inflows. The first and oldest technique is the lockbox system. This system is used to minimize the time involved in receiving, processing, and depositing a firm's collections. The lockbox system works as follows.

A firm's customers mail their payments to specially designated Post Office boxes rather than to the firm itself. These boxes are emptied several times daily by the firm's bank. The bank records the details necessary for the firm's accounting records and immediately makes a deposit to the firm's account. The bank then forwards the transaction record and the deposit slip to the firm.

Use of a lockbox system effects a quick conversion of customer payments to cash by reducing the mail delivery time (called mail float). Essential to the efficient operation of a lockbox system is the optimal selection of lockbox locations. In locating lockboxes, the firm first selects a subset of possible location sites and, second, allocates customers among the selected sites in a manner which minimizes mail float.

A technique often used in conjunction with the lockbox system to speed up cash inflows is referred to as area concentration banking. Under concentration banking, funds which are accumulated at various locations are transferred to a central bank account. The central bank allows the firm to obtain maximum use of its funds.

The method for transferring locally deposited funds to a concentration account is as follows. Deposits made to local banks are reported daily into a data collection network. At some specified time, the stored data is transmitted to the firm's concentration bank. The concentration bank can do one of two things. It can order a wire transfer of funds from the local bank; or it can send a depository transfer check to the local bank which authorizes collection of a designated amount. The depository transfer check is slower, but less costly than the wire transfer. A firm's selection between the two methods depends on the amount and frequency of the transfers.

The benefits realized from speeding up cash inflows have led firms to consider the potential gains from delaying cash outflows. Cash outflow systems, often called disbursement systems, can be viewed as the reverse of cash inflow, or collection, systems. Whereas collection systems are concerned with minimizing float and centralizing funds, disbursement systems concentrate on maximizing float and decentralizing funds. In a disbursement system, a firm is concerned not only with mail float but also with check clearing float (i.e., the time it takes for a check to clear the banking system and be charged to the firm's account). The goal of a disbursement system is to set up bank accounts at location sites which will maximize the total float of cash outflows.

An efficient disbursement system typically results in several bank accounts at varying locations. An efficient collection system, on the other hand, typically results in a single concentrated bank account. It appears, then, that the goals of the disbursement and collection systems are inconsistent. However, this is not true. A number of special arrangements exist which deal effectively with this conflict.

The most common of these arrangements is a zero balance account. Under this system a clearing account with a zero balance is maintained at each local bank. As checks are presented to the local banks for payment, a concentration bank is authorized to transfer funds into the clearing account to cover the payments. A variation of this arrangement is the automatic balance account which maintains a predefined balance and allows receipts as well as disbursements to flow through it.

Utilization of collection and disbursement techniques depends, of course, on the cost to be incurred and the benefits to be realized. Bank collection and disbursement services are generally offered in the form of a package for which a total cost is charged. Thus, in order to establish a basis for cost analysis, all of the firm's banking activities must be considered simultaneously.

The previous discussion has concentrated on the speed-up of cash inflows and the delay of cash outflows. The purpose of these control techniques is to obtain a maximum level of cash. Before deciding how to put this cash to work, the firm must determine an appropriate balance to be kept on hand.

There are essentially three motives for holding cash balances: transactionary, precautionary, and speculative. The speculative motive, while of much interest in the rapid growth period of the 60's, is of little relevance in our present situation of tight money and high interest rates. The transactionary and precautionary motives, however, require attention.

The transaction motive for holding cash results from the lack of synchronization between a firm's cash inflows and outflows. This lack of synchronization requires that a firm hold a positive cash balance to serve as a buffer against unforeseen events.

Determination of an appropriate cash balance involves two basic costs. The first is the investment opportunity cost of holding idle cash. The second is the administrative cost involved in maintaining the cash balance. The objective is to determine a cash balance which minimizes total cost while ensuring that the firm meets its transactionary and precautionary needs.

In conclusion, cash management can be described as a system for: 1) planning cash flows through budgeting and forecasting techniques, 2) making decisions based upon the cash flows, and 3) controlling the cash flows through collection and disbursement systems. This study addresses the decision-making aspect of cash management. The purpose of the study is to provide a cash decison model tailored to the needs of small business. Planning is a preliminary step to the cash decision-making process and, therefore, should not be overlooked by the small business. Control increases the effectiveness of cash decision-making and, while many of the techniques of cash control are not entirely relevant to the small firm, the concept is quite relevant and should be considered in developing a cash management system.

Chapter III

LITERATURE REVIEW

The objective of the following review is to discuss the literature relating to cash management. Because the core of this study is concerned with cash decision-making, the focus of the review concentrates on the decision-making function of cash management. A brief discussion of the literature pertaining to cash planning and control functions will serve as a follow-up.

As previously discussed, cash decision-making is essentially a two-stage process which involves specification of feasible alternatives and selection among these alternatives. The literature provides a substantial amount of information on available financing and investment alternatives (see standard Finanacial Management textbooks). Information includes descriptions of various instruments, institutional sources, costs or returns, restrictions, and intangible considerations. Two noteworthy texts are by Solomon [27] and Stigum [28]. Solomon offers an excellent discussion of financing alternatives which emphasizes relevant factors of comparison and highlights advantages and disadvantages of each financing option. Stigum presents a very thorough analysis of investment alternatives. The analysis includes an historical perspective of rates, restrictions, and policies within the investment market as well as relevant formulas for calculating and comparing returns.

Selection among alternatives comprises the second stage of cash decision-making. Linear programming has been the modeling approach most heavily relied upon in the literature. Potential use of linear programming as a technique for short-term financial decision-making was first demonstrated by Robichek, Teichroew, and Jones [21]. The Robichek et al. model determines the optimal amount of financing to be obtained from a set of alternatives. The model deals only with the financing aspect of cash decision-making. A simplifying assumption is made with regard to investment. The assumption is that all excess cash is invested in a single security which becomes available with interest in the succeeding period.

Four financing alternatives, or decision variables, are explicitly considered in the model: line of credit, term loan, pledging of accounts receivable, and trade credit. (These alternatives are described in a later section of this study.) The objective of the model is to select that combination of alternatives which yields the minimum total financing cost. Total cost includes interest charges as well as implicit costs resulting from qualitative considerations. The optimization is to be carried out subject to constraints on the financing alternatives.

It is appropriate to note that the explicit costs (i.e., interest charges) of the objective function are computed on the accrual basis. That is, costs are realized in the period incurred, rather than in the period when the cash is actually paid. This is in line with generally accepted rules for revenue and expense determination. Naturally, in a cash decision problem, the actual cash transaction cannot be ignored. This conflict is handled by including a cash balance constraint. The constraint requires that cash inflows be equal to cash outflows in each period. That is, any use of cash must be met from some source.

An additional constraint in the model is necessary to account for the short-term planning horizon. Because a firm is an ongoing concern, decisions made under a short-term planning horizon must not jeopardize the future of the firm. The Robichek et al. model deals with this phenomenon by assigning a "one-time" cost to any outstanding loans at the end of the planning horizon, and a "one-time" credit to any excess cash available. The model does not specify the length of the planning horizon, nor does it specify the number of decision-making periods. The only requirement is that the horizon be divided into periods which are of equal length.

An extension of the Robichek model is presented by Mao [15]. The extension is essentially a reformulation. Whereas the Robichek model considers decision variables for each period, the Mao version employs cumulative decision variables. It views the firm's cash shortages or surpluses in a cumulative framework; then defines the decision variables in terms of total outstanding financing, rather than in terms of financing obtained per period. In line with this, the objective function and the cash balance constraint compute total interest costs and returns from the initial planning period to the current period. End conditions are not considered.

The purpose of the Mao approach is to provide a clearer picture of the structure and workings of the model. Once the overall cash problem has been analyzed, the model is reformulated in terms of the decision variables for each individual period. The model is then applied to a case study which includes three financing alternatives: line of credit, term loan, and commercial paper. The investment aspect of the problem is dealt with in the same manner as in the Robichek model, i.e., through a simplifying assumption. The application involves a yearly planning horizon which is divided into 12 monthly periods. Considerable attention is given to dual analysis as a means of gaining additional insights to the cash decision problem.

A further extension of the Robichek model is presented by Pogue and Bussard [20]. Pogue and Bussard directly consider both the financing and investment aspects of the cash problem. In addition to constraints on the various alternatives and the cash balance, they include constraints to reflect policy considerations. Furthermore, they question the appropriateness of the certainty assumption of the linear programming formulation.

The financing decision variables included in the Pogue and Bussard model are: line of credit, term loan, pledging of accounts receivable, trade credit, and commercial paper. The investment decision variables include 1-month, 2-month, and 3-month securities which must be held to maturity.

Three policy constraints are developed in the model. All of these constraints are intended to insure a high degree of liquidity in the firm. The first requires that at least 50% of the investments outstanding at any time be composed of 1-month securities. The second constraint requires that a minimum current ratio (current assets/current liablilities) be maintained in each period. The third constraint requires that a sufficient liquidity reserve be maintained at all times. The liquidity reserve is to be composed of total outstanding investments and any unused financing potential of the firm. As noted earlier, these policy constraints are in addition to the constraints imposed on the decision variables and the cash balance.

The end conditions provided by Pogue and Bussard are slightly different from those of Robichek. Rather than assigning one-time costs or credits to outstanding financing and investments of the last planning period, Pogue and Bussard assign target values to these outstanding amounts. The objective function defines penalizing costs for deviations from the target values. By adjusting the size of the cost penalties, the outstanding financing and investments of the last period can be made to approach any value.

All of the previous models base cash decisions on planning information contained in the firm's cash budget. Robichek and Mao assume this information is known with certainty. Pogue and Bussard, however, recognize the uncertain nature of cash plans and give explicit consideration to this uncertainty element in their model. The problem is first formulated as a chance-constrained program, and then reformulated as an equivalent deterministic linear program. The model requires specification of two parameters: a measure of the deviation associated with each period of the cash budget; and a measure of the probability with which the chance constraints are to be satisfied. It should be noted that the model deals only with the uncertainty of the cash planning information. All other elements, such as interest rates and dollar limitations, are assumed known with certainty.

Another version of the cash decision model is presented by Orgler [17]. In addition to consideration of both financing and investment alternatives, Orgler gives explicit consideration to the interrelationships between financing and investment alternatives. That is, early repayment of financing obligations and sale of investments before maturity are viewed as distinct alternatives of the cash decision. Consequently, amounts outstanding at the beginning of the planning horizon must be accounted for in the model.

The real contribution of the Orgler model lies in its approach to the time dimension of the cash problem. It was noted earlier that a selected planning horizon must be divided into decision-making periods; and that determination of an appropriate number of periods must weigh complexity and cost factors against the usefulness of results. The previous models assumed periods of equal length. The Orgler model abandons this assumption. By allowing unequal periods, the model is able to provide sufficiently detailed information while maintaining control over size and computational burdens.

To emphasize the potential of systematic cash decision-making, Orgler constructs the objective function as a maximization of net returns rather than a minimization of costs. The Orgler model does not define specific financing and investment alternatives; rather it is developed to provide general applicability. The model considers the basic constraints on the alternatives and the cash balances as well as a single policy constraint. This constraint requires that a certain amount of cash be kept on hand for transactionary or precautionary purposes. The amount can be expressed as a minimum, an average, or both. End conditions of the Orgler model simply bound certain amounts outstanding in the last planning period.

Maier and Vander Weide [14] present a cash decision model which is intended to serve the nontechnical user; the model is available on a world-wide time sharing computer network. Through the aid of matrix and report generators, the model allows rapid input of all necessary data and provides easily interpretable results.

The formulation of the Maier and Vander Weide model is relatively simple. Unlike previous authors whose singular goal is the optimization of cash management costs or returns, Maier and Vander Weide choose to maximize the horizon value of outstanding short-term instruments (i.e., investments less financing in the last period). The model considers up to 15 financing or investment alternatives but does not consider the interrelationships between these two variable types. Constraints include only those for the various alternatives and the cash balance. End conditions assign penalty costs to amounts outstanding in the last planning period. These costs are proportional to the length of time remaining to maturity. The time dimension of the Maier and Vander Weide cash decision model relies on Orgler's unequal period approach.

The five previously cited papers represent the major modeling efforts with respect to cash decision-making. Attempts have been made to consider cash decision-making within a systems framework. For example, Smith [25] proposed a model in which the cash decision variables (i.e., short-term financing and investment alternatives) are treated as components of working capital rather than as independent topics. Together with the other current assets and liabilities such as accounts receivable, inventory, and accrued payables, the cash decision variables are viewed within a collective working capital framework. Smith's model evaluates relative changes in the working capital position in a manner analogous to capital investment appraisal procedures. Gentry [8] extends this concept by considering working capital not merely via capital investment analysis, but rather as a capital investment alternative itself. In Gentry's model the cash decision variables provide the necessary link between short-term working capital and long-term capital investment.

Working capital and cash decision-making theories are primarily concerned with liquidity objectives of a firm. Liquidity enables a firm to meet its obligations as they become due. Liquidity is a short-run objective of the firm which must be considered along with long-run objectives such as profitability. Attempts have been made to simultaneously consider multiple financial objectives of a firm.

Sartoris and Spruill [22] present a goal programming approach to working capital management. In a goal programming formulation priorities are established for various goals by assigning weighted penalties to deviations from the goals. The goals are satisfied in a manner which results in a minimum penalty.

In goal programming, satisficing levels of the various objectives must be determined. Krouse [11] suggests a multiple objective programming technique which provides a basis for determining satisficing levels. This procedure establishes a hierarchical ordering of goals in a utility vector. An optimal solution to a working capital problem is obtained with only the highest ordered objective being considered. This value along with the marginal rate of substitution with the goal next in priority determines a satisficing level of the first objective. The problem is then reworked with the second ordered goal as the objective and the satisficing level of the first goal as a constraint. The procedure continues until all goals are considered.

These attempts at viewing cash decision-making as a component of working capital with several objectives do provide considerable insight to cash management. However, the models do not provide the detailed information necessary to make particular cash decisions.

The discussion thus far has concentrated on the decision-making aspect of cash management. The quality of decision-making is, of course, only as good as the quality of information used. Information for cash decision-making is expressed in the form of a budget; therefore, a look at the literature concerning cash budgeting techniques is appropriate.

Cash budgeting involves the selection of a format and the forecasting of variable amounts. Literature in recent years has been concerned with the forecasting element. Recall from the discussion of cash management systems that forecasting can be based on direct estimates, ratio analysis, and quantitative techniques. Hartley [9] offers a discussion of important factors to be considered in direct estimating. The discussion is geared toward the non-financial manager: consideration is given to the behavior of cash flows, environmental forces, uncertainty and reliability, frequency of budgeting, and contingency planning.

Vander Enden [31] provides a modeling approach to ratio analysis. The Vander Enden network method relies on a functional scheme which expresses relationships between cash elements and relationships between cash ratios, each within a period and between periods. The method is based on the assumption that ratios between cash elements are more stable than the elements themselves.

Beehler [3] discusses a need for the use of quantitative techniques to obtain more accurate cash budgets. Beehler presents a time series model which relies on decomposition and exponential smoothing methods. Decomposition methods are used to identify cash flow patterns of seasons, cycles, and trends. Exponential smoothing then separates these patterns from randomness and, in addition, places emphasis on the most recent cash flow periods. The purpose of the Beehler model is to provide a reliable yet simple and inexpensive approach to cash budgeting.

Whereas the techniques employed by Beehler do yield more accurate forecasts than either direct estimating or ratio analysis, the actual level of accuracy cannot be determined. Regression techniques allow this determination through statistical statements. Stone and Wood [30] contend that the key to successful use of regression in cash budgeting lies in the format of the budget itself.

Two basic formats are utilized in constructing a cash budget, receipts & disbursements and adjusted net income (see discussion of the cash management system). Stone and Wood argue that the adjusted net income format is easier and cheaper to implement than receipts & disbursements and, furthermore, readily lends itself to regression techniques. However, adjusted net income has shown relatively little use in practice because it requires stable cash flows. Stone and Wood alleviate this problem by separating the firm's cash flows into stable components and considering cycles and subcycles of the components rather than the flow itself. Regression methods are then appropriate; the particular regression technique employed by Stone and Wood is the dummy-variable regression technique.

Smith [26] also emphasizes the importance of the cash budgeting format. Smith recommends the use of both receipts & disbursements and adjusted net income, concurrently. He suggests that a parallel construction will enable an evaluation of tradeoffs between liquidity and profitability goals of the firm. Smith's model does not attempt to optimize; it is intended merely as a planning tool.

While cash planning provides the information necessary for decision-making, cash control provides the actual funds about which decisions are made. Although this study does not deal specifically with control procedures, a look at the literature is warranted for future research and extensions.

Cash control involves speeding up cash inflows, delaying cash outflows, and economizing on cash holdings. As explained in the discussion of a cash management system, the speeding and delaying functions are reverse problems. Each has received considerable attention in the literature [7,10,12,13,23,24]. The problems involve locating banks to optimize float; they fit into the general category of fixed charge transportation problems and can be solved using implicit enumeration and branch-and-bound techniques.

Recall that the cash inflow and outflow problems must be considered simultaneously due to interdependent cost factors and, furthermore, that the costs themselves should be given explicit consideration in a modeling framework. Calman [5] was the first to propose a comprehensive model of a firm's entire cash flow or banking system. The model is able to determine optimal cash flow activity levels at each bank. The model does not, however, determine the number of and location of banks. Maier and Vander Weide [13] developed a more comprehensive model which is able to specify the number, location, and activity level of banks within a firm's cash control system. The model is formulated as a warehouse location problem and, under certain limitations, can be solved with available integer programming codes.

An additional aspect of cash control remains to be considered; namely, determination of an appropriate cash balance. A cash balance is typically required by a firm to meet transactionary and precautionary needs. Baumol [2] proposed the first modeling framework for determining a cash balance. Baumol applied a relatively simple inventory model (the economic order formula) in an attempt to find the optimal pattern for replenishing a cash balance which is assumed to be steadily drawn down over time. The model uses a fixed administrative cost (or ordering cost) and a constant investment opportunity cost (or carrying cost). The objective of the model is to minimize the sum of these administrative and opportunity costs.

Somewhat different versions of this model have been presented which assume completely random cash flows [19] or which define actual cash flows [29]. All of these versions emphasize the number or timing of transactions affecting the cash balance and deal only indirectly with the cash balance itself. Beranek [4] proposes a dynamic programming approach to directly determine an optimal cash balance. The objective is to minimize total cost while assuring that the firm does not run out of cash. This model is adequate in a single period case for which there exists an analytic solution. The two period case can be solved, somewhat cumbersomely, by complete enumeration. But the multi-period model, in which lies the real value, becomes computationally complex.

The above models provide the required cash balance for transaction purposes. Archer [1] developed the first model for determining an appropriate level for a precautionary cash balance. Archer presents a reasonably operational model which allows a subjective selection of a cash balance based on an analysis of fluctuating cash flows. The model suggests that the firm hold a precautionary balance equal to a constant multiplier of the standard deviation of the cash flows. The multiplier is based on the risk of a cash shortage that the firm is willing to accept.

This chapter has provided an overview of the literature pertaining to cash management. Additional literature is, of course, available. However, those works discussed here are sufficient to provide the required background for this study.

Chapter IV

PROBLEM ENVIRONMENT

It is important that a business firm be prepared at all times to meet its cash demands. It is equally important that a firm avoid the high opportunity cost of holding excess cash. Meeting this dual objective forms the essence of the cash decision-making problem. That is, the firm must determine an efficient and effective manner for financing cash shortages and investing excess cash.

General Description

Cash decisions are based upon information given in the cash budget. A typical cash budgeting form is presented in Figure 1. The upper portion of the budget shows cash collections from sales and other income; and cash disbursements for manufacturing, finance, marketing, and administrative activities. Collections less disbursements gives the cash increase or decrease for the period. Adding the beginning cash balance to this amount gives the cash shortage or surplus for the period. The lower portion of the budget shows decisions which must be made regarding the financing of shortages and the investment of surpluses.

The cash decision model proposed in this study goes beyond the completion of the lower portion of the cash

CASH BUDGETING FORMAT

	January		February		March	
	BUDGET	ACTUAL	BUDGET	ACTUAL	BUDGET	ACTUAL
CASH COLLECTIONS						
Sales	...	...	...	...	...	...
Other Income	...	...	...	...	...	...
CASH DISBURSEMENTS						
Accounts Payable	...	...	...	...	...	...
Labor	...	...	...	...	...	...
Overhead	...	...	...	...	...	...
Notes Payable	...	...	...	...	...	...
Long-term Debt Payable	...	...	...	...	...	...
Selling Expense	...	...	...	...	...	...
Administrative Expense	...	...	...	...	...	...
CASH INCREASE OR (DECREASE)	...	...	...	...	...	...
Beginning Cash Balance	...	...	...	...	...	...
CASH OVER OR (SHORT)	...	...	...	...	...	...
LOANS TO BE OBTAINED						
INVESTMENTS TO BE MADE						

FIGURE 1

budget. Any controllable accounts contained in the budget's upper section are also included in the decision model. For instance, Accounts Payable to suppliers would not be fixed within the budget since suppliers generally allow payments over an extended period. Including purchases implies that a decision must be made beforehand to specify the date for payment of goods. This decision is not to be made in advance. Rather, the model provides the appropriate time period for payment.

Similarly, the account Notes Payable would not be fixed within the cash budget. This implies that notes will be paid on a given date, usually the due date. However, it may be true that a firm would be financially better off by paying the note before the due date. The same holds for any interest earnings from investments which are included under cash collected from Other Income. A firm may be in a better financial position by redeeming or selling investments before their maturity.

For purposes of this study, the three controllable accounts mentioned above are to be removed from the upper portion of the cash budget and grouped along with the decisions to be made in the lower portion of the budget. This implies that the Beginning Cash Balance for all periods beyond the first can no longer be determined in advance.

Consequently, the Beginning Cash Balance must also be considered in the budget's lower section.

Given an adjusted cash budget, the decision-making process begins. The cash decision problem can be approached in two stages. The first stage requires selection of a set of feasible financing and investment alternatives. The second stage involves the specification of the alternative or combination of alternatives which allows the most economic acquisition or utilization of funds. The remaining discussion in this chapter will explore the financing and investment alternatives available to a small firm. The discussion in the following chapter will consider a technique for choosing among these alternatives.

Financing Alternatives

A small firm typically requires financing frequently, in varying amounts, and for varying purposes. Unfortunately, the small firm faces very limited financing alternatives. Small business is viewed as risky and expensive to fund. The risk factor is attributable to a lack of resources needed to protect the use of borrowed funds. The expense factor stems from the relatively fixed transaction costs of financing, which result in a higher cost per dollar for small loans. The effect of these characteristics is a cost of financing which is so high that the alternatives open to a small firm are greatly reduced. Nonetheless, sources for obtaining funds do exist. These include trade credit, line of credit, and term loan.

TRADE CREDIT

Trade credit is an indirect source of short-term funds extended by a firm's suppliers. Trade credit arises from the time lag between receipt of goods and payment for them. Under a trade credit agreement, goods are received along with an invoice which specifies the terms of payment. Such terms usually include the net period within which the invoice is to be paid, as well as a cash discount allowance for early payments. For example, terms of 2/10,n/30 allow a 2% cash discount for payments made within 10 days of the purchase, and require full payment within 30 days.

Trade credit normally bears no interest and is, therefore, a seemingly desireable source of financing. However, an implicit cost is incurred for failure to take advantage of the cash discount. This implicit cost is oftentimes greater than the cost of obtaining funds from other sources in order to meet the cash discount deadline.

LINE OF CREDIT

A line of credit is an agreement which ensures that adequate credit will be continually available to a firm on short notice. Under a line of credit agreement a firm can borrow up to a maximum amount at any time during a specified period. Typically, an annual clean-up of the loan is required. This is a period usually of one or two months during which the loan is completely paid off.

A line of credit represents self-liquidating financing. That is, financing obtained under a line of credit is used for a purpose which will automatically generate cash for repayment. Because of this factor, a firm is generally given the freedom to match both the size and timing of repayments to its subsequent cash flow patterns. Repayments on the credit line increase the amount available for future borrowing.

Interest expense on the amount oustanding under a line of credit is payable monthly. The interest rate is flexible, and is expressed in annual terms as a percentage of prime. In addition to interest, the firm is usually required to maintain a compensating balance. The balance amount is determined as a percentage of the maximum amount available under the line and/or as a percentage of the loan outstanding.

TERM LOAN

A term loan differs from a line of credit in that each loan request is treated on an individual basis. Repayment terms are also individually negotiated. Principal may be repaid in fixed amounts at fixed intervals, or the entire principal may be repaid at the loan expiration. Interest may be paid up-front (i.e., discounted); it may be paid periodically at either a fixed or variable rate; or it may be paid at the term of the loan (i.e., added-on).

The cost of the term loan is not based solely on the interest charge. Restrictions are often imposed to reduce the level of risk involved. These restrictions may include the maintaining of a a minimum working capital, the writing of periodic reports, the limiting of a firm's total debt, etc. Such restrictions tend to reduce the flexibility of the firm and, thus, should be recognized as implicit costs of financing.

By far, the most common type of short-term loan, and the type to be considered in this study, is the 90-day renewable note. This is a discounted note which allows a firm to either repay or renew a loan at the end of 90 days. The note also allows early repayment and appropriate interest credits. The interest rate on a 90-day renewable is stated in annual terms, compounded monthly.

OTHER FINANCING

The three financing alternatives described above are relevant to this study. Commercial paper, which can be issued only by firms with a high credit rating, is not a viable alternative to the small firm and, therefore, not considered here. The pledging of assets such as accounts receivable and inventory entails prohibiting administrative expense and, thus, is also omitted. Other types of financing are generally of a long-term nature and, consequently, are not applicable to this study.

Investment Alternatives

While considerable attention must be given to the financing of cash shortages, the opportunity cost of cash surpluses cannot be neglected. Business firms typically operate under seasonal forces. During peak periods it is common for the firm to acquire cash in excess of its current needs. In order that idle cash balances do not hinder overall operations, plans should be made for putting these balances to work. Excess cash should be invested in one of the many short-term securities which exist.

As with financing, investment alternatives suitable to a small firm are somewhat limited. The small business oftentimes operates in an environment of tremendous uncertainties; change occurs rapidly and extensively.

Consequently, when a small firm invests funds, it must do so in such a way as to be able to realize the investment quickly when cash is again needed. This can be accomplished by investing in securities with very short maturity periods. The shorter the period, however, the lower the earnings and the less desirable the investment. A way of circumventing this problem is to invest in securities which have an active secondary market. This type of security represents potentially better earnings and can be sold prior to maturity, if necessary. An additional consideration in the specification of investment alternatives for the small firm is that the minimum initial investment required by the alternative be reasonable. Investment opportunities which meet these criteria include U.S. Treasury bills, money market funds, and traditional passbook savings accounts.

TREASURY BILLS

U.S. Treasury bills are one of the most widely used instruments for temporary investment of idle cash. Treasury bills, or T-bills, are short-term securities issued in maturity periods of 13 weeks, 26 weeks, and 52 weeks. They are available through banks and brokers in minimum amounts of $10,000 and in multiples of $5,000 above the minimum.

Treasury bills do not bear interest. An investor earns a return by purchasing the bills at a discount and then either 1) redeeming them at maturity for the full face value, or 2) selling them prior to maturity at the prevailing market rate. This study assumes that a small firm invests in T-bills with the intention of keeping them to maturity.

The Treasury bill discount rate is determined competitively in a weekly auction of new issues. This discount or "bid" rate is expressed as an annual percentage. It is interesting to note that while the discount rate to the U.S. Treasury is based on a 360-day year, the earnings rate to the investor is based on a 365-day year.

MONEY MARKET

A money market is a device for pooling the resources of many investors. The benefits to be realized are many. First, the minimum denomination required of many security types, while seemingly exhorbitant to a small firm, is easily accessible through pooled funds. Second, diversification can be attained by investing in differing types and maturities of instruments; such mix can greatly reduce the investors' risk. Third, economies of scale with respect to transaction costs can be achieved; these costs otherwise tend to drag down the earnings of a small investor. Still other advantages include full-time professional management and record keeping services.

Money markets typically require a reasonable initial investment. However, this investment need not be maintained beyond the initial period. Money markets calculate interest daily on outstanding balances, and credit interest to investors' accounts periodically, usually at the end of each month. Withdrawals can be made from money market funds at any time without penalty. Many funds even provide checking services, with the requirement that checks be written above some specified minimum amount.

SAVINGS

Two disadvantages of the money market are the required minimum initial investment and the unsecured nature of the fund. An investment alternative which overcomes these advantages is the passbook savings account. A savings account is guaranteed by the Federal Reserve. Investments and withdrawals can be made in any amounts; and interest is accrued daily on the outstanding balance.

There is a wide deviation between the earnings rate of passbook savings and the earnings rate on other types of short-term investments. This gives rise to the question of why the savings account should be considered among investment alternatives. It will be seen in a later chapter that consideration of savings is important from a modeling standpoint and for this reason is included as an investment alternative.

OTHER INVESTMENTS

Certificates of deposit and commercial paper are common types of short-term investments. However, these alternatives are generally not available to the small firm. Each of these alternatives requires a minimum level of investment which is beyond the reach of a small business. Furthermore, neither of the alternatives has an active secondary market to allow for early redemption of the investment if needed. Other types of short-term investments have been omitted due to complexity factors or infrequency of use by small firms.

Interaction between Alternatives

Before concluding the discussion of alternatives available to the small firm, it is important to comment on the interrelationship which exists between investment and financing alternatives. Cash shortages can be financed through the redemption of investments; consequently, the redemption of investments can be considered as a financing alternative. Similarly, excess cash can be used to reduce financing obligations; thus, reduction of financing can be considered as an investment alternative. In making cash decisions, this interrelationship must be recognized.

Chapter V

PROBLEM APPROACH

The cash decision problem of a small firm does not lie merely in a search for possible financing and investment alternatives. Rather, the problem lies in selecting the most economic and efficient combination of alternatives. The selection must consider several periods simultaneously since cash decisions in one period affect and are affected by decisions in subsequent periods.

Solution Procedure

The literature has shown that a viable solution approach to the multiple period cash management problem is that of linear programming. Linear programming (LP) has the particularly desirable feature of simplicity in both model formulation and implementation. In addition, LP models are very comprehensive in the number of variables and constraints which can be considered. Also, linear programming can play a vital role in determining the impact of changes to a given model. Changes which may result from uncertain environmental elements or from managerial policy-making can easily be accounted for through sensitivity analysis.

Because of its deterministic nature, the linear programming formulation requires that a firm be able to identify all cost factors relating to the set of financing and investment alternatives over the entire planning horizon. Assumptions regarding current knowledge of data from future time periods may seem too restrictive. However, this need not be the case. While decisions of many periods are made simultaneously, only current period decisions are actually implemented. Hence, as costs change, additional runs can be made based on revised estimates.

In addition to the identification of costs for each alternative, linear programming requires that these costs be proportional to the dollar amounts involved. No provision for fixed costs is possible. Again, this is not entirely unreasonable in the case of cash decision-making. Fixed costs typically represent administration costs and these are likely to be approximately equal under each alternative. Therefore, fixed costs are generally not relevant to the decision.

Even with the above assumption on fixed costs, the problem environment for cash decision-making does not entirely lend itself to a linear format. As will be shown later, several of the financing and investment alternatives necessitate modeling with the use of zero-one and integer variables. This introduces some difficulty in terms of solution procedure. The widely-used simplex algorithm for solving linear programs does not lend itself to zero-one and integer modifications. While algorithms do exist for solving mixed zero-one integer problems, these algorithms require phenomenal storage capacities and are, therefore, unsuited to a complex cash decision. In addition, these algorithms are unappealling from an interpretive viewpoint.

In order to maintain the desirable features of linear programming, this study utilizes a hueristic approach for solving a mixed zero-one integer problem which is based on the simplex method. The approach can generally be described by the flowchart shown in Figure 2. The approach consists of applying the simplex method under the assumption that all variables are continuous. (Note that zero-one variables are bounded by the value one). If solving the simplex results in zero-one variables which are equal to zero or one, these variables are set equal to the relevant values. From those zero-one variables which are not equal to zero or one, a search is made to find the variable which is nearest to zero or one and that variable is set equal to the relevant value. The simplex is again applied and the procedure continues until all zero-one variables are equal to zero or one. At this point, all integer variables are rounded to the nearest integer.

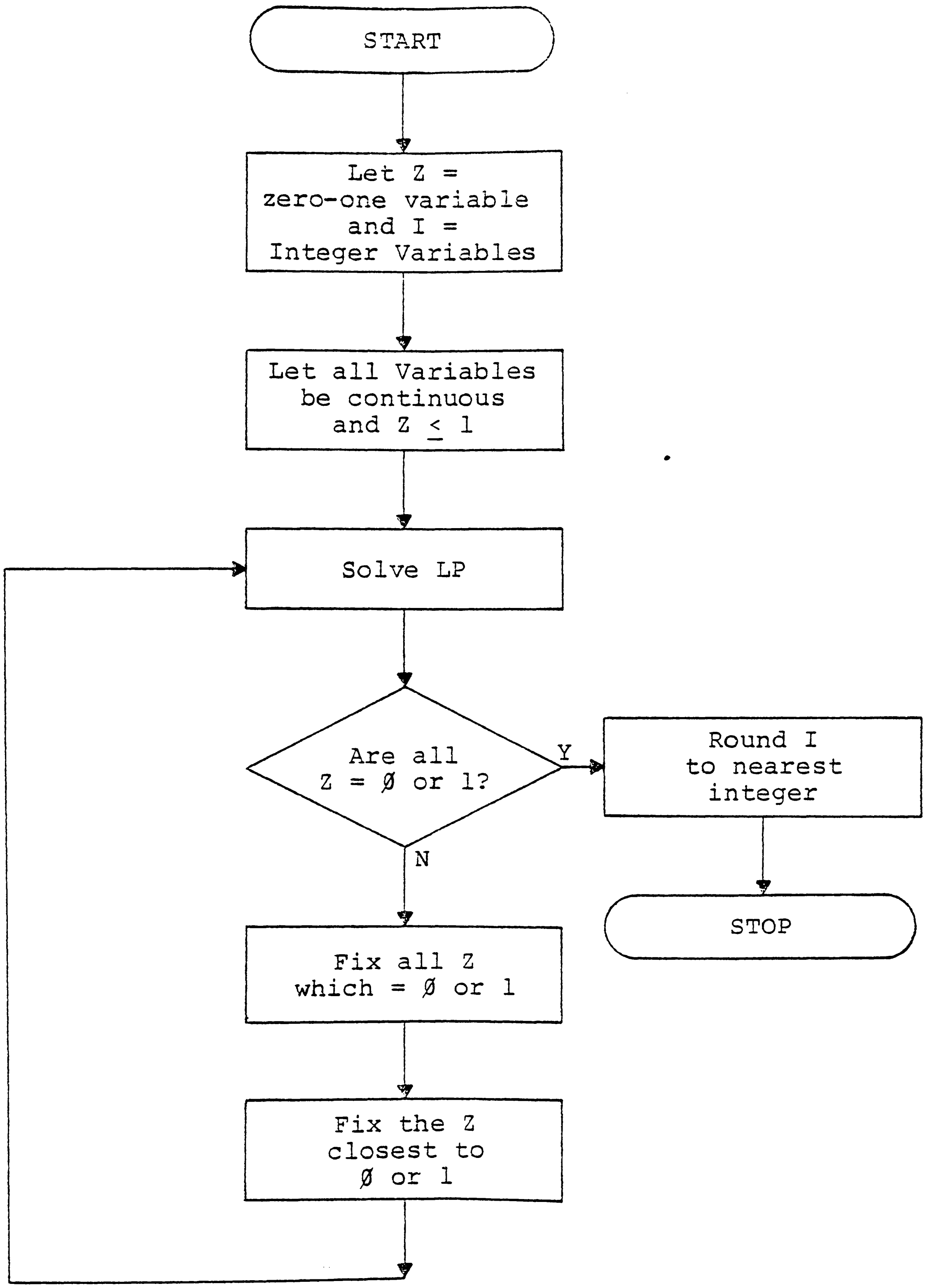
START
Let Z = zero-one variable and I = Integer Variables
Let all Variables be continuous and Z ≤ 1
Solve LP
Are all Z = Ø or 1?
Y
Round I to nearest integer
STOP
N
Fix all Z which = Ø or 1
Fix the Z closest to Ø or 1

Figure 2

A short-coming of this heuristic approach is that it can induce infeasibility in the cash decision problem. For example, setting zero-one financing variables equal to zero can cause a shortage in the cash flow relationship. Similarly, a shortage in the cash flow relationship can occur when zero-one investment variables are set equal to one. It is possible to overcome this potential infeasibility by utilizing a conservative version of the above approach.

Rather than setting zero-one variables in accordance with their nearest value, the hueristic will set those zero-one variables relating to financing equal to one and those relating to investment equal to zero. By so doing, the cash inflow from financing will increase when necessary and the cash outflow from investing will decrease when necessary. Because integer variables in this study relate only to investment alternatives (namely, Treasury Bills), their values will always be rounded down to the nearest integer. This method will achieve a conservative but good result suitable to the small business environment. The revised flowchart appears in Figure 3.

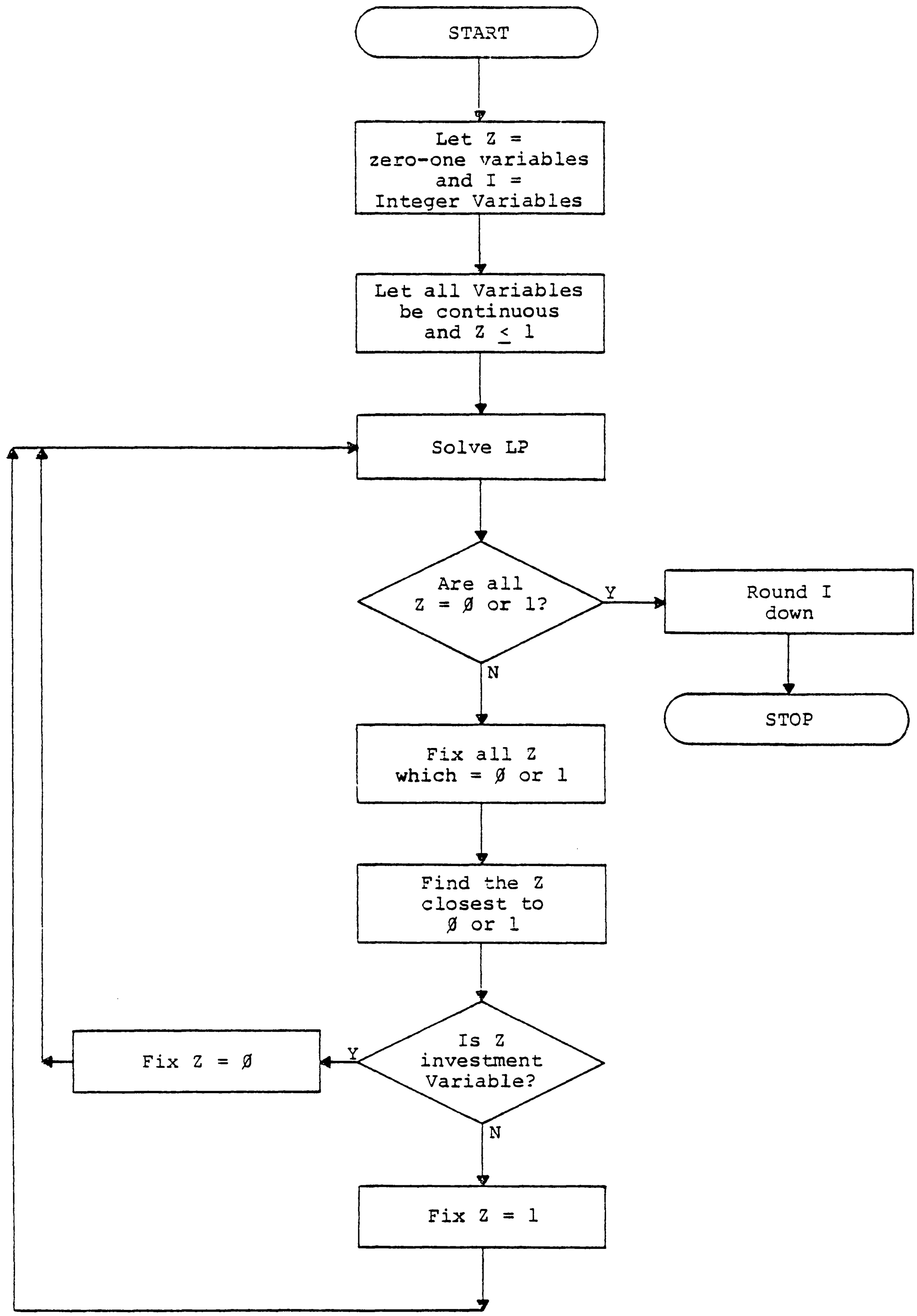
START
Let Z =
zero-one variables
and I =
Integer Variables
Let all Variables
be continuous
and Z ≤ 1
Solve LP
Are all
Z = Ø or 1?
Y
Round I
down
STOP
N
Fix all Z
which = Ø or 1
Find the Z
closest to
Ø or 1
Is Z
investment
Variable?
Y
Fix Z = Ø
N
Fix Z = 1

Figure 3

Model Discussion

Under a linear programming approach, an objective function is optimized subject to a set of constraints. The cash decision problem requires constraints for balancing inflows and outflows for each period. In addition, the cash decision problem requires constraints for recognizing certain restrictions inherent in the decision alternatives themselves. These constraints will be discussed in greater detail in the following section.

Other constraints, as well as the objective function, are not implicitly defined by the cash problem but allow some flexibility with respect to modeling. For instance, a small business may wish to impose constraints which reflect managerial policies. Such managerial policies may specify desired liquidity ratios or minimum cash balances. The cash balance restriction is particularly appropriate for small businesses which often deal with severe uncertainties. Hence, minimum cash balance constraints are included as an option in the model.

The objective function may take many forms in cash decision-making. A typical objective function would be profit maximization. Profit maximization would be reflected by summing the costs and return of decisions over all planning periods. The determination of profit relies on an accrual rather than cash basis of evaluation. However, multiple periods require that the time value of money be considered; and the accrual concept cannot adequately handle the time value of money.

Value maximization extends the concept of profit maximization to a multi-period framework. Value maximization, as reflected in future worth, is able to incorporate the timing of cash decisions in the objective. Value maximization is the objective chosen for this study. For cash decision-making, value maximization includes the cash balance plus investments less financing outstanding at the horizon.

It is important to note that a future worth objective must maximize value at the beginning of the last period in the planning horizon. This is, of course, the same as maximizing value at the end of that planning period which precedes the last. It is impossible to determine future worth at the end of the last planning period since this time point corresponds to a decision which has not been made. The effect of maximizing value at the end of the planning period which precedes the last is to make decisions of the last period irrelevant. The example provided in the following chapter will clarify this point.

Model Formulation

The following section provides the detailed formulation of the cash decision problem for small business. The section is organized according to financing and investment alternatives, with a discussion of the alternatives given first, followed by constraint formulations and appropriate terms to be included in the cash flow relationships and objective function. The following general notation will be used throughout.

Decision Variable
- X = cash inflow
- Y = cash outflow
- Z = cash balance

Superscripts
- initial = identifier of alternative
- = constant

Subcripts
- i = index over source
- j = index over transaction period
- t = index over time period

Parameters
- a = general technological coefficient
- n = period duration
- r = interest rate
- q = percentage
- H = high or upper bound
- L = lower bound
- PH= planning horizon

Special Characters
- α = 0,1
- β = integer

TRADE CREDIT DISCUSSION

(1) Variables. Trade credit requires a single decision variable which represents the use of cash for payment of obligations to suppliers. The decision variable specifies the amount and timing of such payments. It should be noted that under cash discount arrangements, the decision variable reflects the actual amount of payment and not the invoice or purchase amount.

The trade .credit decision variable requires three subscripts. The first subscript identifies the source or supplier of credit. This subscript differentiates only between the terms offered by suppliers, not between individual suppliers themselves. For instance, if two or more sources of trade credit specify identical payment and discount terms, they are grouped as a single supplier. A second subscript represents the transaction period, or period in which the goods are received. It is necessary to identify the transaction period because payment terms are expressed as a function of this period (eg., payment due 30 days after transaction). The final subscript reflects the current time period in which a decision is to be made.

(2) Input. Input parameters for trade credit are of three types: amount of obligation, discount rate, and duration. The amount of obligation comes from a projection

of purchasing requirements over the planning horizon. Purchases must be identified by source (as previously defined) and by transaction date. Outstanding accounts on purchases made before the planning horizon must also be included as input.

The cash discount rate must be specified for each supplier. If it is anticipated that the discount rate for a particular supplier will change in the future, two distinct suppliers with respective cash discount rates should be identified.

Input parameters for duration of payment are twofold. The first specifies the number of periods within which the net payment must be made; the second specifies the number of periods for which a cash discount is offered.

(3) <u>Constraints</u>. Major characteristics of the trade credit constraints reflect the fulfillment of obligations (in terms of both time and dollars) and the consideration of discount arrangements. The general constraint specifies that all payments must be made within the net payment terms. The effect of timing on the payment size is handled through a technological coefficient computed from the discount rate. The value of the coefficient is slightly different from the actual rate because the coefficient applies to the amount of the payment, whereas the discount rate applies to the invoice amount.

An initial condition states that payments for outstanding accounts must begin at period one rather than at the transaction date, since only current and future decisions are to be determined. An ending condition states that payments on obligations due beyond the planning horizon may be scheduled prior to the due date but do not have to be made within that period.

TRADE CREDIT DEFINITIONS

$\tilde{W}_{ij}^{TC}$ = dollar value of goods received from supplier i in transaction period j; where $i = 1,\ldots,S$ and $j = 1 - n_i^{TC},\ldots,PH$ (see n_i^{TC} definition)

Y_{ijt}^{TC} = dollars paid out in time period t for goods received from supplier i in transaction period j; where $t = 1,\ldots,PH$

r_i^{TC} = cash discount rate for goods received from supplier i

n_i^{TC} = number of periods in net payment interval for supplier i

nn_i^{TC} = number of periods in cash discount interval for supplier i

TRADE CREDIT CONSTRAINTS

Payment Obligations

1) $$\sum_{t=1}^{j+n_i^{TC}} a_{ijt}\, Y_{ijt}^{TC} = \tilde{W}_{ij}^{TC} \qquad \text{for } i = 1,\ldots,S \text{ and } j = 1 - n_i^{TC},\ldots,0$$

2) $$\sum_{t=j}^{j+n_i^{TC}} a_{ijt}\, Y_{ijt}^{TC} = \tilde{W}_{ij}^{TC} \qquad \text{for } i = 1,\ldots,S \text{ and } j = 1,\ldots,PH - n_i^{TC}$$

3) $$\sum_{t=j}^{PH} a_{ijt}\, Y_{ijt}^{TC} \leq \tilde{W}_{ij}^{TC} \qquad \text{for } i = 1,\ldots,S \text{ and } j = PH - n_i^{TC} + 1,\ldots,PH$$

where

$$a_{ijt} = \begin{cases} \dfrac{1}{1 - r_i^{TC}} & \text{for } t = j,\ldots,j + nn_i^{TC} \\ 1 & \text{for } t = j + nn_i^{TC} + 1,\ldots,j + n_i^{TC} \end{cases}$$

TRADE CREDIT CASH BALANCE TERMS

$$\sum_{i=1}^{S} \sum_{j=t-n_i^{TC}}^{t} Y_{ijt}^{TC} \qquad \text{for } t = 1,\ldots,PH$$

TRADE CREDIT OBJECTIVE TERMS

$$\sum_{i=1}^{S} \sum_{j=PH-n_i^{TC}+1}^{PH} \left(- \tilde{W}_{ij}^{TC} + \sum_{t=j}^{PH} a_{ijt}\, Y_{ijt}^{TC}\right)$$

where

$$a_{ijt} = \begin{cases} \dfrac{1}{1 - r_{ij}^{TC}} & \text{for } t = j, \ldots, j + nn_i^{TC} \\ 1 & \text{for } t = j + nn_i^{TC} + 1, \ldots, j + n_i^{TC} \end{cases}$$

LINE OF CREDIT DISCUSSION

(1) Variables. Decision variables relating to a line of credit are of two types: a variable to represent the amount borrowed in order to finance a cash shortage, and a variable to represent the use of cash toward repayment. Each of these variable types requires a single subscript to indicate the current time period in which a decision is to be made. Note that a subscript to indicate the source of the line of credit is not necessary since firms typically have only one credit line. Also note that a subscript to indicate the transaction period is irrelevant since the repayment date is not dependent on the transaction date.

(2) Input. Input parameters for a line of credit fall into three categories: amount, cost, and duration. A line of crdit may already have an amount outstanding at the beginning of the planning horizon which must be included as input to the model. If the line of credit is being considered as an alternative for the first time, it is assumed that any compensating balance required on the unused line has been included as a cash outflow of the first planning period. The maximum amount available under the line of credit is also required as input. Note here that repayments have the effect of increasing the amount available for future borrowing.

The interest cost for the balance outstanding under a line of credit is generally tied to the prime interest rate (eg., prime + 3). When the prime rate fluctuates, so does the interest charged. Therefore, it is necessary to subscript the interest rate in order to reflect projected changes over time. It should be noted here that interest under a line of credit is expressed as a simple annual rate and is payable monthly. In addition to interest charges, compensating balances are often required which have the effect of increasing the actual cost of credit. Compensating balance requirements may be expressed as a percentage of the used credit, a percentage of the unused line, or both.

The duration of a line of credit is specified as a fixed point in time at which the entire outstanding balance must be paid off. After this point, a certain interval of time must elapse before borrowing may resume. Input parameters with respect to duration are expressed in terms of the number of periods remaining until the fixed payment date and the number of periods for which the line is then closed.

(3) Constraints. Constraints under a line of credit account for upper limitations on borrowing as well as terms of principal repayment. Interest and compensating balance

requirements do not necessitate constraining equations, but are expressed via the cash balance terms.

LINE OF CREDIT DEFINITIONS

$\tilde{X}^{LC}$ = dollars outstanding on credit line at the beginning of the planning horizon

X_j^{LC} = dollars borrowed on credit line in period j; where $j = 1, \ldots, PH$

Y_j^{LC} = dollars repaid (principal only) on credit line in period j

r_j^{LC} = interest rate for credit line in period j

n^{LC} = number of periods for which credit line is available before clean-up

nn^{LC} = number of periods for which credit line is not available during clean-up

H^{LC} = maximum amount available under credit line

q^{LC} = compensating balance percentage on used credit

qq^{LC} = compensating balance percentage on unused line

LINE OF CREDIT CONSTRAINTS

A. Upper Bounds Before and After Clean-up

1) $\tilde{X}^{LC} + X_j^{LC} + \sum_{k=1}^{j-1} (X_k^{LC} - Y_k^{LC}) \leq H^{LC}$ for $j = 1, \ldots, n^{LC}$

2) $X_j^{LC} + \sum_{k=n^{LC}+nn^{LC}+1}^{j-1} (X_k^{LC} - Y_k^{LC}) \leq H^{LC}$ for $j = n^{LC}+nn^{LC}+1, \ldots, PH$

B. Clean-up Repayment and Availability

1) $\tilde{X}^{LC} + \sum_{k=1}^{i} (X_k^{LC} - Y_k^{LC}) = 0$ for $j = n^{LC} + 1$ and $j < PH$

2) $X_j^{LC} = 0$ for $j = n^{LC} + 1, \ldots, n^{LC} + nn^{LC}$

LINE OF CREDIT CASH BALANCE TERMS

A. Principal

$(1 - q^{LC} + qq^{LC})(Y_j^{LC} - X_j^{LC})$ for $j = 1, \ldots, PH$

B. Interest

1) $r_j^{LC}/PH \sum_{k=1}^{j-1} (Y_k^{LC} - X_k^{LC} - \tilde{X}^{LC})$ for $j = 1, \ldots, n^{LC} + 1$

2) $r_j^{LC}/PH \sum_{k=n^{LC}+nn^{LC}+2}^{j-1} (Y_k^{LC} - X_k^{LC})$ for $j = n^{LC}+nn^{LC}+2, \ldots, PH$

LINE OF CREDIT OBJECTIVE TERMS

$$\sum_{j=n^{LC}+nn^{LC}+1}^{PH} (- X_j^{LC} + Y_j^{LC})$$

Economic diary/Mar. 8-Mar. 12

An alarming rise in business failures

Whatever one calls the current economic malaise, there is no doubt that individual businesses are hurting—and hurting badly. In the past two years there has been a disturbing rise in the percentage of companies that fail, and, according to Edward I. Altman of New York University, a leading expert on bankruptcy prediction, even more will go under in 1982. His econometric bankruptcy model forecasts that the failure rate will climb to 79 per 10,000 U. S. businesses in 1982—the highest level since 1933, when the rate was 100. According to Altman, that translates into a postwar high of 50,500 bankruptcies this year, up from about 47,400 in 1981.

What alarms Altman even more is that by yearend the corporate failure rate will have risen by 182% since 1979, when it stood at 28. "That is a huge increase in just three years," he says. "And I'm being optimistic about my predictions for real growth and interest rates." Assuming that real output rises by 4.6% and that the money supply increases by 5.5% during the second half of 1982, Altman predicts that the failure rate will be 82 per 10,000 for the first two quarters and then drop to 80 and 73 in the third and fourth quarters, respectively.

In past recessions, it was small businesses that fell by the wayside. But in this protracted slide, the disease has spread. "During the past few years bankruptcies have hit all-size businesses, not just small companies," says Altman. And in the coming shake-out, he expects to see a growing number of big bankruptcies, particularly in the airline, retail, construction, and textile industries. He adds: "I also think we're going to see a big increase in forced mergers and government bailouts."

Exhibit 1: News item on Business Failures Illustrating the Dire Need for Better Cash Management (Business Week: March 29, 1982).

TERM LOAN DISCUSSION

(1) Variables. Recall that the term loan alternative refers to a discounted 90-day renewable note. A term loan requires three types of decision variables to represent: availability of loan, amount to be borrowed, and amount to be repaid. Availability of loan is represented by a zero-one variable. The need for this variable arises from a condition under the term loan which allows only one outstanding loan per period. The variable requires a single subscript to indicate the transaction period.

The decision variable representing the amount borrowed under a term loan specifies the cash value of the loan itself, and not the discounted amount of cash received. Since repayment of a term loan depends upon the transaction date, the borrowing variable requires a subscript to indicate the transaction period. This subscript also serves to unite the zero-one and borrowing variables.

The repayment decision variable requires two subscripts which represent the transaction date of the loan and the repayment date. This variable specifies the actual cash repaid after considering any interest credits for payments made before maturity.

(2) Input. Input parameters for the term loan are of three types: amount, cost, and duration. Any amount outstanding at the beginning of the planning horizon must be

recognized along with the relevant transaction date and interest charge. Since early repayments are permitted under a term loan, beginning outstanding amounts may or may not represent the initial or maximum allowable value of the loan. Therefore, the upper limit on the term loan must also be included as input.

The cost of a term loan is expressed as an annual rate compounded monthly. Because a term loan operates on a discounted basis, the interest charge remains fixed over the term of the loan. However, if a loan is renewed, the going interest rate is charged. This requires the projection of interest rates over the planning horizon, with appropriate time period subscripts.

The duration of a term loan simply indicates the number of periods within which the loan must either be paid or renewed.

(3) Constraints. Major characteristics of the term loan constraints reflect loan availability, upper limits on loan renewal, and repayment conditions. Repayment conditions include technological coefficients which account for interest credits on early payments. Initial conditions state that payments on amounts outstanding must begin with the first planning period and not the transaction date. Ending conditions account for loans with maturities extending beyond the planning horizon.

TERM LOAN DEFINITIONS

$\tilde{X}_j^{TL}$ = dollar value of term loan outstanding at the beginning of the planning horizon; loan was acquired in period j where $j < 1$

X_j^{TL} = dollar value of term loan acquired in transaction period j; where $j = 1, \ldots, PH$

Y_{jt}^{TL} = dollars paid out in time period t for loan received in transaction period j; where $t = 1, \ldots, PH$

r_j^{TL} = interest rate for term loan in period j

n^{TL} = number of periods to maturity for term loan

H^{TL} = maximum amount available under term loan

$$\alpha_j^{TL} = \begin{cases} 1 \text{ if term loan is acquired in period } j \\ 0 \text{ otherwise} \end{cases}$$

TERM LOAN CONSTRAINTS*

A. Loan Availability

$$\sum_{k=j+1}^{j+n^{TL}-1} \alpha_k^{TL} \leq 1 \qquad \text{for } j = 1 - n^{TL}, \ldots, PH - n^{TL}$$

B. Upper Bound on Loan

$$X_j^{TL} \leq H^{TL} \alpha_{ij}^{TL} \qquad \text{for } j = 1, \ldots, PH$$

C. Repayment

1) $$\sum_{t=1}^{j+n^{TL}} a_{jt} Y_{jt}^{TL} = \tilde{X}^{TL} \qquad \text{for } j = 1 - n^{TL}, \ldots, 0$$

2) $$\sum_{t=j+1}^{j+n^{TL}} a_{jt} Y_{jt}^{TL} = X_j^{TL} \qquad \text{for } j = 1, \ldots, PH - n^{TL}$$

3) $$\sum_{t=j+1}^{PH} a_{jt} Y_{jt}^{TL} \leq X_j^{TL} \qquad \text{for } j = PH - n^{TL} + 1, \ldots, PH - 1$$

where

$$a_{jt} = \frac{1}{1 - \dfrac{(r_j^{TL})(n^{TL} - t + j)}{12}}$$

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*This formulation assumes j and t denote monthly periods.

TERM LOAN CASH BALANCE TERMS*

$$- a_t X_t^{TL} + \sum_{j=t-n^{TL}}^{t-1} Y_{jt}^{TL} \qquad \text{for } t = 1, \ldots, PH$$

where

$$a_t = 1 - \frac{(r_t^{TL})(n^{TL})}{12}$$

TERM LOAN OBJECTIVE TERMS*

$$\sum_{j=PH-n^{TL}+1}^{PH} (- a_j X_j^{TL} + \sum_{t=j}^{PH} a_t Y_{jt}^{TL})$$

where

$$a_j = 1 - \frac{(r_j)(n^{TL})}{12}$$

and

$$a_t = \frac{1}{1 - \frac{(r_j^{TL})(n^{TL} - t + j)}{12}}$$

*This formulation assumes j and t denote monthly periods.

MONEY MARKET DISCUSSION

(1) Variables. Decision variables relating to money market are of three types. Two of these represent investments and withdrawals. Withdrawals require corresponding zero-one variables which indicate that if a withdrawal is made (x=1) the amount must be greater than a specified minimum; otherwise withdrawal is not permitted (x=0). Both the zero-one and withdrawal variables require a subscript to identify the decision period. Investment variables require this same subscript. Note that there is no relationship between the investment date and the withdrawal date and, consequently, no need for additional subscripts.

(2) Input. The money market alternative requires input parameters for amount and cost. With respect to amount, the outstanding money market balance must be specified as well as the minimum withdrawable amount. If the money market fund is being considered as an alternative for the first time, it is assumed that the initial investment has been included as a cash outflow of the first planning period. In this case, the outstanding balance would be equal to the initial investment.

With respect to cost, money market returns must be projected over the planning horizon. Returns must be specified as the average annual interest rate for the period.

(3) Constraints. Constraints relative to money market include lower and upper limitations on withdrawals. The lower limit is the minimum amount declared by the fund, as specified in the input. The upper limit is, of course, the balance in the money market account. An additional constraint limits the zero-one variables to a value of one. Recall that the solution procedure will then fix the resulting continuous values to the appropriate endpoints, zero or one.

MONEY MARKET DEFINITIONS

$\tilde{Y}^{MM}$ = dollars outstanding in money market at the beginning of the planning horizon

Y_j^{MM} = dollars invested in money market in period j; where $j = 1,...,PH$

X_j^{MM} = dollars withdrawn from money market in period j

r_j^{MM} = interest rate for money market in period j

$$\alpha_j^{MM} = \begin{cases} 1 \text{ if withdrawal is made in period } j \\ 0 \text{ otherwise} \end{cases}$$

L^{MM} = minimum withdrawal

M = an arbitrarily large positive number

MONEY MARKET CONSTRAINTS

A. Lower Bound on Withdrawals

1) $X_j^{MM} \geq L^{MM} \alpha_j^{MM}$ for $j = 1, \ldots, PH$

2) $X_j^{MM} \leq M \alpha_j^{MM}$ for $j = 1, \ldots, PH$

B. Upper Bound on Withdrawals

$$X_j^{MM} \leq a_1 \tilde{Y}^{MM} + \sum_{k=1}^{j-1} a_k (Y_k^{MM} - X_k^{MM}) \qquad \text{for } j = 1, \ldots, PH$$

where

$$a_k = \prod_{\ell=k}^{j-1} (1 + r_\ell)^{1/PH}$$

MONEY MARKET CASH BALANCE TERMS

$$Y_j^{MM} - X_j^{MM} \qquad \text{for } j = 1, \ldots, PH$$

MONEY MARKET OBJECTIVE TERMS

$$\sum_{j=1}^{PH-1} a_j (Y_j^{MM} - X_j^{MM})$$

where

$$a_j = \prod_{k=j}^{PH-1} (1 + r_k)^{1/PH}$$

TREASURY BILL DISCUSSION

(1) Variables. Treasury bills may be purchased in minimum denominations, or in defined multiples bove the minimum. This necessitates the use of three major decision variables. The first variable represents the Treasury bill investment, with subscripts to identify the bill type (i.e., 13-week, 26-week, or 52-week bills) and to identify the date of purchase. The second and third variables correspond to Treasury bill investments: zero-one variables are associated with the minimum denomination and integer variables are associated with the multiple increments. Subscripts for these two variables are the same as those for the corresponding investment variables. Note that there is no variable to represent the return from Treasury bills. Under the assumption that Treasury bills will be held to maturity, no such variable is necessary. The return is fixed and appears in the cash flow relationship.

(2) Input. The only input parameters for Treasury bills are interest or "bid" rate projections for the planning horizon. These projections must be made for each type of Treasury bill to be considered.

(3) Constraints. Major constraints account for the minimum and multiple restrictions. In addition, the zero-one variables must be limited to a value of one.

TREASURY BILL DEFINITIONS

X_{ij}^{TB} = face value of type i T-bills purhcased in period j; where $i = 1,2,3$ for 13-week, 26-week and 52-week T-bills, respectively, and $j = 1,\ldots,PH$

r_{ij}^{TB} = bid rate for i T-bills in period j

n_{i}^{TB} = number of months to maturity for type i T-bills; where $n_i = 3,6,12$ for $i = 1,2,3$

$$\alpha_{ij}^{TB} = \begin{cases} 1 & \text{if type i T-bill is purchased in period j} \\ 0 & \text{otherwise} \end{cases}$$

β_{ij}^{TB} = integer

M = an arbitrarily large positive number

TREASURY BILL CONSTRAINTS*

Investment Multiples

1) $X_{ij}^{TB} = 10000\ \alpha_{ij}^{TB} + 5000\ \beta_{ij}^{TB}$ for $i = 1,2,3$ and $j = 1,\ldots,PH$

2) $\beta_{ij}^{TB} \leq M\ \alpha_{ij}^{TB}$ for $i = 1,2,3$ and $j = 1,\ldots,PH$

*$10,000 minimum denomination; $5,000 multiples.

TREASURY BILL CASH BALANCE TERMS*

$$\sum_{i=1}^{3} (a_{ij}X_{ij}^{TB} - X_{i,j-n_i}^{TB}) \qquad \text{for } j = 1,\ldots,PH$$

where

$$a_{ij} = 1 - \frac{(r_{ij})(n_i)}{12}$$

TREASURY BILL OBJECTIVE TERMS*

$$\sum_{i=1}^{3} \sum_{j=PH-n_i+1}^{PH} a_{ij}X_{ij}^{TB}$$

where

$$a_{ij} = 1 - \frac{(r_{ij})(PH-j)}{12}$$

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*This formulation assumes j denotes monthly periods.

SAVINGS ACCOUNT DISCUSSION

(1) Variables. Two types of decision variables are necessary for the savings account alternative. These variables represent investments and withdrawals. Each variable must be subscripted by the relevant time period.

(2) Input. The savings account alternative requires two input parameters. The first indicates the outstanding savings balance at the beginning of the planning horizon. The second indicates the annual earnings rate. It is assumed that interest is compounded daily and that the interest rate remains fixed throughout the planning horizon.

(3) Constraints. The only constraint relative to a savings account is that a withdrawal must not exceed the balance in the account. If a minimum balance is to be maintained in the account, the minimum cash balance variables described in the next section can be used. It is important to note here that the savings constraints represent relaxations of the money market constraints.

SAVINGS ACCOUNT DEFINITIONS

$\tilde{Y}^{SA}$ = dollars outstanding in passbook savings at the beginning of the planning horizon

Y_j^{SA} = dollars deposited into savings in period j; where $j=1,\ldots,PH$

X_j^{SA} = dollars withdrawn from savings in period j

r^{SA} = interest rate for savings

SAVINGS ACCOUNT CONSTRAINTS

Upper Bound on Withdrawals

$$X_j^{SA} \leq a_1\tilde{Y} + \sum_{k=1}^{j-1} a_k(Y_k^{SA} - X_k^{SA}) \qquad \text{for } j=1,\ldots,PH$$

where

$$a_k = [(1 + r^{SA})^{1/PH}]^{(j-k)}$$

SAVINGS ACCOUNT CASH BALANCE TERMS

$$Y_j^{SA} - X_j^{SA} \qquad \text{for } j=1,\ldots,PH$$

SAVINGS ACCOUNT OBJECTIVE TERMS

$$\sum_{j=1}^{PH-1} a_j(Y_j^{SA} - X_j^{SA})$$

where

$$a_j = [(1 + r^{SA})^{1/PH}]^{(PH-j)}$$

MINIMUM CASH BALANCE DISCUSSION

Variables are necessary to specify ending cash balances and must be subscripted by the related time period. The cash balance variables must be used in conjunction with variables from the financing and investment alternatives to define the cash inflow-outflow relationship. In addition, the variables may be used to require the maintenance of a minimum cash balance, in which case the desired minimum should be included as input.

CASH BALANCE DEFINITIONS

Z_j^{CB} = ending cash balance in period j; where $j = 1, \ldots, PH$

L_j^{CB} = minimum cash balance for period j

NCF_j = net cash flow in period j

CASH BALANCE CONSTRAINTS

$$Z_j^{CB} \leq L_j^{CB} \qquad \text{for } j = 1, \ldots, PH$$

CASH BALANCE TERMS

$$Z_j^{CB} = Z_{j-1}^{CB} + NCF_{j-1} \qquad \text{for } j = 1, \ldots, PH$$

CASH BALANCE OBJECTIVE TERMS

$$Z_{PH-1}^{CB}$$

The cash balance equation and the objective function are presented here in completed form.

CASH BALANCE EQUATION

$$\sum_{i=1}^{S} \sum_{j=t-n_i^{TC}}^{t} Y_{ijt}^{TC}$$

$$+ (1 - q^{LC} + qq^{LC})(Y_t^{LC} - X_t^{LC}) + r_t^{LC}/PH \sum_{j=1}^{t-1} (Y_j^{LC} - X_j^{LC})$$

$$- a_t^{TL} X_t^{TL} + \sum_{j=t-n^{TL}}^{t-1} Y_{jt}^{TL}$$

$$+ Y_t^{MM} - X_t^{MM}$$

$$+ \sum_{i=1}^{3} (a_{it}^{TB} X_{it}^{TB} - X_{i,t-n_i^{TB}}^{TB})$$

$$+ Y_t^{SA} - X_t^{SA}$$

$$+ Z_t^{CB}$$

$$= Z_{t-1}^{CB} + NCF_{t-1} \qquad \text{for } t = 1, \ldots, PH$$

where a takes on values previously specified.

OBJECTIVE FUNCTION

$$\sum_{i=1}^{S} \sum_{j=PH-n_i^{TC}+1}^{PH} \left(- \tilde{W}_{ij}^{TC} + \sum_{t=j}^{PH} a_{ijt}^{TC} Y_{ijt}^{TC}\right)$$

$$+ \sum_{j=n^{LC}+nn^{LC}+1}^{PH} \left(- X_j^{LC} + Y_j^{LC}\right)$$

$$+ \sum_{j=PH-n^{TL}+1}^{PH} \left(- a_j^{TL} X_j^{TL} + \sum_{t=j}^{PH} a_t^{TL} Y_{jt}^{TL}\right)$$

$$+ \sum_{j=1}^{PH-1} a_j^{MM} \left(Y_j^{MM} - X_j^{MM}\right)$$

$$+ \sum_{i=1}^{3} \sum_{j=PH-n_i+1}^{PH} a_{ij} X_{ij}^{TB}$$

$$+ \sum_{j=1}^{PH-1} a_j^{SA} \left(Y_j^{SA} - X_j^{SA}\right)$$

$$+ Z_{PH-1}^{CB}$$

where a takes on values previously specified.

Implementation

In order to benefit a small business, the cash decision-making model must be relatively easy to implement. The previous discussion emphasizes the complexity of the proposed model and dictates the aid of computers in attaining solutions. Large computers are generally unavailable to small businesses except through time-sharing. Even in the case of time-sharing, it is likely that small businesses will be reluctant to participate due to a lack of programming skills. Therefore, this study suggests the use of low-priced, high-powered microcomputers with their relative ease of operations in solving the cash decision problem.

The following discussion relates to a specific microcomputer system. The system is marketed by Apple Computer, Inc. and includes a 48k memory computer, two disk drives, video display, and printer. This system necessitates certain storage saving procedures which must be programmed into the cash decision-making model.

The first step in implementation on the microcomputer involves the programming of input requirements. The user must specify the planning horizon, the projected cash budget, the alternatives to be considered (from a defined set of alternatives), relevant description of alternatives, and projected interest rates. From this information, the computer generates the coefficients and parameters required for the initial tableau of the simplex routine. Information is generated in such a way that all requirements of the simplex routine are met. These requirements include a maximizing objective function, positive right-hand side parameters, and equality constraints.

The generating program includes sections for describing each alternative as well as an additional section for defining the cash inflow-outflow relationship. Since the program is quite lengthy, a good deal of space is needed for storage. In order to maximize storage space utility, the following procedure utilizing two disk drives is used.

First, the main sections of the generating program are segregated into a series of individual programs. These individual programs are called from the first disk drive one at a time. As each program is run the generated information is stored on a disk in the second drive. By running the programs separately, information from any previous programs, as well as the program itself, are erased, thereby freeing memory space. When the generating programs are completed, the stored information which accumulates on the second disk is retrieved for use in the solution program. Relevant programs are provided in the Appendix.

This method of transferring information between drives increases the size of the problem which the computer is capable of handling. However, for cash decision problems which consider many alternatives and many planning periods, the storage will not be adequate. This holds only for the Apple computer used in this study. The computer memory can be increased by upgrading the system with an additional memory control unit. Another option is, of course, to use a microcomputer system with greater storage capabilities.

Chapter VI

APPLICATION

The previous chapter presented the cash decision problem in a linear programming format, with solution procedure, model characteristics, and method of implementation discussed in detail. The purpose of this chapter is to illustrate the workings of the model through an example. The example which has been selected is not too complex, yet it includes most of the relevant aspects of the cash decision problem. A description of the example problem is followed by the model construction, solution, and interpretation.

Example Formulation

This example covers a six-month planning horizon and is based on the projected cash budget given in Figure 4. The format of the cash budget is representative of the format typically used in business. As previously discussed, the information contained in the cash budget excludes portions of information which are normally contained in a budget. Payments for goods from suppliers under Accounts Payable have been omitted, as well as repayment of debt under Notes Payable and interest earned under Other Income. Beginning and Ending Cash Balances have also been omitted. This information is to be provided by the decision model.

CASH BUDGET						
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
CASH COLLECTIONS						
Sales	$206000	$190000	$190000	$256000	$258000	$224000
Other Income	–	–	–	–	–	–
Total	$206000	$190000	$190000	$256000	$258000	$224000
CASH DISBURSEMENTS						
Accounts Payable	–	–	–	–	–	–
Labor & Variable Overhead	$ 90000	$ 99200	$117800	$118200	$105600	$ 99600
Fixed Overhead	15000	15000	15000	15000	15000	15000
Selling & Administrative Exp.	20650	19500	19500	21950	23250	21450
Notes Payable	–	–	–	–	–	–
Long Term Debt Payable	0	0	0	50000	0	0
Taxes	0	0	23880	0	0	0
Total	$125650	$133700	$176180	$205150	$143850	$159930
CASH COLLECTIONS LESS DISBURSEMENTS	–	–	–	–	–	–
Beginning Cash Balance	$ 10000	–	–	–	–	–
NET CASH FLOW	$ 80350	$ 56300	$ 13820	$ 50850	$114150	$ 64070
Loans Required	–	–	–	–	–	–
Loans Repaid	–	–	–	–	–	–
Investments	–	–	–	–	–	–
Withdrawals	–	–	–	–	–	–
Ending Cash Balance	–	–	–	–	–	–

Figure 4

Information required in addition to the cash budget can be found on a firm's current balance sheet. Relevant accounts are given below.

Cash	$ 55,000
Marketable Securities	$ 10,000
Accounts Payable	$ 25,680
Notes Payable	$ 10,000

The beginning cash balance represents the amount of funds available for the first period. The marketable securities account represents an investment in a money market fund and the amount includes any interest accumulations which have been automatically redeposited. The accounts payable account represents outstanding amounts owed to suppliers for goods purchased. The notes payable account represents a 90-day renewable note acquired two months previously at a rate of 14%.

The following alternatives are to be considered in this example:

(1) Trade Credit. The firm has two suppliers, each offering terms of 2/10,n30. Projected purchases from suppliers are:

Period	Supplier 1	Supplier 2
1	$ 25,920	$ 20,000
2	31,460	20,000
3	38,940	20,000
4	37,840	20,000
5	32,200	20,000
6	29,420	20,000

(2) Line of Credit. The firm is considering whether or not to establish a line of credit. Proposed arrangements under the line would include one year availability, one month clean up, 15% compensating balance on used credit, 10% compensating balance on the unused line, and a maximum allowable loan of $50,000.

(3) Term Loan. The term loan alternative applies to Notes Payable. The amount oustanding equals the maximum obtainable amount.

(4) Money Market. The money market fund allows minimum withdrawals of $500.

(5) Treasury Bill. The firm is considering expanding its marketable securities portfolio to include 13-week T-bills.

Projected interest rates for the various alternatives are tabulated below.

Period	Term Loan	Credit Line	Money Mkt	T-bill
1	17 %	16 %	13.5%	15 %
2	16	15	12.5	14.5
3	17.5	16.5	13	15.5
4	18	17	14	16
5	19	18	14.5	16.5
6	18.5	17.5	15	16

The information given here is sufficient for model formulation. The formulation for each alternative is presented in sequence, along with the effect on the cash flow and objective function.

TRADE CREDIT

Note that the trade credit alternative specifies two suppliers with identical payment terms. This allows the combining of suppliers as a single source of credit and, consequently, eliminates the need for a subscript to index the source.

(1) Constraints relative to trade credit are:

$$Y_{01}^{TC} = 25680$$

$$1.0204\ Y_{11}^{TC} + Y_{12}^{TC} = 45920$$

$$1.0204\ Y_{22}^{TC} + Y_{23}^{TC} = 51460$$

$$1.0204\ Y_{33}^{TC} + Y_{34}^{TC} = 58940$$

$$1.0204\ Y_{44}^{TC} + Y_{45}^{TC} = 57840$$

$$1.0204\ Y_{55}^{TC} + Y_{56}^{TC} = 52200$$

$$1.0204\ Y_{66}^{TC} + \text{SLACK} = 49420$$

(2) Cash flow terms for all periods of the planning horizon are:

1: $Y^{TC}_{01} + Y^{TC}_{11}$

2: $Y^{TC}_{12} + Y^{TC}_{22}$

3: $Y^{TC}_{23} + Y^{TC}_{33}$

4: $Y^{TC}_{34} + Y^{TC}_{44}$

5: $Y^{TC}_{45} + Y^{TC}_{55}$

6: $Y^{TC}_{56} + Y^{TC}_{66}$

(3) The objective function term showing the amount outstanding to trade creditors is the amount purchased in period 6 less the amount paid in period 6, adjusted for the cash discount. Since this amount represents an obligation of the firm, its sign in the objective should be negative giving $-49420 + 1.0204\ Y_{66}$. The constant cannot be included in the program and must, therefore, be added to the final solution value.

LINE OF CREDIT

The line of credit is being considered as a financing alternative for the first time. Consequently, a \$5,000 compensating balance on the unused line must be included in the cash budget for period one. This has the effect of reducing the \$55,000 beginning balance by \$5,000. (Note that if the beginning balance had been zero, the net cash flow for period one would have been reduced by \$5,000.) Because the line of credit is newly created, no payments are possible in the first period.

(1) Constraints relative to line of credit are:

$$X_1^{LC} + \text{SLACK} = 50000$$

$$X_1^{LC} + X_2^{LC} + \text{SLACK} = 50000$$

$$X_1^{LC} + (X_2^{LC} - Y_2^{LC}) + X_3^{LC} + \text{SLACK} = 50000$$

$$X_1^{LC} + (X_2^{LC} - Y_2^{LC}) + (X_3^{LC} - Y_3^{LC}) + X_4^{LC} + \text{SLACK} = 50000$$

$$X_1^{LC} + (X_2^{LC} - Y_2^{LC}) + \cdots + (X_4^{LC} - Y_4^{LC}) + X_5^{LC} + \text{SLACK} = 50000$$

$$X_1^{LC} + (X_2^{LC} - Y_2^{LC}) + \cdots + (X_5^{LC} - Y_5^{LC}) + X_6^{LC} + \text{SLACK} = 50000$$

(2) Cash flow terms for line of credit must include interest, repayments, and changes in the cash balance. Relevant terms are given for all periods of the planning horizon.

1: $- .95\ X_1^{LC}$

2: $.0125\ X_1^{LC} - .95\ X_2^{LC} + .95\ Y_2^{LC}$

3: $.0138\ X_1^{LC} + (.0138\ X_2^{LC} - .0138\ Y_2^{LC}) - .95\ X_3^{LC} + .95\ Y_3^{LC}$

4: $.0142\ X_1^{LC} + (.0142\ X_2^{LC} - .0142\ Y_2^{LC}) + \cdots$

$+ (.0142\ X_3^{LC} - .0142\ Y_3^{LC}) - .95\ X_5^{LC} + .95\ Y_5^{LC}$

5: $.0150\ X_1^{LC} + (.0150\ X_2^{LC} - .0150\ Y_2^{LC}) + \cdots$

$+ (.0150\ X_4^{LC} - .0150\ Y_4^{LC}) - .95\ X_5^{LC} + .95\ Y_5^{LC}$

6: $.0146\ X_1^{LC} + (.0146\ X_2^{LC} - .0146\ Y_2^{LC}) + \cdots$

$+ (.0146\ X_5^{LC} - .0146\ Y_5^{LC}) - .95\ X_6^{LC} + .95\ Y_6^{LC}$

(3) The objective function for line of credit simply represents the outstanding balance at the beginning of period 6. This balance is expressed through the following terms:

$$- X_1^{LC} - (X_2^{LC} - Y_2^{LC}) - \ldots - (X_6^{LC} - Y_6^{LC})$$

TERM LOAN

The firm may elect to renew its note payable in period 2. If the firm does not choose to renew the note at this time, it may acquire a new loan in any future period provided that only one loan is outstanding per period.

(1) Constraints relative to the term loan are:

$$1.011\ Y^{TL}_{-1,1} + Y^{TL}_{-1,2} = 10000$$

$$1.028\ Y^{TL}_{23} + 1.014\ Y^{TL}_{24} + Y^{TL}_{25} - X^{TL}_{2} = 0$$

$$1.030\ Y^{TL}_{45} + 1.015\ Y^{TL}_{46} - X^{TL}_{4} + \text{SLACK} = 0$$

$$1.033\ Y^{TL}_{56} - X^{TL}_{5} + \text{SLACK} = 0$$

$$\alpha_2^{TL} + \alpha_3^{TL} + \alpha_4^{TL} + \text{SLACK} = 1$$

$$\alpha_3^{TL} + \alpha_4^{TL} + \alpha_5^{TL} + \text{SLACK} = 1$$

$$\alpha_4^{TL} + \alpha_5^{TL} + \alpha_6^{TL} + \text{SLACK} = 1$$

$$\begin{array}{ccccccc}
-10000\ \alpha_2^{TL} & + & X_2^{TL} & + & \text{SLACK} & = & 0 \\
-10000\ \alpha_3^{TL} & + & X_3^{TL} & + & \text{SLACK} & = & 0 \\
\vdots & & \vdots & & \vdots & & \vdots \\
-10000\ \alpha_6^{TL} & + & X_6^{TL} & + & \text{SLACK} & = & 0
\end{array}$$

(2) Cash flow terms under a term loan include the discount amount of the loan received and the actual payments made. Recall that actual payments are net of interest credits when appropriate.

1: $Y^{TL}_{-1,1}$

2: $- .960\ X^{TL}_{2} + Y^{TL}_{-1,2}$

3: $- .956\ X^{TL}_{3} + Y^{TL}_{23}$

4: $- .955\ X^{TL}_{4} + Y^{TL}_{34} + Y^{TL}_{24}$

5: $- .952\ X^{TL}_{5} + Y^{TL}_{25} + Y^{TL}_{35} + Y^{TL}_{45}$

6: $- .953\ X^{TL}_{6} + Y^{TL}_{36} + Y^{TL}_{46} + Y^{TL}_{56}$

(3) The objective function terms below indicate the amount outstanding under the term loan.

$$- 0.985\ X^{TL}_{4} - 0.968\ X^{TL}_{5} - 0.953\ X^{TL}_{6}$$

$$+ 1.031\ Y^{TL}_{45} + 1.015\ Y^{TL}_{46} + 1.033\ Y^{TL}_{56}$$

MONEY MARKET

Because the money market has a beginning outstanding balance, the minimum initial investment is no longer relevant. If the fund were being opened for the first time, the minimum investment would have been deducted from either the beginning cash balance or net cash flow for period 1 on the cash budget.

(1) In the following constraints relative to the money market fund, M represents an arbitrarily large positive number and has no significance beyond that of a modeling necessity.

$$
\begin{array}{rcrcl}
- X_1^{MM} & + & 500\ \alpha_1^{MM} & + \text{ SLACK} & = 0 \\
\vdots & & \vdots & \vdots & \vdots \\
- X_6^{MM} & + & 500\ \alpha_6^{MM} & + \text{ SLACK} & = 0 \\
X_1^{MM} & - & M\ \alpha_1^{MM} & + \text{ SLACK} & = 0 \\
\vdots & & \vdots & \vdots & \vdots \\
X_6^{MM} & + & 500\ \alpha_6^{MM} & + \text{ SLACK} & = 0 \\
 & & \alpha_1^{MM} & + \text{ SLACK} & = 1 \\
 & & \vdots & \vdots & \vdots \\
 & & \alpha_6^{MM} & + \text{ SLACK} & = 1
\end{array}
$$

$$X_1^{MM} + \text{SLACK} = 10000$$

$$X_2^{MM} + 1.011\ (X_1^{MM} - Y_1^{MM}) + \text{SLACK} = 10106$$

$$X_3^{MM} + 1.021\ (X_1^{MM} - Y_1^{MM}) + 1.010\ (X_2^{MM} - Y_2^{MM}) + \text{SLACK} = 10206$$

$$X_4^{MM} + 1.031\ (X_1^{MM} - Y_1^{MM}) + 1.020\ (X_2^{MM} - Y_2^{MM})$$
$$+ 1.010\ (X_3^{MM} - Y_3^{MM}) + \text{SLACK} = 10310$$

$$X_5^{MM} + 1.042\ (X_1^{MM} - Y_1^{MM}) + 1.031\ (X_2^{MM} - Y_2^{MM})$$
$$+ 1.021\ (X_3^{MM} - Y_3^{MM}) + 1.011\ (X_4^{MM} - Y_4^{MM}) + \text{SLACK} = 10423$$

$$X_6^{MM} + 1.054\ (X_1^{MM} - Y_1^{MM}) + 1.043\ (X_2^{MM} - Y_2^{MM})$$
$$+ 1.033\ (X_3^{MM} - Y_3^{MM}) + 1.022\ (X_4^{MM} - Y_4^{MM})$$
$$+ 1.011\ (X_5^{MM} - Y_5^{MM}) + \text{SLACK} = 10542$$

(2) Cash flows for the money market are:

$$1: \quad - X_1^{MM} + Y_1^{MM}$$

$$2: \quad - X_2^{MM} + Y_2^{MM}$$

$$3: \quad - X_3^{MM} + Y_3^{MM}$$

$$4: \quad - X_4^{MM} + Y_4^{MM}$$

$$5: \quad - X_5^{MM} + Y_5^{MM}$$

$$6: \quad - X_6^{MM} + Y_6^{MM}$$

(3) The objective function terms represent the amount outstanding under the money market. The objective function must also include a constant which represents the horizon value of the beginning outstanding balance. This constant, which equals 10735, must be added to the final solution value.

$$- 1.054\ (X_1^{MM} - Y_1^{MM}) - 1.043\ (X_2^{MM} - Y_2^{MM}) - 1.033\ (X_3^{MM} - Y_3^{MM})$$
$$- 1.022\ (X_4^{MM} - Y_4^{MM}) - 1.011\ (X_5^{MM} - Y_5^{MM}) - 1.000\ (X_6^{MM} - Y_6^{MM})$$

TREASURY BILL

Since the firm is considering 13-week T-bills only, there is no need for a subscript to indicate type of bill. It is assumed that any brokerage costs for acquiring T-bills have been included in the projected bid rates.

(1) In the Treasury bill constraints below, M stands for an arbitrarily large positive number. Zero-one variables are restricted to a value of one.

$$
\begin{array}{rcrcrcl}
-\ 10000\ \alpha_1^{TB} & - & 5000\ \beta_1^{TB} & + & Y_1^{TB} & = & 0 \\
\vdots & & \vdots & & \vdots & & \vdots \\
-\ 10000\ \alpha_6^{TB} & - & 5000\ \beta_6^{TB} & + & Y_6^{TB} & = & 0 \\
-\ M\ \alpha_1^{TB} & + & \beta_1^{TB} & + & \text{SLACK} & = & 0 \\
\vdots & & \vdots & & \vdots & & \vdots \\
-\ M\ \alpha_6^{TB} & + & \beta_6^{TB} & + & \text{SLACK} & = & 0 \\
 & & \alpha_1^{TB} & + & \text{SLACK} & = & 1 \\
 & & \vdots & & \vdots & & \vdots \\
 & & \alpha_6^{TB} & + & \text{SLACK} & = & 1
\end{array}
$$

(2) Cash flows for all planning periods are:

$$1: \quad .962\ Y_1^{TB}$$

$$2: \quad .964\ Y_2^{TB}$$

$$3: \quad .961\ Y_3^{TB}$$

$$4: \quad .960\ Y_4^{TB} - Y_1^{TB}$$

$$5: \quad .959\ Y_5^{TB} - Y_2^{TB}$$

$$6: \quad .960\ Y_6^{TB} - Y_3^{TB}$$

(3) Outstanding Treasury bill investments are indicated by the following objective function terms.

$$.973\ Y_4^{TB} + .986\ Y_5^{TB} + Y_6^{TB}$$

Formulation of the example problem has been provided here in order to demonstrate the transition from the general cash decision model to a given problem. Formulation of the general model has been coded for implementation on the microcomputer. Thus, specific formulations are not necessary; implementation requires only the input given in the example description.

Example Solution

The solution to this example problem requires the manipulation of a Simplex tableau of size 81 x 146. Due to storage limitations of the microcomputer, solution of the complete problem is impossible. The problem must, therefore, be scaled down. This can be accomplished in two ways: 1) by reducing the number of alternatives to be considered, or 2) by reducing the number of planning periods.

Reduction of the number of alternatives can be handled by separating the problem into two parts. The first part includes the financing alternatives and the second part, the investment alternatives. Financing decisions which result from solution of part one are used as input to part two. Solution of part two then provides the investment decisions.

This approach is conservative in that financing decisions are given priority over investment decisions. It is contended here that in a small business environment, where cash budgeting and other projections cannot be estimated with a high level of accuracy, the conservative approach may be the wisest.

Separation of the problem as described above reduces the size of the Simplex tableau which the computer must handle. Solution of part one (financing decisions) for the example involves the manipulation of a 39 x 74 tableau. However, this problem is yet too large for solution on the microcomputer.

A second method for narrowing the problem scope is to reduce the number of periods in the planning horizon. If the number of planning periods is reduced from six to five, the resulting tableau size is 32 x 60. The problem is now solvable under the Simplex procedure; however, tolerance levels under the zero-one routine distort the solution for a problem of this size. By reducing the number of planning periods to four and, consequently, the tableau size to 25 x 46, the problem becomes solvable under both the Simplex procedure and the zero-one routine.

The four-period planning horizon has been used to obtain the financing decisions for the example problem. These results are given below:

TRADE CREDIT	LINE OF CREDIT	TERM LOAN
$Y_{01}^{TC} = 25680$	$Y_{2}^{LC} = 20681$	$Y_{-1,2}^{TL} = 10000$
$Y_{11}^{TC} = 45002$	$Y_{4}^{LC} = 50000$	$Y_{34}^{TL} = 7613$
$Y_{22}^{TC} = 50431$	$X_{1}^{LC} = 21770$	$X_{3}^{TL} = 7844$
$Y_{34}^{TC} = 58940$	$X_{3}^{LC} = 48911$	$\alpha_{3}^{TL} = 1$
$Y_{44}^{TC} = 9307$		$(Z_{3}^{CB} = 110248)$

All other decision variables are equal to zero. The objective value as specified by the model is 119744. This value must be reduced by a constant of 57840 which reflects the amount purchased under trade credit in the last planning period (see Model Formulation or Example Formulation). The final objective value is 61904. The solution required 42 Simplex iterations (30 under Phase I; 12 under Phase II) and an additional 5 iterations for the zero-one routine. Computing time was 25 minutes.

Several points must be made with regard to interpretation of the solution. The trade credit variables specify the actual amounts paid to suppliers. These may or may not be equal to the amounts owed, since appropriate cash discounts have been included. Line of credit variables specify amounts borrowed or paid. Considerations for compensating balances under the line of credit are not indicated by the solution except through the ending cash balances. Term loan variables specify the face value of loans obtained as well as actual amounts repaid on loans net of appropriate interest credits. The cash balance variables specify ending balances for a given period; and the objective value specifies the worth of the firm at the beginning of the last planning period.

These results can now be used as input to the investment side of the problem. In so doing, the first step is to adjust the cash budget to include the effects of the given financing decisions. Additions to the cash budget are presented in Figure 5.

From the revised cash budget it can be seen that there is no surplus cash for investment consideration. The ending cash balance shown in period three does not become available for use until period four. In period four decisions have already been made for putting the surplus cash to use by reducing financing obligations. Hence, there is no need to solve part two (investment decisions) for the example problem.

	Period 1	Period 2	Period 3	Period 4
CASH AVAILABLE	50000	80350	56300	13820
Beginning Balance	0	0	0	110247
Accounts Payable(TC)				
Previous Period	(25680)	0	0	(58940)
Current Period	(45002)	(50430)	0	(9307)
Notes Payable (TL)				
Obtained, net amount	0	0	7497	0
Repaid	0	(10000)	0	(7613)
Other Loans (LC)				
Obtained	21770	0	48911	0
Repaid	0	(20681)	0	(50000)
Compensating Balance	(1089)	1034	(2446)	2500
Interest	0	(272)	(15)	(708)
Ending Balance	0	0	110247	0

Figure 5

As previously stated, the above approach represents a conservative view toward cash decision-making. In this particular case the approach has proven severely conservative by failing to give any consideration at all to the investment aspect of the problem. Even though the example depicts a tight cash flow situation with little opportunity for investment of surplus cash, the investment aspect of the problem should not be ignored. It is both relevant and important since the redemption of investments can be viewed as a financing alternative.

The example includes a money market investment of \$10,000 at the beginning of the planning horizon. This investment should be considered as an alternative in the cash decision problem. Unfortunately, it cannot be included with the other financing alternatives due to storage limitations. However, it can be substituted for another alternative. Because term loan and money market alternatives represent relatively equal availabilities of funds in this example, it is appropriate to delete the term loan from consideration, in favor of the money market.

This substitution results in a tableau size of 34 x 57 which is again too large for the zero-one routine. To circumvent this difficulty, an artificial substitution can be made. Recall that the savings alternative represents a relaxation of the money market alternative. That is, minimum bounds are not necessary with savings as they are with the money market. Minimum bounds require not only additional constraints but also additional variables which capture the zero-one nature of the withdrawal. The savings alternative, thus, requires a much smaller Simplex tableau.

By artificially replacing the money market alternative with the savings alternative, the problem is reduced to a size which is solvable (22 x 41). Note that this substitution of alternatives is with regard to formulation only. Interest rates and other input requirements should reflect money market and not savings conditions. The substitution is not entirely accurate since interest rates for money market are variable and interest rates for savings are fixed. However, this represents only a minor drawback in that a composite of average money market rate can be specified.

Solution of the above problem results in an objective value which is better than that obtained under the conservative approach. That is, by considering money market as an alternative over term loan, the worth of the firm in this example will increase from $61904 to $95653. Relevant decisions are reflected in the revised cash budget given in Figure 6.

	Period 1	Period 2	Period 3	Period 4
CASH AVAILABLE	50000	80350	56300	13820
Beginning Balance	0	0	0	123107
Accounts Payable (TC)				
Previous Period	(25680)	0	0	(58940)
Current Period	(45002)	(50431)	0	(29778)
Other Loans (LC)				
Obtained	11244	0	50000	0
Repaid	0	(11244)	0	(50000)
Compensating Balance	(562)	562	(2500)	2500
Interest	0	(141)	0	(708)
Investments (MM)				
Deposits	0	(19097)	0	0
Withdrawals	10000	0	19307	0
Ending Balance	0	0	123107	0

Figure 6

It is appropriate to note here that simultaneous consideration of trade credit, line of credit, and savings involves no zero-one variables. Since the Simplex procedure is capable of handling a larger problem than the zero-one routine, the planning horizon can be increased here from four to five periods. The effect of increasing the planning horizon is to increase the value of decisions. That is, the model can anticipate and account for events which will occur further on in time. Solution to the five-period counterpart of the previous problem results in cash decisions which are reflected in the revised cash budget shown in Figure 7.

It is certainly possible to solve other combinations of alternatives and/or planning periods before choosing a particular cash decision-making program. It is believed that the intuitive process undergone in this example clearly demonstrates both the gains and shortcomings of the microcomputer-based cash decision model.

	Period 1	Period 2	Period 3	Period 4	Period 5
CASH AVAILABLE	50000	80350	56300	13820	50850
Beginning Balance	0	0	0	0	79361
Accounts Payable(TC)					
Previous Period	(25680)	0	0	0	(57840)
Current Period	(45002)	(50430)	(57761)	0	(24121)
Other Loans (LC)					
Obtained	11244	0	0	50000	0
Repaid	0	(11244)	0	0	(50000)
Compensating Balance	(562)	562	0	(2500)	2500
Interest	0	(141)	0	0	(750)
Investments (MM)					
Deposits	0	(19097)	0	0	0
Withdrawals	10000	0	1461	18041	0
Ending Balance	0	0	0	79361	0

Figure 7

Chapter VII

CONCLUSIONS AND RECOMMENDATIONS

It is only in recent years that research efforts have addressed the need for two distinct approaches in solving the problems of small and large business. Before this time the small business environment had been generally overlooked, or the assumption was made that small firms were miniaturized images of larger organizations. This study has shown the importance of small business to our economy as well as the unique circumstances under which small businesses operate. In addition, this study has attempted to contribute to the growing body of research directed toward the small firm.

The topic for this study, cash management, was chosen because of its critical role in the survival of small business. The decision-making aspect of cash management was modeled with the intent of providing a useful tool to those with limited time or knowledge for dealing with the complexities of a multi-alternative, multi-period cash decision model.

In developing a microcomputer-based cash decision for small business many problems were encountered. Two such problems related to the solution procedure employed. Use of the Simplex method caused serious storage problems which necessitated the separation of finance and investment decisions. The zero-one routine forced adjustments with respect to tolerance limitations around 0 or 1. The model thus yields a result which is good but not optimal.

This solution procedure would not be appropriate for implementation on a large computer. However, the solution procedure is not the focus of this study. Rather, the development of a cash decision model is the central issue. While the solution procedure leaves many areas for improvement, the model itself is of substantial usefulness. Furthermore, model implementation on the microcomputer is believed to provide more benefits than drawbacks from a small business standpoint.

Continued research pertaining to this study could proceed along two lines: 1) further development of the cash decision model, and 2) development of additional tools tailored to small business. With respect to the cash decision problem, one could pursue the following idea regarding the time structure of the problem. In previous models, the planning horizon has been divided into equal or unequal periods. An equal period division introduces a conflict in determining the number of periods to be considered. That is, a large number of periods creates a computational burden while a small number of periods sacrifices information detail. An unequal period division overcomes this conflict by allowing shorter planning periods in the beginning of the model when detailed information is crucial, and longer planning periods in the end of the model; thereby keeping the total number of planning periods small.

Each of these approaches possess a major shortcoming by assuming that decisions must be made at the beginning of a planning period. It is not always possible that actual transactions will coincide with these decision points. This introduces a very real problem. For example, suppose a financing obligation becomes due in the third week of a month-long planning period. The assumption is made that the obligation will be met on the first day of the month. This implies that there is no interest cost for use of the funds during the three-week interval. Of course, the interest cost for the entire month could have been included as easily as omitted. However, an error on this conservative side can have an equally bad effect, particularly if the obligation were due not three weeks but rather three days into the month.

A suggested approach for alleviating this problem involves the combination of equal and unequal time divisions. That is, planning periods must be divided equally with respect to a single alternative, but may be divided unequally among the many alternatives. The length of the period for a given alternative is determined according to the relevant transaction points for that alternative. This approach forces coincidental transaction and decision points, thus, making the previous assumption realistic.

The method proposed above is not feasible for this study under the given solution procedure and microcomputer storage restrictions. However, it may be possible to adopt another solution procedure which requires less storage; namely, a decomposition technique. It can be seen from the model formulation that the problem is decomposable. That is, the problem can be broken down into a series of block diagonal constraint sets, with the cash flow relationship serving as the coupling constraint. This structure lends itself to decomposable techniques and, it may be possible that under such procedures enough storage will be saved to allow for implementation of the time division scheme on the microcomputer. If not, the mainframe computer could be utilized to solve the problem and, while no longer appropriate to the small business environment, the resulting model would contribute to the study of cash decision-making.

With respect to the development of tools for small business, there are abundant prospects for continued research. Several of these lie within the realm of cash management. Recall that cash decision-making comprises only one of the cash management functions. Planning is a prerequisite to decision-making and it is generally true that formal planning is rarely encountered in small business operations. Tools for cash planning could be developed in a manner similar to the cash decision model of this study. That is, forecasting techniques could be tailored to the small business environment and then implemented on the microcomputer.

Cash control tools are not as relevant for small business as are planning and decision tools. This is due to the fact that control procedures for speeding and delaying cash flows are, by their very nature, geared to large operations. However, a control tool for specifying desired cash balances is appropriate to the small business. Procedures for determining a cash balance generally require the specification of certain probabilities and risks which may initially be difficult for a small business to estimate. However, it is contended here that cash planning and decision-making will result in a better understanding of the firm's operations, thereby making probability and risk determinations much easier. In addition, it is contended that cash planning and decision-making will help a firm to achieve growth, thereby making control procedures for the speeding and delaying of cash flows more applicable.

Another example of continued research for this study is the development of a model which specifies a particular microcomputer system appropriate for a given firm. Considerations could be given to both the hardware and software aspects, as well as location of the system within the firm, and scheduling of system use by employees.

An additional example of further research prompted by this study is the creation of a data bank accessible to small firms. The data bank could include such information as projected interest rates, future market conditions, proposed government policies and their effect on small business, as well as historical data necessary for small business management.

APPENDIX

```
10  REM . . . . CASH BAL . . . .

20  HOME : PRINT  TAB( 10);"CASH
     MANAGEMENT DATA "
30  PRINT : PRINT : INPUT "NUMBER
      OF MONTHS IN PLANNING HORIZ
     ON  ";PH
35 D$ =  CHR$ (4)
40  PRINT D$;"OPEN PH, D2"
50  PRINT D$;"DELETE PH"
60  PRINT D$;"OPEN PH"
70  PRINT D$;"WRITE PH"
80  PRINT PH
90  PRINT D$;"CLOSE PH"
100  DIM ROW$(60),COL$(100),QA(60
     ,100),QB(60),NCF(PH): HOME :
      PRINT  TAB( 9);"BEGINNING C
     ASH BALANCE": PRINT : INPUT
     "                $ ";NCF(0)
105  FOR T = 1 TO PH
110  PRINT : PRINT  TAB( 7);"NET
     CASH FLOW FOR PERIOD ";T: PRINT
     : INPUT "               $ ";
     NCF(T): NEXT T
120  FOR T = 1 TO PH
130 T$ =  STR$ (T):CCT = CCT + 1:
     COL$(CCT) = "BAL(" + T$ + ")
     ":RCT = T + 1:ROW$(RCT) = "C
     ASH BAL" + T$:QA(RCT,CCT) =
     1
140  IF T <  > PH - 1 GOTO 155
150 QA(1,CCT) = 1
155  IF T = PH GOTO 170
160 QA(RCT + 1,CCT) =  - 1
170 QB(RCT) = QB(RCT) + NCF(T - 1
     )
200  NEXT T
260  PRINT D$;"OPEN ROW$, D2"
270  PRINT D$;"DELETE ROW$"
280  PRINT D$;"OPEN ROW$"
290  PRINT D$;"WRITE ROW$"
300  FOR I = 1 TO RCT
310  PRINT I
320  PRINT ROW$(I)
330  NEXT I
340  PRINT D$;"CLOSE ROW$"
```

```
350  PRINT D$;"OPEN QB, D2"
360  PRINT D$;"DELETE QB"
370  PRINT D$;"OPEN QB"
380  PRINT D$;"WRITE QB"
390  FOR I = 1 TO RCT
400  PRINT I
410  PRINT QB(I)
420  NEXT I
422  PRINT D$;"CLOSE QB"
440  PRINT D$;"OPEN COL$, D2"
450  PRINT D$;"DELETE COL$"
460  PRINT D$;"OPEN COL$"
470  PRINT D$;"WRITE COL$"
480  FOR J = 1 TO CCT
490  PRINT J
500  PRINT COL$(J)
510  NEXT J
520  PRINT D$;"CLOSE COL$"
530  PRINT D$;"OPEN QA, D2"
540  PRINT D$;"DELETE QA"
550  PRINT D$;"OPEN QA"
560  PRINT D$;"WRITE QA"
570  FOR I = 1 TO RCT
580  FOR J = 1 TO CCT
590  IF QA(I,J) = 0 GOTO 640
600  PRINT I
610  PRINT J
620  PRINT QA(I,J)
630 SS = SS + 1
640  NEXT J
650  NEXT I
660  PRINT D$;"CLOSE QA"
670  PRINT D$;"OPEN MATRIX, D2"
680  PRINT D$;"DELETE MATRIX"
690  PRINT D$;"OPEN MATRIX"
700  PRINT D$;"WRITE MATRIX"
710  PRINT RCT
720  PRINT CCT
730  PRINT SS
740  PRINT D$;"CLOSE MATRIX"
750  PRINT D$;"RUN TRADE CREDIT,D
     1"
760  END
```

```
10  REM . . . . TRADE CREDIT . .
     . .
20  HOME : PRINT " DO YOU WISH TO
      CONSIDER TRADE CREDIT?": PRINT
     : INPUT "                YES/NO
     ?  ";YN$: IF YN$ <  > "YES" GOTO
     1050
30  DIM ROW$(40),COL$(70),QA(40,7
     0),QB(40)
35 D$ =  CHR$ (4)
40  PRINT D$;"OPEN PH, D2"
50  PRINT D$;"READ PH"
60  INPUT PH
70  PRINT D$;"CLOSE PH"
80  PRINT : PRINT : INPUT "NUMBER
      OF TRADE CREDIT SUPPLIERS:
          ";SUP
90  DIM NPTC(SUP),CDTC(SUP),RTC(S
     UP),OUT(SUP,PH),PURCH(SUP,PH
     ): FOR I = 1 TO SUP
100  HOME : PRINT "NUMBER OF MONT
     HS IN NET PAYMNT INTERVAL": PRINT
      TAB( 13);"FOR SUPPLIER ";I;
     ":": PRINT : INPUT "
                 ";NPTC(I)
110  PRINT : PRINT "NUMBER OF MON
     THS IN CASH DSCNT INTERVAL":
      PRINT  TAB( 13);"FOR SUPPLI
     ER ";I;":": PRINT : INPUT "
                         ";CDTC(I)
120  PRINT : PRINT "        CASH D
     ISCOUNT RATE OFFERED": PRINT
      TAB( 14);"BY SUPPLIER ";I;"
     :": PRINT : INPUT "
                ";RTC(I)
130  HOME : PRINT "   AMOUNTS OUT
     STANDING TO SUPPLIER ";I: PRINT
      TAB( 10);"FROM PURCHASES MA
     DE IN:": PRINT : PRINT : PRINT
      TAB( 16);"PERIOD  0:"
140  PRINT : INPUT "
       $ ";OUT(I,0): IF NPTC(I) =
     1 GOTO 170
150  FOR L = 1 TO NPTC(I) - 1
160  PRINT : PRINT  TAB( 16);"PER
     IOD -";L;":": PRINT : INPUT
     "                  $ ";OUT(I,L
     ): NEXT L
```

```
170  HOME : PRINT  TAB( 4);"FUTUR
     E PURCHASES FROM SUPPLIER ";
     I;":": PRINT : FOR J = 1 TO
     PH
180  PRINT : PRINT  TAB( 17);"PER
     IOD ";J: PRINT : INPUT "
                  $ ";PURCH(I,J): NEXT
     J: NEXT I
190  PRINT D$;"OPEN MATRIX, D2"
200  PRINT D$;"READ MATRIX"
210  INPUT ARCT
220  INPUT ACCT
230  INPUT SS
232  PRINT D$;"CLOSE MATRIX"
250 RCT = ARCT:CCT = ACCT
260  FOR I = 1 TO SUP
270 I$ =  STR$ (I):RTC(I) = RTC(I
     ) * .01: FOR L = NPTC(I) - 1
      TO 0 STEP  - 1
280 L$ =  STR$ ( - L):RCT = RCT +
     1:ROW$(RCT) = "TC" + I$ + "-
     " + L$:QB(RCT) = OUT(I,L)
290  FOR T = 1 TO NPTC(I) - L
300 T$ =  STR$ (T):CCT = CCT + 1:
     COL$(CCT) = "TC(" + I$ + "-"
      + L$ + "-" + T$ + ")":QA(T +
     1,CCT) = 1
310  IF T > CDTC(I) - L GOTO 340
320 QA(RCT,CCT) = 1 / (1 - RTC(I)
     )
330  GOTO 350
340 QA(RCT,CCT) = 1
350  NEXT T: NEXT L: NEXT I: FOR
     I = 1 TO SUP
360  FOR J = 1 TO PH
370 I$ =  STR$ (I):J$ =  STR$ (J)
     :RCT = RCT + 1:ROW$(RCT) = "
     TC" + I$ + "-" + J$:QB(RCT) =
     PURCH(I,J)
380  FOR T = J TO NPTC(I) + J
390  IF T > PH GOTO 460
400 T$ =  STR$ (T):CCT = CCT + 1:
     COL$(CCT) = "TC(" + I$ + "-"
      + J$ + "-" + T$ + ")":QA(T +
     1,CCT) = 1
410  IF T > CDTC(I) + J GOTO 440
420 QA(RCT,CCT) = 1 / (1 - RTC(I)
     )
430  GOTO 450
440 QA(RCT,CCT) = 1
450  NEXT T
```

```
460  IF J < PH + 1 - NPTC(I) GOTO
     540
470  FOR T = J TO PH
480  IF T > CDTC(I) + J GOTO 510
490 QA(1,CCT) = 1 / (1 - RTC(I))
500  GOTO 520
510 QA(1,CCT) = 1
520  NEXT T:QB(1) = QB(1) - PURCH
     (I,J):CCT = CCT + 1
530 COL$(CCT) = "SL/TC" + I$ + "-
     " + J$:QA(RCT,CCT) = 1
540  NEXT J: NEXT I
550  PRINT D$;"APPEND ROW$,D2"
560  PRINT D$;"WRITE ROW$"
570  FOR I = ARCT + 1 TO RCT
580  PRINT I
590  PRINT ROW$(I)
600  NEXT I
610  PRINT D$;"CLOSE ROW$"
620  PRINT D$;"APPEND QB, D2"
630  PRINT D$;"WRITE QB"
640  FOR I = ARCT + 1 TO RCT
650  PRINT I
660  PRINT QB(I)
670  NEXT I
672  PRINT D$;"CLOSE QB"
690  PRINT D$;"APPEND COL$, D2"
700  PRINT D$;"WRITE COL$"
710  FOR J = ACCT + 1 TO CCT
720  PRINT J
730  PRINT COL$(J)
740  NEXT J
750  PRINT D$;"CLOSE COL$"
760  PRINT D$;"APPEND QA, D2"
770  PRINT D$;"WRITE QA"
780  FOR I = ARCT + 1 TO RCT
790  FOR J = ACCT + 1 TO CCT
800  IF QA(I,J) = 0 GOTO 850
810  PRINT I
820  PRINT J
830  PRINT QA(I,J)
840 SS = SS + 1
850  NEXT J
860  NEXT I
```

```
870  FOR I = 1 TO PH + 1
880  FOR J = ACCT + 1 TO CCT
890  IF QA(I,J) = 0 GOTO 940
900  PRINT I
910  PRINT J
920  PRINT QA(I,J)
930 SS = SS + 1
940  NEXT J
950  NEXT I
960  PRINT D$;"CLOSE QA"
970  PRINT D$;"OPEN MATRIX, D2"
980  PRINT D$;"DELETE MATRIX"
990  PRINT D$;"OPEN MATRIX"
1000  PRINT D$;"WRITE MATRIX"
1010  PRINT RCT
1020  PRINT CCT
1030  PRINT SS
1040  PRINT D$;"CLOSE MATRIX"
1050  PRINT D$;"RUN LINE OF CREDI
     T,D1"
1060  END
```

```
10  REM . . . . LINE FO CREDIT .
     . . .
20  HOME : PRINT "DO YOU WISH TO
     CONSIDER LINE OF CREDIT?": PRINT
     : INPUT "                    YES/NO
     ?  ";YN$: IF YN$ <  > "YES" GOTO
     1490
30  DIM QA(40,80),QB(40),ROW$(40)
     ,COL$(80)
35 D$ =  CHR$ (4)
40  PRINT D$;"OPEN PH, D2"
50  PRINT D$;"READ PH"
60  INPUT PH
70  PRINT D$;"CLOSE PH"
80  DIM RLC(PH): PRINT : PRINT  TAB(
     9);"MAXIMUM AMOUNT AVAILABLE
     ": PRINT  TAB( 11);"UNDER LI
     NE OF CREDIT": PRINT : INPUT
     "                $ ";MAX
```

```
90  PRINT : PRINT "   NUMBER OF M
     ONTHS FOR WHICH LOAN IS": PRINT
     "    AVAILABLE BEFORE CLEAN U
     P PERIOD:": PRINT : INPUT "
                       ";AV
100  PRINT : PRINT "   NUMBER OF
     MONTHS FOR WHICH LOAN IS": PRINT
     "  NOT AVAILABLE DURING CLEA
     N UP PERIOD:": PRINT : INPUT
     "                        ";NAV
110  HOME : PRINT "      COMPENSAT
     ING BALANCE PERCENTAGE": PRINT
      TAB( 12);"ON USED CREDIT:":
      PRINT : INPUT "
           ";UC
120  PRINT : PRINT "      COMPENSA
     TING BALANCE PERCENTAGE": PRINT
      TAB( 12);"ON UNUSED LINE:":
      PRINT : INPUT "
           ";UNL
130  PRINT : PRINT  TAB( 10);"AMO
     UNT OUTSTANDING": PRINT  TAB(
     9);"UNDER LINE OF CREDIT": PRINT
     : INPUT "                  $ "
     ;LCOUT
140  HOME : PRINT "  PROJECTED IN
     T RATES FOR LINE OF CREDIT":
      FOR I = 1 TO PH
150  PRINT : PRINT  TAB( 16);"PER
     IOD ";I;":": PRINT : INPUT "
                        ";RLC(I): NEXT
     I
160  PRINT D$;"OPEN MATRIX, D2"
170  PRINT D$;"READ MATRIX"
180  INPUT ARCT
190  INPUT ACCT
200  INPUT SS
202  PRINT D$;"CLOSE MATRIX"
220 RCT = ARCT:CCT = ACCT
230 CTCT = CCT + 1:RRCT = RCT:UNL
      = UNL * .01:UC = UC * .01: FOR
     J = 1 TO AV
240 J$ =  STR$ (J): IF J > PH GOTO
     910
```

```
250 RCT = RCT + 1:ROW$(RCT) = "LC
     AV" + J$:QB(RCT) = MAX - LCO
     UT:CCT = CCT + 1:COL$(CCT) =
     "LCBOR(" + J$ + ")"
260 QA(J + 1,CCT) = UC - UNL - 1:
     QB(J + 1) = QB(J + 1) - RLC(
     J) * .3 / 360 * LCOUT
270  FOR T = RRCT + J TO RRCT + A
     V
280  IF T > RRCT + PH GOTO 310
290 QA(T,CCT) = 1
300  NEXT T
310  FOR T = J + 2 TO AV + 2
320  IF T > PH + 1 GOTO 350
330 QA(T,CCT) = RLC(T - 1) * .3 /
     360
340  NEXT T
350 CCT = CCT + 1:COL$(CCT) = "LC
     PAY(" + J$ + ")"
360 QA(J + 1,CCT) = 1 + UNL - UC
370  IF J = AV GOTO 420
380  FOR T = RRCT + J + 1 TO RRCT
      + AV
390  IF T > RRCT + PH GOTO 420
400 QA(T,CCT) =  - 1
410  NEXT T
420  FOR T = J + 2 TO AV + 2
430  IF T > PH + 1 GOTO 460
440 QA(T,CCT) =  - RLC(T - 1) * .
     3 / 360
450  NEXT T
460 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(RCT):QA(RRCT + J,C
     CT) = 1
480  NEXT J:QB(AV + 2) = QB(AV +
     2) - RLC(AV + 1) * .3 / 360 *
     LCOUT
490  IF AV >  = PH GOTO 910
500 RCT = RCT + 1:J$ =  STR$ (AV +
     1):ROW$(RCT) = "LCPAY" + J$:
     QB(RCT) =  - LCOUT
510 CCT = CCT + 1:COL$(CCT) = "LC
     PAY(" + J$ + ")":QA(RCT,CCT)
      =  - 1
```

```
530 QA(AV + 2,CCT) = 1 + UNL - UC
     : FOR J = 1 TO AV
540 J$ =  STR$ (J): FOR T = CTCT TO
     CCT
550  IF COL$(T) = "LCBOR(" + J$ +
     ")" THEN QA(RCT,T) = 1
560  IF COL$(T) = "LCBOR(" + J$ +
     ")" THEN  GOSUB 1550
570  IF COL$(T) = "LCPAY(" + J$ +
     ")" THEN QA(RCT,T) =  - 1
580  IF COL$(T) = "LCPAY(" + J$ +
     ")" THEN  GOSUB 1550
590  IF COL$(T) = "LCPAY(" + J$ +
     ")" THEN  GOTO 610
600  NEXT T
610  NEXT J
620  FOR T = AV + 1 TO AV + NAV
630 T$ =  STR$ (T):RCT = RCT + 1:
     ROW$(RCT) = "LCNAV" + T$:QB(
     RCT) = 0:CCT = CCT + 1:COL$(
     CCT) = "LCBOR(" + T$ + ")":Q
     A(RCT,CCT) = 1

660  NEXT T: FOR J = AV + NAV + 1
      TO PH
670 J$ =  STR$ (J):RCT = RCT + 1:
     ROW$(RCT) = "LCAV" + J$:QB(R
     CT) = MAX
680 CCT = CCT + 1:COL$(CCT) = "LC
     BOR(" + J$ + ")"
690 QA(1,CCT) =  - 1
700 QA(J + 1,CCT) = UC - UNL - 1
710  IF J + 1 > PH GOTO 750
720  FOR T = J + 1 TO PH
730 QA(T + 1,CCT) = RLC(T) * .3 /
     360
740  NEXT T
750  FOR T = RRCT + J + 1 TO RRCT
      + PH + 1
760 QA(T,CCT) = 1
770  NEXT T: IF J = AV + NAV + 1 GOTO
     870
780 CCT = CCT + 1:COL$(CCT) = "LC
     PAY(" + J$ + ")"
```

```
790 QA(1,CCT) = 1
800 QA(J + 1,CCT) = 1 + UNL - UC
810  IF J = PH GOTO 870
820  FOR T = J + 1 TO PH
830 QA(T + 1,CCT) =  - RLC(T) * .
     3 / 360
840  NEXT T: FOR T = RRCT + J + 2
      TO RRCT + PH + 1
850 QA(T,CCT) =  - 1
860  NEXT T
870 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(RCT)
880 T = RRCT + J + 1:QA(T,CCT) =
     1
890  NEXT J
910 RRCT = RCT: FOR L = 1 TO PH:L
     $ =  STR$ (L)
911 RCT = RCT + 1:ROW$(RCT) = "LC
     PUB" + L$:QB(RCT) = LCOUT
920  FOR T = CTCT TO CCT
930  IF COL$(T) <  > "LCBOR(" + L
     $ + ")" GOTO 950
932  FOR K = L + RRCT TO RRCT + P
     H
934 QA(K,T) =  - 1
936  NEXT K
940 QA(1,T) =  - 1
950  IF COL$(T) <  > "LCPAY(" + L
     $ + ")" GOTO 970
952  FOR K = L + RRCT TO RRCT + P
     H
954 QA(K,T) = 1
956  NEXT K
960 QA(1,T) = 1: GOTO 972
970  NEXT T
972 CCT = CCT + 1:COL$(CCT) = "SL
     / " + ROW$(RCT):QA(RCT,CCT) =
     1
980  NEXT L
990  PRINT D$;"APPEND ROW$, D2"
1000  PRINT D$;"WRITE ROW$"
1010  FOR I = ARCT + 1 TO RCT
1020  PRINT I
1030  PRINT ROW$(I)
1040  NEXT I
```

```
1050  PRINT D$;"CLOSE ROW$"
1060  PRINT D$;"APPEND QB, D2"
1070  PRINT D$;"WRITE QB"
1080  FOR I = ARCT + 1 TO RCT
1090  PRINT I
1100  PRINT QB(I)
1110  NEXT I
1112  PRINT D$;"CLOSE QB"
1130  PRINT D$;"APPEND COL$, D2"
1140  PRINT D$;"WRITE COL$"
1150  FOR J = ACCT + 1 TO CCT
1160  PRINT J
1170  PRINT COL$(J)
1180  NEXT J
1190  PRINT D$;"CLOSE COL$"
1200  PRINT D$;"APPEND QA, D2"
1210  PRINT D$;"WRITE QA"
1220  FOR I = ARCT + 1 TO RCT
1230  FOR J = ACCT + 1 TO CCT
1240  IF QA(I,J) = 0 GOTO 1290
1250  PRINT I
1260  PRINT J
1270  PRINT QA(I,J)
1280 SS = SS + 1
1290  NEXT J
1300  NEXT I
1310  FOR I = 1 TO PH + 1
1320  FOR J = ACCT + 1 TO CCT
1330  IF QA(I,J) = 0 GOTO 1380
1340  PRINT I
1350  PRINT J
1360  PRINT QA(I,J)
1370 SS = SS + 1
1380  NEXT J
1390  NEXT I
1400  PRINT D$;"CLOSE QA"
1410  PRINT D$;"OPEN MATRIX, D2"
1420  PRINT D$;"DELETE MATRIX"
1430  PRINT D$;"OPEN MATRIX"
1440  PRINT D$;"WRITE MATRIX"
1450  PRINT RCT
1460  PRINT CCT
1470  PRINT SS
1480  PRINT D$;"CLOSE MATRIX"
1490  PRINT D$;"RUN TERM LOAN, D1
     "
1500  END
```

```
10  REM . . . . TERM LOAN . . . .

20  HOME : PRINT "   DO YOU WISH
     TO CONSIDER TERM LOAN?": PRINT
     : INPUT "                 YES/NO
     ?  ";YN$: IF YN$ <  > "YES" GOTO
     1350
25 D$ =  CHR$ (4)
30  PRINT D$;"OPEN PH, D2"
40  PRINT D$;"READ PH"
50  INPUT PH
60  PRINT D$;"CLOSE PH"
70  DIM ROW$(45),COL$(75),QB(45),
     QA(45,75)
80  DIM TLR(PH): HOME : PRINT  TAB(
     9);"MAXIMUM AMOUNT AVAILABLE
     ": PRINT  TAB( 13);"UNDER TE
     RM LOAN": PRINT : INPUT "
                 $  ";TMAX
90  PRINT : PRINT  TAB( 7);"NUMBE
     R OF MONTHS TO MATURITY": PRINT
      TAB( 14);"FOR TERM LOAN:": PRINT
     : INPUT "                    ";
     TERM
100  PRINT : PRINT  TAB( 12);"AMO
     UNT OUTSTANDING": PRINT  TAB(
     13);"UNDER TERM LOAN": PRINT
     : INPUT "                  $  "
     ;DOLOUT: IF DOLOUT = 0 GOTO
     120
110  PRINT : INPUT "  MONTH IN WH
     ICH LOAN WAS RECEIVED: ";P: PRINT
     : INPUT " INTEREST RATE ON O
     UTSTANDING LOAN: ";PP
120  HOME : PRINT "PROJECTED INTE
     REST RATES FOR TERM LOAN": PRINT

130  FOR I = 1 TO PH
140  PRINT : PRINT  TAB( 16);"PER
     IOD ";I;":": PRINT : INPUT "
                        ";TLR(I): NEXT
     I
```

```
150  PRINT D$;"OPEN MATRIX, D2"
160  PRINT D$;"READ MATRIX"
170  INPUT ARCT
180  INPUT ACCT
190  INPUT SS
200  PRINT D$;"CLOSE MATRIX"
210 RCT = ARCT:CCT = ACCT
260 CTCT = CCT:RRCT = RCT + 1
270  FOR I = P + TERM TO PH - P -
     TERM
290 RCT = RCT + 1:I$ =  STR$ (I):
     ROW$(RCT) = "TLAV" + I$:QB(R
     CT) = 1
300  IF I > P + TERM GOTO 340
310  FOR T = I TO I + TERM - 1
320 T$ =  STR$ (T):CCT = CCT + 1:
     COL$(CCT) = "Z/O TL(" + T$ +
     ")"
330  NEXT T: GOTO 350
340 CCT = CCT + 1:J = I + TERM -
     1:J$ =  STR$ (J):COL$(CCT) =
     "Z/O TL(" + J$ + ")"
350  FOR L = CTCT + I - 1 TO CTCT
      + I - 2 + TERM
360 QA(RCT,L) = 1
370  NEXT L: NEXT I
380 ZZCT = CCT: FOR I = RRCT TO R
     CT
390 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(I):QA(I,CCT) = 1
410  NEXT I:YCCT = CCT + 1: FOR T
      = P + TERM TO PH
420 T$ =  STR$ (T):RCT = RCT + 1:
     ROW$(RCT) = "TLBD" + T$:QB(R
     CT) = 0:CCT = CCT + 1:COL$(C
     CT) = "TLBOR(" + T$ + ")":QA
     (RCT,CCT) = 1
450 QA(T + 1,CCT) =  - (1 - (TLR(
     T) * TERM * .303 / 360))
460  FOR L = CTCT TO ZZCT
470  IF COL$(L) = "Z/O TL(" + T$ +
     ")" GOTO 490
```

```
480  NEXT L
490 QA(RCT,L) =  - TMAX
500 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(RCT):QA(RCT,CCT) =
     1
510  NEXT T
520 YYCT = CCT:RCT = RCT + 1:ROW$
     (RCT) = "TLPAYOUT":QB(RCT) =
     DOLOUT
530  FOR T = 1 TO P + TERM
540 T$ =  STR$ (T):P$ =  STR$ (P)
     :CCT = CCT + 1:COL$(CCT) = "
     TLPAY(" + P$ + "-" + T$ + ")
     ":QA(RCT,CCT) = 1 / (1 - (PP
      * .303 * (TERM - T + P) / 3
     60))
560 QA(T + 1,CCT) = 1
570  NEXT T: IF P + TERM > PH - T
     ERM GOTO 700
580  FOR J = P + TERM TO PH - TER
     M
590 J$ =  STR$ (J):RCT = RCT + 1:
     ROW$(RCT) = "TLPAY" + J$:QB(
     RCT) = 0
600  FOR L = YCCT TO YYCT
610  IF COL$(L) = "TLBOR(" + J$ +
     ")" GOTO 630
620  NEXT L: GOTO 640
630 QA(RCT,L) =  - 1
640  FOR T = J + 1 TO J + TERM
650 T$ =  STR$ (T):CCT = CCT + 1:
     COL$(CCT) = "TLPAY(" + J$ +
     "-" + T$ + ")":QA(RCT,CCT) =
     1 / (1 - (TLR(J) * .303 * (T
     ERM - T + J) / 360))
670 QA(T + 1,CCT) = 1
680  NEXT T
690  NEXT J
700  FOR J = PH + 1 - TERM TO PH -
     1
710 RCT = RCT + 1:J$ =  STR$ (J):
     ROW$(RCT) = "TLPAY" + J$:QB(
     RCT) = 0
```

```
720  FOR L = YCCT TO YYCT
730  IF COL$(L) = "TLBOR(" + J$ +
     ")" GOTO 750
740  NEXT L: GOTO 770
750 QA(RCT,L) =  - 1:QA(1,L) =  -
     (1 - (TLR(J) * .303 * (J - T
     ERM + 1) / 360))
770  FOR T = J + 1 TO PH
780 T$ =  STR$ (T):CCT = CCT + 1:
     COL$(CCT) = "TLPAY(" + J$ +
     "-" + T$ + ")":QA(RCT,CCT) =
     1 / (1 - (TLR(J) * .303 * (T
     ERM - T + J) / 360))
800 QA(1,CCT) = 1 / (1 - (TLR(J) *
     .303 * (TERM - T + J) / 360)
     )
810 QA(T + 1,CCT) = 1
820  NEXT T:CCT = CCT + 1
830 COL$(CCT) = "SL/" + ROW$(RCT)
     :QA(RCT,CCT) = 1
840  NEXT J
841 PH$ =  STR$ (PH): FOR L = YCC
     T TO YYCT
842  IF COL$(L) = "TLBOR(" + PH$ +
     ")" THEN  GOTO 844
843  NEXT L
844 QA(1,L) =  - (1 - (TLR(PH) *
     .303 * TERM / 360))
850  PRINT D$;"APPEND ROW$, D2"
860  PRINT D$;"WRITE ROW$"
870  FOR I = ARCT + 1 TO RCT
880  PRINT I
890  PRINT ROW$(I)
900  NEXT I
910  PRINT D$;"CLOSE ROW$"
920  PRINT D$;"APPEND QB, D2"
930  PRINT D$;"WRITE QB"
940  FOR I = ARCT + 1 TO RCT
950  PRINT I
960  PRINT QB(I)
```

```
970  NEXT I
980  PRINT D$;"CLOSE QB"
990  PRINT D$;"APPEND COL$, D2"
1000  PRINT D$;"WRITE COL$"
1010  FOR J = ACCT + 1 TO CCT
1020  PRINT J
1030  PRINT COL$(J)
1040  NEXT J
1050  PRINT D$;"CLOSE COL$"
1060  PRINT D$;"APPEND QA, D2"
1070  PRINT D$;"WRITE QA"
1080  FOR I = ARCT + 1 TO RCT
1090  FOR J = ACCT + 1 TO CCT
1100  IF QA(I,J) = 0 GOTO 1150
1110  PRINT I
1120  PRINT J
1130  PRINT QA(I,J)
1140 SS = SS + 1
1150  NEXT J
1160  NEXT I
1170  FOR I = 1 TO PH + 1
1180  FOR J = ACCT + 1 TO CCT
1190  IF QA(I,J) = 0 GOTO 1240
1200  PRINT I
1210  PRINT J
1220  PRINT QA(I,J)
1230 SS = SS + 1
1240  NEXT J
1250  NEXT I
1260  PRINT D$;"CLOSE QA"
1270  PRINT D$;"OPEN MATRIX, D2"
1280  PRINT D$;"DELETE MATRIX"
1290  PRINT D$;"OPEN MATRIX"
1300  PRINT D$;"WRITE MATRIX"
1310  PRINT RCT
1320  PRINT CCT
1330  PRINT SS
1340  PRINT D$;"CLOSE MATRIX"
1350  PRINT D$;"RUN TREASURY BILL
     , D1"
1360  END
```

```
10  REM . . . . TREASURY BILL . .
     . .
20  HOME : PRINT " DO YOU WISH TO
      CONSIDER TREASURY BILLS?": INPUT
     "               YES/NO?  ";YN$
     : IF YN$ <  > "YES" GOTO 730

30  DIM QA(40,70),QB(40),ROW$(40)
     ,COL$(70)
35 D$ =  CHR$ (4)
40  PRINT D$;"OPEN PH, D2"
50  PRINT D$;"READ PH"
60  INPUT PH
70  PRINT D$;"CLOSE PH"
80  IF PH <  = 6 THEN TTB = 1
90  IF PH > 6 THEN TTB = 2
100  HOME : DIM TBR(TTB,PH): FOR
     I = 1 TO TTB
110  IF I = 1 THEN I$ = "3"
120  IF I = 2 THEN I$ = "6"
130  IF I <  > 1 THEN  HOME
140  PRINT : PRINT " PROJECTED BI
     D RATES FOR ";I$;"-MONTH TBI
     LLS": PRINT : FOR J = 1 TO P
     H
150  PRINT : PRINT  TAB( 16);"PER
     IOD ";J;":": PRINT : INPUT "
                         ";TBR(I,J)
     : NEXT J: NEXT I
160  PRINT D$;"OPEN MATRIX, D2"
170  PRINT D$;"READ MATRIX"
180  INPUT ARCT
190  INPUT ACCT
195  INPUT SS
200  PRINT D$;"CLOSE MATRIX"
210 CCT = ACCT:RCT = ARCT
220  FOR I = 1 TO TTB
230  IF I = 1 THEN T = 3
240  IF I = 2 THEN T = 6
250  FOR J = 1 TO PH
260  IF J = PH - T + 1 THEN GG =
     CCT + 1
```

```
270 T$ =  STR$ (T):J$ =  STR$ (J)
     :RCT = RCT + 1:ROW$(RCT) = "
     TBINV" + T$ + "-" + J$:QB(RC
     T) = 0:CCT = CCT + 1:COL$(CC
     T) = "Z/O TB(" + T$ + "-" +
     J$ + ")"
280 QA(RCT,CCT) =  - 10000
300 CCT = CCT + 1:CTCT = CCT:COL$
     (CCT) = "INT/ TB(" + T$ + "-
     " + J$ + ")":QA(RCT,CCT) =  -
     5000
310 CCT = CCT + 1:COL$(CCT) = "TB
     INV(" + T$ + "-" + J$ + ")":
     QA(RCT,CCT) = 1
320 QA(J + 1,CCT) = 1 - TBR(I,J) *
     .303 * T / 360
330  IF J + T + 1 > PH + 1 GOTO 3
     50
340 QA(J + 1 + T,CCT) =  - 1
350 RCT = RCT + 1:ROW$(RCT) = "TB
     MULT" + T$ + "-" + J$:QB(RCT
     ) = 0
360 QA(RCT,CTCT) = 1
370 CTCT = CTCT - 1:QA(RCT,CTCT) =
      - 99
380 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(RCT):QA(RCT,CCT) =
     1
390 RCT = RCT + 1:ROW$(RCT) = "TB
     Z/O" + T$ + "-" + J$:QB(RCT)
      = 1
400 QA(RCT,CTCT) = 1
410 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(RCT):QA(RCT,CCT) =
     1
420  IF J < PH - T + 1 GOTO 470
430  FOR L = GG TO CCT
440  IF COL$(L) = "TBINV(" + T$ +
     "-" + J$ + ")" GOTO 460
450  NEXT L
460 QA(1,L) = 1 / (1 - (TBR(I,J) *
     .303 * (PH - J) / 360))
470  NEXT J: NEXT I
500  PRINT D$;"APPEND ROW$, D2"
```

```
501  PRINT D$;"WRITE ROW$"
502  FOR I = ARCT + 1 TO RCT
503  PRINT I
504  PRINT ROW$(I)
505  NEXT I
506  PRINT D$;"CLOSE ROW$"
507  PRINT D$;"APPEND QB, D2"
508  PRINT D$;"WRITE QB"
509  FOR I = ARCT + 1 TO RCT
510  PRINT I
511  PRINT QB(I)
512  NEXT I
513  PRINT D$;"CLOSE QB"
514  PRINT D$;"APPEND COL$, D2"
515  PRINT D$;"WRITE COL$"
516  FOR J = ACCT + 1 TO CCT
517  PRINT J
518  PRINT COL$(J)
519  NEXT J
520  PRINT D$;"CLOSE COL$"
521  PRINT D$;"APPEND QA, D2"
522  PRINT D$;"WRITE QA"
523  FOR I = ARCT + 1 TO RCT
524  FOR J = ACCT + 1 TO CCT
525  IF QA(I,J) = 0 GOTO 530
526  PRINT I
527  PRINT J
528  PRINT QA(I,J)
529 SS = SS + 1
530  NEXT J
531  NEXT I
532  FOR I = 1 TO PH + 1
533  FOR J = ACCT + 1 TO CCT
534  IF QA(I,J) = 0 GOTO 539
535  PRINT I
536  PRINT J
537  PRINT QA(I,J)
538 SS = SS + 1
539  NEXT J
```

```
540  NEXT I
541  PRINT D$;"CLOSE QA"
660  PRINT D$;"OPEN MATRIX, D2"
670  PRINT D$;"DELETE MATRIX"
680  PRINT D$;"OPEN MATRIX"
690  PRINT D$;"WRITE MATRIX"
700  PRINT RCT
710  PRINT CCT
715  PRINT SS
720  PRINT D$;"CLOSE MATRIX"
730  PRINT D$;"RUN MONEY MARKET,
     D1"
740  END

10  REM . . . . MONEY MARKET . .
     . .
20  HOME : PRINT " DO YOU WISH TO
      CONSIDER MONEY MARKET?": PRINT
     : INPUT "              YES/NO?
       ";YN$: IF YN$ <  > "YES" GOTO
     1170
30  DIM QA(40,70),QB(40),ROW$(40)
     ,COL$(70)
35 D$ =  CHR$ (4)
40  PRINT D$;"OPEN PH, D2"
50  PRINT D$;"READ PH"
60  INPUT PH
70  PRINT D$;"CLOSE PH"
80  HOME : DIM MMR(PH + 1): PRINT
     : INPUT "AMOUNT INVESTED IN
     MONEY MARKET: $";MO
90  PRINT : INPUT "               M
     INIMUM WITHDRAWAL: $";MW
100  HOME : PRINT "  PROJECTED MO
     NEY MARKET EARNINGS RATES ":
      FOR I = 1 TO PH
110  PRINT : PRINT  TAB( 17);"PER
     IOD ";I;":": PRINT : INPUT "
                       ";MMR(I):
      NEXT I
120  FOR T = 1 TO PH
130 MMR(T) = (1 + MMR(T) * .01) ^
     (1 / 12): NEXT T
```

```
140  PRINT D$;"OPEN MATRIX, D2"
150  PRINT D$;"READ MATRIX"
160  INPUT ARCT
170  INPUT ACCT
180  INPUT SS
182  PRINT D$;"CLOSE MATRIX"
200 RCT = ARCT:CCT = ACCT
210 ZCCT = CCT + 1: FOR T = 1 TO
     PH
220 T$ =  STR$ (T):RCT = RCT + 1:
     ROW$(RCT) = "MMWL" + T$:QB(R
     CT) = 0
230 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(RCT):QA(RCT,CCT) =
     1
240 CCT = CCT + 1:CTCT = CCT:COL$
     (CCT) = "MMWD(" + T$ + ")":Q
     A(RCT,CCT) =  - 1
250 QA(T + 1,CCT) =  - 1
260 QA(1,CCT) =  - 1: FOR I = T +
     1 TO PH
270  IF T <  > PH GOTO 300
280 QA(1,CCT) =  - 1
290  GOTO 310
300 QA(1,CCT) = QA(1,CCT) * MMR(I
     ): NEXT I
310 CCT = CCT + 1:COL$(CCT) = "Z/
     O MMW(" + T$ + ")":QA(RCT,CC
     T) = MW
320 RCT = RCT + 1:ROW$(RCT) = "MM
     WLL" + T$:QB(RCT) = 0
330 QA(RCT,CTCT) = 1
340 CTCT = CTCT + 1:QA(RCT,CTCT) =
      - 999999
350 CCT = CCT + 1:COL$(CCT) = "SL
      /" + ROW$(RCT):QA(RCT,CCT) =
     1
360 RCT = RCT + 1:ROW$(RCT) = "MM
     Z/O" + T$:QB(RCT) = 1
```

```
370 QA(RCT,CTCT) = 1
380 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(RCT):QA(RCT,CCT) =
     1
390  NEXT T:ZZCT = CCT:RRCT = RCT
     : FOR T = 1 TO PH
400 T$ =  STR$ (T):RCT = RCT + 1:
     ROW$(RCT) = "MMWU" + T$:QB(R
     CT) = MO
410  FOR JJ = 1 TO T
420 QB(RCT) = QB(RCT) * MMR(JJ): IF
     T = PH THEN MO = MO * MMR(JJ
     )
430  NEXT JJ
450  IF T <  > PH GOTO 470
460 QB(1) = MO + QB(1)
470  FOR J = ZCCT TO ZZCT
480  IF COL$(J) = "MMWD(" + T$ +
     ")" GOTO 500
490  NEXT J
500 QA(RCT,J) = 1: FOR I = RCT +
     1 TO RRCT + PH
510 QA(I,J) = QA(I - 1,J) * MMR(A
     A)
520 AA = AA + 1: NEXT I
530 CCT = CCT + 1:COL$(CCT) = "MM
     INV(" + T$ + ")"
540 QA(1,CCT) = 1: FOR I = T + 1 TO
     PH
550  IF T <  > PH THEN  GOTO 580
560 QA(1,CCT) = 1
570  GOTO 590
580 QA(1,CCT) = QA(1,CCT) * MMR(I
     ): NEXT I
590 QA(T + 1,CCT) = 1
600  IF T = PH GOTO 650
610 AA = 2:QA(RCT + 1,CCT) =  - M
     MR(AA): FOR I = RCT + 2 TO R
     RCT + PH
```

```
620  IF I > RRCT + PH GOTO 650
630 QA(I,CCT) = QA(I - 1,CCT) * M
     MR(AA)
640 AA = AA + 1: NEXT I
650 CCT = CCT + 1:COL$(CCT) = "SL
     /" + ROW$(RCT):QA(RCT,CCT) =
     1
660  NEXT T
670  PRINT D$;"APPEND ROW$, D2"
680  PRINT D$;"WRITE ROW$"
690  FOR I = ARCT + 1 TO RCT
700  PRINT I
710  PRINT ROW$(I)
720  NEXT I
730  PRINT D$;"CLOSE ROW$"
740  PRINT D$;"APPEND QB, D2"
750  PRINT D$;"WRITE QB"
760  FOR I = ARCT + 1 TO RCT
770  PRINT I
780  PRINT QB(I)
790  NEXT I
792  PRINT D$;"CLOSE QB"
810  PRINT D$;"APPEND COL$, D2"
820  PRINT D$;"WRITE COL$"
830  FOR J = ACCT + 1 TO CCT
840  PRINT J
850  PRINT COL$(J)
860  NEXT J
870  PRINT D$;"CLOSE COL$"
880  PRINT D$;"APPEND QA, D2"
890  PRINT D$;"WRITE QA"
900  FOR I = ARCT + 1 TO RCT
910  FOR J = ACCT + 1 TO CCT
920  IF QA(I,J) = 0 GOTO 970
930  PRINT I
940  PRINT J
950  PRINT QA(I,J)
960 SS = SS + 1
```

```
970  NEXT J
980  NEXT I
990  FOR I = 1 TO PH + 1
1000  FOR J = ACCT + 1 TO CCT
1010  IF QA(I,J) = 0 GOTO 1060
1020  PRINT I
1030  PRINT J
1040  PRINT QA(I,J)
1050 SS = SS + 1
1060  NEXT J
1070  NEXT I
1080  PRINT D$;"CLOSE QA"
1090  PRINT D$;"OPEN MATRIX, D2"
1100  PRINT D$;"DELETE MATRIX"
1110  PRINT D$;"OPEN MATRIX"
1120  PRINT D$;"WRITE MATRIX"
1130  PRINT RCT
1140  PRINT CCT
1150  PRINT SS
1160  PRINT D$;"CLOSE MATRIX"
1170  PRINT D$;"RUN SAVINGS, D1"
1180  END

10  REM . . . . SAVINGS . . . .
20  HOME : PRINT "     DO YOU WISH
      TO CONSIDER SAVINGS?": PRINT
     : INPUT "                    YES/
     NO?  ";YN$
30  IF YN$ <  > "YES" GOTO 335
40  DIM QA(50,70),QB(50),RCT(50),
     CCT(70),ROW$(50),COL$(70)
50  PRINT : INPUT "      SAVINGS A
     CCOUNT BALANCE $ ";SB: PRINT
     : INPUT "                INTERES
     T RATE ";SRT
60 SRT = (1 + (SRT * .01)) ^ (1 /
     12)
65 D$ =  CHR$ (4)
70  PRINT D$;"OPEN PH,D2"
80  PRINT D$;"READ PH"
90  INPUT PH
100  PRINT D$;"CLOSE PH"
110  PRINT D$;"OPEN MATRIX, D2"
120  PRINT D$;"READ MATRIX"
130  INPUT ARCT
140  INPUT ACCT
150  INPUT SS
```

```
160  PRINT D$;"CLOSE MATRIX"
170 RCT = ARCT:CCT = ACCT
190  FOR I = 1 TO PH
200 I$ =  STR$ (I):RCT = RCT + 1:
     ROW$(RCT) = "SWD" + I$
205 QB(RCT) = SB * (SRT ^ (I - 1)
     )
210 CCT = CCT + 1:COL$(CCT) = "SW
     D(" + I$ + ")":QA(RCT,CCT) =
     1:QA(I + 1,CCT) =  - 1:QA(1,
     CCT) =  - (SRT ^ (PH - I))
216  IF I = PH GOTO 260
220  FOR J = 1 TO PH - I
230 QA(RCT + J,CCT) = QA(RCT + J -
     1,CCT) * SRT
240  NEXT J
260 CCT = CCT + 1:COL$(CCT) = "SI
     NV(" + I$ + ")":QA(RCT,CCT) =
      - 1:QA(I + 1,CCT) = 1:QA(1,
     CCT) = SRT ^ (PH - I)
266  IF I = PH GOTO 310
270  FOR J = 1 TO PH - I
280 QA(RCT + J,CCT) = QA(RCT + J -
     1,CCT) * SRT
290  NEXT J
300  NEXT I
310  FOR I = 1 TO PH
320 CCT = CCT + 1:COL$(CCT) = "SL
     / " + ROW$(ARCT + I):QA(ARCT
      + I,CCT) = 1
330  NEXT I
340  PRINT D$;"APPEND ROW$, D2"
350  PRINT D$;"WRITE ROW$"
360  FOR I = ARCT + 1 TO RCT
370  PRINT I
380  PRINT ROW$(I)
390  NEXT I
400  PRINT D$;"CLOSE ROW$"
410  PRINT D$;"APPEND QB, D2"
420  PRINT D$;"WRITE QB"
430  FOR I = ARCT + 1 TO RCT
```

```
440  PRINT I
450  PRINT QB(I)
460  NEXT I
470  PRINT D$;"CLOSE QB"
480  PRINT D$;"APPEND COL$, D2"
490  PRINT D$;"WRITE COL$"
500  FOR J = ACCT + 1 TO CCT
510  PRINT J
520  PRINT COL$(J)
530  NEXT J
540  PRINT D$;"CLOSE COL$"
550  PRINT D$;"APPEND QA, D2"
560  PRINT D$;"WRITE QA"
570  FOR I = ARCT + 1 TO RCT
580  FOR J = ACCT + 1 TO CCT
590  IF QA(I,J) = 0 GOTO 640
600  PRINT I
610  PRINT J
620  PRINT QA(I,J)
630 SS = SS + 1
640  NEXT J
650  NEXT I
660  FOR I = 1 TO PH + 1
670  FOR J = ACCT + 1 TO CCT
680  IF QA(I,J) = 0 GOTO 730
690  PRINT I
700  PRINT J
710  PRINT QA(I,J)
720 SS = SS + 1
730  NEXT J
740  NEXT I
750  PRINT D$;"CLOSE QA"
751  PRINT D$;"OPEN MATRIX, D2"
752  PRINT D$;"DELETE MATRIX"
753  PRINT D$;"OPEN MATRIX"
754  PRINT D$;"WRITE MATRIX"
```

```
755  PRINT RCT
756  PRINT CCT
757  PRINT SS
758  PRINT D$;"CLOSE MATRIX"
760  PRINT D$;"RUN CONT, D1"
900  PRINT "ROW(";RCT;") = ";ROW$
     (RCT): RETURN
910  PRINT "COL(";CCT;") = ";COL$
     (CCT);"    QA(";RCT;",";CCT;"
     ) = ";QA(RCT,CCT): RETURN
920  PRINT "QA(1,";CCT;") = ";QA(
     1,CCT): RETURN
960  PRINT "QB(";RCT;") = ";QB(RC
     T): RETURN
```

```
5  REM  . . . . SOLUTION PROGRAM
    . . . .
10 D$ =  CHR$ (4)
12  PRINT D$;"OPEN PH, D2"
13  PRINT D$;"READ PH"
14  INPUT PH
15  PRINT D$;"CLOSE PH"
20  PRINT D$;"OPEN MATRIX, D2"
30  PRINT D$;"READ MATRIX"
40  INPUT RCT
50  INPUT CCT
60  INPUT SS
70  PRINT D$;"CLOSE MATRIX"
80  DIM ROW$(RCT + 1),A(RCT + 1,C
     CT),B(RCT + 1),COL$(CCT),BAS
     IS(RCT + 1)
90  PRINT D$;"OPEN ROW$, D2"
100  PRINT D$;"READ ROW$"
110  FOR I = 1 TO RCT
120  INPUT I
130  INPUT ROW$(I)
140  NEXT I
150  PRINT D$;"CLOSE ROW$"
160  PRINT D$;"OPEN QB, D2"
170  PRINT D$;"READ QB"
180  FOR I = 1 TO RCT
190  INPUT I
200  INPUT B(I)
210  NEXT I
220  PRINT D$;"CLOSE QB"
230  PRINT D$;"OPEN COL$, D2"
240  PRINT D$;"READ COL$"
250  FOR J = 1 TO CCT
260  INPUT J
270  INPUT COL$(J)
280  NEXT J
290  PRINT D$;"CLOSE COL$"
300  PRINT D$;"OPEN QA, D2"
310  PRINT D$;"READ QA"
320  FOR N = 1 TO SS
```

```
330  INPUT I
340  INPUT J
350  INPUT A(I,J)
370  NEXT N
380  PRINT D$;"CLOSE QA"
390 N = CCT:RMCT = RCT
400  PRINT D$;"PR#1"
410  HOME : FOR J = 1 TO N
420  FOR I = 2 TO RMCT
430 A(O,J) = A(O,J) + A(I,J): NEXT
     I: NEXT J
438  FOR I = 2 TO RMCT
440 B(O) = B(O) + B(I): NEXT I:EP
     S = .0001
450 GPV = 0: PRINT "     ITERATION
      # ";ITER + 1: FOR J = 1 TO
     N
460  IF A(K,J) <  = GPV + EPS GOTO
     480
470 GPV = A(K,J):PIVCOL = J
480  NEXT J: IF GPV <  = EPS GOTO
     690
490 MINFRACT = 1000000:ROWPIV = R
     MCT + 1: FOR I = 2 TO RMCT
500  IF A(I,PIVCOL) <  = EPS GOTO
     530
510 FRACT = B(I) / A(I,PIVCOL): IF
     FRACT >  = MINFRACT GOTO 530

520 MINFRACT = FRACT:ROWPIV = I
530  NEXT I: IF K = 0 GOTO 590
540  FOR I = 2 TO RMCT
550  IF BASIS(I) <  > 0 GOTO 580
560  IF  ABS (A(I,PIVCOL)) <  = E
     PS GOTO 580
570 ROWPIV = I
580  NEXT I
590 V = A(ROWPIV,PIVCOL):BASIS(RO
     WPIV) = PIVCOL:ITER = ITER +
     1: IF ROWPIV = RMCT + 1 GOTO
     680
```

```
600  FOR I = K TO RMCT
610  IF I = ROWPIV GOTO 660
620  FOR J = 1 TO N
630  IF J = PIVCOL GOTO 650
640 A(I,J) = A(I,J) - A(I,PIVCOL)
     * A(ROWPIV,J) / V
650  NEXT J:B(I) = B(I) - A(I,PIV
     COL) * B(ROWPIV) / V:A(I,PIV
     COL) = 0
660  NEXT I: FOR J = 1 TO N
670 A(ROWPIV,J) = A(ROWPIV,J) / V
     : NEXT J:B(ROWPIV) = B(ROWPI
     V) / V: GOTO 450
680  PRINT : PRINT  TAB( 15);"IS
     UNBOUNDED": GOTO 1090
690  IF K = 1 GOTO 730
700  IF B(0) <  = .1 GOTO 720
710  PRINT : PRINT "B(0) = ";B(0)
     : PRINT  TAB( 16);"INFEASIBL
     E": GOTO 1090
720 K = 1: GOTO 450
730  GOTO 840
740  PRINT : PRINT "    SOLUTION
     OPTIMAL AFTER ";ITER;" ITERA
     TIONS":ZIMBOX =  - B(1):ZIMB
     OX =  INT (ZIMBOX * 10 ^ 2 +
     .5) /  INT (10 ^ 2 + .5): PRINT
     : PRINT  TAB( 5);"OBJECTIVE
     VALUE = ";ZIMBOX
750  PRINT : PRINT "    VARIABLE"
     ; TAB( 18);"STATUS"; TAB( 30
     );"VALUE": FOR J = 1 TO N
760 JCOL$ = COL$(J): FOR I = 2 TO
     RMCT
770 II = I: IF BASIS(I) = J GOTO
     790
780  NEXT I:X = 0:BASIC$ = "NONBA
     SIC": GOTO 830
790 X = B(II)
800 BASIC$ = "BASIC"
820 X =  INT (X * 10 ^ 2 + .5) /
      INT (10 ^ 2 + .5)
830  PRINT : PRINT  TAB( 5);JCOL$
     ; TAB( 18);BASIC$; TAB( 30);
     X: NEXT J
835  GOTO 1090
```

```
840 UU = 0:LL = 1:LTRACK = 0:UTRA
     CK = 0: FOR J = 1 TO N
850  FOR I = 2 TO RMCT
860  IF BASIS(I) = J GOTO 880
870  NEXT I
880 JJ$ = COL$(J):SET$ =  LEFT$ (
     JJ$,3): IF SET$ <  > "Z/O" GOTO
     950
890  IF B(I) < LL THEN LL = B(I)
900  IF LL = B(I) THEN LTRACK = J

910  IF LL = B(I) THEN LROW = I
920  IF B(I) > UU THEN UU = B(I)
930  IF UU = B(I) THEN UTRACK = J

940  IF UU = B(I) THEN UROW = I
950  NEXT J
960  IF LL > 1 - UU GOTO 990
970  IF LTRACK = 0 GOTO 990
980 COL$(LTRACK) = "SET" + COL$(L
     TRACK):A(LROW,LTRACK) = 0: PRINT
     "SET ";COL$(LTRACK);" = 0"
982  FOR I = 1 TO N
984 A(0,I) = A(LROW,I): NEXT I:B(
     0) = B(LROW):K = 0: GOTO 450

990  IF UTRACK = 0 GOTO 740
1000 COL$(UTRACK) = "SET" + COL$(
     UTRACK):A(UROW,UTRACK) = 0:B
     (UROW) = 1 - B(UROW): FOR J =
     1 TO N
1002 A(0,J) = A(UROW,J): NEXT J:B
     (0) = B(UROW): PRINT "SET ";
     COL$(UTRACK);" = 1":K = 0: GOTO
     450
1090  PRINT : PRINT  TAB( 5);"STO
     P": PRINT D$;"PR#0": END

]
```

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