AN EXPERIMENT IN APPLICATION OF THE MONTE CARLO METHOD FOR SIMULATING CAPITAL BUDGETING DECISIONS UNDER UNCERTAINTY

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ABSTRACT

AN EXPERIMENT IN APPLICATION OF THE MONTE CARLO METHOD FOR SIMULATING CAPITAL BUDGETING DECISIONS UNCER UNCERTAINTY

by Leon Warren Woodfield

A decision to invest in an asset involves assumptions about the future, for by its nature an asset, to have value, must yield benefits in future periods of time. The decision is therefore subject to elements of uncertainty since future technological and economic events cannot be projected with any great degree of preciseness.

A theory that purports to explain the decision process should include as one of its bases the recognition of uncertainty. Any method that is designed to aid in the decision process should also take uncertainty into consideration.

The hypothesis made is that a model (for capital budgeting decisions), in which uncertainty is considered explicitly, can be applied to actual situations in business organizations with the conclusions furnishing useful information in the capital budgeting decision process.

A model using the Monte Carlo method was applied to a limited number of actual asset acquisition proposals in a variety of companies, each representing a different

Through continual improvement of the subjective estimates and refinement of the model it can become a useful tool to aid management in meeting and evaluating the factor of uncertainty as it concerns capital budgeting.

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By

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CHAPTER I

INTRODUCTION: Statement of Purpose and Discussion of Problem

Purpose

My hypothesis is that a model (for capital budgeting decisions), in which uncertainty is considered explicitly, can be applied to actual situations in business organizations with the conclusions furnishing useful information in the capital budgeting decision process. It is proposed to study the capital budgeting decision making process of a limited number of firms; apply the model to some of the alternative proposals for the use of capital funds; analyze the results; suggest uses of the data obtained and attempt to indicate the advantages and disadvantages of the proposed model when compared with methods currently being used to aid management in this decision making area.

Risk versus Uncertainty

Any decision yet to be made is concerned with a future choice between the available alternatives and is always subject to unknown elements concerning the future. The lack of complete data in the decision environment should not limit the attempt to forecast and to use the forecast as a guide for action. The reliability of the estimates will, in part, depend upon whether the individual is faced with a risk or an uncertainty situation. Dr. Shewhart wrote the following:

> What can we say about the future behavior of a phenomenon acting under the influence of unknown or chance causes? I doubt that, in general, we can say anything. For example, let me ask: "What will be the price of your favorite stock thirty years from today?" Are you willing to gamble much on your powers of prediction in such a case? Probably not. However, if I ask: "Suppose you were to toss a penny one hundred times, thirty years from today, what proportion of heads would you expect to find?" Your willingness to gamble on your powers of prediction would be of an entirely different order than in the previous case.[1]

The above statement indicates that certain decision areas may be treated by the mathematics of probability. In

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[1]W. A. Shewhart, Economic Control of Quality of Manufactured Product (Princeton, New Jersey: D. Van Nostrand Co., Inc., 1931), p. 8.

these areas the chance or probability of occurrence of a certain event can be measured objectively. The knowledge of the future event is imperfect; however, because of objective verifiable data the probabilities of the alternatives can be determined. This kind of circumstance should be referred to as risk. Some examples of risk taking are playing black jack for money and buying insurance (preferring a certain small expense to a small chance of a large loss).

When the knowledge of the outcome of future events is imperfect and the probability of the event cannot be objectively determined the area of ignorance should be referred to as uncertainty.[1] The forecast of economic events will always include elements of uncertainty since there are always variables whose value cannot be objectively measured. It is not realistic to assume that uncertainty is ignored in the decision process. Each assumption implicitly or explicitly made includes its own degree of uncertainty. The assumptions may be thought to have a minor effect on the accuracy of the final result when in fact the total effect may be material in amount.

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[1]For a discussion on alternative approaches to the theory of choice, refer to Kenneth J. Arrow, "Alternative Approaches to the Theory of Choice in Risk Taking Situations," Econometrica, Vol. 19, No. 4 (October, 1951), pp. 404-37.

A theory that purports to explain the decision process should surely include as one of its variables the area of uncertainty. Any method that is designed to aid in the decision process should also take uncertainty into consideration. Joel Dean has made the following statement concerning uncertainty in the decision area:

> Adjustments to allow for uncertainty may be challenged as nothing more than guesses. Perhaps they are. But even so, they are guesses that must be made, and will be made, either explicitly or implicitly. Failure to apply the probability adjustment does not enable management to avoid the problem; it merely transfers the guess element in a disguised form to some other stage of the decision-making process.[1]

Capital Expenditure Decision

The decision to invest in an asset involves the future since by its nature the asset to have value must benefit future periods of time. The importance of skilled decision making in the area of capital budgeting is adequately demonstrated by referring to the successes and failures of business firms as reported periodically in financial reports, magazines and newspapers.

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[1]Joel Dean, Managerial Economics (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1951), Tenth printing 1960, p. 568.

There are numerous methods that can be used in estimating the worthiness of capital expenditures. These will include among others, the payback method which will indicate the length of time required to recover the initial investment; the accounting average rate of return which indicates an estimate of a rate of return based on the cost of the asset; and discounted cash flow methods. Of all the methods currently in use the discounted cash flow methods appear to have the best theoretical justification. Assuming that the data is accurate, these methods can indicate the excess of the present value of a stream of future benefits over the cost, or can give the rate of return that is to be expected from the investment. The information required is by its nature subject to uncertainty; however, a condition of certainty is assumed or at least implied in the very fact of using these methods.

Even though current methods used assume that estimates of the future are correct, the existence of uncertainty is recognized implicitly and is adjusted for by modification of desired rate of return, differential handicaps, informal judgements, selection of arbitrary payback periods, and sensitivity analysis. These methods of adjustment are deficient in that they do not provide an estimate of the

likelihood of obtaining a particular value. Harry V. Roberts has noted:

> The most serious deficiency in the present state of knowledge about capital budgeting is the absence of a satisfactory framework for incorporating uncertainty into the analysis. Much of the ultimate success or failure of analytical methods of capital budgeting will hinge on future developments in the treatment of uncertainty.[1]

Whenever a person is involved in uncertainty he is dealing with a subjective phenomenon, the reason being that there is not sufficient historical data upon which a mathematical probability can be based. Subjective probabilities can be determined; however, the expectations cannot be established with objective certainty.[2]

"Subjective probability technique" is a means by which an individual quantifies his attitudes toward the investment opportunity. John H. Norton has noted that subjective probabilities could be determined by questioning the person directly to express his judgements as to the chance

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[1]Harry V. Roberts, "Current Problems in the Economics of Capital Budgeting," Elements of Financial Administration, ed. John O'Donnell and Milton S. Goldberg (Columbus, Ohio: Charles E. Merrill Books, Inc.), pp. 278-84.

[2]Milton H. Spencer and Louis Siegelman, Managerial Economics - Decision Making and Forward Planning (Homewood, Illinois: Richard D. Irwin, Inc.), p. 8.

of an event occurring.[1] A second method has been suggested by Robert Schlaifer; an individual is offered the choice between an uncertain event and a reference event (standard lottery) having an equal reward. The point at which the individual is indifferent between the uncertain event and a given percentage of the total lottery tickets is his probability estimate for the uncertain event.[2]

Methods used to obtain the subjective probability may be successful in quantifying the person's estimate in the problem; however, they do not add to the validity of the judgements that are required. The possibility of poor estimates on the part of the individual points up the need to obtain the judgement of mature persons having experience in related situations. Even though subjective probabilities are judgements that cannot be objectively verified it has been demonstrated, experimentally, that subjective probabilities can be amazingly accurate (the estimates

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[1]John H. Norton, "The Role of Subjective Probability in Evaluating New Products Ventures," Symposium Series 42 "Statistics and Numerical Methods in Chemical Engineering", Vol. 59 (American Institute of Chemical Engineers, 1963), pp. 49-54.

[2]Robert Schlaifer, Probability and Statistics for Business Decisions, (New York: McGraw-Hill Book Co., Inc., 1959), pp. 12-13.

made reflect the actual conditions known to exist in the experiment) when opinions of mature persons are sought.[1]

The problem of uncertainty should be recognized in capital budgeting projects undertaken for study. The subjective estimates should be made since uncertainty is a factor that must be adjusted for. Therefore, it is better that the estimates required to be made be in an explicit form.

A mathematic analysis (where appropriate) furnishes a formula that will provide an appropriate answer to all problems having similar characteristics. Through experimentation, an approximation of the mathematical analysis can be obtained. Solving these problems through experimentation, when the mathematical analysis is not applied, is known as the Monte Carlo method.[2] A number of experiments will be conducted using subjective probabilities and random numbers in an attempt to apply to actual business situations a method that considers uncertainty in an explicit form. A discussion of the proposed model and its use is included in Chapter II.

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[1]Norton, loc. cit.

[2]Schlaifer, Robert, Probability and Statistics for Business Decisions (New York: McGraw-Hill Book Company, Inc., 1959), p. 320.

CHAPTER II

METHODOLOGY AND USES OF INFORMATION

Methodology

There are numerous methods that may be used in estimating the worthiness of capital expenditures. Of these methods the discounted cash flow approach appears to have the best theoretical justification and will therefore, be used in this model

The internal rate of return method of discounting the net cash flow is a procedure whereby we solve for "r" (internal rate of return), so that the expected profit rate of a project can be compared with other proposed projects and also with the firm's cost of capital. The yearly net cash benefit when discounted at the appropriate rate of return would equal the present value of the cost of the investment required to undertake the proposed project. This rate is the maximum average rate that could be disbursed over the life of the asset without incurring a loss on the project.

A formula to determine the internal rate of return is:

$$C = \frac{B_1}{(1 + r)} + \frac{B_2}{(1 + r)^2} + \ldots + \frac{B_n + S}{(1 + r)^n}$$

Where C is the cost of the investment, B is the net periodic cash benefit, S the salvage value in period n and r the unknown rate of return that is to be solved for.

The present value method of discounting the net cash flow determines the present value of future benefits when discounted at an assumed rate of return. The discounted value is then compared to the required investment to establish a ratio of profitability by which various alternatives can be ranked. A formula that can be used to arrive at the present value is:

$$PV = \frac{B_1}{(1 + r)} + \frac{B_2}{(1 + r)^2} + \ldots + \frac{B_n + S}{(1 + r)^n}$$

Where PV is the unknown discounted present value of the future cash benefits and r is the assumed rate of return (cost of capital).

These two methods will lead to the same decision in an accept or reject decision unless there is a problem of dual rates of return.[1] When using the present value method,

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[1]Ezra Solomon, "The Arithmetic of Capital Budgeting Decisions," The Management of Corporate Capital, ed. Ezra Solomon (Chicago: The Free Press of Glencoe, Graduate School of Business, The University of Chicago, 1963), p. 77.

under conditions of certainty, any project will be accepted if the discounted present value is greater than the investment required for the project. The decision will be favorable when using the internal rate of return approach if the calculated rate of return on the proposal is greater than the rate of cost of capital.

When the decision involves mutually exclusive projects (non-independent) and a choice has to be made between one or the other, the two discounted cash flow methods may not lead to the same solution (i.e. decision) to the problem. A contradiction as to the ranking of mutually exclusive projects may appear whenever there is a time disparity (different timing of receipts over the life of the project), a size disparity (different total investment requirements) and/or a difference in the estimated useful life of the mutually exclusive events.

The source of the problem is an implicit assumption made under each of the methods. The internal rate of return approach assumes that the net cash benefits will be reinvested at the rate of return noted in the computation. The present value approach assumes that the funds will be reinvested at the company's rate of cost of capital.[1]

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[1] Ibid., p. 76.

If the proposals do not have equal lives when dealing with mutually exclusive investments it is then necessary to determine a rate of return on each proposal. The period on which the rate of return computation is based is the life of the asset having the greatest longevity. This adjustment requires an explicit assumption as to the rate to be applied to the reinvested funds. The reinvestment rate used may be any rate that is consistent with the firm's policies with the minimum normally being at least equal to the firm's cost of capital. If the mutually exclusive proposals have equal lives but the timing of the net cash benefits and/or the size of the required investments differ, the return on the incremental benefits must be determined before the internal rate of return approach will furnish a guide that is consistent with that of the discounted present value method.

If the rate of discount varies from year to year the two methods will not give identical results.[1] The variation in the rate of discount may result from the limitation of available capital funds with management changing the required discount rate from year to year in

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[1]Harold Bierman and Seymour Smidt, The Capital Budgeting Decision (New York: The Macmillan Company, 1960), p. 34.

an attempt to limit the number of proposals that qualify for capital funds in a particular year.

Except as noted, the two discounted present value methods will furnish consistent results if they are used correctly.

When an individual is trying to reach an optimal position between investments (which some authors have suggested is a process whereby individuals distribute consumption over time) and the consumption function, it has been claimed that the discounted present value methods will maximize the investment area (opportunity for production); however, the individual may be able to improve his position by borrowing funds and thus enabling him to reach a higher indifference curve. This optimal position may not be obtained if the individual invests without considering the means of financing the asset acquisition.[1]

The discounted present value approach appears to be the easier of the two methods to use since adjustments to the normal means of computation are not required to arrive at the "correct" solution. The internal rate of return is

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[1]For a discussion on reaching the optimal position, refer to J. Hirshleifer, "On the Theory of Optimal Investment Decisions," The Management of Corporate Capital, ed. Ezra Solomon (Chicago: The Free Press of Glencoe, Graduate School of Business, The University of Chicago, 1963), pp. 205-28.

preferred by some in that the solution is given in a form of a rate of return on the investment. Others may prefer to analyze and compare different ratios of the discounted present value to cost.

The method to be preferred is a matter of personal opinion and both methods could be used in the model under consideration. Thus, keeping in mind the possible problem areas, the internal rate of return method will be used for this discussion since it is felt that the results will be more easily interpreted and understood when expressed in terms of an estimated rate of return.

The Simulation Model

The decision to invest in an asset involves variables that are stochastic in nature (subject to a range of possibilities). By introducing these variables and an estimate of the subjective probability into the analysis, an approximation of the proposed project's rates of return and the relative frequency of each is possible. A probability will be assigned to each rate of return that is equal to the relative frequency determined in the analysis.

As was noted in Chapter I, the problem under consideration is in the realm of uncertainty and as such the probability of occurrence cannot be objectively verified and therefore, subjective data must be used. It has been suggested by Elwood S. Buffa, Robert Schlaifer, Sidney W. Hess and Harry A. Quigley that a mathematical analysis to arrive at a probability distribution may prove to be very difficult, costly and in some cases impossible.[1, 2, 3] Therefore, a next best substitute, a simulation model, will be used to arrive at the likelihood of each particular rate of return of any given project.

In Chapter I, a distinction was made between risk and uncertainty. It was noted that in a condition of uncertainty subjective data must be used to arrive at an estimate of the probability of an event occurring. After

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[1]Elwood S. Buffa, Models for Production and Operations Management (New York: John Wiley & Sons, Inc., 1963), p. 506.

[2]Robert Schlaifer, Probability and Statistics for Business Decisions (New York: McGraw-Hill Book Company, Inc., 1959), p. 320.

[3]Sidney W. Hess and Harry A. Quigley, "Analysis of Risk in Investments using Monte Carlo Techniques," Symposium Series 42 "Statistics and Numerical Methods in Chemical Engineering", Vol. 59 (American Institute of Chemical Engineers, 1963), p. 57.

the estimate of probability has been established the analysis will then proceed as if it were an analysis of a risk situation; that is, although the knowledge of the future event is imperfect, we use the best information we have (probability estimates) to project the "values" of the several possible outcomes. If subjective data is not available so that a probability estimate concerning the future is impossible the uncertainty problem would then have to be approached by use of game theory if it (uncertainty) were to be explicitly considered.[1]

The problem under consideration is only a portion of the larger area of capital budgeting which in turn is part of the overall management and administration of the firm. Uncertainty is involved in the determination of the internal rate of return and/or discounted present value and the likelihood of each. Other factors such as the firm's cost of capital, availability of funds, control, areas of responsibility and overall goals of the organization are not to be considered at this time.

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[1]For a discussion of game theory and capital budgeting, refer to Edward G. Bennion, Capital Budgeting and Game Theory (Harvard Business Review, Nov.-Dec. 1956, Vol. 34, No. 6), pp. 115-23 and to W. G. Nelson, "Could Game Theory Aid Capital Budgeting," NAA Bulletin 43, Section 1 (June, 1962), pp. 49-58.

The minimum factors whose values will have to be determined are the estimated cost of the proposed investment (the relevant cost being the incremental cash expenditures of the proposed project), the incremental operating expenses being classified as fixed and variable and the estimated useful life of the project. The proceeds to be received in case of a new revenue producing project, or the annual cost savings for projects reducing the costs of operation, and the estimated terminal salvage value of the asset are also necessary factors that will have to be determined.

Where applicable, the market share, production capacity level and other factors that would materially affect the decision under study will also be considered. For each of the above, subjective probability estimates will be obtained.

At this point in the analysis, each relevant factor, with its range of values and the probability of each, will have been obtained for each capital budgeting proposal to be studied.

If the model were to be applied with the use of hand calculators the distribution of each variable would be assigned numbers ranging from 0 to 99 (refer to Appendix A). The size of the group of numbers assigned will be dependent upon the subjective probability of the factor

under consideration. For example: If there is estimated to be a 15% chance that the sales will be X dollars, numbers 00-14 will be assigned to that particular level of sales. This same procedure will be duplicated for each factor having a range of values. Then, by use of random number tables, factors such as the level of sales, cost, estimated useful life will be obtained. Based on this information a range of rates of return, with their likelihoods of occurrence, can be determined; however, in order to obtain an estimate of a possible range of rates of return and their likelihood of occurrence, a number of experiments (determination of individual rates of return) will have to be made. The number of trials will depend upon the time, cost, and availability of equipment with the greater number of trials giving the more reliable results. The illustrated problem (Appendix A) consists of fifty experiments requiring approximately eight hours of work when using a hand calculator. The results based on the fifty experiments are very similar to the solution arrived at when using the expected value for each factor.

Harry A. Quigley and Sidney W. Hess have suggested that one hundred experiments will give results that are

very close to the theoretically correct solution.[1] The problem of sample size has not been completely solved in current literature; however, this should not affect the basic methodology under consideration. With this in mind a minimum of one hundred experiments will be established for this model.

Use of the Data

The data obtained should furnish information to management that will aid them to predict the outcome of the project and be useful to them within reasonable limits of cost.

When there are no limits on the available capital, and adjustments for time and size disparity (problems noted in prior section) have been made, a decision rule may be established that, for any project, if the rate of return is greater than the cost of capital the project should be accepted. This rule is made under an assumed condition of certainty. When uncertainty is introduced into the analysis, if the individual is indifferent between two projects having

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[1]Hess and Quigley, loc. cit., p. 55-63.

the same expected rate of return even though the range of possible gains or losses is different the comparison should be made between the rate of cost of capital and the expected rate of return. The use of this model will furnish the information required to determine the expected rate of return.

The condition of being indifferent between two projects having the same expected rate of return has been referred to as being linear with respect to money, it is, however, unreasonable to expect each individual (management group) to be linear with respect to money inasmuch as they may have an aversion to or a liking for projects subject to risk and uncertainty. Management's attitude toward uncertainty will have to be determined before the acceptability of a project can be known. Under these conditions the information obtained would have to be presented to management and, depending upon its attitude toward uncertainty, the accepted project could very well have an expected value greater than, equal to or less than the expected value of an alternative project. Robert Schlaifer has suggested that an "expected utility" can be determined when comparing the proposed project with a reference contract. By determining the indifference point between the two contracts,

the individual's (or organization's) attitude toward risk, profit and loss in a particular type of situation can be determined, and based on the finding of this type of analysis, the utilities of various cash consequences could be determined.[1] Therefore, management's attitude and its acceptance or rejection of a particular project could be predicted by referring to the "expected utility" function for this organization. This type of analysis is beyond the scope of this study; however, the information obtained from the present model could be used as a basis for extension into the "expected utility" if it was so desired.

A limitation by management may be placed on the size of the capital budget in any one period of time. This limitation may take the form of either a limit on expenditures or an arbitrary rate of return that is greater than the firm's cost of capital. Under these conditions there is no longer an accept or reject decision in the sense that a comparison is made between the estimated return and the cost of capital but it is now necessary to obtain the best combination of projects all having rates of return that are

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[1]Robert Schlaifer, Probability and Statistics for Business Decisions, (New York: McGraw-Hill Book Co., Inc., 1959), chpt. 2.

greater than the cost of capital. In this respect each project is competing with the other projects for limited capital funds. One suggestion for a solution to this problem is that when dealing with limited funds competing projects (proposals competing for funds) may be treated as conflicting projects (mutually exclusive). The best combination being the one yielding the greatest effective rate of return balanced against the objectives of management.[1]

Under conditions of uncertainty it may no longer be sufficient that the rate of return is greater than the rate set by management in its attempt to limit the use of funds for capital expenditures. It may be necessary to consider the aggregate of projects in such a way that the total return is maximized subject to the limits of a certain expenditure amount and the limits of variance in the rates of return and/or in the estimated costs of projects.

Neil R. Paine and Joel Cord have suggested possible solutions to this problem area; however, each assumes that

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[1]For a more complete discussion of the limited capital problem under conditions of certainty, refer to James H. Lorie and Leonard J. Savage, "Three Problems in Rationing Capital," The Management of Corporate Capital, ed. Ezra Solomon (Chicago: University of Chicago, 1963), p. 56-66.

subjective probability estimates can be obtained.[1, 2] No completely satisfactory solution to the problem of how to allocate limited capital funds has been found. It is evident that any adequate solution must contain some explicit considerations of uncertainty, and in order to do that, it must be possible to obtain and apply subjective probability estimates.

The information obtained from the model indicates the likelihood of a return being received based on the subjective estimates furnished by those individuals having good judgement, experience and a knowledge of the capital budgeting process as demonstrated by past performance; still, it should be remembered that two persons furnishing estimates on the same project may assign probabilities that vary from one another; however, individuals having the same experience should be expected to assign probabilities to the event that are quite similar.

The quantifying of uncertainty does not add to the validity of the estimates required. The analysis of the

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[1]Neil R. Paine, "Uncertainty and Capital Budgeting," Accounting Review, Vol. XXXIX, No. 2 (April, 1964), pp. 330-32.

[2]Joel Cord, "A Method for Allocating Funds to Investment Projects When Returns are Subject to Uncertainty," Management Science, Vol. 10, No. 2 (January, 1964), pp. 335-41.

rate of return and its likelihood will not in and of itself answer the question as to what happens if the actual results differ from that forecasted. That is, what will be the effect on the rate of return if the range of values and the subjective probabilities are in error. By making a sensitivity analysis of the factors used in computing the rate of return it is possible to explain the way in which each factor interacts within the system which would aid in evaluating this problem area. Assume, for example, that the data was fed into a computer and one hundred or a thousand individual computations were made of the rate of return. By having the computer print out the factors (cost, estimated useful life, etc.) that were used in the determination of each rate of return and through an analysis of this data it will be possible to determine the effect, for example, of changes in the useful life on the estimated rate of return. This type of analysis should furnish additional information that will aid in arriving at the final decision as to whether the proposal should be accepted or rejected.

The model generates the frequencies of each of the factors used in the computation of the rate of return; from these frequencies statistical tools such as the mean and

standard deviation could be used. The use of the standard deviation generally assumes a normal distribution of the factors under consideration; however, as was noted by Frederick S. Hillier that if the distribution was non-normal the only result is that a precise probability statement cannot be made.[1] The analysis of the factors using the standard deviation would furnish an indication as to the probability that the factor being analyzed would fall within a given range of values. However, since the subjective estimates are based on the judgement and experience of the individual furnishing the data and assuming that the original estimates are rational, the basis for revision of the subjective probabilities would be from added experience and as such the analysis of factors using the mean and standard deviation would not be a reason for rejecting the prior probabilities and for a posterior probability (revision of prior probabilities as a result of additional information and experience). It is for this reason that these tools will not be used in this analysis.

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[1]Frederick S. Hillier, "The Derivation of Probability Information For the Evaluation of Risky Investments," Management Science, Vol. 9, No. 3 (April, 1963), pp. 443-451.

Successful application of the proposed model will depend on whether there is available data, and if not immediately available, whether it is obtainable. To be useful the information furnished from the application of the model should describe within reasonable limits the actual experience and should aid in the prediction of the operating results that pertain to the capital budgeting project in question.

The added information resulting from this model will be of value to the organization, if the costs of obtaining the data are less than or equal to the benefits received. The benefits received, in most cases, will not be of the type that are entirely measurable in dollar and cents; nevertheless, the net results (hopefully) should be an improvement in the application of principles that underlie the practice of capital budgeting and should be an aid in the profitable employment of capital invested.

The model and information obtained from its application will not replace sound judgement, for the program as outlined is no better than the judgement of the individuals who have furnished the information. It should furnish, at a minimum, additional data that will enable an individual to maintain and improve his competitive position

through more sound decisions made possible by useful data upon which to base a decision.

Sources of Data

By way of preparing for a better understanding of corporate capital budgeting problems so that a better application of the model can be made, individuals responsible for the capital budgeting decision will be interviewed. In addition, a number of completed projects will be analyzed and traced through the organization of the firm from the inception to completion of the project. This review will furnish information on the procedures currently in use and also furnish an indication as to where in the decision process and in what form uncertainty is introduced into the process.

It is proposed that a postdictive study be made. Either projects that have currently been approved or will be completed in the immediate future will be used for the review. Based on this data, the necessary factors to apply the model will be determined. Each variable to be applied will be discussed with the individual having the responsibility for the area. An example is a forecast of sales

being reviewed with the salesmanager and other interested persons. The subjective probability will be a quantification of the manager's opinions as to the likelihood of each occurring.

The source of the information will be firms currently involved in capital budgeting decisions. The number of firms involved in the study will depend upon the size of the firms. It is necessary to have a considerable number of capital budgeting "projects" to apply the technique to. One or two larger firms would be adequate for the purpose; however, if smaller firms are available a larger number would be required in order to obtain a sufficient sample of individual project cases.

CHAPTER III

ANALYSIS OF THE PROPOSALS FOR ASSET ACQUISITION

Business organizations, the industry in which each operates, the economic climate, and the political setting have peculiar characteristics that make a reference to an average of little value in this type of analysis; if indeed one could be determined. The following introductive material applies to five firms in different industries with no attempt being made to compare them with an average. The purpose of interviewing and obtaining information was to determine if the model can be applied to actual capital budgeting proposals.

Background Information

The business concerns contacted were interested in the project. As expected, some of the organizations, even though expressing an interest, did not make themselves

available because of the time required to determine the necessary data, and/or their particular business did not lend itself to this type of analysis. All of the firms that cooperated in the study were very helpful in their willingness to furnish data, discuss the problem area and also to make available individuals who were responsible for this area of the business activity. There was some difficulty in finding companies that were willing to cooperate; however, this problem fell within the realm of expectation.

The asset acquisition proposals studied can be grouped as cost savings, competing proposals to meet the need for increments to an established line of business, establishment of new branch offices and retail outlets for existing services and products, and asset replacement. Various types of projects were deliberately reviewed to aid in the evaluation of the applicability of the proposed model. The acquisition proposals studied were those that were currently being approved, or those for which approval had just been granted. One exception was a project that had been in operation for a few years, that still had elements of uncertainty surrounding the future course of action to be taken in regard to the asset.

The availability of proposals to be reviewed within the organization was limited when individuals having made the original proposals were unavailable; when the acquisition was so large as to not be practical for the purpose of the study; and also when a quantitative analysis had not been made to help justify the acquisition of the asset. When individuals within a company were unavailable so that proposals of a certain area or type could not be studied, a second source or company was located. An example of where there was a size limitation and also a limitation because quantitative methods of analysis had not been made is a firm that proposed a complete change in the data processing system. A study taking the major portion of a year had been made to determine if there was a need and also if the proposed system would meet the need. In their analysis no attempt was made to determine the information necessary to calculate return on the investment.

Sources of data are an insurance company, a financial institution, a refining and marketing company of oil products, a manufacturer of industrial products and a manufacturer of component parts for the auto industry. Although these organizations are in different industries there seemed to be at least two common characteristics for

the group. The first being that each felt that the competitive situation and the conditions of supply and demand were peculiar for their firm and industry and that the risk and uncertainty facing them were as great, if not greater, than in other types of business activity. The second similarity was a desire to obtain a reasonable return on the investment.

Before the model could be effectively applied to specific proposals it was necessary to obtain an understanding of the procedures used by each firm. The procedures being used will be summarized in order to provide the reader with an understanding of the methods used.

Of the firms interviewed, two were using a discounted present value method; the internal rate of return and the profitability index. Two firms used the payback method, supplemented with the accounting rate of return analysis. One organization did not have or did not use an analysis that attempted to indicate a promised rate of return or a capital recovery period, but attempted to determine if a need existed and if the proposal would meet that need. All of the firms stated that the quantitative methods used, if any, in the last analysis were only a tool

and that good judgement on the part of the individual or group making the decision was required for effective operations.

When the proposal has been analyzed, a decision must be made as to whether it will be accepted or rejected. Many authors of financial literature have suggested that this decision could best be met by establishing a standard upon which to judge each proposal. The two firms using the payback method establish a minimum period of one to five years, with the organization requiring the one year recovery having recently changed from a three year period. The firm using the profitability index method established a minimum payback period of five years. This then was converted to a minimum rate of return after adjusting for tax effects and the method of depreciation accounting. The reasons given for the level of each established standard were the competitive conditions in which the firms found themselves and also the availability of funds for long term asset acquisition. No mention was made of an attempt to earn a return which at least equaled a cost of capital.

The organization using the internal rate of return stated that a standard could not be established; that each

project had to be analyzed individually with the promised rate of return being only one factor to be considered.

Other standards used were the effect on the cost per transaction, and a comparison of the out-of-pocket cost of the old and new projects to see if there was a reduction in the dollar amount of the yearly net expenditure.

The control over the authorized expenditures was through the normal organization of the internal control established by the firm. The supporting documents varied with the size of the organization and the method of analysis used. In all firms an authorization had to be received before the project could be undertaken. The control over costs during the construction and/or acquisition stage was normally a function of the purchasing and accounting department, with excess funds requiring additional authorization before they would be supplied.

There was a tendency to establish control by using total dollar amounts which could and did allow for variations within the various parts of the project. As a result, surplus funds were diverted to other projects or to additions to the approved project without authorization from the individual or group responsible for the original authorization.

Post audits were not generally made, although one firm indicated that in one of its operating areas a sample was taken and the selected asset's performance was compared with the estimate made in the original proposal. The other firms indicated that the estimates were indirectly reviewed by an analysis of the overall operating performance. For an example: Standards were adjusted for changes in the methods and the variations from standards were in turn analyzed. The major limitation of the post audit in cases where it was felt to have merit was that the classification of revenue and expense was such that the evaluation of an individual asset's performance was very difficult, if not impossible. The importance of the post audit was recognized and where it was currently not a normal procedure it was anticipated that improvements would be forthcoming.

The retirement of assets was controlled by the accounting department after approval was obtained from one having the authority with a yearly inventory of fixed assets being made by some establishments.

The procedures, as outlined by the firms (if followed), were adequate to provide a physical control over the assets. The major weakness noted was that of what seemed to be a lack of control over appropriations that were

approved in total but not related to specific projects and subgrouping within the project, and the limited analysis of estimates versus actual performance.

Operating budgets were common for both long and short run estimates; however, the long term estimates for asset acquisition both as to the individual project and the dollar requirement, were felt to be either unsatisfactory and in need of improvement or were non-existent. The annual budgets for asset acquisitions were reasonably reliable when compared with the uses to which they were put; still, this does not mean that improvements would not be necessary in the budgeting procedures if additional information and analysis were desired.

The individuals responsible for preparation and interpretation of the analysis used to quantify the estimates of the project's performance, with few exceptions, seemed to understand the major assumptions made under each method and its limits. However, a majority of the firms were in need of improved communications concerning their purposes and objectives in this area since individuals not directly responsible did not know the procedures that were being followed or if they did; did not appear to have an adequate understanding of them.

Most of the ideas for use of funds were the result of a need to meet a customer's specific requirements, to reduce costs of the current operating methods or to fulfill general guide lines as established by management. A general weakness involving an insufficient number of alternatives investigated was apparent. An example of this is that one organization had established a need for new information and methods to obtain data; the analysis of ways to meet the need was limited to one source and type of asset when other sources with competitive methods were available.

The problems of risk and uncertainty were met through judgements made by officers responsible for the decision area and were based upon past experience and a feeling as to the future business conditions. An attempt to quantify uncertainty took the form of either making several estimates based upon two or three assumed levels of activity or the establishment of standards that, for all practical purposes, approved only those projects having very little uncertainty as to the recovery of the required investment. The requirement that each project should have a payback period of one or less years is an example of this.

To summarize: For each company interviewed there was an attempt being made to improve the means of analysis. This included such things as changing the financial reporting so that better control over specific asset areas could be obtained; selling the necessity of good budgeting procedures to supervisors and employees; a growing awareness that something better must be looked for; a willingness to investigate new ideas and procedures; and the establishment of a group of individuals within the organization whose purpose it is to study the systems and procedures and also be a source of new ideas and alternative ways of accomplishing the goals of the organization.

Summary of Data

Table 1 represents the estimates of a proposal for the acquisition of an asset that was reviewed and for which the model has been applied. The classification of information obtained on each of the twelve proposals studied has been the same. Of these proposals, one has been selected as an example to illustrate the data collected with the final output and analysis being made for each acquisition proposal in a later section of this chapter. Limiting factors were

TABLE 1

RANGE OF VALUES AND SUBJECTIVE PROBABILITIES

		DOLLAR OR YEAR	CUMULATIVE SUBJECTIVE PROBABILITY
I	Estimated Useful Life	10 Years	25%
		15	65
		20	100
II	Estimated Investment Required	$64,640	50%
		61,560	75
		58,480	100
III	Gross Benefits		
	Years one - three	$29,370	34%
		26,700	67
		24,030	100
	Fourth Year (Illustration of distribution for years four - twenty)	$31,670	11%
		31,420	23
		31,090	34
		28,800	45
		28,570	56
		28,290	67
		25,930	78
		25,760	89
		25,490	100
IV	Operating Expenses	$ 7,400	10%
		6,000	30
		5,000	100
V	Asset Replacement	None	
VI	Value of Asset at the end of its Useful Life		
	End of tenth year	$38,780	40%
		36,930	60
		35,080	80
		27,180	90
		25,850	95
		24,560	100
	End of the fifteenth or twentieth year	None	

considered in arriving at the estimates of the variables used in the model, for example: The level of plant capacity and limitations of demand were considered in determining the level of sales and expenses, and obsolescence was considered in the estimated useful life of each asset.

The company, in analyzing the proposal noted in Table 1, used the payback period to justify the acquisition with a three year period being established as a standard. The original proposal did not include an estimate of the useful life since it was not required in the payback analysis used.

It is interesting to note that the investment figure used in the original analysis was $61,560, even though it was not the most likely one. The estimated gross benefits were determined by estimating the possible rates of growth and the variation from each over the asset's life and then assigning the subjective probability to each attainable level of activity. For the first three years it was felt that the gross benefits would not change, with the years thereafter changing at a rate of from 6% through 8%. The fourth year's gross benefit had a range from $25,490 to $31,670. In the twentieth year the range was

from $64,500 to $101,650 with the subjective probability being an equal chance for each.

The operating expenses (made up of maintenance expense) would vary over the life of the asset; however, it was the opinion of the engineer that the pattern of variability could not be estimated with a reasonable amount of accuracy; therefore, an average annual amount was estimated for the life of the project.

The asset was felt to have a value for resale or for use within the organization if used within a ten year period. The higher range of $35,080 to $38,780 is the estimated value of the asset if used within the organization. The value of $24,560 to $27,180 is the estimated sales value of the asset if sold within a ten year period. The asset for tax purposes was to be depreciated over a twenty five year period, even though the maximum useful life was felt to be twenty years.

Persons questioning their ability to make subjective probability estimates normally gave one of the following reasons for their inability to do so: First, that the estimates made in the original proposal were realistic and correct. When the assumption being made, as to the condition of certainty, was pointed out, each person was willing to

acknowledge that there were other estimates that had merit and they were then willing to express a probability for each. A second reason, usually implied by various statements concerning their method of analysis, was that only a figure that was certain to be obtained would be used in the estimate since the individual would be held accountable for an estimate made that was not attained. The third reason was actually not a reason but a statement that only those estimates that would assure the acceptance of the project would be furnished in the analysis. For example: One organization noted that a minimum sales figure would always be used to assure that the project would be accepted. The last two reasons are an indication that the organization has not communicated to the individuals the goals of effective capital budgeting which would enable management to better meet their responsibility as effective custodians of the corporation's resources. Not being able to make an estimate was given as the last reason; however, those who did not seem to have an understanding of the capital budgeting process and were normally not directly involved in the area of asset acquisition gave this reason.

The comment was made by some of the firms that in certain types of business operations, in order to stay in

a competitive position, investments were required to be made in areas that were subject to a great amount of uncertainty and because current investments were required that would not promise a return for twenty to thirty years that when using the discounted cash flow method the present value of the uncertain future benefit would be zero or next to it; therefore making this form of analysis almost worthless. It is recognized that the above condition may exist in a few areas of asset acquisition; however, if these conditions are very prevalent, the author suggests that it may be necessary to analyze not the single asset acquisition but the overall area of business and if these conditions are normal, then other types of investment may be a better source of investment of equity funds that do not fall in the classification of funds for speculation.

Application of the Data to the Model

A detailed description of the steps required to apply the model is included in Appendix B. The first part of Appendix B is the description of the input and output requirements for each factor used in analyzing each proposal. Parts II through V are the steps required to convert the

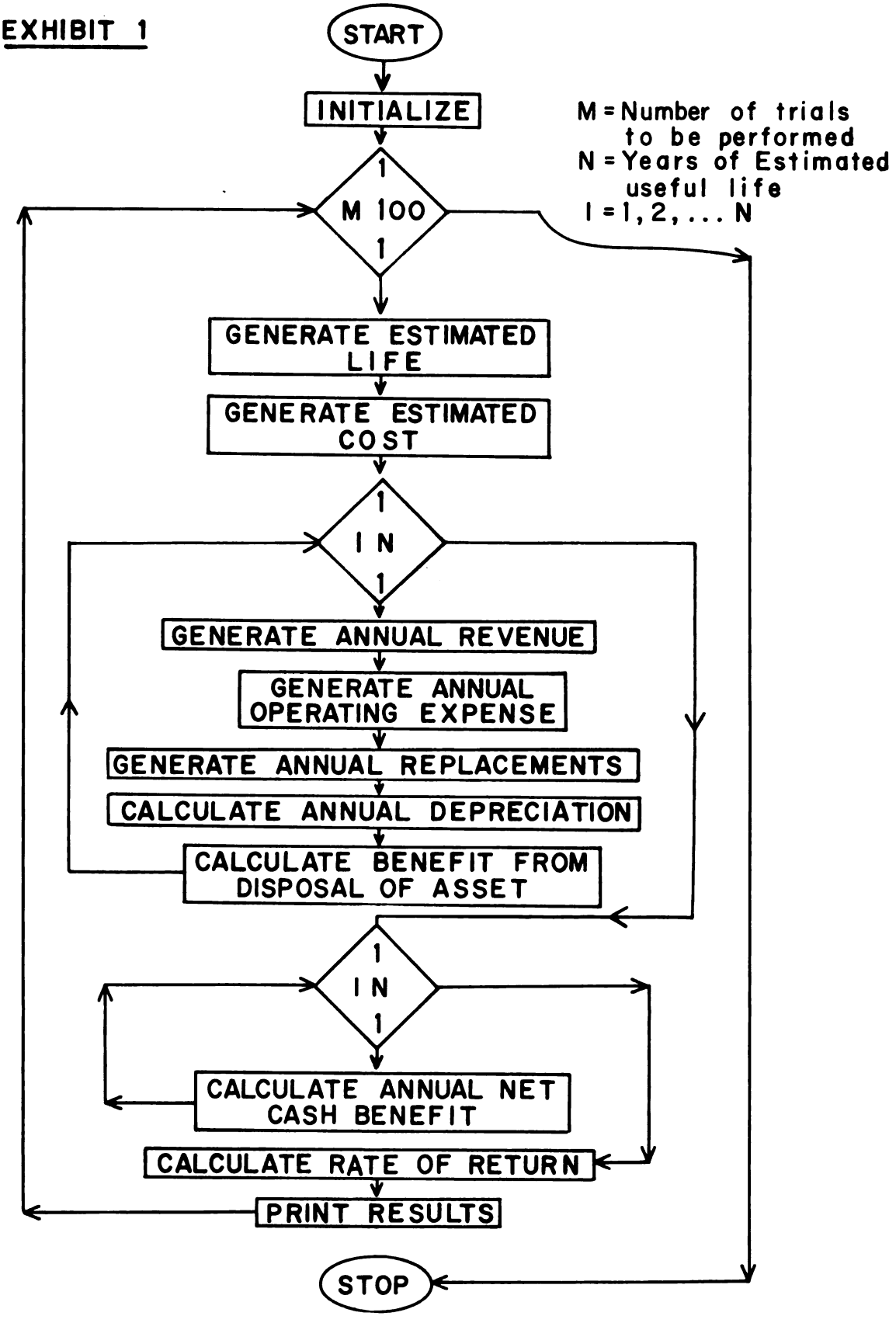
data into an estimate of the rate of return and furnish the desired output. Reference is also made to Exhibit 1 for a flow chart of the computer program used in the analysis. A detailed computer program is included in Appendix C.

For the purpose of applying the data to the model the level of activity in any one year is assumed to be independent within that year; that is, any value within the range indicated for a particular year is assumed to be possible for the proposal under study. An example is that the lowest value in one year would not restrict the attainment of the highest level in subsequent years. It is recognized that for certain types of investment alternatives this assumption would have to be modified; however, for the projects under study it is felt to be a reasonable assumption.

Losses and gains from disposal of assets in the year of retirement are assumed to be offset against other capital gains or losses in the year each is incurred. Operating profit and losses are also assumed to be offset against other operating areas.

The tax law has special provisions that affect the capital asset acquisition decision. Such items as the investment credit that applies to tangible personal property and other tangible property used in certain types of business

EXHIBIT 1


START
INITIALIZE
M = Number of trials to be performed
N = Years of Estimated useful life
I = 1, 2, ... N
1
M 100
1
GENERATE ESTIMATED LIFE
GENERATE ESTIMATED COST
1
I N
1
GENERATE ANNUAL REVENUE
GENERATE ANNUAL OPERATING EXPENSE
GENERATE ANNUAL REPLACEMENTS
CALCULATE ANNUAL DEPRECIATION
CALCULATE BENEFIT FROM DISPOSAL OF ASSET
1
I N
1
CALCULATE ANNUAL NET CASH BENEFIT
CALCULATE RATE OF RETURN
PRINT RESULTS
STOP

operations allow a 7% credit to be applied against the tax liability subject to limitations as specified in the Internal Revenue Code. There is also a first year allowance on an aggregate cost of $10,000 at the rate of 20% that is allowed to be deducted to arrive at taxable income. The accelerated depreciation methods, along with the above noted examples (if used for tax purposes) could affect the annual net benefits that are used in an analysis of this type. For this study the straight line method of depreciation is used. The residual value is deducted to arrive at the depreciable base only when it is material in amount. The investment credit and first year 20% depreciation allowance are not included in the model.

It is assumed that the cash is received and disbursed in the year the revenue is earned and expense incurred and/or the balance of the receivables and accrual and accounts payable do not vary from year to year so that in effect the analysis is on a cash basis. Asset replacements that are minor in amount are handled as an expense item in the year of replacement. For replacements that are material in amount the annual depreciation is adjusted to reflect the change in the depreciable base of the investment.

The basic assumption underlying the application of the model is that the dollar range for each factor and the subjective probabilities furnished are reasonable in amount and are rational. In interviewing companies care was taken to obtain the estimates from persons having responsibility and experience in the operations of the particular investment area and the principles involved in the application of capital budgeting techniques.

Analysis of Cases

The following is a summary of the twelve acquisition proposals that were used in applying the model to actual capital budgeting projects. For each case the data has been summarized into three areas. They are a summary of the rates of return obtained in the simulation of the asset acquisition, an analysis of the factors affecting the rates of return and a comparison of the results of the simulation model and the capital budgeting methods currently used to evaluate the proposals for investment of long term capital funds.

With the exception of Case 8, a Figure is furnished indicating the relevant rates of return and the probability that each will be obtained. The source of the data appearing

in each Figure is a summary of the individual calculations of the rates of return. For this analysis one hundred computations were made. The rates of return are summarized and the probabilities assigned are equal to the frequency of each rate of return obtained in the simulation.

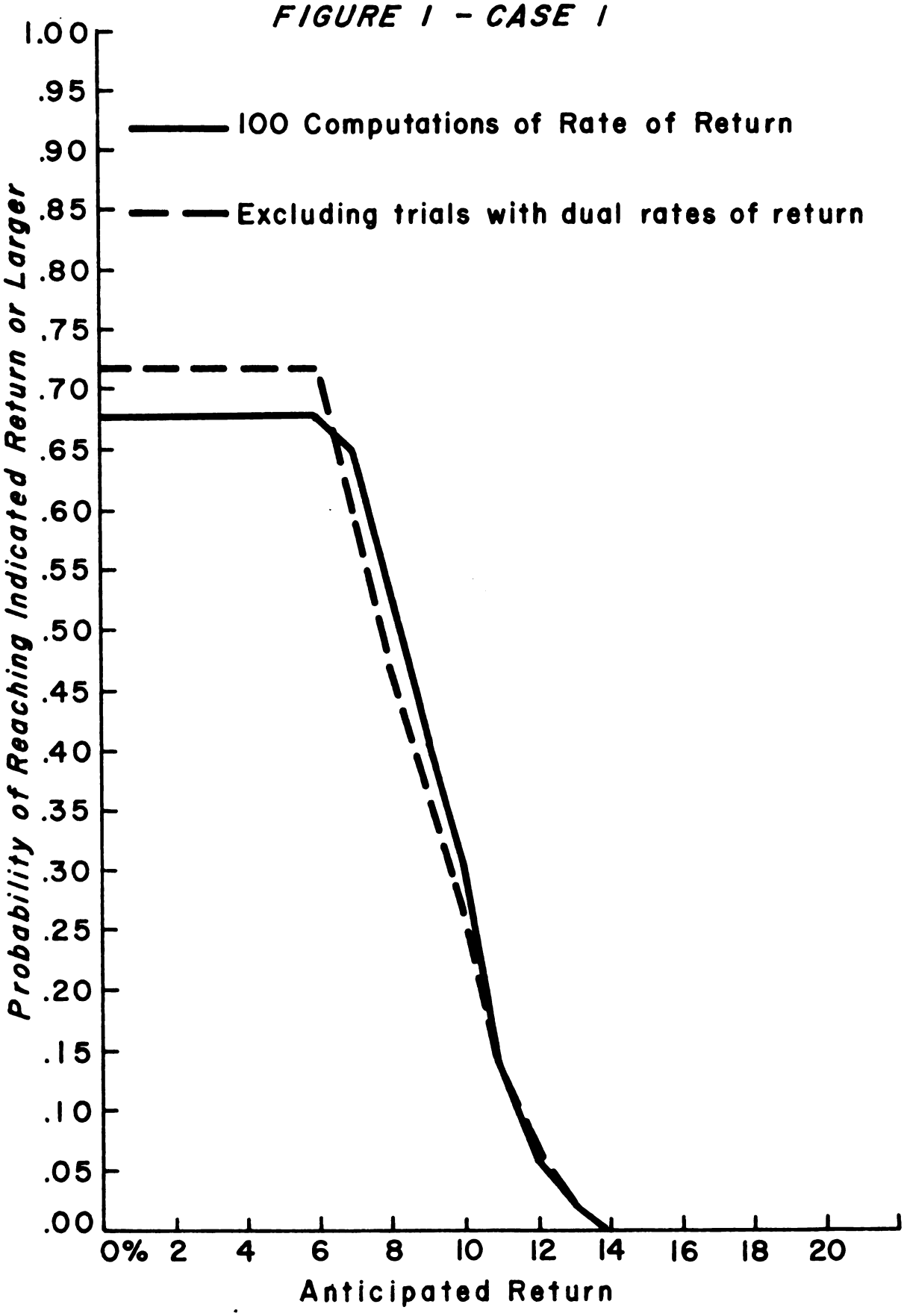
The simulation of the results of the asset proposals for eleven cases was through the use of the computer using the Fortran language. (Refer to Appendix C for an example of the program). One simulation of an asset proposal was performed by the use of a hand calculator. The reason for this is that the time involved to obtain the simulation results by hand methods was less for this particular proposal than what would have been required to write a computer program. This condition was an exception and would not normally be expected to apply.

Case 1 (Figure 1)

Rate of Return

There is a 68% probability that the present value of the net cash benefits will be equal to or greater than the present value of the required investment, in other words, a positive rate of return is promised 68% of the time, with the maximum rate being 14%.

FIGURE 1 - CASE 1



Analysis of Factors Affecting the Rate of Return

Factors having the major effect on the rate of return are the estimated useful life and the level of annual revenue and expense. The resale value of the asset, acquisition cost and asset replacements have limited ranges in which they can vary; therefore, the variation of these factors does not have a material effect on the calculated rate.

The useful life is estimated to be two, three and twelve years with a probability of .25, .05 and .70 respectively. The net benefits for years one through three are not sufficiently large to provide for a positive return on the investment requirement. Management felt that if the proposal could survive past the third year the useful life would then be twelve years. The effect of the variation in the estimated useful life can be illustrated by referring to Figure 1. For all computations of the rate of return based on a two or three year useful life the resultant return is zero or less. The rates of return obtained when a twelve year useful life is assumed has a range from 6% to 14%. (Refer to the solid line on Figure 1). The interaction of the factors other than the variation in the useful life causes the rate of return to have a 6% to 14% range

with the annual revenue and expense being the major factor accounting for the variation.

In Chapter II it was noted that the internal rate of return would not provide a ranking of projects that was consistent with the discounted present value method if there were a condition where dual rates of return were possible. This problem arises whenever there is what has sometimes been called a nonconventional flow of annual net benefits. It is normally assumed that the initial investments and any negative net amounts will occur during the initial part of the asset's useful life. Positive net benefits are then assumed to follow the initial investment and the negative net benefits. In some cases there will be a positive annual net benefit that is followed by an annual figure in which the benefits are negative in amount. When this occurs a dual rate of return is possible. This problem may be adjusted for by carrying forward, at an assumed reinvestment rate, the positive net benefits that fall between the negative values to a future year where there are consistently positive values; the rate of return can then be computed on the revised values.

There were a number of computations within the simulation of this case that could give rise to the problem

being discussed. If these situations were eliminated from the sample the effect on the range of rates of return and the probabilities of each can be observed in Figure 1 by reference to the dotted line which represents the smaller sample. The major effect of the elimination of these computations from the sample is an increase in the frequency in which a positive rate of return is estimated to be received. This is demonstrated in Figure 1 by the increase in the assigned probability from 68% to 72% for a rate of return being equal to a positive rate of return.

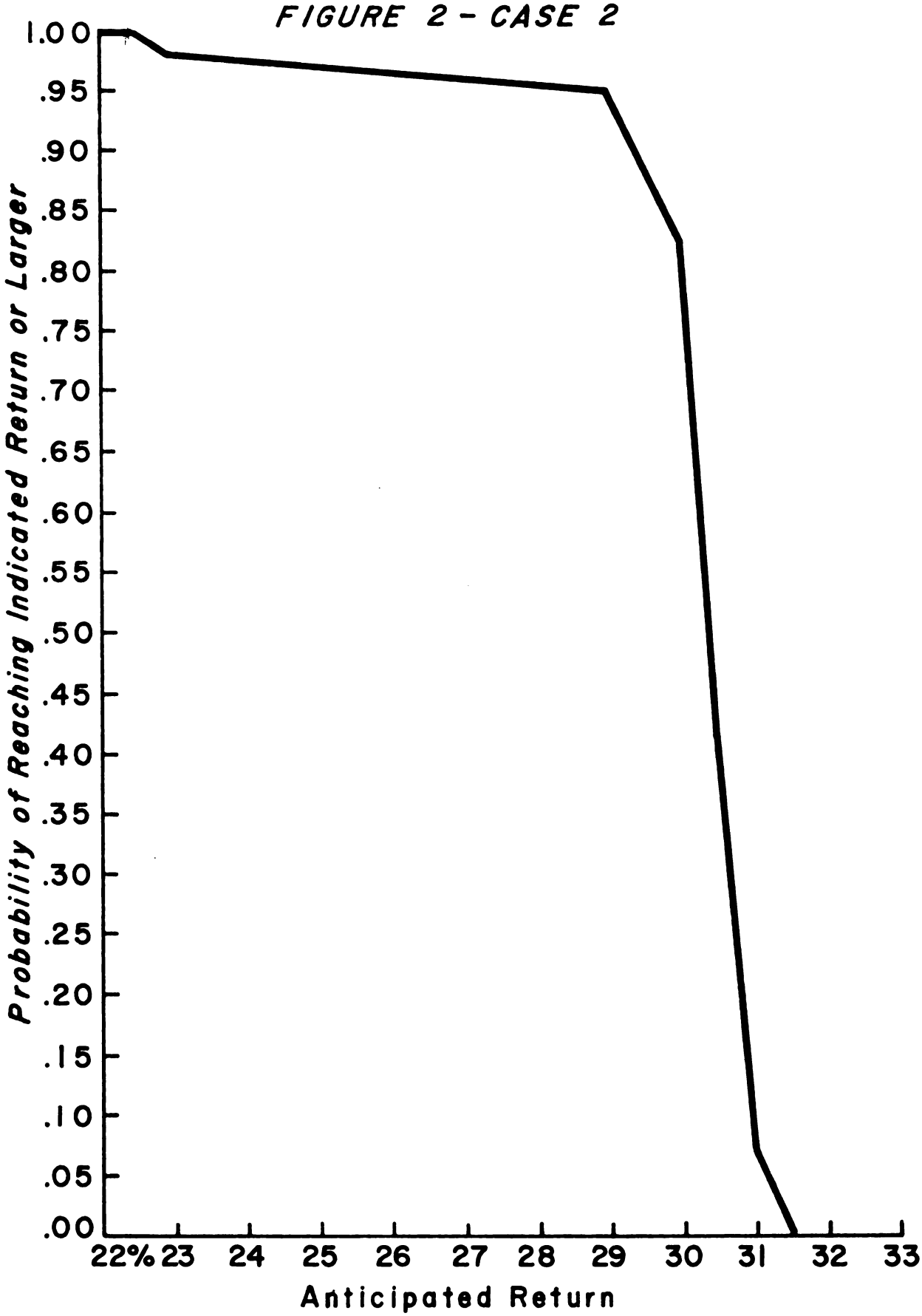
The individual computations of rates of return, when there was a possibility for a dual rates of return problem were adjusted and recomputed. The effect of this adjustment did not change the original distribution of the rates of return and the frequency of each; therefore, the probabilities being indicated by the solid line in Figure 1 are the appropriate weights to be used for this analysis.

Case 2 (Figure 2)

Rate of Return

The relevant rates of return for Case 2 are 22% through 31.5%. This represents a limited range in that a return equal to or greater than 30% will be received over

FIGURE 2 - CASE 2



80% of the time, with the probability of a greater rate of return decreasing very rapidly. The reason for the limited range is that the case was handled, in the model, as if the investment were incurred in the current year and the net benefits for years one through five were certain to be received.

The internal rate of return method determines the rate that causes a condition of equilibrium between the present value of the required investment and the annual future net benefits. In the case under study, inasmuch as the investment was made prior to the current date and also as there have been benefits derived from the investment, it would normally be necessary to carry forward at an assumed reinvestment rate the costs incurred and net benefits received. The resultant figure would then be the present value of the past transactions. This value would then be compared with the future benefits in arriving at the internal rate of return as of the current date. This type of analysis was not made since it was desired to analyze the effect of factors on the rate of return that are certain to occur during the early part of the asset's useful life.

Analysis of Factors Affecting the Rate of Return

As noted above the investment required for the acquisition of the asset and the gross benefits and expenses for the first five years are assumed to be certain; thereafter, a range and subjective probability is introduced for each of the remaining years of the asset's useful life. The relative certainty of the major factors accounts for the majority of the promised rates of return falling into a narrow range. One factor, however, causes a variation in the return that is material in amount even under conditions that are relatively certain. This is illustrated by noting that whenever the asset's estimated useful life is ten years, the calculated return is between 22.5% to 24% or only a variation of 1.5%. The effect of the useful life is demonstrated in that when the useful life is greater than ten years the return is increased by approximately one-fourth. It was felt by management that if the asset was not disposed of within the first ten years it would then have a very good chance of being in operation for an additional ten to twenty years, therefore contributing to the profitability of the investment.

Case 3 (Figure 3)

Rate of Return

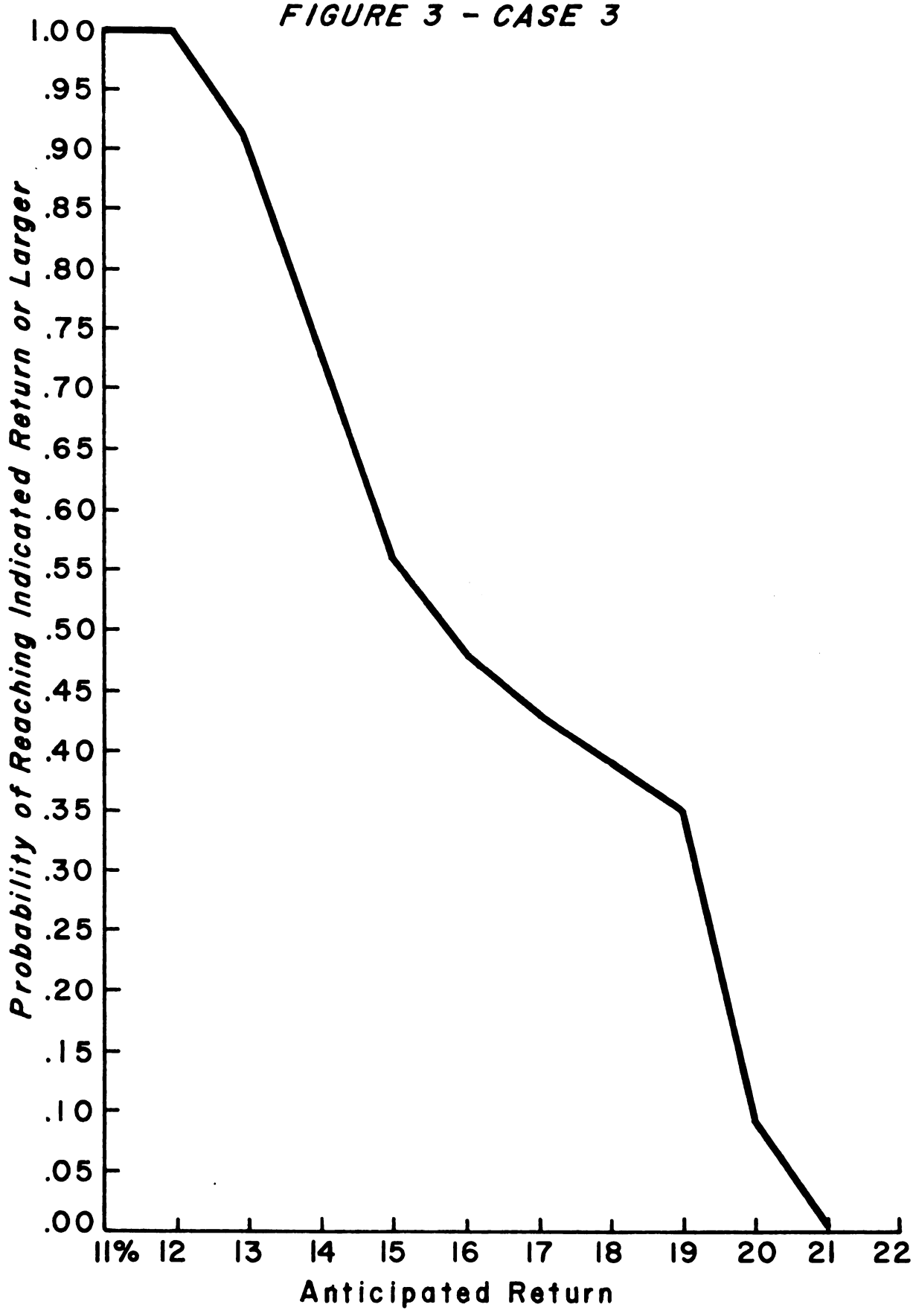
Figure 3 illustrates that the return should be between 12% and 21% based on an investment of $161,000. The investment required to undertake this business opportunity is known; all other factors are subject to uncertainty.

Analysis of Factors Affecting the Rate of Return

The useful life of the asset is estimated to be between ten and thirty years and is the single most important factor limiting profitability for this asset acquisition. When the minimum life is used the lowest level of returns are due to a combination of a low level of revenue, salvage value and average or higher operating expenses. This means that, if the useful life of ten years is held constant, and other factors are all improved, the maximum return that can be received is 15.8%

The useful life is also the most significant factor in obtaining the highest return on the investment with other factors causing a variation in the rate within a fairly narrow range. An example of the variation due to factors other than the useful life is that 18% is the lowest

FIGURE 3 - CASE 3



return calculated when the useful life is assumed to be thirty years, with a maximum being 20.9%.

It is observed in Figure 3 that a return of 19% or greater has a probability of 35%; whereas, a return greater than or equal to 20% has a 9% probability. The reason for this significant change in the probability with a change of 1% in the return is due again to the estimated life and the subjective probabilities being assigned to each. The useful life of each is ten, fifteen and thirty years, having a probability of 50%, 12% and 38%. The maximum return received when the useful life is fifteen years or less is 18%; however, the 18% return is the upper limit as can be observed in Figure 3 in that the frequency of occurrence is decreasing for this value. It should be recalled that for an analysis of this type the probabilities assigned in each figure are equal to the frequency of occurrence of each rate of return.

The 18% is also the lower limit when the useful life is thirty years with the combination of other factors contributing to the 18% return occurring infrequently.

To summarize: Since the estimated useful life is the major factor in determining the return in this analysis the frequency of occurrence of a ten year life will be the

greatest since it is assigned a subjective probability of 50%. The life of fifteen years and the rates of return it contributes will be the most infrequent inasmuch as it was felt to occur only 15% of the time. The frequency of occurrence for this range of rate of return will be greater than 15% inasmuch as the extreme upper and lower returns obtained when the useful life is ten and thirty years respectively, also fall within this range. The rates of return acquired when a thirty year life is used is the second most frequent as can be observed in Figure 3.

Comparison with Methods Currently Being Used

Cases 1 through 3 are similar types of investment opportunities that are available to a single business organization. Case 1 is felt to be the most uncertain. The factors in the second case are assumed to be constant for the first five years. Case 3 is subject to uncertainty in all areas with the exception of the required initial investment.

The analysis made by the firm was a proforma statement of income, with individual classifications of expense and revenue being fairly well detailed and supported. The projection was made to determine the period of time

required to break-even, with the analysis then being discontinued; that is, the projections were not made beyond the required time to break-even, unless it occurred prior to the third year. In this event it was a normal procedure to estimate the operating results for a three year period.

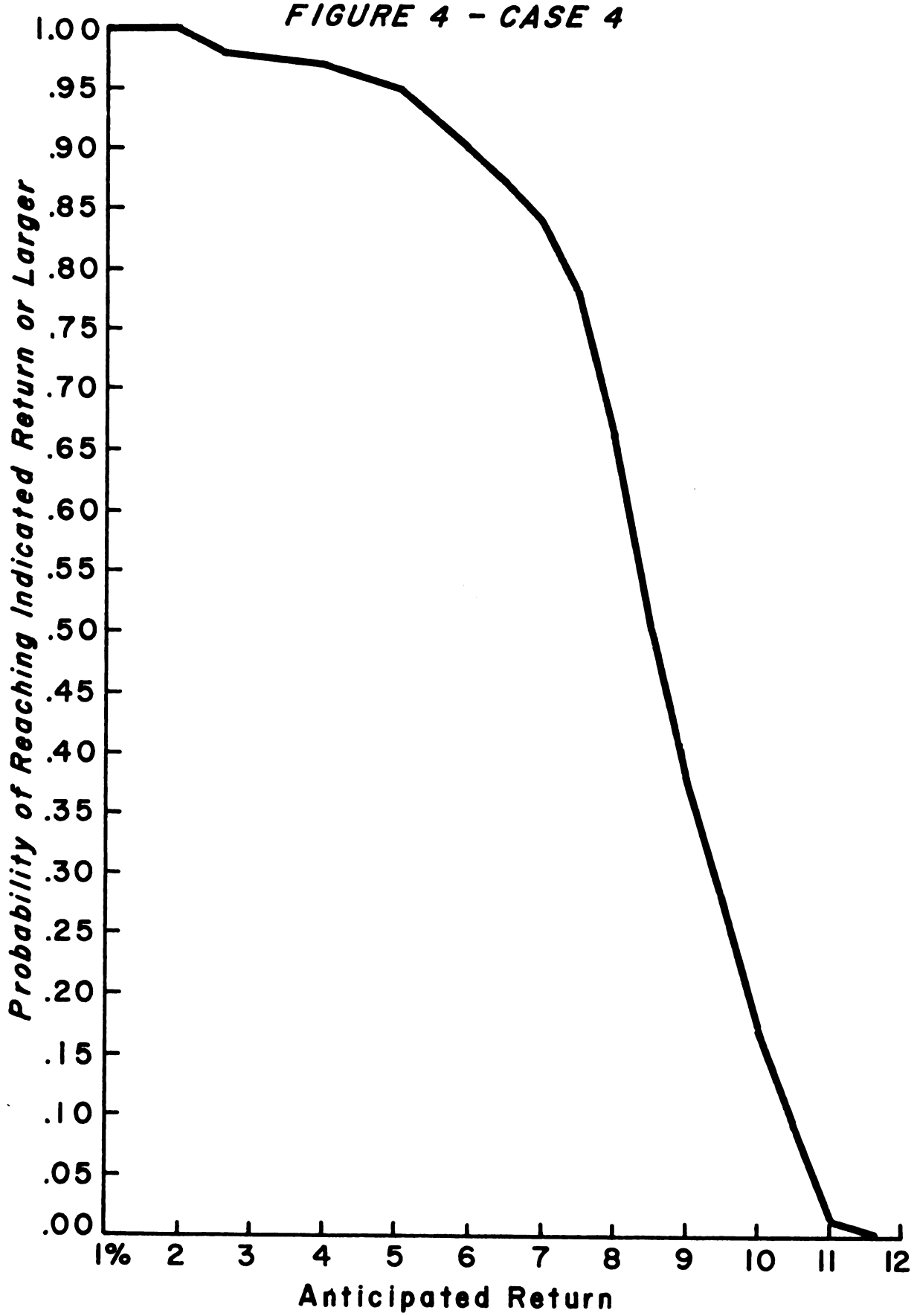
The model and the information obtained from its application provides an estimate of the rates of return and likelihood of occurrence; a means by which the major factor affecting the return may be analyzed; data that may be used to determine the break-even point; payback period; etc. and the analysis is carried beyond the break-even point and also provides information that can be used as a basis for future decisions providing the subjective estimates need not be revised (the revision, if any, being based on added experience gained with the passage of time). The analysis used by the firm does not provide this information in an explicit form.

Case 4 (Figure 4)

Rate of Return

The rate of return varies from 1.9% to 11.6%. The wide range for this particular type of asset is contributed

FIGURE 4 - CASE 4



to by all factors considered in the computation of the rate of return.

Analysis of Factors Affecting the Rate of Return

The most important factors affecting the lower rates of return are the resale value and the useful life of the asset. The estimated resale value is $50,000 to $150,000, with an equal probability being assigned to each value within the range. A combination of a short life, low resale value, and average or lower revenue results in a low return. If all factors remain the same except for increments in the resale value, the effect on the return will be an improvement of 3% to 4%.

The higher extremes of rates of return will be received if the useful life is fifteen to twenty years as compared with ten years in the prior analysis and also if the promised revenue is average or better. The resale value still has an effect on the return; however, this will be offset with a lengthening of the useful life. The cost of the asset can range from $160,000 to $180,000; however, this factor has very little effect on the final result. The reason for this being that even though there is a range of $20,000 the probability of the cost being an extreme value is quite small.

Comparison with Methods Currently Being Used

The organization used the internal rate of return to analyze this asset proposal. Four rates were determined ranging from 11% to 7.9%. The variation in the return was due to the elimination of cost and expense factors. The higher returns were the result of excluding from the computation the cost of the land and incremental overhead. The lower limit was the result of including the land cost and also an incremental overhead allowance. All factors used in the analysis were handled as if they were certain to occur.

The 7.9% is comparable with the model under consideration except that the salvage value was ignored in the organization's computation and as was noted this factor was one of the major ones affecting the return. Since the majority of the resale value is due to the land involved in the transaction and the organization is not in the land speculation business it may be suggested that the return should exclude the gains due to factors other than the normal operations of the business. The effect of this on the results of the application of the model would be to reduce the probability of obtaining a given return. Each return, excepting the higher extremes, would still be probable.

The analysis used by this company indicates the effects of variations in two factors; the overhead and land investment. It does not provide information as to the effect of other factors used in the computation and does not furnish any information as to the possible range and frequency that each may be received. The figures used as a basis in the original proposal were based on past experience of a similar type of operation. When attempting to assign a range of values and the subjective probabilities of each it was noted that past experience had a limited application as the new operation was servicing a different market; therefore, the uncertainty surrounding the gross revenue estimates and useful life was greater than if the asset was to service the normal market area. The simulation model furnishes data that is useful in evaluating this uncertainty.

Cases 5 through 7 are analyses of one operating area. The first two represent the promised return on two mutually exclusive investments with a substantial rate of return. The reason for the extremely high return is that the proposal is an addition to an existing and established operating area having excess capacity. A relatively small

investment results in an incremental revenue that is very large without a proportional increase in the operating expenses. Case 7 is an incremental analysis of Cases 5 and 6.

Case 5 (Figure 5)

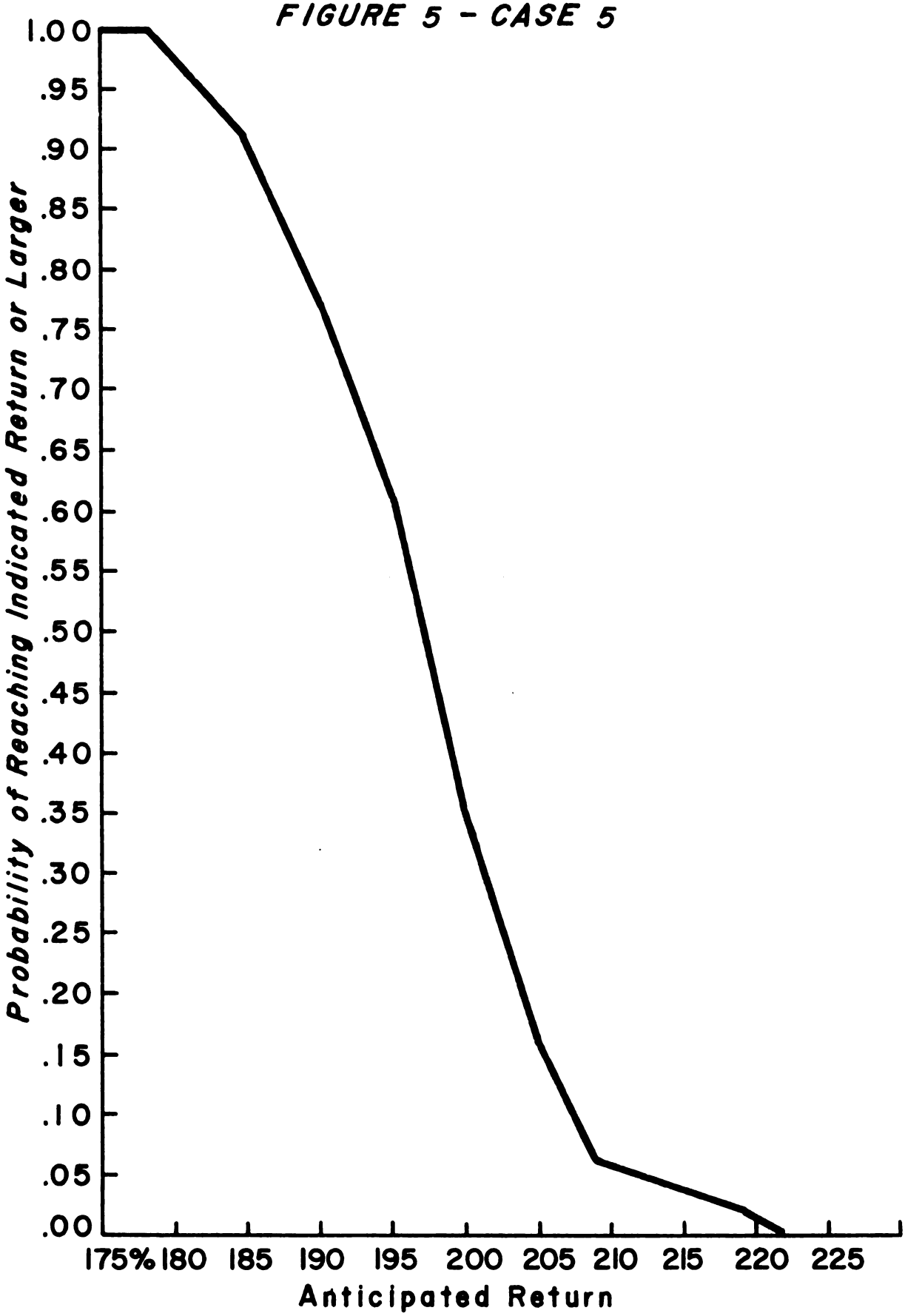
Rate of Return

The return has a range of 43% with an upper and lower limit of 221.8% and 178.7% respectively. The return is based on an estimated investment of between $59,000 and $65,000.

Analysis of Factors Affecting the Rate of Return

A major factor causing an increase or decrease in the profitability is the level of revenue and expense in the first few years. The return being received is high enough so that the present value of benefits to be received (when discounted at the current rate) after only a few years has a negligible present value and therefore has a minor effect on the final results. The lower limit (if 178% is low) is the result of a combination of (relatively speaking) a low annual revenue and a high level of annual expenses. The greatest rates of return are due to the opposite condition; that of a high level of revenue and

FIGURE 5 - CASE 5



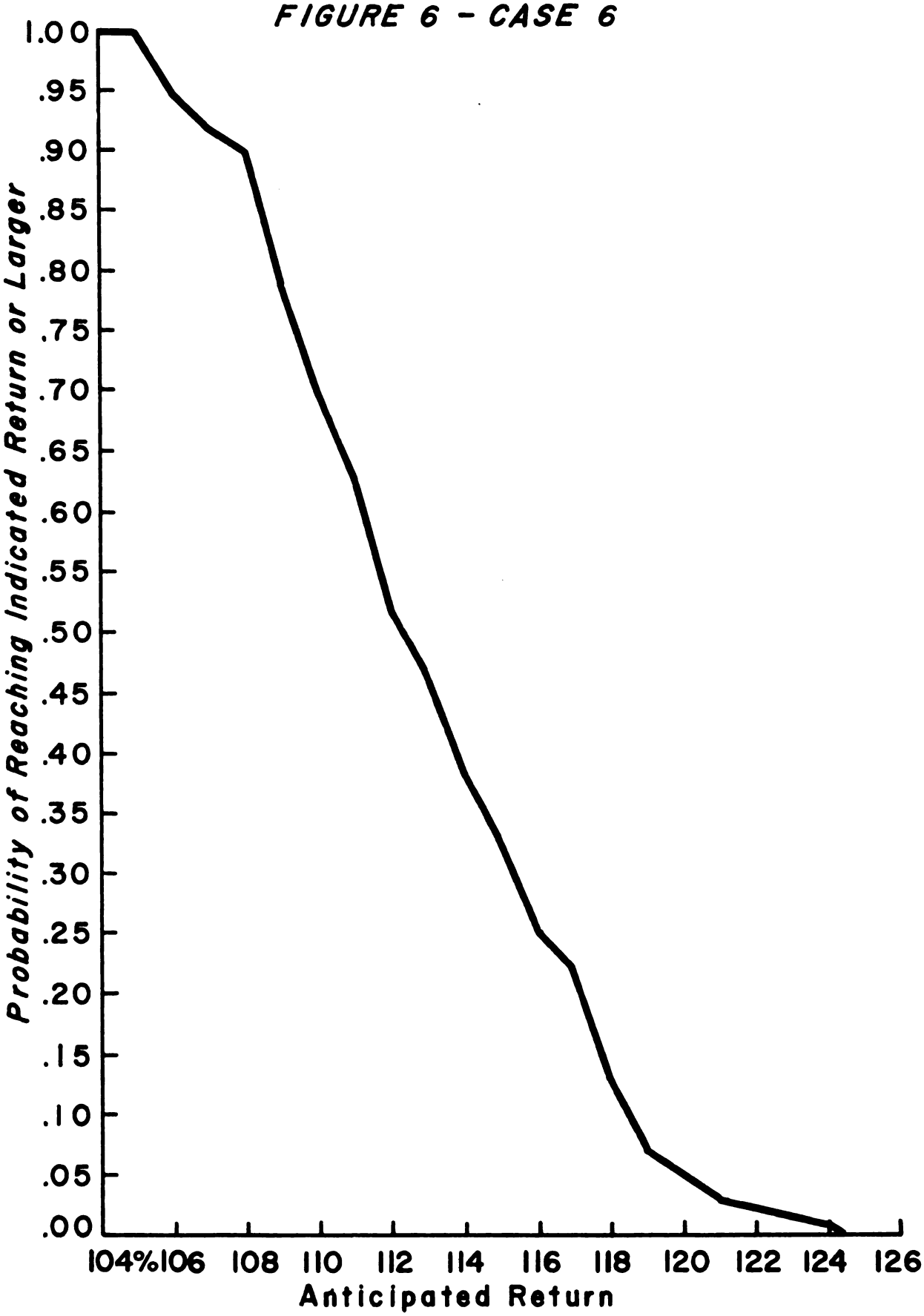
low operating expenses in the first few years of operation. The minimum life for the asset is ten years with a maximum of twenty years. The variation in life does not affect the return since the present value of a dollar to be received in the tenth year is nil when discounted at the rates of return promised from the investment. An example of this is that both upper and lower extremes of rates of return include proposals whose assumed useful life is ten years. The lowest return obtained in the simulation model is from an assumed useful life of twenty years; however, the net benefit for the first and second years are below average. The amount of the required investment affects the return. This is evident in that the highest rates of return had the lowest cost figure of the alternatives available. The lower promised rates of return each were calculated on the highest required investment for this project.

Case 6 (Figure 6)

Rate of Return

The range for this proposal is 19% with the limits being 105% to 124% based on an investment of $117,000 to $130,000, with the upper limit of cost being the most likely to occur.

FIGURE 6 - CASE 6



Analysis of Factors Affecting the Rate of Return

Cases 5 and 6 each have identical revenue possibilities. The area of difference is in the required investment and operating expenses. The factors accounting for the majority of the rate variation are the level of revenue, expense, and the required investment. The discussion of factors affecting the return for Case 5 therefore apply to this case study.

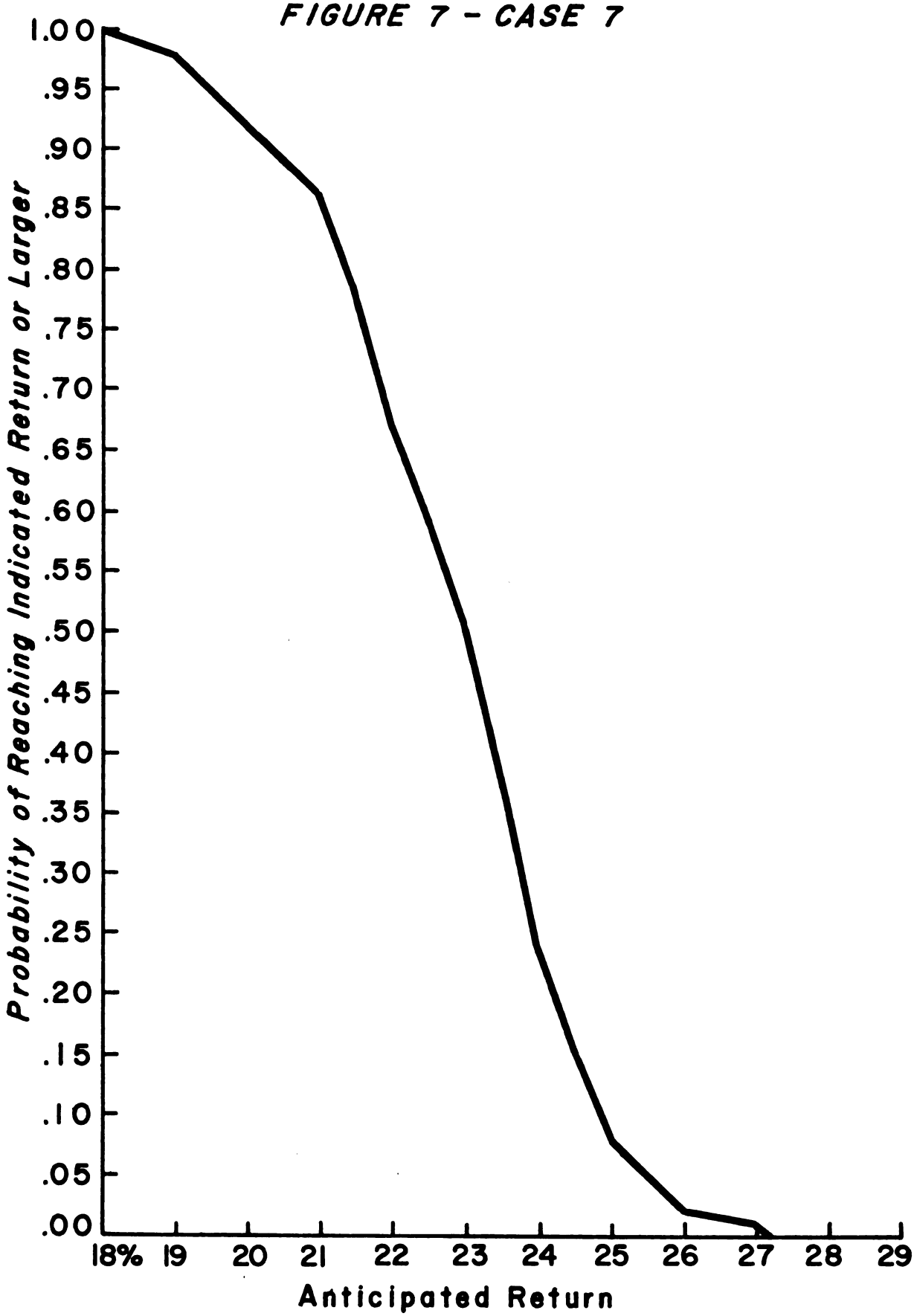
Case 7 (Figure 7)

In this incremental analysis the excess investment of Case 6 over 5 is compared against the savings in operating expenses that Case 6 will provide.

Rate of Return

The incremental investment having a range of $58,000 to $65,000 will provide to the investors a return with a range of 9% having a lower and upper limit of 18% through 27%. The major factors contributing to a lower limit are a useful life of ten years and the investment of $65,000; which is the upper limit for this factor. The highest rates of return are due to an increase in the useful life accompanied with a minimum investment requirement.

FIGURE 7 - CASE 7



The factors causing a variation in the return based on an incremental value differ from Case 5 and 6 in that the estimated life beyond ten years becomes a contributing factor; also, the net benefits for the first and second years are not as influential in determining the overall promised return.

Comparison with Methods Currently Being Used

When using the internal rate of return approach (as was noted in Chapter II) if there is a disparity in the size of the required investment between two mutually exclusive projects, in order to arrive at the "correct" solution a return must be computed on the incremental values. If the rate is greater than the established standard (assumed to be the cost of capital) the more costly proposal should be accepted. If it could be assumed that the return to be received as determined in the incremental analysis is greater than the cost of capital the 6th proposal (Case) should then be undertaken even though it does not promise a rate of return that is as great as that being received under Case 5, inasmuch as it provides for a profitable investment opportunity for available resources.

If the organization is not investing in capital assets until the return on the last proposal is equal to the cost of capital, the comparison should be between the alternative (competing) projects and the return on the incremental investment. This then becomes a problem of limited capital funds which has been commented on in the second chapter.

An incremental analysis should be undertaken even if a condition of certainty is assumed in order to maximize the firm's position when using the internal rate of return method. The business, in analyzing this investment opportunity, recognizing the potential of the asset, made an incremental analysis to help determine between the two mutually exclusive proposals. The payback method was used with a minimum of three years being established as the standard. Under certain conditions the reciprocal of the payback period will provide an estimate of the return that is very close to the return as determined under the discounted present value methods. Assuming the payback reciprocal was used as the minimum standard the company's analysis would have rejected the 6th project in favor of the 5th.

The information obtained from the application of the model provides management with a range of rates of return

and the frequency that each should occur. It provides the means whereby the more important variables affecting the return may be isolated and evaluated. It also provides the information necessary to make the choice between the two mutually exclusive projects providing some realistic standard has been established. The above information is not furnished in an explicit form when the payback method is used.

Case 8

This case is concerned with an area where there are rapid technological changes taking place. As a result the estimated useful life of the asset is between two and five years. The two year useful life was assigned a subjective probability of 50% whereas the chance of the asset being used in the fifth year was felt to be only 5% or 6%.

The benefits to be obtained are in the form of cost savings, with each being assigned a range of values. The cost of the asset is assumed to be certain since it would be acquired through a supplier who manufactures similar products at a fixed selling price with the installation costs etc. being minor in amount.

Rate of Return

The computation of the return indicates that there is only a 6% probability that the investment will earn a return greater than zero. In other words, there is a 94% probability that the net benefits received will be less than the required investment.

Analysis of Factors Affecting the Rate of Return

The major area of uncertainty is the useful life of the asset. A positive return will be obtained only if the asset could profitably be used for five or more years. Because of the continuing improvement and change in the equipment being considered the chance of profitably using the equipment for this length of time is very small. As a result, the major factor to be considered is that of useful life of the equipment. Unless management prefers to take a large amount of risk with only a limited promised return, the project in that form would be rejected.

Comparison with Current Methods Being Used

There was no attempt made to determine if a favorable return was possible from the proposed investment. There are investments for particular assets that are required

to support the overall operations of the business which, because of their characteristics, may not be profitable from a quantitative analysis approach; this is recognized. It is suggested, however, that before management can intelligently perform their functions it is necessary to at least know what the prospective gain or cost (in the form of possible losses) of a decision is. When an analysis is made that does not attempt to quantify the data this information is not available in an explicit form. It is not a question of the data not being available, since it was obtained when the request was made. The reason is that a quantitative capital budgeting policy has not yet been established within the organization.

Case 9 (Figure 8)

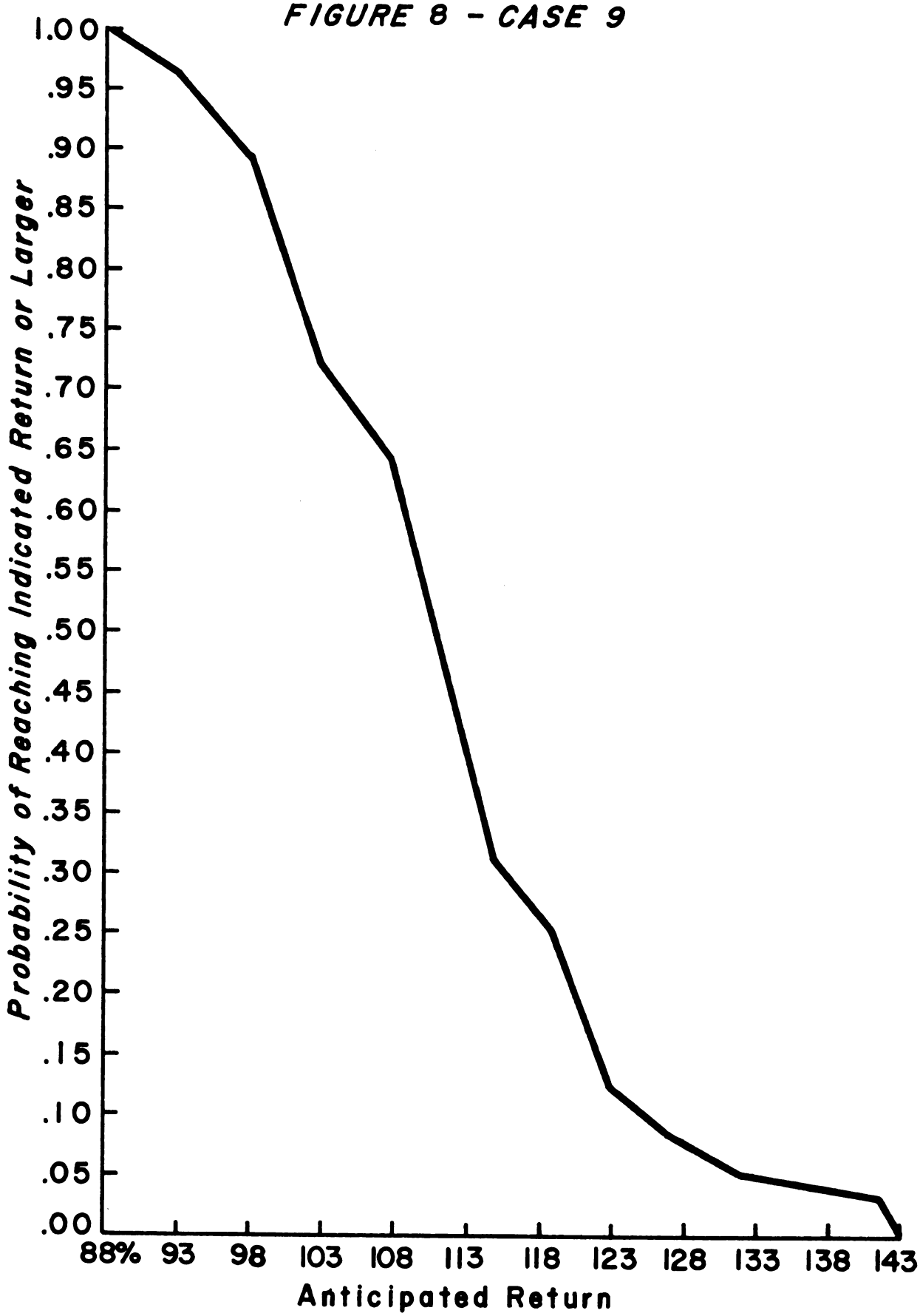
Rate of Return

There is a variation of 45% between the two limits of 88% through 143%. This return is based on an investment having a minimum cost of $9,960 with a maximum of $14,370.

Analysis of Factors Affecting the Rate of Return

The factors causing the major variations in the rate of return are the estimated cost, and the reduction in

FIGURE 8 - CASE 9



operating expenses to be obtained within the immediate future. The estimated useful life beyond the minimum of ten years does not have a material effect on the return to be received. The reason is the extremely small present value of a dollar when discounted at the rate of return to be earned from the investment. The wide range of possible returns is caused by a combination of nine values that are obtained from the range of costs and probabilities assigned to each, along with three combinations of cost savings. An example illustrating this variation in return is a comparison of two computations of rates of return. All factors are identical for the first six years with the exception that computation A receives in the first year a benefit that is greater than B by $4,000. A's rate of return is greater than B's by 12%.

Comparison with Methods Currently Being Used

The method of analysis to justify this proposal was the payback method supplemented with a rate of return determined by the accounting method. The payback period for the asset was less than one year. The rate of return for the first two years before taxes was 216% and 232%, and

after taxes was 100% and 107%. The analysis was not carried beyond the second year.

The advantages of the discounted present value methods when compared with other evaluation methods will not be discussed inasmuch as they are readily available in financial literature. It is sufficient to say that the advantages would equally apply to the model used in this analysis. The discussion of the prior cases have also noted advantages that equally apply in this case, an example being the determination of the rate of return and its probability.

An organization that establishes a goal of a single payback period and can locate proposals to meet this standard for all practical purposes is facing a problem of limited capital and is using the established standard to help determine which of the capital budgeting proposals should be accepted. It would be easy to conclude that proposals which promise such an obvious and profitable return could be accepted without the cost involved in computing the rate of return by a method having theoretical justification since an accounting loss will not be incurred on any of the proposals. If it is a logical assumption

that the business, when possible, is trying to maximize its income position it is then faced with a problem of trying to decide which proposal should be accepted to meet the established goal. Reference is again directed to Chapter II and the discussion of the limited capital problem. The data obtained from the application of the model should furnish information that will aid management in meeting the limited capital problem. The necessary information is not furnished when using the payback and accounting rate of return methods.

Case 10 (Figure 9)

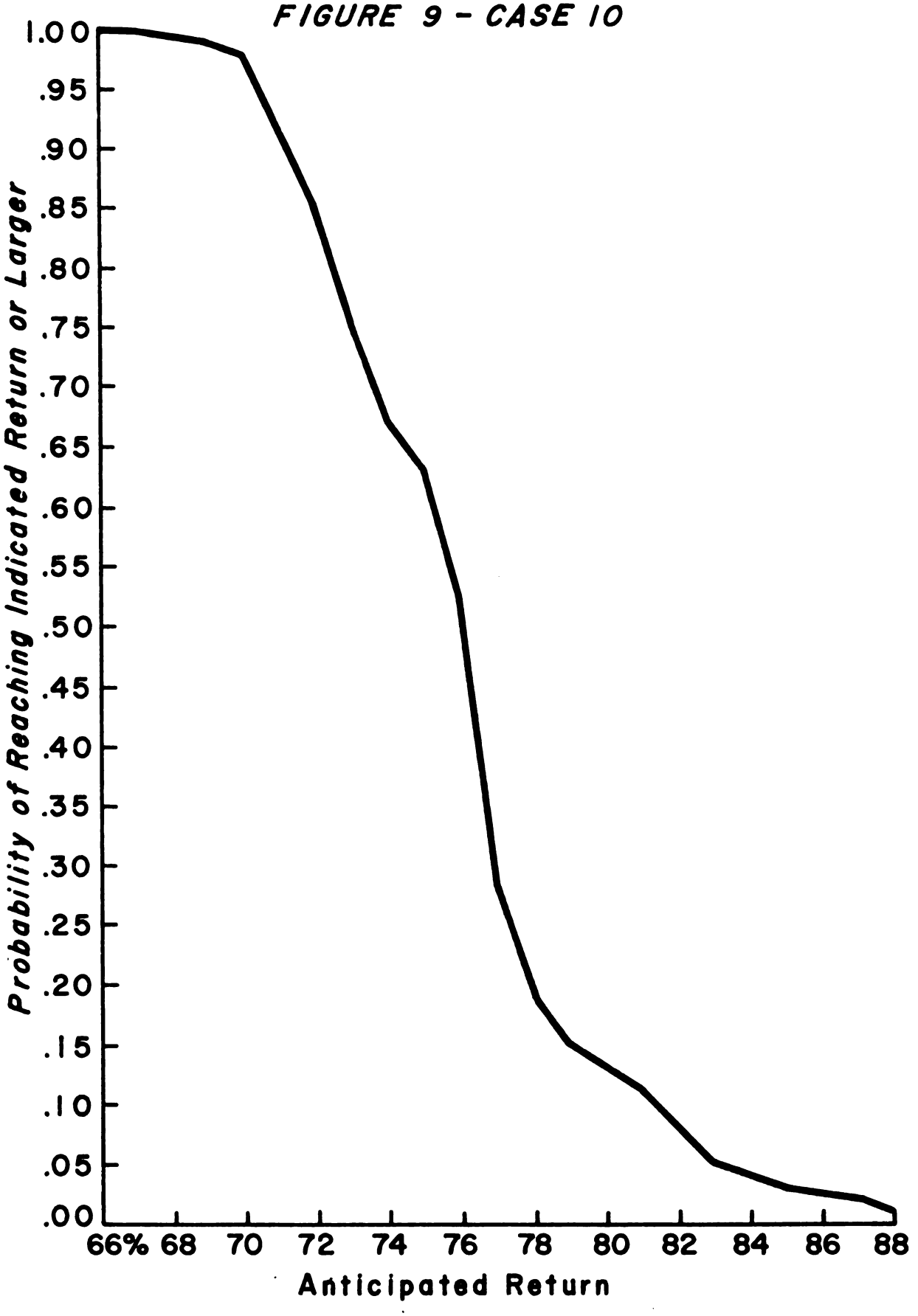
Rate of Return

The rate of return obtained in simulating this investment opportunity was between 88% and 67%, with there being a 52% chance of obtaining a return equal to or greater than 76%. The return is calculated upon an investment of between $7,000 and $8,000.

Analysis of Factors Affecting the Rate of Return

The cost of the asset and variation in annual net benefits accounts for the major portion of the variation in the calculated rate. The variations in the estimated useful

FIGURE 9 - CASE 10



life do not affect the return since the minimum useful life is sufficiently long so that the present value of a dollar would be nil if received in a period beyond the minimum life of the asset.

Comparison with Methods Currently Being Used

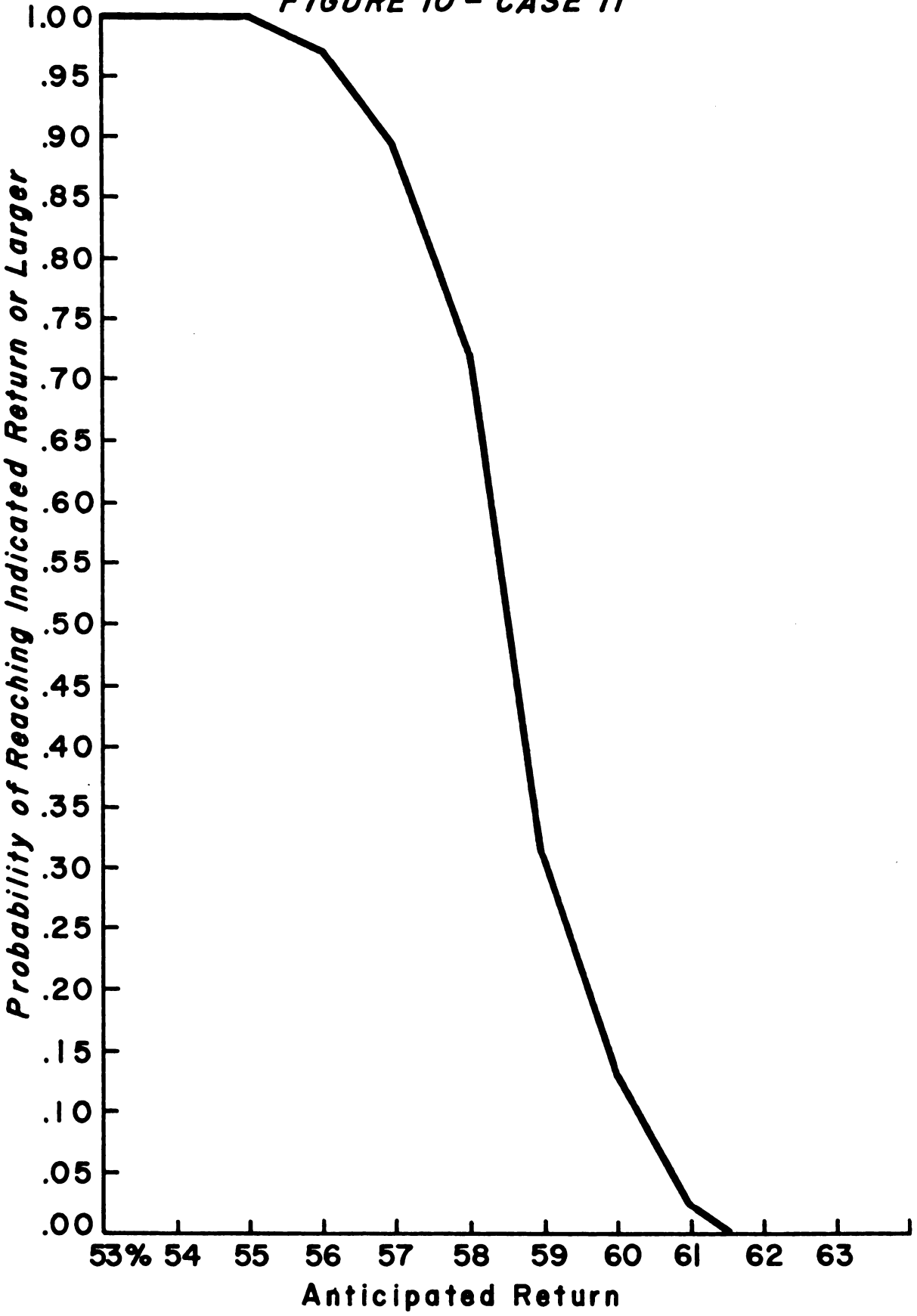
The accounting rate of return and payback method were used to analyze the proposal. The payback period for this particular asset was one year. The rates of return as determined by the organization for the first and second years were 80% and 103% before taxes and 37% and 48% after taxes. Refer to the discussion of Case 9 for additional comments in this area since the projects being analyzed and the methods used are similar and the comments apply equally to this analysis.

Case 11 (Figure 10)

Rate of Return

An investment of $3,040 promises to return a rate of between 55% and 61.5%. The reason the rate of return has limited range is that investment is subject to very little uncertainty.

FIGURE 10 - CASE 11



Analysis of Factors Affecting the Rate of Return

The variation in the net annual benefits accounts for changes in the rate of return for this asset proposal. The other factors, with the exception of the useful life are either minor in amount or subject to a limited amount of uncertainty. The minimum useful life is estimated to be ten years with the maximum life of twenty five. However, the benefits received after the tenth year have a present value that is so small in amount that it would not have a material effect on the rate computation.

Comparison with Methods Currently Being Used

The original analysis indicated a payback period of less than one year with a rate of return computed by use of the accounting method in the first and second year and before taxes of 213% and 224% and after taxes at a rate of 98% and 102%.

A more careful examination of the company's original proposal indicated that there was a duplication of benefits between this and another investment; therefore reducing the annual benefits by almost one half. Reference is again made to the discussion of Case 9 which applies equally to this case analysis.

Case 12 (Figure 11)

Rate of Return

An investment of $16,300, plus or minus $300, will return a rate having a range of 4%. The narrow range of the rate of return is the result of a limited capacity of the equipment. Within the first five years of the asset's life it is estimated that this particular item of equipment will be operating at its maximum level. The result of this being a limitation of the range of values of one of the major factors causing a variation in the profitability of the investment.

Analysis of Factors Affecting the Rate of Return

The factor causing the narrow range of rates of return was noted above as being due to the limited capacity of the equipment. Within this range the variations in the estimated useful life and level of annual benefits are the major factors affecting the calculated rate of return. The major source of benefits obtained from the investment is assumed to be certain after the maximum level of capacity is obtained with the other annual benefits and the variation in the cost of the asset and salvage value being minor in

FIGURE 11 - CASE 12

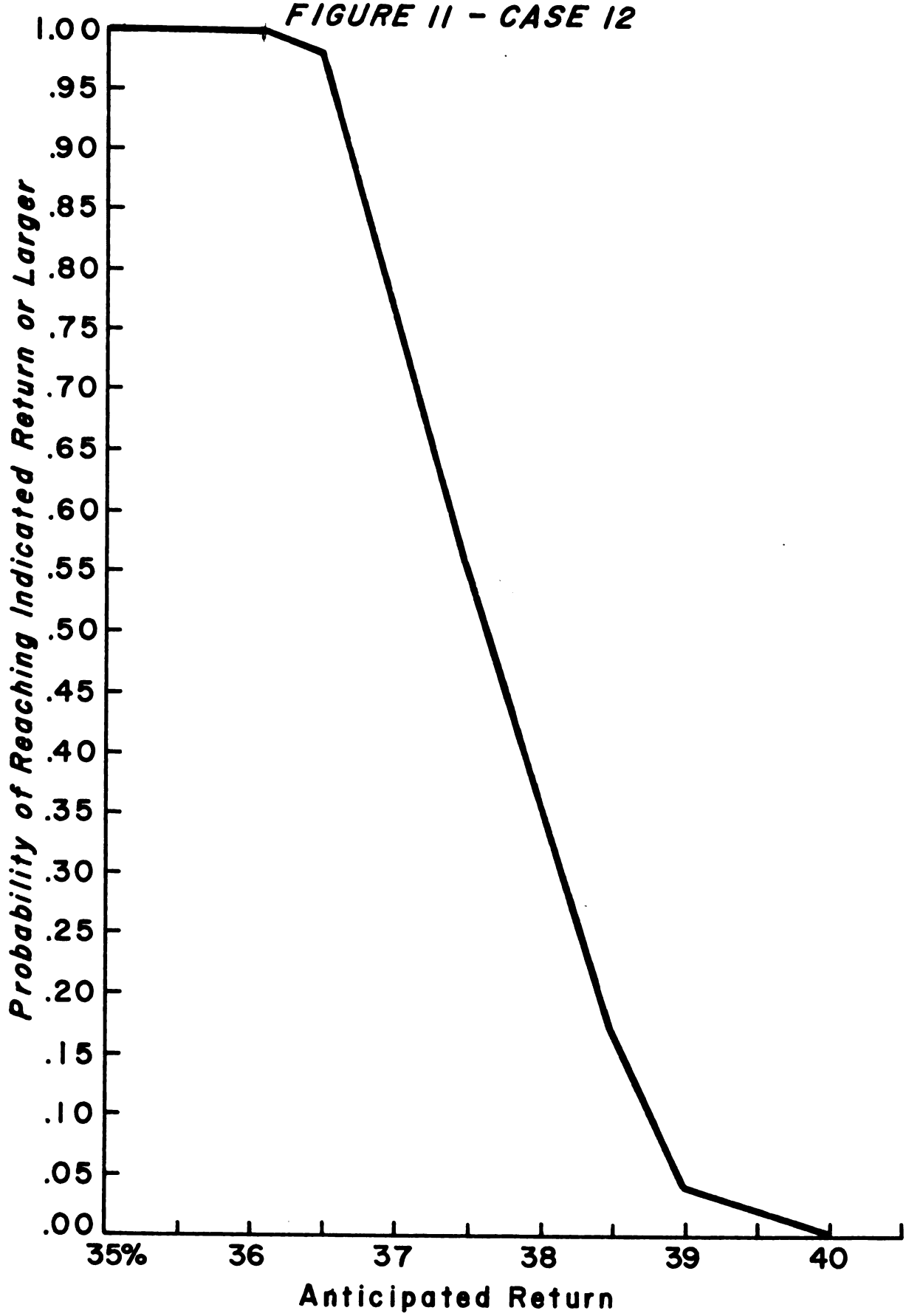
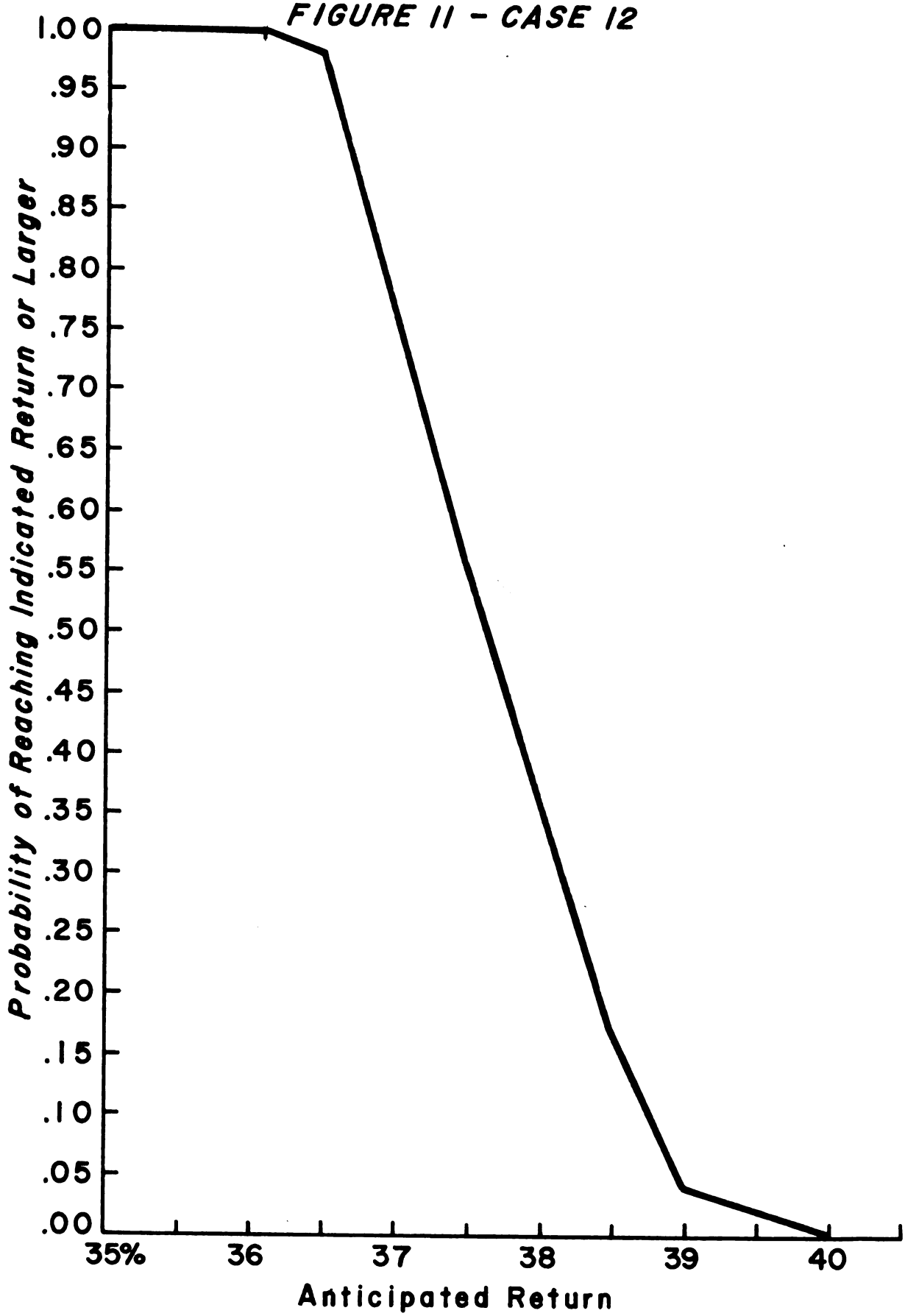


FIGURE 11 - CASE 12



amount. The effect of these factors when combined with any one of the assumed useful lives is a variation of approximately 2% in the rate of return. A return of 36% through 38% is received for assets having a useful life of ten years. The 37% through 40% return is obtained when the useful life is eighteen through twenty five years. There is some overlapping of the return between the above areas; however, the useful life of the asset is the factor causing the expected rate to fall within the higher or lower extremes of rate of return.

Comparison with Methods Currently Being Used

The organization used the profitability index for evaluating the asset proposal. The estimates were made for the investment of funds and other factors such as the incremental savings and operating expenses with the amounts so determined then being assumed to remain constant over the useful life of the asset with a resultant profitability of 24.7%.

The method used in arriving at the level of profitability assumes the factors for each year will be identical to the preceding one and that a condition of certainty exists. These assumptions are, of course, subject

to question. The results obtained do not furnish in an explicit form, information that enables an evaluation of the effect of each factor on the return and it furnishes limited information that can be used in evaluating the uncertainty of the project. The application of the model contributes information in each of these areas that is not available from the normal evaluation method used.

Summary

Chapter III summarizes the capital budgeting methods employed by five business establishments with no inference being made as to the methods being used for all business organizations. An example of the data obtained is furnished in Table 1. It is felt that an adequate description of the methods being used is provided in the body of the report and also in the Appendices. To provide complete details of each case study would be a violation of confidences that exist between the interviewer and organization.

A description of the procedures followed in applying the data to the model is furnished, with the results of each study being analyzed in the form of a comparison of the model with methods currently being used, a discussion of the rate

of return and an analysis of the major factors affecting the return. Where applicable, a Figure illustrating the range of rates of return and the probability of each is furnished and is the basis for the discussion.

CHAPTER IV

EVALUATION OF THE PROPOSED MODEL

Comparison with Methods Currently Being Used

The model includes a discounted present value method for determining the rate of return. It is, therefore, subject to the same strengths and weaknesses of these methods. It does not assume a condition of certainty for the factors being used in the computation of the rate of return, as is normally assumed in the current methods being employed. However, one of the basic assumptions is that a person having business experience can provide rational subjective probability estimates that are in turn used in applying the model.

This assumption has been accepted as reasonable; if it is, the model is an improvement over the current methods being used in that it furnishes additional information in an explicit form that will aid management in evaluating

capital budgeting proposals that are subject to conditions of uncertainty. If this basic assumption is not true, the model, though workable, will provide information that is of questionable value. It is suggested that if the assumption is not true then the discounted present value methods currently being used are also of questionable value inasmuch as they are subject to subjective estimates concerning future economic events.

Cost versus Results

The application of the model is itself subject to incremental costs, by virtue of the work necessary for its application although the organization using a quantitative analysis in the capital budgeting area does have at its disposal the information required to apply the model. Therefore, the incremental costs apply to the mechanical application of the model. The major cost (assuming the use of a computer) is the initial cost of obtaining a workable computer program. For a skilled programmer this should involve, at the most, a single working day. For someone with limited experience additional time should be allowed. For example: The programs used in this study, with the aid

of an experienced programmer to guide the author's progress, were composed in three days, on the average, for the eleven programs. This, it is felt, should be the maximum time required. When the program has once been obtained future applications can use the same program with minor modifications being necessary. The maximum computer time was one and a half minutes to compute and print out the results. There are, of course, other costs such as the material (cards) and time required to key punch the data; however, based on the experience of this study it is suggested that if the information obtainable from the use of the proposed model is felt to have value to the prospective user, the cost of obtaining the data should not be the limiting factor.

The organization currently using non-quantitative methods in analyzing proposals will find the model more costly to apply inasmuch as the required data would not have been generated in the normal operating procedures. At such time as there is a policy change so that an analysis in a quantitative form is desired the application of the model would not add materially to the incremental costs.

Problem of Size (Number of Computations of Rates of Return)

The number of computations of rates of return used in each application of the model was one hundred. In order to determine if the results obtained would be reasonable, a number of tests were applied to the model. The first attempt to justify the sample size was the use of fifty computations in Appendix A. It was noted that the results of this analysis, based on fifty computations, was similar to the return obtained when the expected value of each factor was used. In preparing the computer program an intermediate step was taken to have the computer determine the average value for the major factors generated within the program. This was then compared against the expected value of the appropriate factor. The results of this test furnished values whose variation from the expected value was not material in amount. Reference is also directed to Figure 12. Using Case 3 as a basis, one and two hundred computations of the rates of return were obtained. It can be observed that the two lines have similar slopes with the major turning points being almost identical. The one area of the greatest deviation results in a variation of nine-tenths of a percentage in the rate of return. Reference is

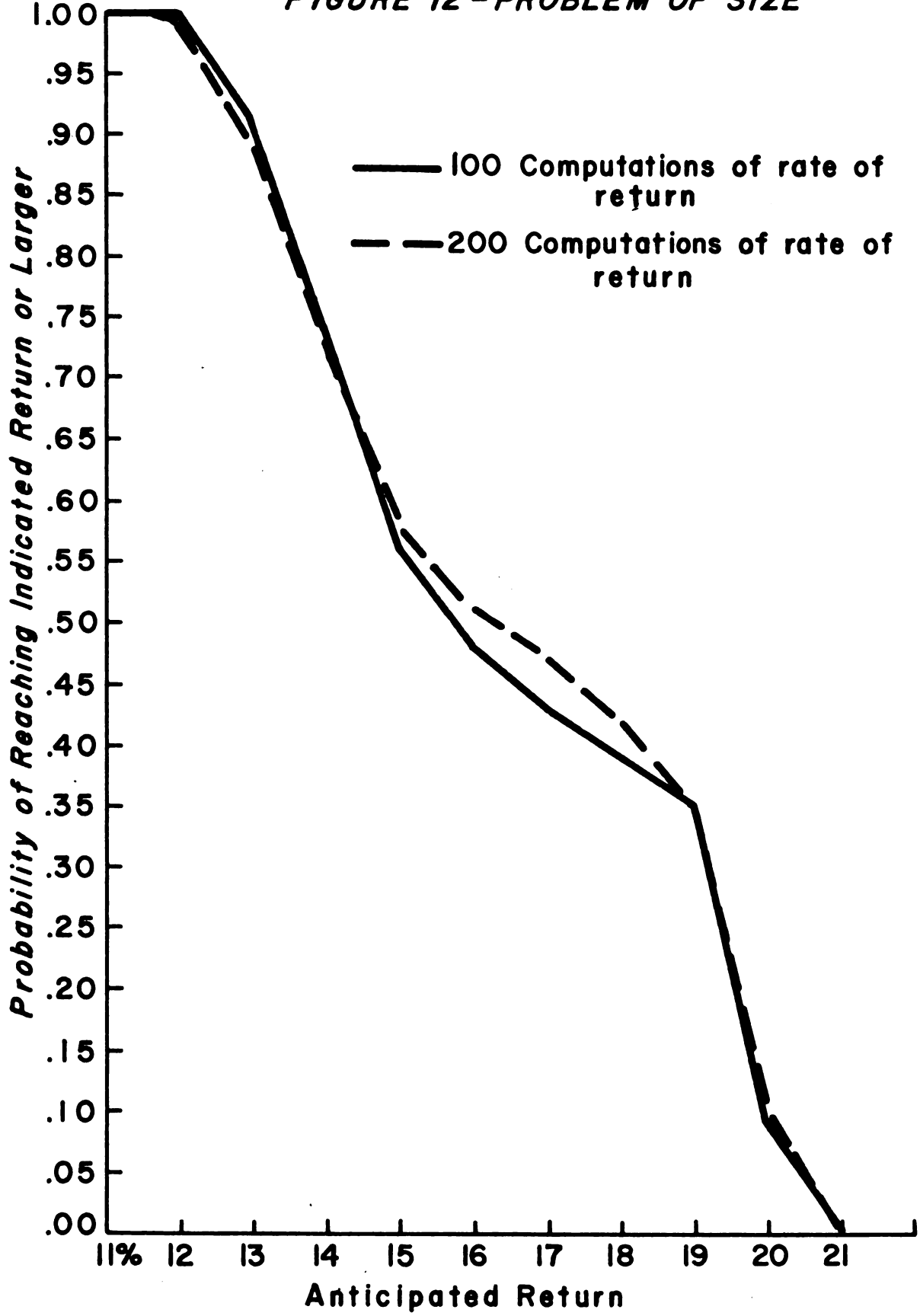
also made to Chapter II wherein this problem was discussed.

The review of literature and the limited tests made in applying the model resulted in the selection of one hundred experiments to be made in each case. It is not suggested that the problem of sample size has been resolved; however, for the purposes of the study the results obtained were reasonable.

Availability of Data

The factors obtained in applying the simulation model are basic to the application of the discounted present value methods under the assumed condition of certainty. To obtain the dollar range for each variable and the subjective probability estimates it was advantageous to use the proposal forms as prepared by the firm. The individual originating the data had considered the factors without attempting to express the range of each in an explicit form. It was therefore necessary to have the person express his estimates, using the data already obtained as a basis for his estimates. The procedure of some of the firms was to indicate the revenue and the

FIGURE 12 - PROBLEM OF SIZE



operating expenses for a few years and then assume that the subsequent years' results would be identical to those of prior years. For example, one organization, in determining the cost savings to be obtained for the proposed acquisition, estimated the savings for the first year and then used the same estimate for the remaining fifteen years of the asset's life. This type of analysis not only assumes that the figure used is certain to occur in the first year but also that each year thereafter will be identical to the first. The analysis would be improved, even assuming a condition of certainty, if each year were to be considered individually and changes between periods of time were recognized. The process of asking the individual to assign a range of values and estimate the probability encouraged a more comprehensive evaluation of the items to be included in the determination of the rate of return.

Organizations using the payback and accounting rate of return methods generally had not considered explicitly all of the variables required in the application of the discounted present value methods. An example of factors not being considered was the total useful life and an estimate of the salvage value. The period required to

recover the investment was determined in the payback analysis. If the payback period met the established standard the proposal was generally accepted with the remaining life of the asset not being considered in an explicit form. The rate of return determined by the accounting method was calculated for the first few years, with the balance of the asset's useful life being ignored. Even though some of the variables were not included in the proposal when the above noted methods were used the original investigation of the acquisition proposal furnished data that enabled an estimate of these variables to be made.

Most of the factors needed to apply the model under study were determined when the quantitative analysis was made. Thus the information was available as needed. When quantitative methods were not used to justify an acquisition the data was not readily available; however, it was obtainable.

Aid in the Evaluation and Prediction of Future Results

Since this analysis does not extend over a period of time that allowed for the comparison of the estimates and

actual results, the following advantages in the evaluation and prediction of future results are suggested for this form of analysis over the procedures assuming a condition of certainty.

Living with uncertainty is a way of life; to the extent that information is obtained that aids in predicting future results of a decision yet to be made, the likelihood that the organization will reach its goals will be improved. This model furnishes data that more clearly presents the alternative outcomes of a decision to commit funds whose benefits, if any, will be received in the future. The information furnished makes it possible to have a more complete analysis of factors affecting the rate of return. This information is obtained from analyzing the individual calculation of the rates of return and observing the factors that cause an improvement or reduction in them.

Prerequisite for Effective Application and Use

The factors contributing to a well managed capital budgeting program include, among others, a means to measure the worth of the project and a standard to judge the results

by.[1] A well managed organization must be present for the most effective application of the model.

There should be adequate communication and cooperation between departments so the desired information may be obtained and prescribed procedures will be adhered to. When the individuals involved with the program feel they have made a contribution in the prescribed methods being used, the communication and cooperation will be improved.

In order to obtain adequate input data experienced personnel must be used as a basis for estimating the factors required to apply the model. These individuals should also have an understanding of the procedures being used. The application of the data can be by hand methods or designed so a computer may generate the output data. When the model is to be applied to a number of projects, the most practical application would be to use the computer. The application after the data has once been obtained is not too difficult; however, to apply it by the use of a hand calculator is a time consuming project. If a computer is not available the

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[1]Joel Dean, "Measuring The Productivity of Capital," The Management of Corporate Capital, ed. Ezra Solomon (Chicago: The Free Press of Glencoe, Graduate School of Business, The University of Chicago, 1963), p. 21-34.

mechanical generation of variables from the data would not require highly trained personnel; although the final preparation and interpretation of the results should be reserved for those individuals understanding the complete capital budgeting system.

The information obtained from the model is based on subjective estimates; therefore, the forecasts should be reviewed and revised as new data and added experience is gained for it is only by having rational estimates and improving the ability to furnish them that will enable the model to become a useful tool to aid in the effective management of the company.

CHAPTER V

SUMMARY AND CONCLUSIONS

An investment involves suppositions about the future, since by its nature an asset, to have value, must yield benefits in future periods of time. The decision is therefore subject to elements of uncertainty inasmuch as future technological and economic events cannot be forecasted with any great degree of preciseness. Even though the investment decision is subject to future events that cannot be objectively verified, a condition of certainty is assumed when using the techniques currently in use to evaluate capital investment opportunities. In order to overcome this weakness an experimental method (Monte Carlo) using subjective probability estimates and random numbers was used in this study in an attempt to consider uncertainty in an explicit form.

The hypothesis made is that a model (for capital budgeting decisions), in which uncertainty is considered explicitly, can be applied to actual situations in business organizations with the conclusions furnishing useful information in the capital budgeting decision process.

The model was applied to a limited number of actual asset acquisition proposals in a variety of companies, each representing a different industry. A range of values and subjective probabilities therefor were obtained for each of the five factors used in determining the internal rate of return. These sets of values and probabilities served as inputs to the computerized Monte Carlo model. The data were obtained from individuals having experience and a knowledge of the capital budgeting procedures being used by each firm; the proposals analyzed were those being considered currently by the business organizations interviewed.

When the above data had been obtained, random numbers were used to determine the value of each factor to be used in the computation of the internal rate of return. Having obtained each factor's value the internal rate of return was then determined by use of a formula such as the following:

$$C = \frac{B_1}{(1 + r)} + \frac{B_2}{(1 + r)^2} + \ldots + \frac{B_n + S}{(1 + r)^n}$$

Where C is the cost of the investment, B is the net periodic cash benefit; S the salvage value in period n and r the unknown rate of return that is to be solved for. A hundred trials (computation of individual rates of return) were made to obtain a range of rates of return and the frequency of each. A probability equal to the frequency of occurrence was then assigned to each rate of return.

The model made use of the "internal rate of return method" to evaluate the investment alternatives; however, unlike the normal procedures used when computing the internal rate of return, a condition of uncertainty is assumed to exist.

The data required to apply the model were generally available; however, where not readily available it was obtainable with a relatively small effort on the part of the organization. There was also a demonstrated willingness to provide an estimate of a range of values and the required subjective probabilities.

Generation of New Information

The results obtained yielded, in each case, information which had not been explicitly considered in the firms' evaluation of the expenditure proposals. For example, where a single year payback had been the acceptance criterion or standard, the analysis via the model demonstrated that the firm could not only expect a payback period of less than one year, but could also expect a 111% rate of return or greater having a probability equal to 50%. In another case, where a uniform standard of acceptance had not been established, an asset promised to return the required investment in five years. However there was only a 6% probability that a positive rate of return would be received. The reason for the limited probability was the uncertainty surrounding the useful life of the asset.

This type of information aids in the evaluation of the outcomes of predicted economic events. This is possible as it furnishes information whereby an analysis of the effect of factors on the rate of return and the alternative outcomes of a commitment to invest funds can be determined. The importance of duration of life, initial cost, etc., as factors bearing on the rate of return and

the determination of the alternative outcomes of investment of funds was demonstrated in Chapter IV. The availability of this data enlarges the scope of the analysis so that it is possible to compare the relative value of the possibility of a substantial gain or loss against an alternative investment opportunity that is relatively certain.

Effective Application

The model can best be applied where there is a well managed capital budgeting program. The most critical requirement for effective application is that of having individuals with experience and knowledge of the procedures used being required to furnish the range of values and subjective probability estimated for each factor required in computing the internal rate of return.

Existing Awareness of Uncertainty

In the particular firms visited there was an awareness of the existence of uncertainty. The uncertainty problem was met through subjective judgements and limited quantification of data. The judgements were based on past experience and a feeling as to future business conditions. Quantification of data was in the form of

either making several estimates based on different assumed levels of activity without attempting to indicate the likelihood of occurrence or through a felt need to anticipate a higher rate of return.

Incremental Cost of Applying the Model and Test to Determine the Reliability of the Results

The incremental costs of applying the model, when compared with applying the discounted present value methods, was found to be an immaterial factor when considering the relative merits of the results of the model. Limited tests were applied to determine the number of trials (individual computations of rates of return) necessary to obtain reasonable results; one hundred trials were concluded to be sufficiently large to produce dependable results for the problem under study.

Improvement of Procedures Being Used for Capital Budgeting

Furnishing information in the form of a range of values for each factor and the subjective probability of each will help to limit such practices as using an average performance for each factor, submitting only values that "guarantee" acceptance of the project, and estimating

values that will be attainable 100% of the time. In other words, the application of the model should encourage the use of sound capital budgeting procedures. The method used here requires specific managerial consideration of, and specific statement of, feelings and expectations about whether relevant events are or are not likely to occur, and expression in finite form of judgements about factors bearing on the capital budgeting decision. Such formulation increases the likelihood of communication between individuals as to what decision criteria are considered important by managers responsible for the commitment of corporate resources.

Aid to Unsolved Problems

Though the solution to each of the following is not provided since it is beyond the scope of this study, the information furnished in applying the model is useful when attempting to solve the problems of limited capital, and evaluating the quantifying attitudes toward uncertainty. There have been suggestions in current literature as to how these problems should be solved; however, it is normally assumed that subjective probabilities are given. The data used in applying the model will provide the sub-

jective probabilities for each factor used in the determination of the internal rate of return and the application of the model will provide the probability that each rate will occur; each of these probability estimates have been suggested as being necessary to arrive at solutions for the above noted areas.

Sound Judgement is Always Required

The application of the model will not replace sound judgement, for the results cannot be better than the judgement of the individuals furnishing the data. Only through continual improvement of the subjective estimates and refinement of the model will it become a useful tool to aid management in meeting and evaluating the uncertainty area as it concerns capital budgeting.

There was an awareness within each company interviewed that an attempt to continually improve must be a policy of management. The improvement not only should include the application of new tools and techniques to furnish data but also include all areas included in the management of capital budgeting with one of the most critical areas being that of generating ideas for alternative uses of capital funds.

Suggestion for Further Study

The assumption that rational subjective probability estimates were obtained for the application of the model, though accepted for this study, needs further analysis and investigation. This may take the form of obtaining posterior probabilities and also the comparison of actual and forecasted results by the use of a post audit. These two areas are the subject of anticipated studies to be undertaken in the future.

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APPENDIX A

EXAMPLE CASE

The following information is used to demonstrate the proposed use of the internal rate of return and a simulation method. It is assumed that the model is applied with the use of a hand calculator. The assumed information of the case is as follows:

	1st Year	2nd Year	3rd Year
Estimated cost	$ 14,000		
Estimated life - 3 years			
Estimated net cash flows	8,050	$ 8,925	$ 9,020
Salvage value	0		

Based on the above information the prospective rate of return is 19%.

The decision whether to invest will be determined when the rate of return is compared with the firm's cost of capital, other alternative uses of funds, and judgement factors such as an evaluation of risk inherent in project, needs and goals of the organization.

The above analysis does not determine the likelihood of obtaining the indicated 19% on the investment; it also is limited in that the main factors causing the experienced

rate of return to vary from the forecasted rate have not been isolated.

To overcome the above weaknesses, subjective probabilities were obtained from individuals having the responsibilities and experience in the area under study. The following is the information required to determine the rate of return and the likelihood of a given rate of return being earned for this particular example.

Cost of Equipment		Estimated Life of Asset	
Estimated Probability	Cost	Probability Estimated	Life
.10	$17,000	.20	2
.20	15,000	.70	3
.40	14,000	.10	4
.20	13,000		
.05	12,000	1.00	
.05	10,000		

Estimated sales and cost figures:

Sales price per unit: $1.00

Costs (except for depreciation):

Units sold at $1.00	Variable Costs	Fixed	Variable Costs	Fixed	Variable Costs	Fixed
75,000	65¢	$20,250	65¢	$20,000	64¢	$25,400
80,000	65	20,250	65	20,000	64	25,400
90,000	64	25,400	64	25,400	64	25,400
100,000	64	25,400	62	25,400	63	30,000
107,500	62	32,350	62	25,400	63	30,000
110,000	62	32,800	62	32,800	62	32,800
115,000	62	32,800	62	32,800	62	32,800
120,000	64	33,200	64	33,200	62	33,200
125,000	64	33,200	64	33,200	64	33,200

The fourth year is assumed to have the same sales and cost estimates as the second year.

The following are the estimates of quantities that will be sold over the life of the asset:

First Year		Second Year		Third Year		Fourth Year	
Probability	Items sold	Probability	Items sold	Probability	Items sold	Probability	Items sold
.10	75,000	.10	80,000	.10	90,000	same as	
.25	90,000	.25	90,000	.30	100,000	second year	
.40	107,500	.35	110,000	.35	110,000		
.20	110,000	.25	115,000	.20	120,000		
.05	120,000	.05	120,000	.05	125,000		
1.00		1.00		1.00			

The distribution of each variable is assigned numbers from 0 to 99. The numbers assigned depend upon the subjective probability of each factor. For example: In the first and second year there is a 10% and a 25% probability that 75,000 and 90,000 units will be sold. Numbers 0 - 9 for the first year's probability and 10 - 34 for the second year are therefore assigned to each level of units sold in their respective year. The same procedure was repeated for the remaining levels of sales in the first and remaining years. The same procedure was followed for the estimated life and cost of the asset since these factors also have a distribution of possible values. In this problem it is assumed that there were no inventories and

and thus the costs of production were the same as cost of sales. As a result the expenditures were based on the quantity of goods sold.

The next step is to refer to a table of random numbers. Reading the numbers from the table will indicate the level of sales, costs and estimated life, since the corresponding number has been assigned to each factor. Having obtained the required information, a rate of return is determined. The following example will demonstrate the pricing out procedure.

The period of three years, level of sales of $90,000, $110,000 and $110,000; cost of $17,000 were obtained from the numbers noted in the random table and the number assigned to each factor. As was indicated before, the expenditures are based on the quantities sold.

	Period		
	1	2	3
Revenue	$90,000	$110,000	$110,000
Expenditures	83,000	101,000	101,000
Excess	7,000	9,000	9,000
Depreciation	5,666	5,666	5,666
Net income before taxes	1,334	3,334	3,334
Tax (assume 50%)	667	1,667	1,667
Net income	667	1,667	1,667
Plus non-cash expenses	5,666	5,666	5,666
Net cash flow	$ 6,333	$ 7,333	$ 7,333

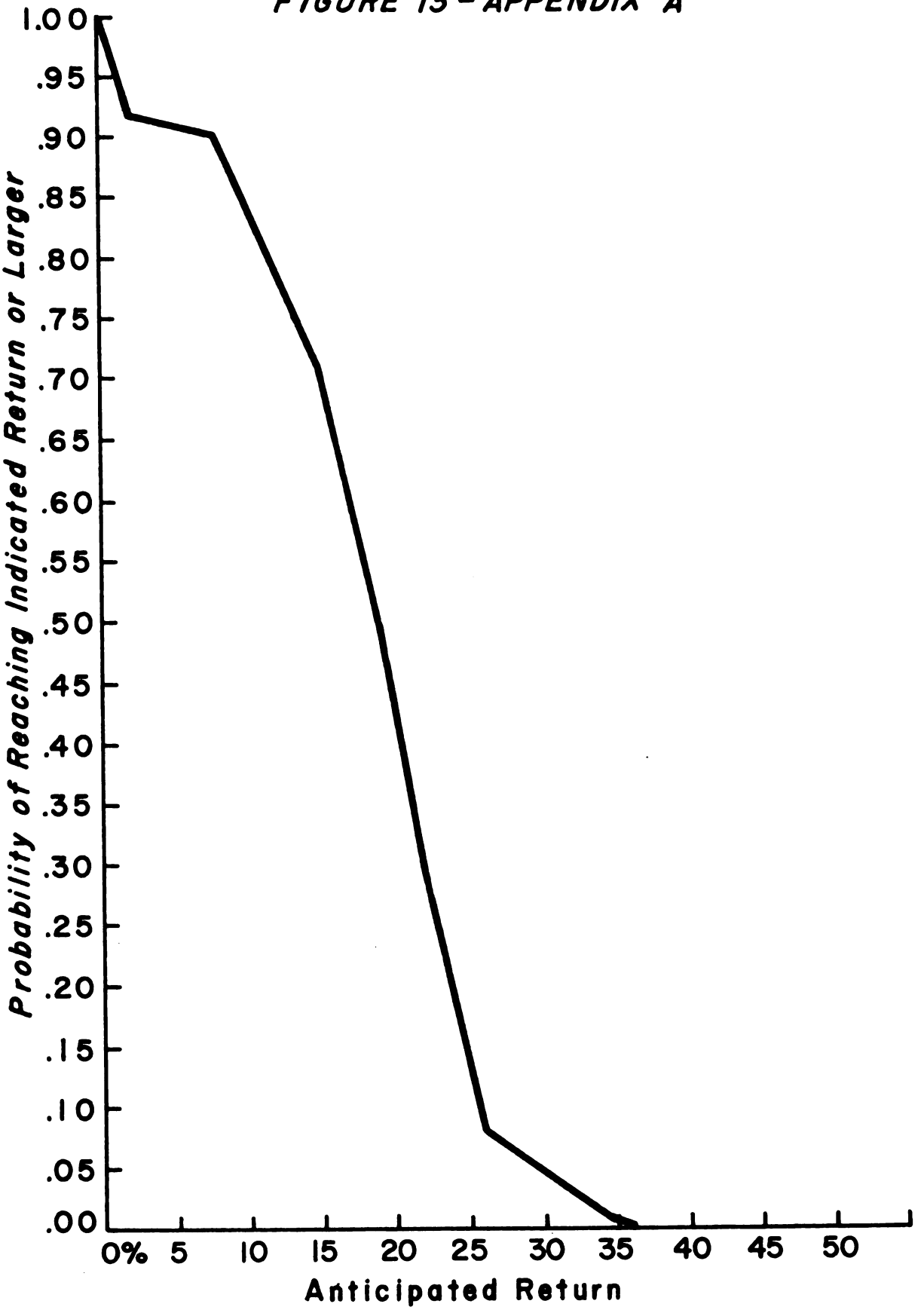
Discounted rate of return: 11%
Total net cash flow: $21,000
Total cost: $17,000
Life of Asset: Three years
Depreciation: $5,666

Fifty such trials were made. This then gave fifty estimates of the rate of return which were then grouped into a frequency distribution. The frequency distribution was converted into an estimate of probability for each rate of return as noted in Figure 13.

In the original presentation of the investment proposal the asset acquisition promised a rate of return of 19% with an implied condition of certainty. The proposed model indicates the likelihoods attaching to a range of rates of return (Figure 13). For example: It is noted that there is a 50% chance of obtaining a 19% or better return on the asset.

In addition, it was determined through a sensitivity analysis that the main reason for a low rate of return (there is a 10% chance of obtaining less than an 8% return) is due to an asset life of two years or less. For all of the experiments that reported a return of 6% or less the expected life was two years. The highest return obtained with a life of two years was 16% and this was a result of

FIGURE 13 - APPENDIX A



a low required investment and fairly high total net cash receipts. Of the rates of return of 26% and above the main contributing factor was a low cost of the asset (mean of under $12,000) and a life of three years and above.

The two main factors affecting the rate of return are the estimated life of the asset and the cost of the asset. The variation in revenue was not too important in this problem since the majority of the costs were variable in nature.

APPENDIX B

PROGRAM PROCEDURES

The following is a detailed description of the steps required to be taken to apply the model to asset acquisition proposals when using a computer to process the data.

Part I

Required steps - determination of:

I Estimated useful life
II Estimated cost of the asset
III Gross benefits
IV Operating expenses
V Asset replacement
VI Salvage value
VII Depreciation expense
VIII Net benefit from sale of assets

Part II

Determination of the yearly net cash flow (Source of the information--Part I)

Gross Benefits:	
Revenue from operations (1)	xxxxx
Cost savings (1)	xxxxx
Total Benefits:	xxxxx (A)

Total Benefits: (continued)	xxxxx (A)
Less Operating expenses	xxxxx (B)
Net Cash Benefit before non-cash expenses and taxes	$ xxxxx
52% of a negative net Cash Benefit if B is greater than **A**	(xxxxx)

OR

52% of Net Cash Benefits if **A** is greater than B	xxxxx
Plus:	
48% of the yearly depreciation (increase in cash benefits from tax savings because of the tax deductibility of depreciation expense)	xxxxx
Net Cash Benefits from Operations	xxxxx
Plus:	
Funds received because of a gain or loss on the sale of an asset (2)	xxxxx
Less:	
Replacement of assets (3)	(xxxxx)
Net Cash Benefits for a given Year	xxxxx

The above would have to be repeated for each year of the asset's useful life as determined in Step 1 of Part I.

(1) The particular project would be either type of project but not both.

(2) Only a periodic item (arising when an asset is replaced during the life of the project or at the end of the asset's useful life).

(3) **A** periodic disbursement over the project's useful life.

Part III

Determination of the internal rate of return--an example of the formula that may be used.

$$C = \frac{B_1}{(1 + r)} + \frac{B_2}{(1 + r)^2} + \ldots + \frac{B_n + S}{(1 + r)^n}$$

C = Cost of the asset
B = Net cash flow
n = Estimated useful life
r = The rate of return to be determined
S = Salvage value

Part IV

Repeat the prior three parts for as many trials as is wanted or required.

Part V

The final product:

1. Summary of the frequency of each rate of return.
2. Print out of the factors used in Part III and the rate of return for use in sensitivity analysis.

Detail of Part I

Step I--Estimated useful life of the asset:

A. Input

	Years	Subjective Probability	Cumulative Probability
Example	xxx	.xx %	.xx %
	xxx	.xx	.xx
	xxx	.xx	x.xx

B. Machine

Compare:

1. Random numbers obtained from the program determining random numbers.
2. The above cumulative probability.

C. Output

The appropriate estimated useful life obtained from the comparison made by the machine. The life of the project, so determined, will determine the number of yearly revenue, expense, etc. that has to be used in each case to arrive at a rate of return.

Step II--Asset cost (two possible forms):

Form 1--Estimated cost (asset cost broken down into parts with a cost range and likelihood given for each).

A. Input

Item	Cost Range	Subjective Probability	Cumulative Probability
Press	$ xxxx	.xx %	.xx %
	xxxx	.xx	.xx
	xxxx	.xx	x.xx

Item	Range	Subjective Probability	Cumulative Probability
Chutes	$ xxx	x.xx %	x.xx %
Conveyor sections	xxx	x.xx	x.xx
Installation costs	$ xxx	.xx %	.xx %
	xxx	.xx	.xx
	xxx	.xx	x.xx
Rearrangement costs	$ xxx	.xx %	.xx %
	xxx	.xx	.xx
	xxx	.xx	x.xx
Contingency	$ xxxx	.xx %	.xx %
	xxxx	.xx	.xx
	xxx	.xx	x.xx

B. Machine

1. Compare the random numbers obtained from the program with each assigned number noted above.

2. Sum the cost of each item determined from the above comparison to obtain the total cost.

C. Output

The total cost of assets to be acquired.

Form 2--Total costs are given with no detail breakdown.

A. Input

Cost Range	Subjective Probability	Cumulative Probability
$ xxx	.xx %	.xx %
xxx	.xx	.xx
xxx	.xx	x.xx

B. Machine

Same as item 1 under machine above.

C. Output

Cost of the asset to be used.

Step III--Gross Benefits (two forms: revenue producing and cost savings)

Form 1--Revenue producing

A. Input

	Amount	Subjective Probability	Cumulative Probability
Revenue	$ xxxx	.xx %	.xx %
	xxxx	.xx	.xx
	xxxx	.xx	x.xx

(Note: There may be more than one source with various likelihoods.)

B. Machine

Compare and select one of each of the above for each year of the asset's life. There will, in some cases, be more than one source of revenue; therefore, the machine will have to select one revenue amount from each source and then sum these items. The total will then be used in arriving at the yearly net cash benefits.

C. Output

Total gross benefits to be received for each year of the asset's useful life.

Form 2--Cost savings (The data will be in the same form as the revenue producing case).

Step IV--Operating Cost

A. Input

	Range	Subjective Probability	Cumulative Probability
Operating costs	$ xxx	.xx %	.xx %
	xxx	.xx	.xx
	xxx	.xx	x.xx

B. Machine

Compare and select one of each of the above for each year of the asset's useful life. There will be, in some cases, more than one source of expense; therefore, the machine will have to select one expense amount from each source and then sum these items.

C. Output

The total operating expenses to be incurred for each year of the asset's useful life.

Step V--Asset Replacement

A. Input

Range	Subjective Probability	Cumulative Probability
$xxxx	.xx %	.xx %
xxxx	.xx	.xx
xxxx	.xx	x.xx

B. Machine

Comparison of the assigned numbers and the random numbers and selection of the amount to be used. (There may be more than one source; therefore, a total figure will have to be arrived at.)

C. Output

The total dollar amount and the year the expenditure applies to.

(Note: These will not be yearly figures in most cases. They may take the form of an expenditure every fifth year, etc.)

Step VI--Salvage Value

A. Input

Estimated Amount	Subjective Probability	Cumulative Probability
$xxxx	.xx %	.xx %
xxxx	.xx	.xx
xxxx	.xx	x.xx

(Note: There may be more than one asset disposed of; therefore, a total salvage value will have to be determined from the estimated amounts and likelihood of each asset. Also the salvage value may be different depending upon the year of retirement.)

B. Output

The total salvage value selected and the year it applies to.

Step VII--Depreciation

A. Input

1. Bases of depreciation - cost of the asset as determined by the machine in Step II of Part I.

2. Estimated life for depreciation purposes will be the tax life - this figure will be given.

B. Machine

1. Method to be used - the straight line method (cost ÷ tax life) equals yearly depreciation.

2. The time period that the depreciation is to be taken over life of project:

   a) The tax life
   or
   b) The useful life of the project, whichever is less.

3. A depreciation amount will have to be determined for each asset acquired since they will have different tax lives, cost ranges and likelihoods.

4. The accumulated depreciation taken on each asset class will have to be maintained for the use in the determination of the gain or loss on sales of the asset.

C. Output

The output is the total depreciation expense for each year. This amount will be the total taken for each year adjusted for replacements and items retired, since the retirement of the asset would reduce the years depreciation amount and a replacement will increase the annual charge.

Step VIII--Net Benefit from the sale of the asset (net after taxes)

How determined:

Net book value of asset-cost (determined in Step 1)	$ xxx	
Less Accumulated depreciation (determined in Step 8)	(xxx)	
	xxx	(1)
Value of asset at date of sale (Step 6)	xxx	(2)
Gain on sale of asset (if 2 > 1)	xxx	
Loss on sale of asset (if 1 > 2)	(xxx)	

Tax effect:

If gain on sale Gain x 25% = tax due

If loss on sale Loss x 25% = tax benefit

Total benefit:

	If gain	If loss
Salvage value (Step VI)	xxxx	xxx
if gain deduct tax	(xxx)	
if loss add tax benefit		xx
Total net cash benefit from sale of asset	xxx	xxx

APPENDIX C

COMPUTER PROGRAM

```
JOB,460117,MOCSER,5.WOODFIELD,LEON W.
SCOPE 5.1008
FTN,L,X,*
      PROGRAM MOCSER
      DIMENSION ESTLIFE(100), ESTCOST(100),R(100),SALV
     1AGE(100),DEPRACC(100),PROFITA(100),SALEGAIN(100),
     2XNETBV(100),ESTCOSTL(20),ESTCOSTB(20),ESTCOSTE(20
     3),ESTCOSTY(20),GRYRREV(20),OTHERINC(20),OPEREXYR(
     420),OTHEREXP(20),CASHBBTX(20),CASHBATX(20),BENOPE
     5R(20),NETCSHBN(20),FNC(21),REPLACE(20),DEPREXPB(2
     60),DEPREXPY(20), DEPREXPE(20),DEPREXP(20)
      DO 700 M=1,100
      ESTLIFE(M)=0.0
      ESTCOST(M)=0.0
      R(M)=0.0
      SALVAGE(M)=0.0
      DEPRACC(M)=0.0
      PROFITA(M)=0.0
      SALEGAIN(M)=0.0
  700 XNETBV(M)=0.0
      PRINT 5000
 5000 FORMAT(1H1)
      DO 1000N=1,100
      DO701 J=1,20
      ESTCOSTL(J)=0.0
      ESTCOSTB(J)=0.0
      ESTCOSTE(J)=0.0
      ESTCOSTY(J)=0.0
      GRYRREV(J)=0.0
      OTHERINC(J)=0.0
      OPEREXYR(J)=0.0
      OTHEREXP(J)=0.0
      CASHBBTX(J)=0.0
      CASHBATX(J)=0.0
      BENOPER(J)=0.0
      NETCSHBN(J)=0.0
      FNC(J)=0.0
      REPLACE(J)=0.0
      DEPREXPB(J)=0.0
      DEPREXPY(J)=0.0
```

```
      DEPREXPE(J)=0.0
  701 DEPREXP(J)=0.0
      FNC(21)=0.0
      J=1
      RN=RANF(-1)
      IF(RN-.10)1,2,2
    1 ESTLIFE(N)=10
      GO TO 5
    2 IF(RN-.55)3,4,4
    3 ESTLIFE(N)=15
      GO TO 5
    4 ESTLIFE(N)=20
    5 RN=RANF(-1)
      IF(RN-.05)6,7,7
    6 ESTCOSTB(J)=23760
      GO TO 10
    7 IF(RN-.95)8,9,9
    8 ESTCOSTB(J)=21600
      GO TO 10
    9 ESTCOSTB(J)=19440
   10 ESTCOSTL(J)=100000
      RN=RANF(-1)
      IF(RN-.34)11,12,12
   11 ESTCOSTE(J)=33610
      GO TO 15
   12 IF(RN-.67)13,14,14
   13 ESTCOSTE(J)=32610
      GO TO 15
   14 ESTCOSTE(J)=31610
   15 RN=RANF(-1)
      IF(RN-.02)16,17,17
   16 ESTCOSTY(J)=22000
      GO TO 120
   17 IF(RN-.07)18,19,19
   18 ESTCOSTY(J)=17160
      GO TO 120
   19 IF(RN-.97)20,21,21
   20 ESTCOSTY(J)=15600
      GO TO 120
   21 ESTCOSTY(J)=14040
  120 ESTCOST(N)=ESTCOSTB(J)+ESTCOSTL(J)
     1+ESTCOSTE(J)+ESTCOSTY(J)
C    C OMPUTE GROSS BENEFITS
      J=1
      RN=RANF(-1)
      IF(RN-.10)22,23,23
   22 OTHERINC(J)=43680
      GO TO 30
   23 IF(RN-.20)24,25,25
   24 OTHERINC(J)=34944
      GO TO 30
   25 IF(RN-.40)26,27,27
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```
26 OTHERINC(J)=26208
   GO TO 30
27 IF(RN-.90)28,29,29
28 OTHERINC(J)=21840
   GO TO 30
29 OTHERINC(J)=15720
30 J=J+1
   RN=RANF(-1)
   IF(RN-.10)31,32,32
31 OTHERINC(J)=52420
   GO TO 39
32 IF(RN-.20)33,34,34
33 OTHERINC(J)=43680
   GO TO 39
34 IF(RN-.40)35,36,36
35 OTHERINC(J)=26210
   GO TO 39
36 IF(RN-.80)37,38,38
37 OTHERINC(J)=21840
   GO TO 39
38 OTHERINC(J)=17472
39 J=J+1
   RN=RANF(-1)
   IF(RN-.10)40,41,41
40 OTHERINC(J)=61150
   GO TO 52
41 IF(RN-.20)42,43,43
42 OTHERINC(J)=52416
   GO TO 52
43 IF(RN-.30)44,45,45
44 OTHERINC(J)=43680
   GO TO 52
45 IF(RN-.50)46,47,47
46 OTHERINC(J)=39310
   GO TO 52
47 IF(RN-.60)48,49,49
48 OTHERINC(J)=30576
   GO TO 52
49 IF(RN-.90)50,51,51
50 OTHERINC(J)=26210
   GO TO 52
51 OTHERINC(J)=15720
52 J=J+1
   DO93J=4,20,1
   RN=RANF(-1)
   IF(RN-.03)53,54,54
53 OTHERINC(J)=61150
   GO TO 93
54 IF(RN-.05)55,56,56
55 OTHERINC(J)=52416
   GO TO 93
56 IF(RN-.08)57,58,58
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```
57 OTHERINC(J)=43680
   GO TO 93
58 IF(RN-.13)59,60,60
59 OTHERINC(J)=39310
   GO TO 93
60 IF(RN-.15)61,62,62
61 OTHERINC(J)=30576
   GO TO 93
62 IF(RN-.23)63,64,64
63 OTHERINC(J)=26210
   GO TO 93
64 IF(RN-.25)65,66,66
65 OTHERINC(J)=15720
   GO TO 93
66 IF(RN-.28)67,68,68
67 OTHERINC(J)=57852
   GO TO 93
68 IF(RN-.30)69,70,70
69 OTHERINC(J)=50616
   GO TO 93
70 IF(RN-.33)71,72,72
71 OTHERINC(J)=42180
   GO TO 93
72 IF(RN-.38)73,74,74
73 OTHERINC(J)=37968
   GO TO 93
74 IF(RN-.40)75,76,76
75 OTHERINC(J)=29520
   GO TO 93
76 IF(RN-.48)77,78,78
77 OTHERINC(J)=25308
   GO TO 93
78 IF(RN-.50)79,80,80
79 OTHERINC(J)=15180
   GO TO 93
80 IF(RN-.56)81,82,82
81 OTHERINC(J)=56952
   GO TO 93
82 IF(RN-.60)83,84,84
83 OTHERINC(J)=48816
   GO TO 93
84 IF(RN-.66)85,86,86
85 OTHERINC(J)=40680
   GO TO 93
86 IF(RN-.76)87,88,88
87 OTHERINC(J)=36612
   GO TO 93
88 IF(RN-.80)89,90,90
89 OTHERINC(J)=28476
   GO TO 93
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   90 IF(RN-.96)91,92,92
   91 OTHERINC(J)=24408
      GO TO 93
   92 OTHERINC(J)=14640
   93 CONTINUE
      DO94J=1,20,1
      GRYRREV(J)=OTHERINC(J)
   94 CONTINUE
C    C OMPUTE OPERATING EXPENSE
   95 J=1
      OTHEREXP(J)=15216
   96 DO97J=2,20,1
      OTHEREXP(J)=4308
   97 CONTINUE
   98 DO99J=1,20,1
      OPEREXYR(J)=OTHEREXP(J)
   99 CONTINUE
C    C OMPUTE ASSET REPLACEMENT
      DO100J=1,10,1
      REPLACE(J)=0.0
  100 CONTINUE
      J=11
      REPLACE(J)=3210
      DO101J=12,20,1
      REPLACE(J)=0.0
  101 CONTINUE
C    C OMPUTE SALVAGE VALUE
      RN=RANF(-1)
      IF(RN-.34)102,103,103
  102 SALVAGE(N)=150750
      GO TO 106
  103 IF(RN-.67)104,105,105
  104 SALVAGE(N)=100500
      GO TO 106
  105 SALVAGE(N)=50250
C    C OMPUTE DEPRECIATION EXPENSE
  106 J=1
      ADAMB=ESTCOSTB(J)/15
      DO107J=1,15,1
      DEPREXPB(J)=ADAMB
  107 CONTINUE
      J=1
  108 ADAMY=ESTCOSTY(J)/15
      DO109J=1,15,1
      DEPREXPY(J)=ADAMY
  109 CONTINUE
      J=1
      ADAME=ESTCOSTE(J)/6
  110 DO111J=1,6,1
```

```
      DEPREXPE(J)=ADAME
  111 CONTINUE
  112 DO113J=7,20,1
      DEPREXPE(J)=0.0
  113 CONTINUE
  114 DO115J=16,20,1
      DEPREXPB(J)=0.0
  115 CONTINUE
  116 DO117J=16,20,1
      DEPREXPY(J)=0.0
  117 CONTINUE
  118 DO119J=1,20,1
      DEPREXP(J)=DEPREXPB(J)+DEPREXPY(J)+
     1DEPREXPE(J)
  119 CONTINUE
C   C OMPUTE NET CASH BENEFIT FROM SALE OF ASSET
      J=1
      IF(ESTLIFE(N)-10)121,121,122
  121 DEPRACC(N)=DEPREXPB(J)*10+DEPREXPY(J)*
     110+DEPREXPE(J)*6
      GO TO 123
  122 J=1
      DEPRACC(N)=ESTCOSTB(J)+ESTCOSTY(J)+
     1ESTCOSTE(J)
  123 XNETBV(N)=ESTCOST(N)-DEPRACC(N)
      PROFITA(N)=SALVAGE(N)-XNETBV(N)
      IF(SALVAGE(N)-XNETBV(N))124,124,125
  124 SALEGAIN(N)=SALVAGE(N)+(PROFITA(N)*.25)
      GO TO 126
  125 SALEGAIN(N)=SALVAGE(N)-(PROFITA(N)*.25)
  126 DO802J=1,20,1
      CASHBBTX(J)=GRYRREV(J)-OPEREXYR(J)
      CASHBATX(J)=0.52*CASHBBTX(J)
      BENOPER(J)=CASHBATX(J)+0.48*DEPREXP(J)
      IF(J-ESTLIFE(N))800,801,801
  800 NETCSHBN(J)=BENOPER(J)-REPLACE(J)
      GO TO 802
  801 NETCSHBN(J)=BENOPER(J)-REPLACE(J)+SALEGAIN(N)
  802 CONTINUE
      R(N)=0.0
      SFNC=0.0
      N2=ESTLIFE(N)+1
      N3=ESTLIFE(N)
      FNC(1)=-1.0*ESTCOST(N)
      DO 803 L=2,N2
  803 FNC(L)=NETCSHBN(L-1)
      DO 2003 J=1,N2
 2003 SFNC=SFNC+FNC(J)
      IF(SFNC)2009,2102,2004
 2004 DO 2052 J=1,7
```

```
 2050 R(N)=R(N)+0.1**J
      SFNC=0.0
      DO 2051 J=1,N2
      M=N3+1-J
 2051 SFNC=SFNC+FNC(J)*(1.0+R(N))**M
      IF(SFNC)2052,2050,2050
 2052 R(N)=R(N)-0.1**J
      R(N)=R(N)*100.0+0.0005
      GO TO 2102
 2009 DO 2012 J=1,7
 2010 R(N)=R(N)-0.1**J
      SFNC=0.0
      DO 2011 J=1,N2
      M=N3+1-J
 2011 SFNC=SFNC+FNC(J)*(1.0+R(N))**M
      IF(SFNC)2010,2010,2012
 2012 R(N)=R(N)+0.1**J
      R(N)=R(N)*100.0-0.0005
 2101 FORMAT(*3RATE = *F8.3* , ESTLIFE = *F2.0*, ESTCOST =
     1*F6.0*, SALVAGE = *F6.0* , DEPRACC = *F6.0* , SALEGA
     2IN = *F7.0)
 2102 PRINT 2101,R(N),ESTLIFE(N),ESTCOST(N),SALVAGE(N),DEP
     1RACC(N),SALEGAIN(N)
      LIFE=ESTLIFE(N)
      PRINT 2103
 2103 FORMAT(1H0,6X,*YEAR*16X*GRYRREV*15X*OPEREXYR*16X*DEP
     1REXP*16X*REPLACE*16X*NETCSHBN*)
      PRINT 2104,((J,GRYRREV(J),OPEREXYR(J),DEPREXP(J),REPL
     1ACE(J),NETSCHBN(J)),J=1,LIFE)
 2104 FORMAT(8X,J2.0,17X,4(F6.0,17X),F7.0)
      NAME=8HMOCFER
      PUNCH 2105,NAME,R(N)
 2105 FORMAT(A8,2X,F8.3)
 1000 CONTINUE
      END
LOAD
RUN,5,5000
```

APPENDIX D

MISCELLANEOUS INFORMATION

Steps Taken While at Individual Company

The following steps were taken in gathering the necessary information:

A. A tour of the business was taken in order to obtain a knowledge of the type of organization and some of its problems.

B. Individuals responsible for decisions were interviewed in the capital budgeting area. The purpose of this was to determine the policies and organizational structure. (Refer to the list of general and specific areas determined.)

C. Some of the current asset acquisitions were reviewed and investigated with the documents and working papers being traced from the inception to completion of the project. The purpose of this was to gain additional information concerning the policies and organizational structure.

D. The projects studied were obtained from either projects just currently being completed and/or projects for which approval was just given the go-ahead.

E. The data gathered was applied to the model.

F. The data was then summarized and interpreted.

G. The organizations were revisited and the results of the tests were reviewed.

The following general areas were investigated in order to gain an understanding of the firm and its organization and procedures:

A. What are the sources of the ideas for the proposed projects.

B. Is there a long range capital budgeting plan which is related to the overall goals of the firm.

C. Is a yearly (short term) budget prepared listing the proposed projects to be undertaken by the firm.

D. What measurement is used to determine the worth of each project (payback, average rate of return, etc.).

E. What standards are required to be met before approval is given (cost of capital, payback period, etc.).

F. What is the system of control over authorized outlays.

G. Is there a review and comparison of actual and forecasted results.

H. What are the policies for retirement of the asset.

I. Obtain a knowledge of forms and procedures used by the organization.

J. Does there seem to be an understanding of the economics of capital budgeting.

K. How is uncertainty currently being accounted for.

In order to apply the model the following specific factors were determined for each project that was reviewed:

A. Estimated cost of the project.

B. Estimated life of the asset.

C. Estimated cash proceeds or cost savings and year of receipt.

D. Estimated operating costs (fixed and variable) and year of expenditure.

E. Estimated salvage value.

For each of the above, the range of values and subjective probability was determined.

Depending upon the nature of the project, other factors such as production capacity, share of the market, were added to the above list.

APPENDIX E

PROPOSED LETTER

The following letter was sent to each firm indicating the purpose of the study. Introductions were made previously through a faculty member and through appointments at the several companies. This letter was presented to each firm requesting a written description of the analysis to be made.

Dear Sir:

The following will present, in general terms, a description of what is involved and the estimated time required for the study.

Whenever an individual is considering the purchase of an asset, an assumption is made that there is a possibility of a future net benefit to be received. It is common to estimate the required operating expenditures and future benefits. Estimates are also made as to the cost and life of the project. After determining this information, through some means such as a feeling, determination of a rate of return, a minimum recovery period of the investment, past experience, or a combination of these a decision is made to accept or reject the proposal.

It has been said that the only thing that is certain is death and taxes. The decision to purchase assets is subject to uncertainty concerning future events; however, in trying to determine when to acquire an asset the problem is

treated by many as if we were in a state of certainty. For example: A manager will ask the engineering department to estimate the cost of the project; the sales manager will be asked to estimate the sales and the accountant the operating costs. These will then be combined and through the experience of management a judgement will be made. The single sales and cost figures may not be enough to make the decision and so each department may be asked to furnish the most likely, highest possible and lowest range in order to shed some light on the problem. But even now the data, in most cases, will be handled as if the results were certain. In some cases the results may be adjusted because of experience when the forecasts seem to be a little high or low but by how much?

I hope to determine that a method (for capital budgeting) in which uncertainty is considered explicitly can be applied to actual situations with the conclusions furnishing useful information. I propose to become acquainted with the capital budgeting decision making process of your firm, apply a model to some investment proposals you are now completing or have currently approved, analyze the results, make suggestions as to possible uses of the data obtained and attempt to indicate the advantages and disadvantages of the proposed method when compared with methods currently being used.

While at your organization I would like to approach the problem in the following manner:

1. Take a tour of your organization in order to obtain a knowledge of the organization and a feeling for some of the problems.

2. Interview individuals responsible for decisions and making estimates in the capital budgeting area.

3. Review and investigate some of the current asset acquisitions tracing the documents and working papers from the inception to completion of the project.

4. Select some projects to be studied from the currently approved projects or those currently being completed. (These projects would then be used in an attempt to apply the model I will be using.)

5. After having studied the projects and applied the model the results would be summarized and discussed with you.

In general terms; I will be attempting to determine the factors that affect the decision such as cost of the project, estimated operating cost, estimated revenue or cost savings, life of the asset, etc. These required items will normally already be available. Using this information I would then attempt, by interviewing each individual who has had experience in each area and helped to furnish an estimate of each factor, to determine a range of possible values and the likelihood of each. After having obtained this data it will be worked with, the result being, at a minimum, an estimate of the internal rate of return and the likelihood of each.

It is realized that this will be subjective in nature and the data will be no better than the judgements made; however, it is felt that these can be made. A quote by Joel Dean, a noted author and teacher, may best indicate, in general, what I hope to accomplish: "Adjustments to allow for uncertainty may be challenged as nothing more than guesses. Perhaps they are. But even so, they are guesses that must be made, and will be made, either explicitly or implicitly. Failure to apply the probability adjustment does not enable management to avoid the problem; it merely transfers the guess element in a disguised form to some other stage of the decision making process." It is my hope that this adjustment can be brought out in an explicit form and the results, at a minimum, being useful to management in attempting to arrive at solutions to their capital budgeting problems.

It is difficult to suggest the time that will be required while at your organization; however, it is estimated that the minimum would be one week with the maximum of two. The cost to you would involve the time

required in interviewing your personnel and also any inconvenience created by my presence within your organization. In return, it is felt that some benefit will be received by your organization; a minimum being an exchange of ideas which may help in the capital budgeting area. I am sure that from this experience I will gain a better understanding of business operation and the problems involved.

Very truly yours,