Management Services: A Magazine of Planning, Systems, and Controls

Volume 4 | Number 1 Article 8

1-1867

Lessening the Dangers of Uncertainty

Leon W, Woodfield

Uncertainty—unlike risk—is commonly assumed to be entirely unrelated to probabilities. Yet with the proper techniques and the judgment of mature executives a range of probabilities can be established based on subjective opinions—

LESSENING THE DANGERS OF UNCERTAINTY

by Leon W. Woodfield
Brigham Young University

A DECISION to invest is concerned with a choice among the available alternatives and is always subject to unknown elements concerning the future. The lack of complete data, however, 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]

As this statement indicates, certain decision areas may be treated by the mathematics of probability. In 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 the existence 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 blackjack for money and buying insurance (preferring a 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 re-

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

ferred to [illegible] the investment of a project). These methods of adjustment are deficient in that they do not provide an estimate of the likelihood of obtaining a particular value. As 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."[4]

cast 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.

Need for improved methods

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 dis-

the decision making process."[3]

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 organizations as reported periodically in financial reports, magazines, and newspapers.

There are numerous methods that can be used in estimating the worthiness of capital expenditures. These 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 are 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.

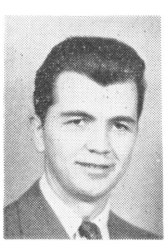
Even though current methods in use assume that estimates of the future are correct, the existence of uncertainty is recognized implicitly and is adjusted for in various ways —by modification of the desired rate of return, by assignment of differential handicaps, by application of informal judgments, by selection of arbitrary payback periods, and by sensitivity analysis (analysis of the effect that a given percentage change in each cost, price, and sales factor would have

Use of subjective data

Whenever a person is involved in uncertainty, he is dealing with a subjective phenomenon since there are 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.[5]

"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 asking the person directly to express his judgments as to the chance of an event's occurring.[6] 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)

[2] For a discussion of 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.



LEON W. WOODFIELD, CPA, is assistant professor of accounting in the College of Business of Brigham Young University, Provo, Utah. In the past he was a staff member at Arthur Young & Company. He received his B.S. and M.B.A. degrees from the University of Utah and earned his D.B.A. degree from Michigan State University in 1965. Dr. Woodfield is president-elect of the Southern Chapter of the Utah Association of CPAs and is a member of the California Society of CPAs and the American Accounting Association.

[3] Joel Dean, *Managerial Economics,* Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1951, tenth printing 1960, p. 568.

[4] Harry V. Roberts, "Current Problems in the Economics of Capital Budgeting," *Elements of Financial Administration,* ed. John O'Donnell and Milton S. Goldberg, Charles E. Merrill Books, Inc., Columbus, Ohio, 1962, pp. 278-84.

[5] Milton H. Spencer and Louis Siegelman, *Managerial Economics — Decision Making and Forward Planning,* Richard D. Irwin, Inc., Homewood, Illinois, 1964, p. 8.

[6] 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, New York, 1963, pp. 49-54.

having an equal reward. The point at which the individual is indifferent to the choice between the uncertain event and a given percentage of the total lottery tickets is his probability estimate for the uncertain event.[7]

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 judgments that are required. The possibility of poor estimates on the part of the individual points up the need to obtain the judgment of mature persons having experience in related situations. Even though subjective probabilities are judgments that cannot be objectively verified, it has been demonstrated experimentally that subjective probabilities can be amazingly accurate (the estimates made reflect the actual conditions known to exist in the experiment) when opinions of mature persons are sought.[8]

The problem of uncertainty should be recognized in capital budgeting projects undertaken for study. The subjective estimates should be made explicitly. Since uncertainty is a factor that must be adjusted for, the estimates required will be made. It is better and safer if they are made in an explicit form.

When the model (for capital budgeting decisions) described in this article was applied to situations in business organizations, uncertainty was considered in an explicit form. The model used the Monte Carlo method. A range of values and subjective probabilities was obtained for each factor used in determining the internal rate of return. The data were obtained from individuals having experience and knowledge of the capital budgeting procedures being used by each company. The proposals analyzed were those being considered currently by the business organizations interviewed.

RANGE OF VALUES AND SUBJECTIVE PROBABILITIES
MACHINERY PROPOSAL

	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 1-3	$29,370	34%
	26,700	67
	24,000	100
Fourth year (illustration of distribution for years 4-20)	$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	

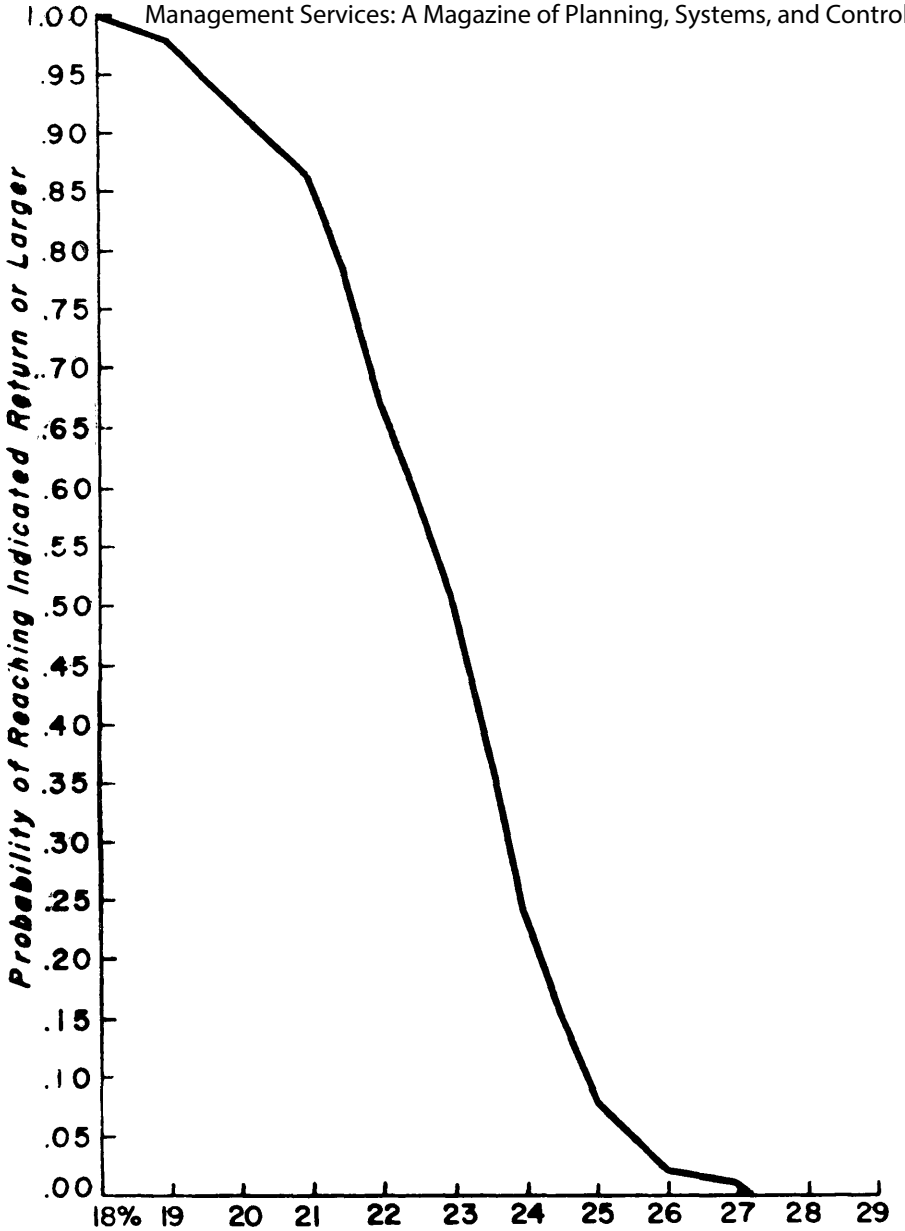
TABLE

A computer was used to simulate the capital budgeting decisions. However, for the purposes of this article, the illustration of the application of the model will be simplified if the use of a hand calculator is assumed.

The distribution of each variable was assigned numbers ranging from 0 to 99. The size of the group of numbers assigned was dependent upon the subjective probability of the factor under consideration. For example: If there was estimated to be a 15 per cent chance that the sales would be X dollars, numbers 00-14 were assigned to that particular level of sales. This same procedure was duplicated for each factor having a range of values. By the use of random number tables, factors such as the level of sales, cost, and estimated useful life were obtained.

Based on this information a range of rates of return, with their likelihoods of occurrence, was determined; however, in order to obtain an estimate of a possible range of rates of return and their likelihoods of occurrence, a number of experiments (determinations of individual rates of return) had to be made. The number of trials used was limited to one hundred since a larger number of experiments did not materially affect the

[7] Robert Schlaifer, *Probability and Statistics for Business Decisions*, McGraw-Hill Book Co., Inc., New York, 1959, pp. 12-13.
[8] Norton, *loc. cit.*



MACHINERY PROPOSAL

EXHIBIT 1

results of the study that was made.

The analyses of two capital budgeting proposals to which the model was applied are illustrated in the exhibits. One of them was the acquisition of a major item of machinery, the other, an investment in a new retail outlet. The range of values of the proposal for the machinery acquisition is shown in the table on page 53. Items having a limiting effect upon the factors used in the model were considered in arriving at the estimates of the variables. For example, the level of plant capacity and the 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 data received from the application of the model consisted of the rates of return and the factors used in the computation of each rate of return. By summarizing the rates of return obtained, a range and the frequency of each were determined. A probability equal to the frequency of occurrence was then assigned to each rate of return. The probability was then charted as illustrated in Exhibit 1 on the left.

Use of data

The information obtained from the application of this model aids in the evaluation of the outcome of predicted economic events. It furnishes information that permits analysis of the effect of factors on the rate of return and of the alternative outcomes of a commitment to invest funds. The importance of duration of life, initial cost, etc., as facts bearing on the rate of return can be determined. This can be demonstrated by referring to the data obtained and summarized in Exhibit 1 and in Exhibit 2 on page 55.

Exhibit 1 is a summary of the proposal to acquire a major item of machinery. An investment of between $58,000 and $65,000 promised an estimated rate of return of between 18 and 27 per cent. By reviewing the information output of the model it was determined that the major factors affecting the return were the estimated useful life and the initial investment. The variations in gross benefits, operating expenses, and salvage value had only a minor effect on the results.

Exhibit 2 summarizes the proposal to invest in a new retail outlet, which would distribute existing products produced by the organization studied. The rates of return to be obtained were between 1.9 and 11.6 per cent. The variation in the future benefit was a result of all factors used in the computation of the rate of return. The major elements causing the lower rates of return were the resale value and the projected useful life. The subjective judgments for the resale value ranged between $50,000 and $150,000, with an equal probability being assigned to each value within the range. The estimated useful life was between five and fifteen years. A variation in the termination value (assuming all other factors were held constant) caused a change of 3 to 4 per cent

in the expected return. There was an expected variation of $20,000 in the initial costs of the asset; however, this did not materially affect the promised return since the probability of the extreme value was small.

Probability estimates such as these are subjective in nature and are subject to human error. Because the results are no better than the original estimates, the individuals who make the estimates should be persons of experience in the areas affected by the asset proposal. The mechanical application of the model after it is once established could be handled by a clerk.

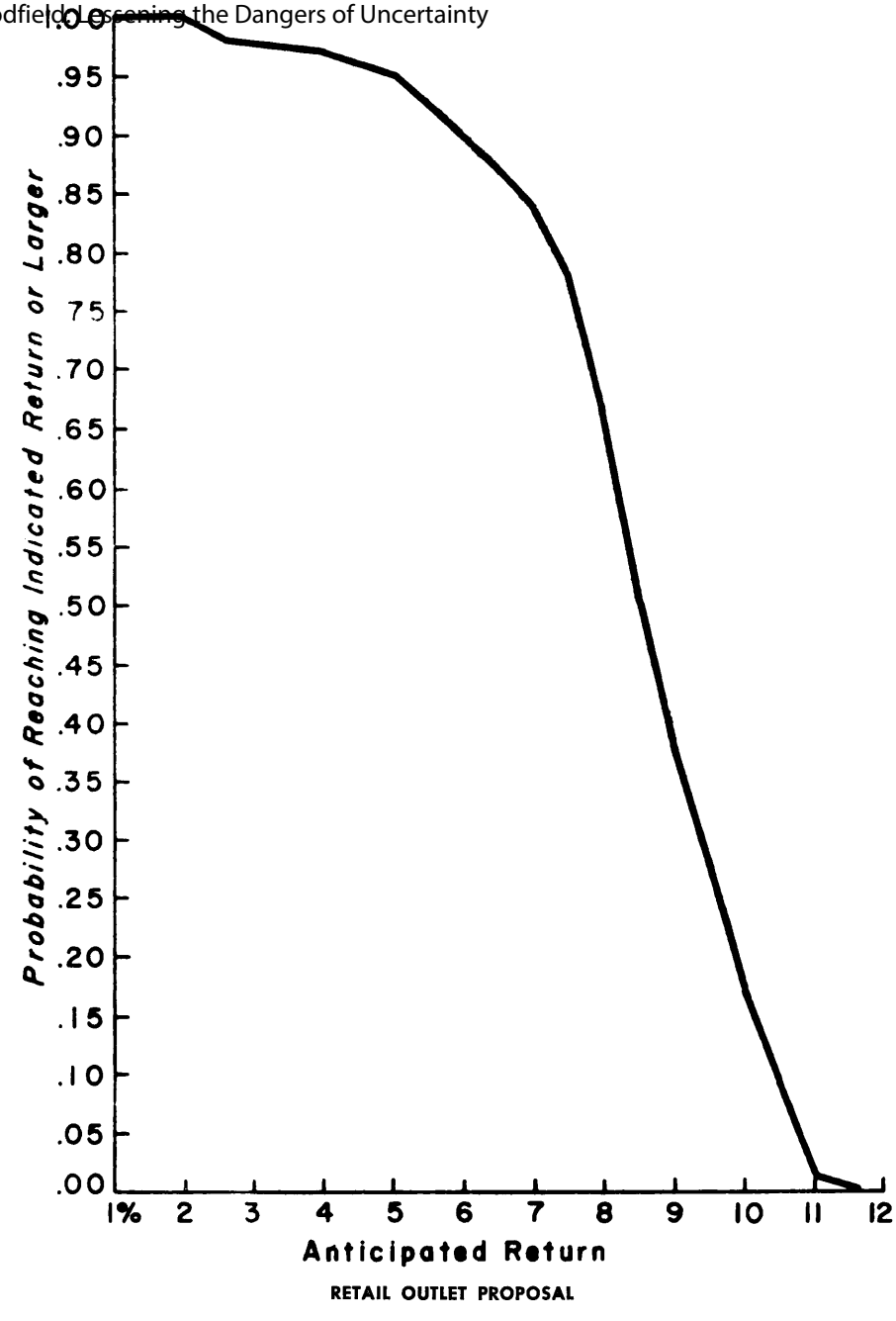
The need for reliable estimates is not a weakness of this particular model any more than it is of any tool currently being used to aid in this type of decision. To obtain reliable data from any proposed method, whether it is the payback method, accounting rate of return, or some other, requires estimates, and the results can be no better than the estimates furnished. In using this model, however, the subjective probabilities are assumed to be realistic. As was noted, studies have been made which indicate that this assumption is valid.[9] This problem is currently being reviewed and studied by the author.

The proposed procedure furnishes information that is not available with the more common capital budgeting methods. A single-year payback was used as the standard for acceptance of one acquisition proposal studied. The analysis, via the proposed model, not only demonstrated a payback period of one year but also showed that there was a 50 per cent probability of obtaining a return of 111 per cent. In another case a proposal that was looked upon with favor by management had only a 6 per cent probability of a positive return.

Being able to determine the range of rates of return, the probability that a given return will be realized and the factors materially affecting the profitability of the outcome aids in the evaluation of the aftermath of the predicted economic event. The availability of this data also enlarges the scope of the analysis so that it is possible to balance the relative value of the possibility of a substantial gain or loss against an alternative investment opportunity that is relatively certain.

The employment of the model encourages improvement of capital budgeting procedures being used within the company. The incremental costs of applying the model were found to be immaterial in most cases.

There was awareness within each company interviewed that continuous effort to improve capital budgeting procedures should be a policy of management. New tools and techniques should be applied to improve both the quality of data and the management of capital budgeting. One of the most critical needs for improvement is in generating ideas for alternative uses of capital funds.



RETAIL OUTLET PROPOSAL

EXHIBIT 2

[9] Norton, *loc. cit.*