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Use of Sensitivity Analysis in Capital Budgeting

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Any investment always involves an estimate of the expected rate of return. But no one can guarantee that the estimate will be correct. What a company can do, however, is calculate the possible degree of error in its estimate and weigh this against the alternative uses of its capital —

USE OF SENSITIVITY ANALYSIS IN CAPITAL BUDGETING

by William C. House
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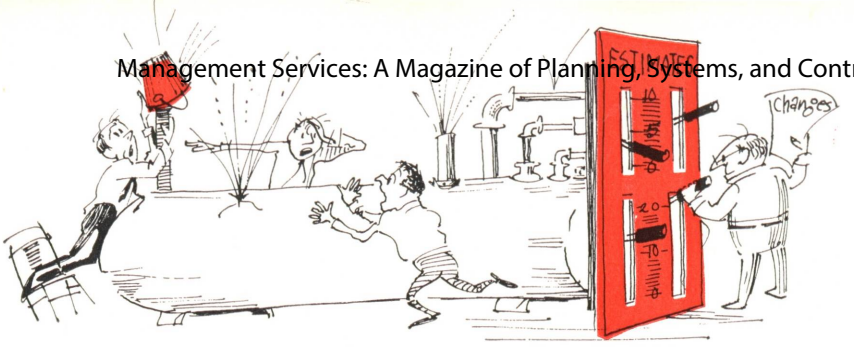
THE ANTICIPATED rate of return on investment is one of the principal criteria used by corporate managements in deciding whether to accept or reject a proposed capital expenditure. Like any forecast, however, the rate of return estimate may prove to be inaccurate.

Estimates of rates of return are based on forecasts of such elements as sales volumes, selling prices, product purchase or production prices, operating expenses, capital investment outlays, and project economic lives. Any or all of these forecasts may be erroneous, and the result may be an actual rate of return that falls far below what has been anticipated.

Thus, management needs some method for determining the likelihood and amount of such errors before making a final decision to accept or reject a given proposal. It is sometimes possible to develop probability distribution curves that indicate the likelihood of occurrence of specific rates of return for individual projects. If enough information is available about the outcomes of similar past proposals, then management can make its choice on the basis of expected values (i.e., the values with the highest probability of occurrence) derived from a probability distribution of rates of return. In many cases, however, capital investment proposals represent unique events for which there is little or no relevant past experience. Then expected values cannot be determined objectively, and the likelihood of errors cannot be predicted.

It is always possible, however, to calculate in advance what effect errors in estimation would have on the estimated rates of return and thus to determine the significance of such errors. The appropriate technique to use is that of sensitivity analysis. Its application, illustrated by means of a case example, is explained in this article.

Analysis of the sensitivity to er-



Sensitivity cannot be measured precisely. Management may have to ignore the fact that a change in one estimate (e.g., sales volume) may cause changes in another estimate; such changes are difficult to measure.

ror of rates of return is the process of determining whether small changes in various estimates cause significant changes in estimated rates of return. If management finds that a 5 or 10 per cent error in forecasting a certain estimate (e.g., production costs) will cause the estimated rate of return for a given project to decline below the estimated rate of return for a competing project or below a prescribed minimum figure, it will probably decide to investigate more thoroughly the likelihood of changes in production costs before making a final decision to accept or reject the project under consideration. On the other hand, if management discovers that a relatively large error (e.g., 25 or 30 per cent) must occur in forecasting production costs before the estimated rate of return is affected significantly, then further efforts to reduce errors in forecasting production costs may not be deemed economically justifiable.

Even when estimated rates of return are sensitive to errors in certain estimates (i.e., a small change in an estimate causes a significant change in the estimated rates of return), management may not always be able to reduce significantly either the likelihood or the impact of estimating errors. However, knowing the conditions of sensitivity puts management in a better position to decide if the risks are large enough to cause the rejection of investment proposals under consideration.

Measurement

The sensitivity of estimated rates of return to errors in estimates cannot be measured precisely for several reasons. First, management must base its analysis of the relationships among the variables which affect the rates of return on past experience; these relationships, however, may not hold completely true in the future. Second, in its examination of the sensitivity of rates of return to errors in estimating individual variables, management may have to ignore the fact that a change in one estimate (e.g., sales volume) may cause changes in another estimate (e.g., operating expenses) because such cause and effect relationships are difficult to measure. Third, autocorrelation[1] may exist between two or more estimates for a given variable, distorting what appears to be the sensitivity or insensitivity of estimated rates of return to errors in estimation.

Thus, lack of actual data on how one estimate will vary if another is altered may make it difficult for management to determine the precise effects of errors of estimation on estimated rates of return. However, management does not need to know precisely the sensitivity of estimated rates of return to errors in estimation. If the relative differences in the effects of errors in estimating various elements can be determined, management will be able to identify the estimates that deserve further attention. Selection of estimates to investigate more thoroughly can be made on the basis of whether or not the sensitivity of estimated rates of return to errors in any given estimate is significant.

Significance

How can management determine whether a significant degree of sensitivity of rates of return to errors in estimation exists if sensitivity cannot be measured precisely? Two major guidelines are helpful. First, a stated degree (e.g., 10 per cent) of error in an estimate must cause the estimated rate of return for a proposal to decline below that for a competing proposal or some prescribed minimum figure. Second, the stated degree of change in the estimate being considered must be within a range of error (e.g., 10 per cent) considered to be feasible, based on management's past experience or its subjective evaluations. When both these conditions are met, the sensitivity of rates of return to errors in estimation can be said to be significant.

If the sensitivity of a measure of return to errors in a given estimate is significant (i.e., a stated degree of error in the estimate would cause management to reverse its decision to accept a given proposal), what can management

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[1] Autocorrelation is, to a certain extent, the dependence of the estimated value of a variable in one year on the value of that variable in a previous year. Thus, a 5 per cent change in selling prices in one year may actually cause a change of more or less than 5 per cent in selling prices the next year. See Michael J. Brennan, *Preface to Econometrics*, Southwestern Publishing Co., Cincinnati, Ohio, 1960, p. 348.

do? It should examine such estimates more thoroughly or collect more information in an effort to reduce errors in forecasting and the likelihood of making the wrong choice.[2] It may need to recalculate the estimates of rates of return on the basis of new underlying data, perhaps using discounted measures of return.

The changes that occur in estimated rates of return when the basic estimates are changed are difficult to compare for two reasons. If the estimated rates of return for the different projects vary widely, the same amount of change in estimated rates of return for any two given proposals may not have the same significance for both proposals. If both simple and discounted rates of return with different original values are calculated for each proposal, the changes in these values caused by any particular error in estimation may not be comparable. To solve these problems, the sensitivity of estimated rates of return to errors in estimation can be measured in terms of the percentage increase or decrease from base-case values for rates of return resulting from errors of a given size.

More valid comparisons of the sensitivity of different estimated rates of return to errors in the estimates for the same project or of the same rates of return for different projects can be made by stating the change in the estimated rates of return as a function of a percentage deviation from the original estimated values. This approach surmounts many of the difficulties ordinarily encountered in comparing rates of return for projects of different sizes and/or different measures of return when base-case values are different.

Case example

The following case example illustrates some of the significant aspects of the application of sensitivity analysis applied to a capital investment decision. The table on this page shows the discounted cash flow rate of return for an oil company manufacturing project based on original estimates or base-case assumptions. The effects of 10 per cent changes in various estimates used to compute the discounted cash flow rate of return are also shown. It can be seen that 10 per cent errors in certain estimates (sales prices and raw materials costs, for example) are much more significant than errors in other estimates in terms of their effect on the discounted cash flow rate of return.

Let us assume further that the management of the oil company in question has established a cutoff rate of return of 8 per cent for all manufacturing projects. The base-case discounted cash flow rate of return for this proposal is 12 per cent, well above the cutoff rate. If the base-case estimates are used to compute the discounted cash flow rate of return, the project will probably be accepted.

However, a 10 per cent decrease in sales prices or a 10 per cent increase in raw material cost will cause the discounted cash flow rate of return to decline below the cutoff rate of 8 per cent. Therefore, an investment decision based on the discounted cash flow rate of return in this case is sufficiently sensitive to errors in estimates of sales prices and raw materials costs to justify further investigation of the accuracy of such estimates before accepting the proposal in question. Errors of 10 per cent in the remaining four estimates do not cause the discounted cash flow rate of return to decline to or below the cutoff point. Therefore, further investigation of the accuracy of these estimates is not required.

If there are no formal cutoff points in effect, the percentage changes that occur in the discounted cash flow rate of return when various estimates are altered by a fixed percentage can be used

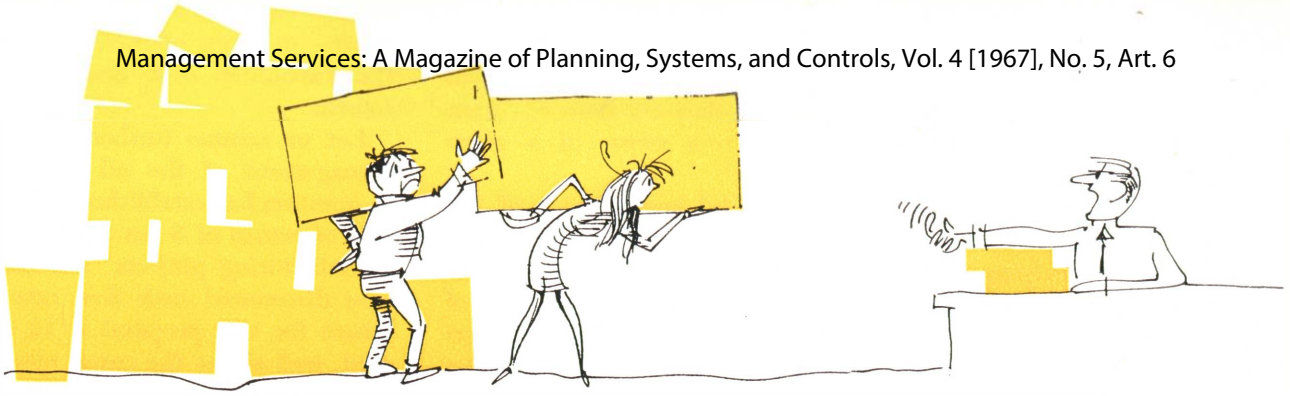
[2] An incorrect decision is one that management could have avoided if more complete information about the future had been available. It may be possible for management to reduce its uncertainty about expected values of estimates by applying managerial resources to the task of improving its accuracy in forecasting. This, in turn, would decrease the likelihood of management's selecting projects which would have been rejected if more complete information had been available.

Sensitivity Analysis of a Manufacturing Project

Likely Maximum Error in Given Estimate	Discounted Cash Flow Rates of Return[1]			
	Base-Case	Base-Case Revised	Increase (Decrease)	Percentage[2] Change
10% decrease in estimated sales prices	12.0%	4.7%	(7.3)%	60.8%
10% decrease in estimated sales volume	12.0%	10.1%	(1.9)%	15.8%
10% increase in estimated low material cost	12.0%	7.4%	(4.6)%	38.3%
10% increase in estimated processing cost	12.0%	11.6%	(0.4)%	3.3%
10% increase in estimated overhead/maintenance cost	12.0%	11.4%	(0.6)%	5.0%
10% increase in capital investment	12.0%	11.2%	(0.8)%	6.7%

[1] Based on an estimated economic life of 20 years

[2] Calculated by dividing the increase or decrease in the discounted cash flow from the base-case figure by the base-case discounted cash flow rate of return



If sensitivity of a measure of return to errors in a given estimate is significant, management can collect more information in an effort to reduce errors in forecasting and the likelihood of making the wrong choice.

as a gauge of the significance of such errors. In the case cited, a 10 per cent decrease in estimated sales prices causes a 60.8 per cent decrease in the discounted cash flow rate of return (from the base-case figure) and a 10 per cent increase in raw materials cost causes the discounted cash flow rate of return to decline 38.3 per cent. A ten per cent decrease in sales volume causes the discounted cash flow rate of return to decline by 15.8 per cent. Errors of 10 per cent in processing cost, overhead/maintenance cost, and capital investment cause the discounted cash flow rate to decline by 7 per cent or less.

These results indicate that a decision to invest in this project (on the basis of the discounted cash flow rate of return) is very sensitive to errors in estimates of sales prices and of raw materials costs and moderately sensitive to errors in estimates of processing cost, overhead/maintenance costs, and capital investment. Assuming that management cannot investigate the accuracy of all estimates more thoroughly, it would seem advisable to concentrate on the most significant estimates (i.e., sales prices, raw material costs, and possibly sales volume.)

Some would argue that much the same information as that shown here can be obtained using conventional breakeven analysis. However, the use of a discounted measure of return within the sensitivity analysis framework offers several important advantages. First, it permits cash flows to be related to invested capital; this cannot be done easily with breakeven analysis, and the productivity of capital may be impossible to portray in a meaningful manner. Second, it gives consideration to the time value of money while breakeven analysis does not. Finally, breakeven analysis is based on the assumption that the variables being considered are linearly related. In actual practice this may not be true. The sensitivity analysis approach does not require a strictly linear relationship among the variables being considered.

Implications for management

Determining, among a selected group of estimates, those in which errors have the most significant impact on measures of return and identifying cases in which calculation of discounted rates of return gives significantly different results from calculation of simple measures of return could be extremely helpful to management. It would indicate which estimates must be forecast more precisely than others if a correct investment decision is to be made and when the use of a discounted rate of return is economically justifiable. Such information will aid management in allocating scarce managerial resources such as time, money, and effort to the process of measuring and reducing or eliminating the risks involved in capital budgeting.

The amount of information sensitivity analysis can convey to management is limited. The approach outlined here would not permit management to draw precise conclusions about possible combinations of errors in estimating significant variables and the resultant effects on estimated rates of return. Nor would it indicate what effect a change in one estimate might have on another estimate. Despite these drawbacks, information about the effects of errors in estimation on the choice of capital investments may be significant for management since it will often indicate where the greatest risks in making investments lie.

Fortunately, determinations of the sensitivity of rates of return to errors in estimates need not be precise to be useful to management. If the relative difference between the effects of error in various estimates on rates of return is known, management will often be able to determine which estimates deserve more attention than others and in what cases the use of discounted as opposed to simple rates of return is economically justified.