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Economic Analysis Handbook

CHAPTER V

A. PREFACE

Now that the costs and benefits of each of the proposed alternatives have been quantified, it is possible to analyze them side by side, present this analysis in a useful format, and finally, select the preferred alternative.

Up to this point, we have concentrated on determining the cost and benefit of discrete, non-divisible alternative systems. However, we normally deal with more than a single discrete system within each alternative proposal. For example, a quantity of a certain type of aircraft or school bus, will normally give us a greater level of effectiveness than a smaller quantity. We must now study a continuum of cost and continuum of benefit so that we may determine in what manner benefit will vary with cost and vice versa.

The proposed method of comparison of alternatives (see Chart page 33) employs a graphic format. It should be emphasized that graphic analysis is not necessarily a substitute for mathematical calculations which rank the proposals. Rather, this format serves to display the results of computations in a manner which is easily understood when we have a continuum of cost and effectiveness measures. Using graphs serves two functions. First, the graphs may suggest the appropriate ranking of the alternatives over a given range of time or effectiveness, thus performing an analytic function. Second, the use of a graph allows the decision maker to see at a glance all the information which may become lost in a tabular maze.

B. THE PROCESS - GRAPHIC ANALYSIS

The graphic techniques which follow may be applied as necessary to constant, current or discounted dollars. In fact, each of the alternatives not only can, but should be examined using at least constant and discounted dollars when dollar costs are available. Tables or graphs may be plotted from raw data, assuming that the costs and benefits have both been fully quantified in terms of some measure of merit such as dollars. That is not to say that some other measure of effectiveness or benefit might not be more appropriate. One could measure benefits in theoretical units of utility or in some more real-world related unit such as calories for a heating system or passengers carried for a bus pool.

1. Graphic Analysis of the data can be accomplished by plotting the total costs over the period of comparison for each alternative as a function of the benefits as in Figure 1.

The Process of Comparing Alternatives

Fig1a.gif

Fig1b.gif

Fig1c.gif

Fig1d.gif

Figure 1: COST VS BENEFITS

Fig2a.gif

Fig2b.gif

Figure 2: COST BENEFITS WITH DOMINANCE AND TWO DIFFERENT BUDGET CONSTRAINTS

Fig3.gif

Fig4.gif

Figure 3 & 4: COST/BENEFITS WITH NO DOMINANCE AND WITH UNCERTAINTY

In figure 1, one alternative (A3) dominates all the others (has lower total costs for any level of benefit), regardless of the dollar base chosen. In such a case, the decision is clear-cut and constrained only by the budget limitation.

In figure 2, we see the effect of a budget limitation. If the budget is expected to be at the level BH shown in figure 2a, then it is immediately clear to the decision maker that he can achieve levels EH1, EH2, and EH3, of effectiveness with alternatives Al, A2, and A3, respectively. The alternative which has the greatest benefit for the expected budget constraints ranks highest.

Unfortunately, it is not often that there exists such strict dominance of one alternative over the other. Figure 3 is probably somewhat more typical of the problems encountered in the real world. In fact, if uncertainty about costs and benefits is taken into consideration, the problem more closely resembles figure 4, where each alternative now presents a non-discrete band on the graph of cost vs benefit.

2. Graphic Analysis of benefits Over Time (Fixed Cost) - (Branch "a" in the graphic presentation of the Process).

If complete dominance of one alternative over the others does not occur in a total cost vs benefit plot, or if it occurs only in constant dollars but not in discounted dollars, for example, then further analysis is needed before the proposals can be ranked conclusively. The most common constraint on the problem is a fixed budget level. In such a case, one can limit the level of expenditure for any alternative and then compute the benefits or effectiveness of each alternative in some common measure of merit at that fixed level. For instance, one might plot the benefits for each alternative as a function.of time for the given budget constraint (see figure 5). The budget limitation could be either an annual or a total expenditure limit.

Again, if there is clear dominance of one alternative over the others (figure 5a) for all periods of time considered, then this proposal rank highest. As mentioned before, this is not the most common situation in the real world, since alternatives tend to overlap or to have uncertain benefits over time as figures 5b and 5c indicate.

If the economic life of a given alternative is known with some probability to be 10 or 11 years, then we can select the alternative which maximizes benefits over an economic lifetime as indicated by figure 5b.

We may also plot each alternative with respect to the working time or Flextime we expect from our alternative systems. That is, the benefits of two machines might vary widely, depending upon the intensity with which they are employed. For example figure 5c would indicate that alternative A1 is the proper choice for all usage times less than U1, while A2 would be the choice for the higher range of system use time.

Fig5a.gif

Fig5b.gif

Fig5c.gif

Figure 5: BENEFITS VS TIME AT FIXED BUDGET LEVEL

Fig6a.gif

Fig6b.gif

Figure 6: ALTERNATIVES WITH UNEQUAL COSTS AS A FUNCTION OF TIME AT FIXED OR SPECIFIED EFFECTIVENESS LEVELS

Fig7a.gif Fig7b.gif

Figure 7: CUMULATIVE COSTS VS TIME AS A FUNCTION OF TIME AT FIXED OR SPECIFIED EFFECTIVENESS LEVELS

Fig8a.gif Fig8b.gif

Figure 8: ANALYSIS OF SAVINGS OVER TIME

3. Graphic Analysis of Cost Over Time (Fixed or Specified Benefit) -(Branch "b" in the graphic presentation of The Process.)

If the budget constraint is variable and subject to control by the immediate level of decision maker, as is often the case for base level projects, then a fixed benefit/variable cost analysis may be appropriate. The procedure is conceptually similar to that just covered.

Again, as in the case of fixed cost/variable effectiveness, there is rarely a dominant alternative for all periods of time. One must usually do some further analysis to be able to rank the proposals.

One very simple procedure is to plot the cumulative costs over time at the same fixed effectiveness schedule used before in plotting the annual costs. Using this straight-forward technique, it is quickly apparent to the decision maker at which point in time one alternative begins to represent savings (the difference between cumulative costs of each alternative) with respect to the other (see figure 7), and the total expenditure at that point. In fact, one alternative may not have to dominate the other for all periods of time if the useful life (or economic lifetime) of both alternatives ends (at L in figure 7) before the second one begins to show savings.

From the cumulative cost calculations, one can also derive a very useful presentation by simply subtracting the costs of one alternative from the other, thus plotting savings (this method is not limited to two alternatives, but graphical presentation of more than two may be difficult unless each is compared to some status quo alternative). Thus, the plot of savings over time will show the decision maker at a glance the savings for any given year.

In figure 8 we will suppose AO is our status quo alternative. We can see (figure 8a) that up to time To our status quo situation (AO) costs less than either alternative A1 or A2. However, beyond To, alternative A1 appears to be less costly. Moreover, later in time, (t2), A2 becomes less costly than either of the other alternatives and least costly overall.

In figure 8b, we plot the relative savings of alternatives A1 and A2, using AO as our base. With a graph such as this, the decision-maker can determine quite easily, the net savings due to each alternative. If the cumulative savings over the period of comparison is positive for either alternative A1 or A2, then they are relatively better investments than the status quo alternative, AO. If the period of comparison is longer than t2, then A2 will clearly have the greatest savings of the 3 alternatives.

4. A Comprehensive Format

Now that the bulk of the analysis has been performed and the results displayed in basic graphical format, it might be interesting to consider other informative, useful

Fig9a.gif

Fig9b.gif

Fig9c.gif

Fig9d.gif

Figure 9: SUMMARY PRESENTATION

means of presenting these graphs to the decision maker. When there are several types of dollar bases to consider or if one wants to see the benefits or costs at several constraint levels, the following format is useful.

Basically this presentation is a sequence of four graphs oriented as shown in figure 9. In the upper left one would display the basic data of the problem, e.g., costs versus benefits (figure 9a). One might fix the benefits at some appropriate schedule and display the cumulative or annual costs to achieve the given benefit level as a function of time on a graph immediately below the first one (figure 9c). Alternatively, one could adopt the fixed cost level approach and plot benefits versus time for a given budget (figure 9b).

Finally, one may plot savings over time with fixed effectiveness in the fourth quadrant graph to complete the summary of key information. The point of comparison where one is indifferent between alternatives (tl) should be clearly indicated. The four plots can usually be compressed to a single page so that the reader may track quickly from one to the other and draw the appropriate conclusions.

This four graph technique can ,be used for each of the steps of the analysis and for as many levels of detail as desired. We may use discounted dollars or other dollar bases. Figure 9d shows a concise presentation of the savings analysis. Clearly, this four graph method can be used to display data in several useful ways. One should exercise some judgment in not attempting too much detail or use multigraph approach when a single one would make the case adequately.

C. CONCLUSION: WHAT TO DO WITH THE RESULT OF THE ANALYSIS

1. When Results are Inconclusive

It is not unusual to perform all of the above analyses and discover that it is still not possible to arrive at a concrete ranking of the alternatives because the constraints on the problem fall within wide ranges. If this difficulty arises there may be several reasons, normally involving an amount of uncertainty in cost and benefit quantification, knowledge of the budget limitations, or uncertain specification of the benefits to be achieved. Depending on the particular difficulty involved, there are several complex tools for analysis which may be more useful than the ones discussed here. Linear programming, Lagrange multipliers, dynamic programming, Markov processes, game theory, the Delphi Technique, network analysis, and integer programming are some of the more commonly used of these more sophisticated techniques. A detailed discussion of each of these methods is beyond the scope of this book. In addition, the vast majority of economic analyses which will be performed can be adequately conducted by the techniques outlined in detail above.

2. When Results are Conclusive

When the analysis has been sufficient to provide a means of ranking the alternatives conclusively one is faced with a new problem. Should the decision maker be presented with a hard and fast conclusion made explicit in the text of the study, or should one simply make a few final observations and let the analysis speak for itself? The answer to this question depends on the attitude of the decision maker and on the nature of the analytical results. Many decision makers dislike being given a single answer. They prefer to examine the graphical presentation and draw their own conclusions. This is more a question of personalities than analytical expertise, but should be taken into consideration if the study is to be well received.

On the other hand, most analyses won't be conclusive and will allow various rankings of the proposals subject to certain sets of constraints. In this case it is helpful to present a ranking of alternatives for each set of constraints and to provide information needed for the decision maker to form his own opinions about the likelihood of each of the constrained problems.

In order to aid the decision maker in determining which of these subsets is more likely and which alternative should be selected from the rankings, the intangible considerations must be presented. Format "B" of DoD Instruction 7041.3 may be used to present intangible outputs. Little can be said about the details of this presentation due to the number of different situations that may be encountered. However, one should attempt to be impartial and complete in describing each relevant factor and arranging them in some appropriate format.

Finally, if the salvage or other residual value of a proposed investment is quite uncertain and has not been included in the cumulative cost calculations, then it might be better to rank the alternatives, initially, without considering the residuals. Then, as an aid to the decision maker in considering sensitivity, residual value can be shown as an intangible and the ranking procedure repeated.

3. The Big Picture - Externalities

No study of alternative proposals for an investment should be conducted in the dark. This is to say, an analyst should try to be aware of other investment proposals which will be competing for the same budget dollars. For instance, it would be short sighted indeed to perform the above analyses at fixed cost levels which required the entire budget to be dedicated to each alternative. A good analyst would also realize that the decision maker will not be able to consider an alternative which exceeds his budget, regardless of the levels of effectiveness achieved.

On the other hand, once a budget limitation is established, it is still useful to rank the alternatives according to effectiveness at several levels of fixed cost within the given budget constraint. The premise here is that even a low investment alternative may be better than the status quo. But if the decision maker is shown only an array of high investment proposals, he may not accept any of them, leaving the problem with what could be a highly undesirable status quo solution. In short, the analyst should attempt to incorporate the big picture into his initial approaches to the problem, not realize too late that the conclusions will be unacceptable to the decision maker, regardless of the accuracy of the computational work.

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