# SOME COMMENTS ON
# CONCEPTUAL FRAMEWORKS FOR COMPARING ALTERNATIVES

G. H. Fisher

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G. H. Fisher*

The Rand Corporation, Santa Monica, California

Since our national resources are limited, a government agency or jurisdiction cannot set out to do all the things that it feels might be beneficial to the general welfare. Choices must be made; and more often than not, long-range planning (LRP) decisionmakers find these choices to be agonizing ones. The main task of analytical activities in support of LRP is to provide information that will assist the decisionmakers in exercising their judgment about appropriate actions to be taken in the future. What kind of information? Many kinds, of course. But by far the most important is information (both quantitative and qualitative) that will help the decisionmakers in making *comparisons* among alternative future courses of action.

How can this be done? Conceptually, it may be done very easily. (Here, we emphasize "conceptually.") For example, if three alternative future courses of action are under consideration, if their respective costs and utilities can be represented in terms of single dimensions, if there are no uncertainties, and if dominance is present, the results of an analysis of the problem may be presented in a comparative format like that portrayed in Fig. 1. Here, we have an example of a very clear-cut comparison: Alternative C is best (least cost) for any level of utility over the relevant range of U--a case of complete dominance.†

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*These comments stem from notes I have used as a basis for informal talks on systems analysis at Rand and elsewhere. It has been suggested that I make these comments available to a wider audience; hence, the occasion for this paper.



†Alternatively, for any specified level of cost, alternative C has the greatest utility.

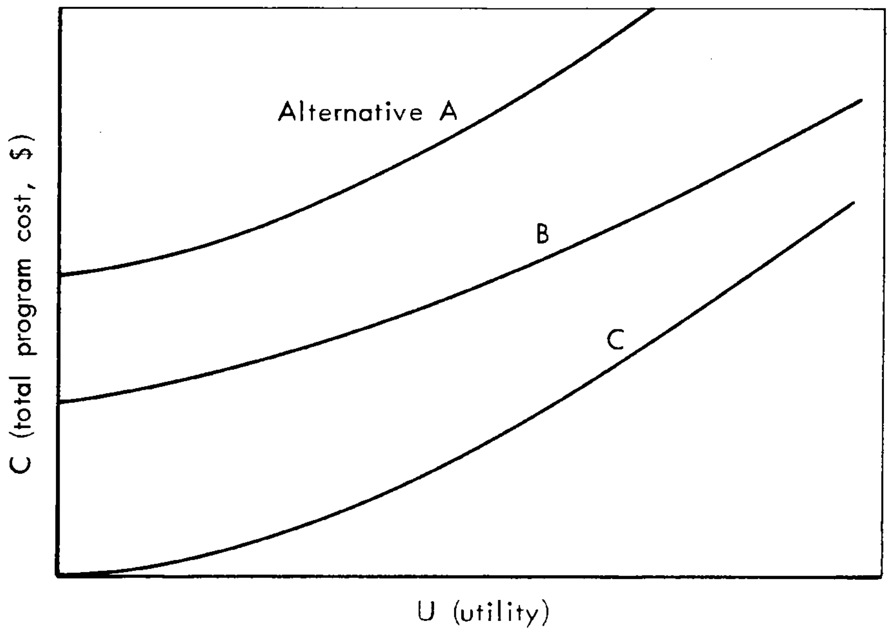


*Fig. 1--Comparison of alternatives A, B, and C*

This, of course is rarely found in real life. For one thing, it is very rare that one alternative will *completely* dominate all others. The results are more likely to turn out like those shown in Fig. 2,

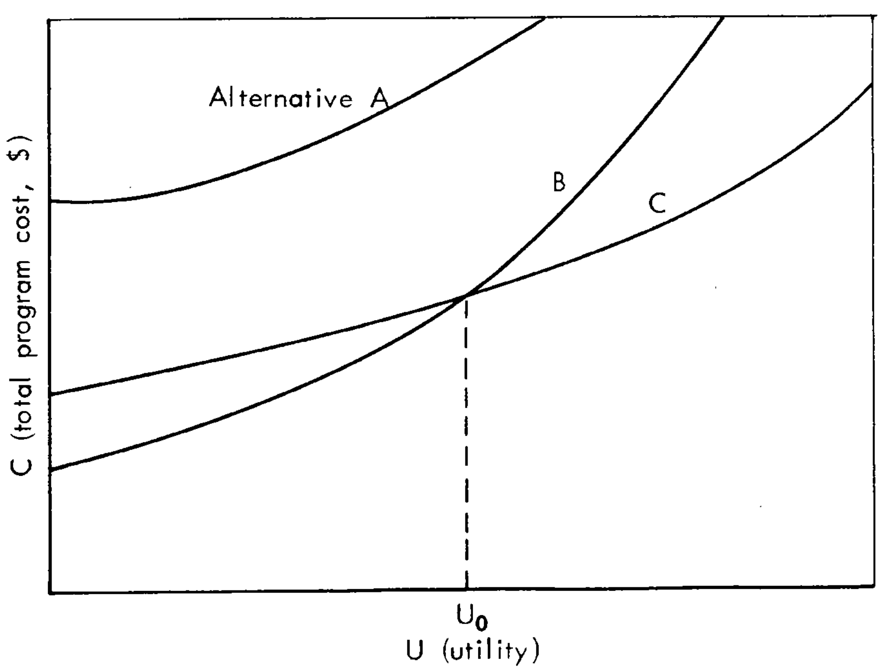


*Fig. 2--Comparison of alternatives A, B, and C.*

where alternative B is preferred up to utility level $U_o$, and C is preferred thereafter.

However, when uncertainties are present--as they always are in LRP problems--the comparative results can be even less precise. Instead of lines on a chart, bands may be used to reflect uncertainties, and the outcome may look like Fig. 3.* Here, because of uncertainty, we have a wide overlapping region (from $U_o$ to $U_1$), and alternative B is preferred for $U < U_o$, and C is preferred for $U > U_1$.

The preceding examples are, of course, "static." Time is not taken into account explicitly. However, in many long-range planning problems time is very important, and it is most desirable to introduce time-phasing explicitly when comparing alternatives. How might this be done?

Again, *in principle* this can be accomplished easily, *provided* certain conditions are fulfilled. The ideal case (which is rare in practice) is where both the benefits and the costs of alternative programs or projects to be compared can be measured in terms of dollars. If so,

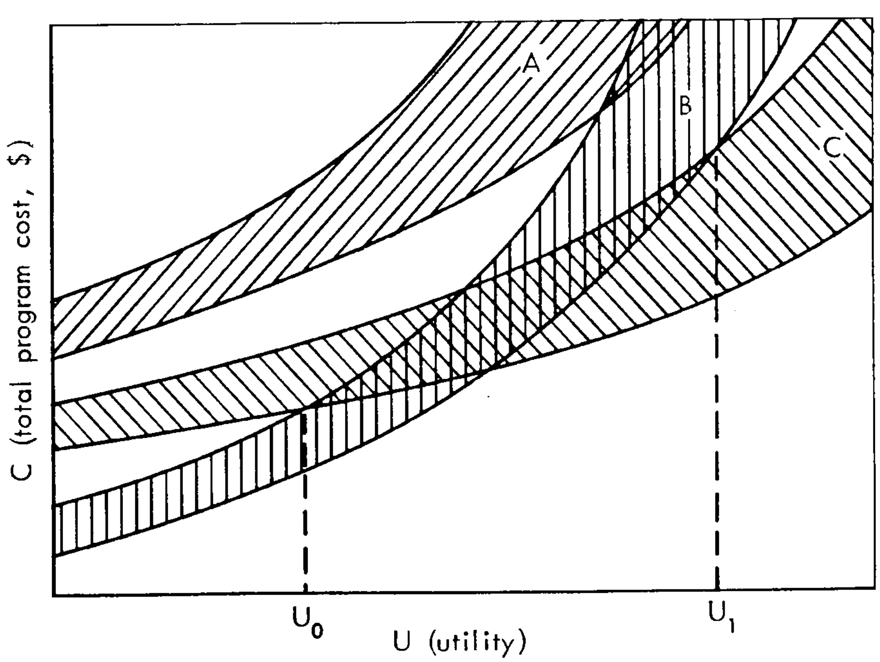


*Fig. 3--Comparison of alternatives A, B, and C*

*For example, see Harry P. Hatry, *Economic Analysis in the Selection of Space Systems*, SP-130 (Santa Barbara, California, 1961), pp. 10-14.

the analysts can compute the time-phased streams of benefits and costs of the alternatives over an appropriate future planning time horizon, take the difference between the benefits and costs, and calculate the present value of the net benefits using an appropriate rate of discount.* Then the alternatives can be compared on the basis of their respective discounted net benefits. Or, in some cases, it may be preferable to compare them on the basis of their respective "internal rates of return"--i.e., that rate of discount which makes the present value of net benefits zero.† In any event, when both benefits and costs can be reasonably well approximated by monetary measures, a satisfactory framework for comparing alternatives over time can be established.

So much for conceptual examples of frameworks for comparing alternatives. These illustrations perhaps serve a purpose in helping us think about how alternatives might be compared in principle; but in practice these concepts can rarely be applied in any simple or straightforward way. Why? The main reason is that we rarely have well-defined utility functions: e.g., a "military worth" function for defense, a general "space worth" function for NASA, or "general welfare" function for total society. As a consequence, in most substantive LRP problems it is not possible to deal with a single, general measure of utility; and it is usually not possible to measure utility and cost in the same terms--e.g., dollars.

Another complicating factor is that practically all LRP problems contain elements of major uncertainty. When significant uncertainties are present, comparisons among alternatives cannot (or should not) be conducted in terms of average values alone, neglecting variances or ranges of values. When the latter are taken into account explicitly, the comparisons become more complicated. (Refer back to Fig. 3.)

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*The "discounting" procedure arises because of the time-preference problem--that is, decisionmakers are usually not indifferent about dollar gains or costs 5 years from now versus 15 years from now. For a discussion of this and related problems, see Roland N. McKean, *Efficiency in Government Through Systems Analysis* (New York: John Wiley & Sons, Inc., 1958), Chap. 5, "Time Streams and Criteria."

†Ibid., pp. 89-92.

Where does all this leave us? In view of the difficulties posed above, is there any hope of making comparisons among alternative future courses of action that will help the long-range planners in reaching conclusions about appropriate next steps in the sequential decisionmaking process? On the one hand, we think the answer is generally "no" *if* the analysts are striving for "hard core" optimizations that will essentially "make" the decision. On the other hand, if comparative analysis is viewed in terms of providing information (both quantitative and qualitative) that will provide a basis for the decisionmakers to better exercise their judgment, then we think a great deal can be done. Let's explore this latter idea further.

First, consider the utility or worth assessment problem. Here, as stated previously, the analysts will usually find that it will be impossible to come up with a definitive utility or worth function. Instead, they must focus on various "effectiveness measures" that are not direct measures of utility or worth *per se*, but nevertheless, are somehow positively correlated with it. For example, certain indexes serving as proxies for the scientific effectiveness of alternative space programs are not general measures of "space worth," but they are correlated with it. Similarly, one measure of the contribution of space programs to national security is the potential cost savings to the Defense Department that result because separate programs would not be needed to obtain the information, technology, or capabilities provided by prior NASA activities. Again, this is not a direct measure of the "military worth" of space programs; rather, it serves as an indirect or proxy measure.

What does all this have to do with frameworks for comparing alternative future courses of action? One important implication is the following: To the extent that effectiveness measures can be quantified in a meaningful way, they facilitate making comparisons among alternatives in the "fixed effectiveness" or "specified task-to-be-done" type of framework of analysis. Here, the idea is to structure the analysis so that all alternatives under consideration are essentially geared to the same future task or accomplishment, so that the minimum cost way to do the job might be determined.

A moment's reflection will suggest that applicability of the stipulated effectiveness approach is likely to increase as the context of the problem at hand narrows--i.e., it is more likely to be useful at lower levels of "suboptimization" than at the higher levels.

For example, in attempting to make broad comparisons of alternative agency-wide program mixes it is extremely difficult to specify overall sets of effectiveness levels to be attained by the alternatives under consideration. Not only is it difficult because many effectiveness measures at such a high level are hard to quantify, but also because a large number of measures must be taken into account, and hence the analysts have severe aggregation problems to contend with. The latter can sometimes be handled by presently-available worth-assessment schemes (e.g., Delphi or the Miller procedure*). However, these procedures are not always applicable, they can be very time-consuming and hence expensive, and there are certain difficult problems to be dealt with--e.g., the "worth interdependence" problem.

At lower levels of suboptimization, all of these difficulties are less severe. For example, in examining alternative configurations of a certain type of system to accomplish a desired future mission or task--say, a specified type of planetary probe--the fixed-effectiveness approach may not only be feasible, but also a very appropriate framework for conducting the comparisons. This may be done in a "static" context with time not treated explicitly. Or, it may be done in a dynamic context where the alternatives are required to meet a stipulated time-phased effectiveness schedule, and their costs are also displayed as a function of time (see Fig. 4). Here, the preferred alternative would be the one that has the lowest discounted (present value) cost.

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*For a good discussion of Delphi, see Norman C. Dalkey, *The Delphi Method: An Experimental Study of Group Opinion*, RM-5888-PR (Santa Monica, Calif.: The Rand Corporation, June 1969). The Miller worth-assessment procedure is discussed in James R. Miller, III, *Assessing Alternative Transportation Systems*, RM-5865-DOT (Santa Monica, Calif.: The Rand Corporation, March 1969).

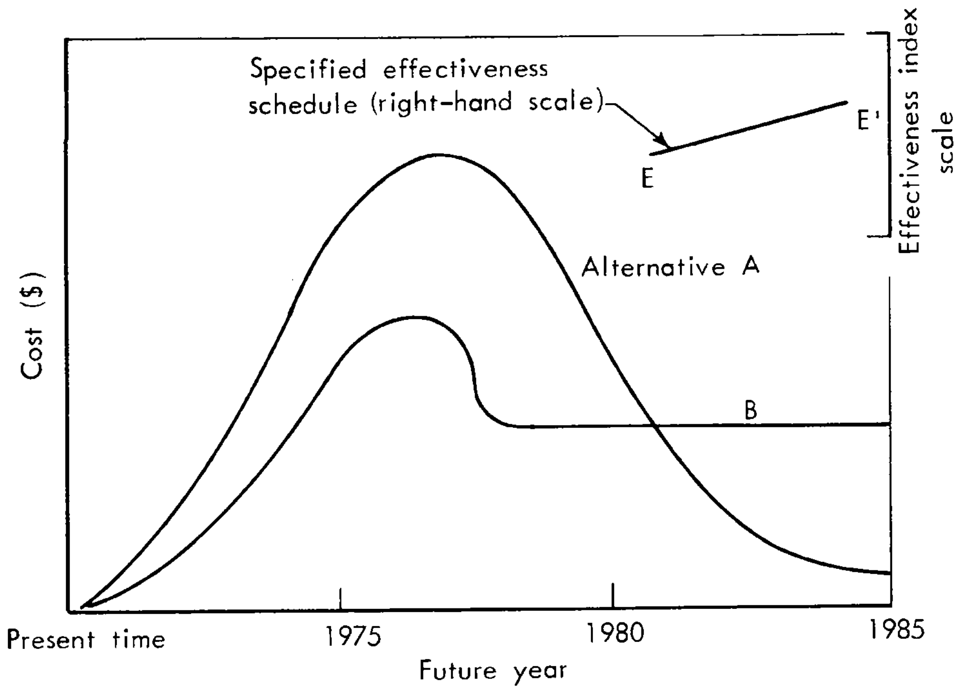


*Fig. 4--Time-phased costs of alternatives A and B to meet effectiveness schedule EE'*

Let us now discuss a second type of framework for comparing alternatives--the "specified resource constraint" approach. Here, the alternatives to be considered in the LRP process are required to be within a stipulated resource level, expressed either in "static" terms or as a schedule over time--e.g., a time-phased total obligational authority (TOA) constraint.* The alternatives are therefore, in effect, "normalized" with respect to cost, and they are then compared on the basis of their estimated effectiveness in the attainment of future sets of objectives.

Does this approach have any merit over the "fixed effectiveness" framework of analysis? In principle, no, since the two approaches are essentially opposite sides of the same coin. In practice, however, a difference often exists. This difference is related to the difficulties involved in dealing with the utility or worth assessment problem referred to earlier.

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*Very often, more than one resource level is considered. The comparative analysis may be repeated for, say, three levels: high, medium, and low.

Now, of course, the utility problem is conceptually the same no matter which comparative framework is used. However, in actually dealing with the problem in practical applications, it is usually much easier to "normalize" the alternatives with respect to cost than it is with respect to effectiveness; that is, it is easier to generate equal-cost alternatives than it is to generate equal-effectiveness alternatives. The main reason is that cost may often (though certainly not always) be measured in terms of dollars--a convenient "common denominator" for placing complex and disparate entities on the same footing.

This difference between the two approaches generally becomes more and more significant as we move up the suboptimization ladder and consider decision problems with increasingly broader scope. At the top levels of the Federal Government, for example, the analysts have virtually no hope of generating meaningful "equal-worth" or "equal effectiveness" alternative total program mixes for the decisionmakers to consider.

On the other hand, if reasonably good parametric cost models are available, it is not only feasible but very desirable to develop equal-cost program mixes at the overall agency level. Since the alternatives are "normalized" with respect to cost, the LRP decisionmakers can concentrate their attention on the difficult problem of making judgments about the relative utility or worth of the various alternative program mixes. Here, of course, the analysts must provide all the relevant information they can to help the decisionmakers in exercizing their judgment. This may include various quantitative measures of effectiveness, qualitative statements and arguments, results of the use of Delphi or other worth assessment techniques to develop indexes of utility, and so on (see Table 1*). Notice that this involves something far less than a "hard core optimization." However, if the analysts have done their job properly, the decisionmakers will be in a much better position to make comparative judgments than they would be without results like those shown in Table 1. And as we indicated earlier, this is the main objective of an analytical activity supporting the LRP process.

*Time is not treated explicitly in this example.

Table 1

ILLUSTRATIVE EXAMPLE OF A FORMAT FOR COMPARING EQUAL-COST ALTERNATIVES

Resource constraint = $\$B_o$

| Type of Information | Alternative A | B | C | D | E |
|---|---|---|---|---|---|
| Selected quantitative measures: | | | | | |
| $Q_1$ | | | | | |
| $Q_2$ | | | | | |
| . | | | | | |
| . | | | | | |
| . | | | | | |
| Qualitative statements: | | | | | |
| $S_1$ | | | | | |
| $S_2$ | | | | | |
| . | | | | | |
| . | | | | | |
| . | | | | | |
| Worth assessment indexes: | | | | | |
| $I_1$ | | | | | |
| $I_2$ | | | | | |
| . | | | | | |
| . | | | | | |
| . | | | | | |

NOTE: A similar table could be prepared for alternative resource constraints: e.g., $\$B_o + \Delta$; $\$B_o - \Delta$.

Are there other frameworks for comparing alternatives? Yes, but in most cases they must be used with great care. As an example, let us consider the use of effectiveness/cost ratios.

Here, we have the practical problem of developing an appropriate single measure of effectiveness--something that is difficult to do when an overall dollar measure of benefits is not available (like profits for a business organization). But even given a relevant measure of effectiveness, other problems are likely to be present.

Consider the following example:

| Alternative | Effectiveness(E) | Cost(C) | E/C |
|---|---|---|---|
| A | 20 | 10 | 2 |
| B | 200 | 100 | 2 |
| C | 20,000 | 10,000 | 2 |

If the planners are preoccupied with ratios, the implication of the example is that they can be indifferent regarding the choice among A, B, and C. But *should* they be indifferent? Most probably not, because of the wide differences in *scale* among A, B, and C. In fact, with such great differences in scale, the planners might not even be comparing relevant alternatives at all.*

In other words, absolute amounts usually have to be taken into account. To bring this point closer to home, let us consider the following example from McKean.† Suppose I am looking for a new house. I find Home A with 1500 sq ft and costing $18,000. Home B has 2800 sq ft and costs $28,000. If we assume that floor space is a relevant measure of effectiveness, the E/C ratios are 1 to 12 for A and 1 to 10 for B. Is B an obvious choice? Not necessarily, because the use of ratios as a basis for comparison conceals the vital question: Is B's extra 1300 sq ft worth an extra $10,000?

Also, if I have only $20,000 to spend, then the fact that B has a more favorable effectiveness/cost ratio is irrelevant. Here, we have to put the constraint in the problem explicitly: For example, I have $20,000 to spend for a house; of the homes available for that amount, which one is likely to maximize utility to me? But now we are back to a framework considered previously: the "specified resource constraint" approach. Again, absolute amounts usually *do* matter, and if so, then we are driven away from the use of unconstrained ratios in making comparisons among alternatives.

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*This has happened in past studies of space system alternatives where "cost per pound of payload in orbit" was used as a selection criterion.

†McKean, op. cit., p. 36.

## SUMMARY

A vital part of the LRP process is the systematic comparison of alternative future courses of action. The most important function of an analytical activity in support of the LRP process is to develop information that will help the decisionmakers in making comparisons among the alternatives under consideration. Several types of conceptual frameworks of analysis are available for formulating comparisons. However, for most LRP problems, the specified effectiveness or job-to-be-done approach and the specified resource constraint approach are the two frameworks that are likely to be most useful.

Either approach may be used at the lower levels of suboptimization, depending on the specifics of the problem at hand. But at the higher levels--e.g., at the overall agency level--the specified resource constraint approach is likely to be the most feasible and useful. Use of unconstrained effectiveness/cost ratios is not generally recommended.