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ABSTRACT

This packet contains the materials necessary for presentation of the fifth of ten modules that comprise a portion of the National Training and Development Service Urban Management Curriculum Development Project. This module focuses on cost benefit and cost effectiveness analysis, a methodology for coping with the problem of allocating scarce resources. The packet includes an instructor's manual which presents the module purposes and assumptions, the course structure, and lecture materials and a student/participant manual which presents an overview of the module and the cases used to study analysis methods. (Author/MK)

COST-BENEFIT AND COST-EFFECTIVENESS ANALYSIS

Instructor's Manual

Prepared by Harvey Goldstein

Module Number Five
of
POLICY/PROGRAM ANALYSIS AND
EVALUATION TECHNIQUES Package VI

Developed by

CENTER FOR URBAN AND REGIONAL STUDIES
DIVISION OF ENVIRONMENTAL AND URBAN SYSTEMS
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Package VI

Instructor's Manual

TABLE OF CONTENTS

INSTRUCTOR'S MANUAL
COST-BENEFIT AND COST-EFFECTIVENESS ANALYSIS

1. Introduction: Purpose and Assumptions

The purpose of this manual is to provide guidance to the instructor in the use of the NTDS Curriculum Module on Cost-Benefit and Cost-Effectiveness Analysis. This guidance is of two kinds: (1) an overview of the cost-benefit and cost-effectiveness analytic framework so that the instructor will be better prepared to answer the more conceptual and general questions regarding these techniques and their practical uses; and (2) a step-by-step approach to presenting the lecture material, the case studies, and the scenarios in the two-day workshop setting but still incorporating sufficient flexibility to fit the particular abilities, experiences and needs of both the students and the instructor.

It will be assumed that the instructor has:

(1) been exposed to the underlying basis of cost-benefit and cost-effectiveness analysis - marginality, economic efficiency and the Pareto criterion from neo-classical welfare economics, and can explain such technical terms as externalities, risk, uncertainty, demand curves, etc. in a pratical context should the glossary prove to be insufficient or questions arise from the discussion of the case studies and scenarios which entail these concepts.

(2) had some experience in real-world project evaluation and is thus sensitive to the practical difficulties of identifying and measuring all relevant costs and benefits of an alternative course of action, and able to suggest surrogate or "short-cut" measures in the evaluation process.

(3) a good familiarity with the principles of capital investment planning including the choice of the appropriate discount rate, the discounting procedure, evaluation of the opportunity costs of capital, and the proper incorporation of risk and/or uncertainty in the planning process.

Little prior background is assumed on the part of the student, but any previous academic coursework in microeconomics or management techniques would relieve the instructor of some time in explaining the logic of cost-benefit analysis. Obviously any prior practical experience on the part of the students will allow for better discussions of some of the practical problems encountered in project evaluation.

The course is designed for approximately 16-18 hours. A significant portion of the second day will be in a free-format exercise in which groups of three students will be conducting a prototype cost-benefit or cost-effectiveness analysis on a problem of their own choosing. Naturally such an exercise can have a variable time-length depending upon the problem chosen. Also, at least two of the scenarios can be discussed generally rather than going through the

written exercises and detailed calculations. Thus there is a fair degree of time flexibility for the length of the course.

It is suggested that the class size range from 6 to 18. A larger size will place an undue burden on one instructor as "consultant" for the final group projects, while a class size of less than 6 would probably not produce a sufficiently "rich" level of total resources for the group to draw upon.

2. Instructor Preparation

Cost-benefit and cost-effectiveness analysis are deceivingly simple techniques but as such can be easily and unknowingly misused by the naive practitioner. The main task facing the instructor is to instill in the students this appreciation through a critical approach in the instruction. This entails a solid knowledge of the "basics" on the part of the instructor, because the naive student will more than likely want to proceed uncritically without regard to understanding the underlying assumptions of the techniques. The instructor should also become familiar and facile with the technical language of cost-benefit and cost-effectiveness analyses (refer to the glossary) so that the student will more comfortably ease into the unknown territory. In addition the instructor should have in the front of his(her) mind the most common errors committed in application of these techniques and be able to spot them in the students' work.

The following resource materials and/or suggestions should be found helpful for the instructor in preparation for presenting the course:

(1) For the economic theory underlying cost-benefit analysis, E. J. Mishan, Elements of Cost-Benefit Analysis (London: George Atlen and Unwin Ltd.), 1972, or E. J. Mishan, Cost-Benefit Analysis (New York: Praeger), 1976 (new and enlarged edition) is easily the most comprehensive and readable work around.

(2) For a critique of benefit-cost analysis and a guide to the major problems in its use, read, Leonard Merewitz and Stephen H. Sosnick, The Budget's New Clothes, (Chicago: Markham Publishing Co.), 1971.

(3) For a selection of other cases covering various functional areas, see Harley Hinrichs and Graeme Taylor, Program Budgeting and Benefit-Cost Analysis.

(4) Read the case studies and scenarios in the Instructor's Guide Appendix and become familiar enough with these to envisage likely questions and problems from the students.

(5) In addition to being able to explain the calculations necessary in the case study and being able to perform the calculations needed to solve the scenario problems, the instructor should also be able to explain the rationale of why the problems are structured the way they are, and, if relevant, to discuss alternative ways of structuring the same problems. The author has learned from the experiences in teaching this material that

approaches to problem structuring are the most important skills to be learned but are also among the most difficult. A particular case study and scenario then offer one way of approaching a problem but the instructor should explore with the students alternative ways for each general problem situation that is posed in the curriculum materials.

(6) The last exercise asks each small group of students to articulate a problem and then to outline the appropriate solution using either cost-benefit or cost-effectiveness as an analytic framework. Be prepared with several rich problem ideas in case a group is not able, or unwilling to provide its own.

(7) Try to talk to someone else who has conducted this course in order to share his/her experiences and be warned of possible pitfalls.

(8) Read the Overview Section of the manual to see how cost-benefit and cost-effectiveness relate to the overall policy-analysis process.

(9) Become familiar with the material in "Building a Learning Community," No. 6, The NTDS Training Series, by David A. Kolb, which may be helpful to the instructor for providing an atmosphere conducive especially to adult learning.

In addition you should make the following arrangements (or make sure they have been made for you) for the actual operation of the course:

(10) Have available a room large enough for eighteen students with tables that can be rearranged for groups of three students to work in relative isolation. For most of the course a "U" shaped arrangement of tables with the instructor at the open end is suggested.

(11) A wall blackboard or large portable blackboard and chalk for the instructor's presentations and solution to scenario problems.

(12) A portable blackboard and chalk or rolls of newsprint, tape, markers and vertical surface for every three students.

(13) A portable electronic calculator for each student (each student should be notified to bring a personal calculator).

(14) Accessibility to a copying machine on an "on-call" basis.

(15) Name Tags, writing utensils and sheets of legal size paper for each student.

In addition to all of this, the instructor should make sure that each student will have been mailed the Overview Section and Glossary of the Student Manual at least two weeks before the workshop date. Information on the relevant background of each student would be valuable for the instructor to have prior to conducting the workshop.

3. Course Structure

The workshop, as has been noted, has been designed for between 16-18 instructor-student contact hours. Elements of the course include lecture material, exercises, case studies, and scenarios. Normally the course would be scheduled on two consecutive days from 8:00 a.m. to 5:00 p.m. with appropriate meal and coffee breaks. A prototypical schedule is provided in Table 1. The instructor and students can, however, shorten the course in ways described earlier or by meeting at night the first day.

Each element of the course will now be described in turn. In many cases the rationale for the element is discussed and also some suggestions for discussion have been included.

3.1 Analysis of Decision To Attend (page VI.5.9)

(a) Ask each participant to complete the questionnaire (included in student manuals). You should allow about 15 minutes.

(b) Now ask each participant to introduce himself (herself) and to share with the group any information and thoughts elicited on the questionnaire that he(she) wishes to publicly express at this time.

(c) Collect the questionnaires and save.

3.2 Outline of the Elements of the Cost-Benefit Analytic Framework

Before presenting the lecture material outlined below, it is recommended that the instructor: (i) remind the participants that included in their student manuals are the Overview Section and the Glossary of Frequently-Used Terms in Cost-Benefit and Cost-Effectiveness Analysis, and that they should refer to these materials in the course of the workshop when appropriate; (ii) ask (somewhat rhetorically) the students for their perceptions of what cost-benefit/cost-effectiveness is, and prod them to improve upon their answers. Finally write the best suggested description in one corner of the blackboard to which you may refer back after the lecture material has been presented and point out its inadequacies.

Much of the scope of this material may be gleaned from parts of the Overview section and from introductory chapters of books on cost-benefit analysis and/or project evaluation, e.g., E. J. Mishan, Elements of Cost-Benefit Analysis, or Arnold C. Harberger, Project Evaluation; see bibliography (page VI.5.45) for a more complete list of references.

3.2.1 Scope of questions/problems which would make use of cost-benefit/cost-effectiveness analysis: decision-making among alternative choices with limited resources.

TABLE 1. Protoptypical Schedule of Cost-Benefit and Cost-Effectiveness Workshop

Element	Time	Description
	Day 1	
	8:00 - 8:15	Coffee, Announcements
1	8:15 - 8:45	Analysis of reason to attend
2	8:45 -10:15	Overview of cost-benefit analytic framework
3	10:15 -10:30	Exercise 1: Present-value technique
	10:30 -10:45	Coffee Break
4	10:45 -11:15	Discussion of Exercise 1
5	11:15 -12:00	Exercise 2: Criteria for evaluation
	12:00 - 1:00	Lunch
6	1:00 - 2:30	Case Study and Scenario 1
7	2:30 - 3:15	Case Study and Scenario 2
	3:15 - 3:30	Coffee Break
	3:30 - 4:15	Discussion of Scenario 2
8	4:15 - 5:00	Case Study 3
	Day 2	
	8:00 - 8:15	Announcements, Coffee
9	8:15 - 9:30	Discuss Scenarios 3a, 3b
10	9:30 -10:45	Case Study and Scenario 4
	10:45 -11:00	Coffee Break
11	11:00 -12:00	Discussion of Scenario 4
	12:00 - 1:00	Lunch
12	1:00 - 3:00	Exercise 3: Group Projects
	3:00 - 3:15	Break
13	3:15 - 5:00	Group presentations

a. Allocation of resources among different levels of a hierarchical system (e.g., central, regional, local).

b. Allocation of resources to alternative systems (technologies) for meeting a designated (set of) objective(s), (e.g., photocopying vs. subscription of technical jorunal articles in libraries).

c. Capital investment decisions.

d. Program proposal alternatives (when program benefits can be expressed in dollars, or when two or more programs would achieve equal levels of benefits or levels of effectiveness). This is a characteristic problem in the overall context of program budgeting.

3.2.2. Brief history of the use of cost-benefit and cost-effectiveness analysis in the public sector in the U.S.

(See Overview section in the student manual and instructor's manual for the briefest history; for a longer (but still brief) history, see L. Merewitz and S. Sosnick, The Budget's New Clothes, Chicago: Markham, 1971, pp. 9-12. Other standard books on project evaluation usually provide short sections on the history of cost-benefit analysis.)

3.2.3. Relationship To Program Budgeting Framework (See Figure 1).

(a) Cost-benefit/cost-effectiveness serve as evaluative tools of current programs and sub-programs.

(b) They are also useful for planning purposes--evaluating the economic feasibility of future projects when future costs and benefits can be identified.

3.2.4 Identifying and Estimating Benefits and Costs (This will be discussed in more detail later.)

(a) Types of benefits
  (i) Increased willingness of users to pay (increased demand) (See Figure 3 and explanation of estimating consumers' surplus)
  (ii) Increases in capital values
  (iii) Cost savings (e.g., from a fall in price)
  (iv) Increase in "societal income" (e.g., through increased productivity)
(b) Types of costs (see Figure 2)
  (i) Research and planning costs
  (ii) Investment outlays
  (iii) Operational/maintenance costs
  (iv) External costs and opportunity costs

Figure 1: Cost-Benefit/Cost-Effectiveness Analysis In Program Budgeting Framework.

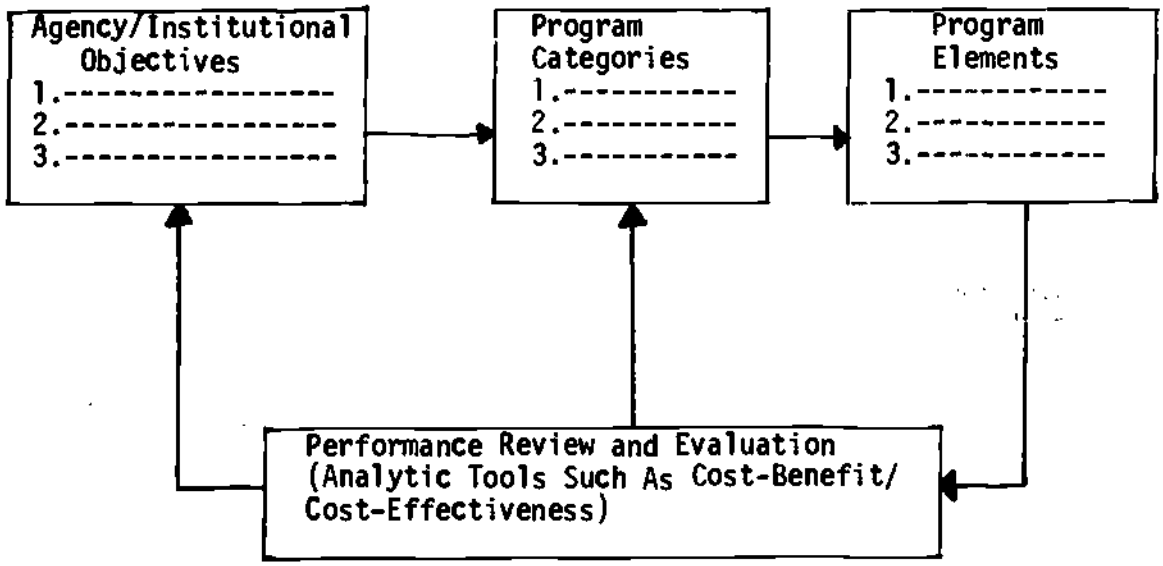
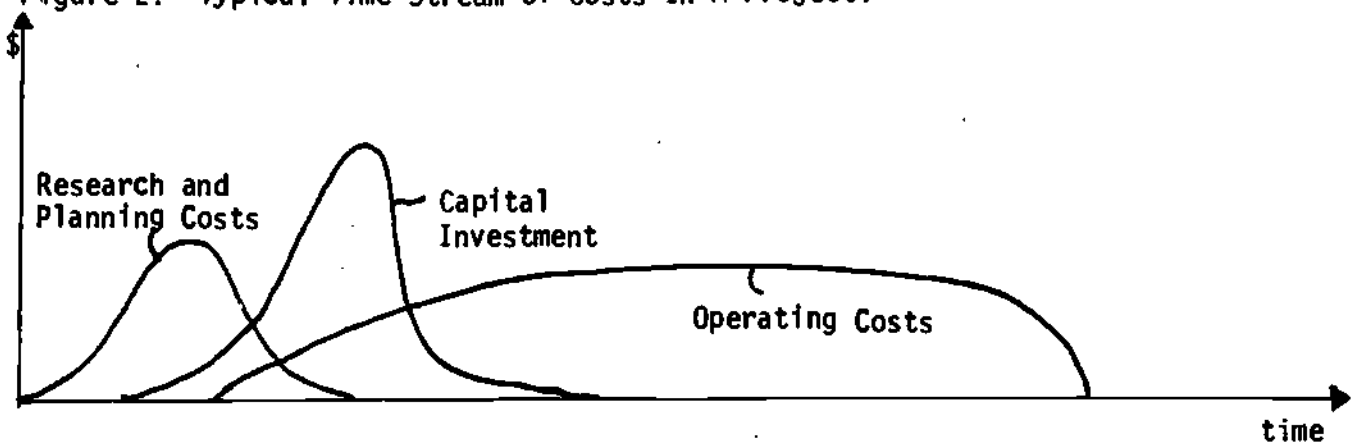


Figure 2: Typical Time Stream of Costs In A Project.



3.2.5 Estimating Consumers' Surplus

As an example, suppose that a new bridge is planned to be built in a community. We seek to estimate the benefits owing to potential consumers of the services provided by the new bridge.

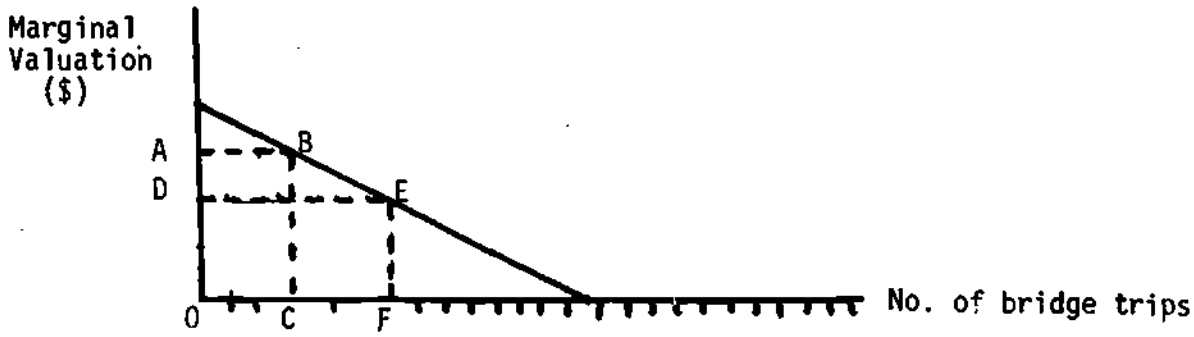
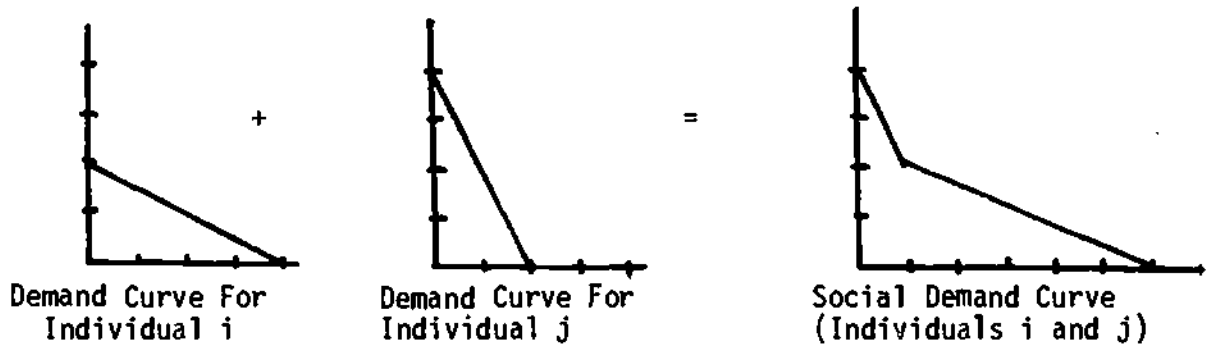


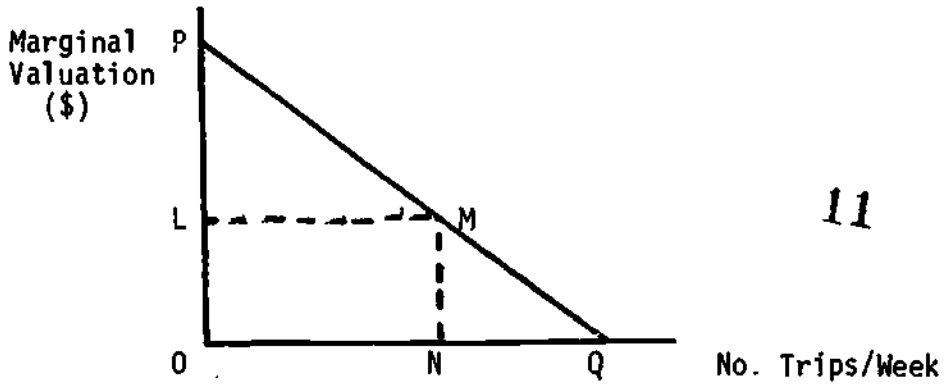
Figure 3. Individual Demand Curve

The demand curve in figure 3 indicates the maximum price an individual would be willing to pay for the nth trip across the bridge/unit time (e.g., one working week). Thus the individual is willing to pay $A for the C trip but only $E for the F trip. The market demand curve is the horizontal summation of all individual demand curves and can be regarded as the marginal valuation curve for society.

Figure 4. Adding Individual Demand Curves



Assume the demand curves for all potential users of the bridge have been estimated and added together to form a total demand curve for the services of the bridge (Figure 5).



Suppose that N trips across the bridge would be taken in one week. Society's benefits of having the services of the bridge can be represented by the area underneath the demand curve up to N (OPMN). If the price charged is OL (toll), the total expenditure by users is the area OLMN (price times quantity). The difference between the total benefits accruing to the use of the bridge and the total expenditures by the users is the area in the triangle LPM, which is the measure of the total consumers' surplus.

- If no tolls were charged, the total consumers' surplus would be OPQ.

- Estimates made of consumers' surplus that would accrue due to a project are entered as benefits in the costs and benefits ledger.

- The instructor may wish to explore the estimation of consumers' surplus when a project under consideration when completed would reduce the cost of provision of a service:

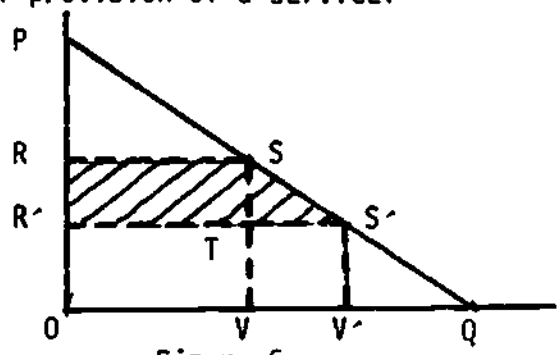


Figure 6

If a given capital investment (branch library were to result in the price of a service (e.g. travel costs to use a library) to be reduced from R to R´, and PQ was the estimate of the demand curve for the new branch library, the consumers' surplus would be the cross-hatched area R´RSS´. This is composed of two components--the costs-savings rectangle (R´RST) which is the savings per trip times the original number of trips, and the consumers' surplus accruing either from an additional number of library trips made by the same users (because of added convenience) or by new users.

- The cost-savings of rectangle is usually accepted as the minimum estimate of the total benefits.

- Of course this does not take into account lost usage of the other branches of the library and should when examining all relevant costs and benefits.

- In summary, the estimation of consumers' surplus is an extremely important element in the estimation of benefits in any cost-benefit framework.

3.2.6. The Valuation of Time: Need For Converting The Time Stream Of Benefits and Costs Into Present-Value.

(a) Homogeneity and comparability require that dollars (benefits and costs) be evaluated at one point in time.

(b) Ask class how much money they would need to be offered one year from now so that they would be indifferent to having $100 today. The ratio is their individual discount rate.

(c) The "proper" discount rate measures the social rate of time preference - reflecting society's greater value placed on things in use now than their potential use tomorrow.

(d) What discount rate should we use in practice? - Investment opportunity rate as a minimum rate, which is the cost of obtaining capital to the organization.

(e) Stream of benefits and costs over the life of the project.

t_o	t_1	t_2	t_3		t_n
B_o	B_1	B_2	B_3	.....	B_n
C_o	C_1	C_2	C_3	.....	C_n

(f) We use the discount rate to transform all future benefits and costs to present value (B_o, C_o).

(g) Present Value (P.V.) =

$$B_o + \frac{B_1}{(1+r)} + \frac{B_2}{(1+r)^2} + \frac{B_3}{(1+r)^3} \cdots\cdots \frac{B_n}{(1+r)^n}$$

(same for costs)

where B_o, B_1, B_2 ..... B_n is the stream of benefits

r is the social rate of discount

$$P.V. = \sum_{i=0}^{n} \frac{B_i}{(1+r)^i}$$

(h) If the stream of Benefits and stream of costs were proportional to one another, there would be no need to convert to present-value. It is because benefits and costs typically accrue at different points in time that present value techniques must be used.

3.2.7 Calculating the benefit-cost ratio.

(a) Need only the total present value of benefits and costs.

(b) Benefit-cost ratio = $\frac{\text{P.V. benefits}}{\text{P.V. costs}}$

for each alternative course of action.

(c) That alternative which has the highest benefit-cost ratio is the most efficient and hence the "best" course of action to meet the agency's objectives - assuming all relevant benefits and costs were properly identified and measured.

3.3 Exercise 1: Present Value Technique (page VI.5.11)

3.3.1. Ask the participants to read Exercise 1 and to write down the answers to the two questions at the end of the exercise. Allow about 15-20 minutes to complete the exercise.

3.3.2. Discussion of Q.1. Ask the class question 1. Prod them closer to the correct answer(s), or ask the question slightly differently, "Why does Proposal II come out better under a higher discount rate"?

(a) Proposal II's costs are proportionately farther in the future than Proposal I's.

A higher discount rate will more heavily discount (lower in present-value $) Proposal II's cost stream than Proposal I's.

(b) To emphasize this point, ask the class to examine the present-value table attached to Exercise 1.

(i) Point out the fact that when looking down any column, the increments get progressively smaller.

(ii) Across any row (e.g., 30 years), $10/year in costs gets reduced from $300 total costs undiscounted to only $130.77 at 6% and only $80.05 at 12%.

3.3.3. Ask anyone for the answer to Q.2.
Correct answer:
At 8%, over 20 years of useful life.

(i) P.V.I. = 15M + 9.818M = $24,818,000
(ii) P.V.II.= 5M + 19.636M = $24,636,000

Proposal II is preferred.

3.3.4. Now ask the class to calculate at what discount rate (over 20 years useful life) one would be indifferent between the two proposals. (Allow about 8-10 minutes for this).

Answer:

Proposal I		Proposal II
15.0 + 1.0 PVF	=	5.0 + 2.0 PVF

where PVF is the present value factor.

Solving for PVF,
PVF = 10.0

Find 10.0 in present-value table for 20 year useful life.
The discount rate at which we would be indifferent is just under 8%.
This is the internal rate of return between the two alternatives.

3.3.5. Briefly explain the significance of the internal rate-of-return as an alternative to discounted present-value.

(a) Internal rate of return for a single alternative is that rate-of return which yields the total costs = total benefits.

(b) Example of use of internal rate of return as criterion.

	t_o	t_1	t_2
Proposal A			
Benefit Stream	0	210	100
Cost Stream	100	100	100
Proposal B			
Benefit Stream	0	100	221
Cost Stream	100	100	100

Convert to net benefit stream:

	t_o	t_1	t_2
Proposal A	-100	+110	0
Proposal B	-100	0	+121

Internal Rate of Return of Proposal A:

Costs		Benefits
100	=	$\frac{110}{(1+r)}$

r = 0.10

Internal Rate of Return of Proposal B:

$$100 = \frac{121}{(1+r)^2}$$

$$(r^2 + 2r + 1) = 1.21$$
$$(r^2 + 2r - 0.21) = 0$$
$$(r - 0.1)(r + 2.1)$$
$$r = 0.1$$

In this case the internal rates of return for each proposal are equal. Now, if the discount rate were actually = 1%, proposal B would have the higher discounted present value of net benefits:

	t_o	t_1	t_2	Internal Rate Of Return	B-C C at 1%	B-C C at 10%	B-C C at 20%
A	-100	110	0	0.10%	.09	0.0	-0.08
B	-100	0	121	0.10%	.19	0.0	-0.16

If the actual discount rate were higher than 10%, both proposals would produce negative rates of return, but Proposal B would be <u>more</u> negative than Proposal A.

(c) Now consider other alternatives in addition to A:

	t_o	t_1	t_2	Internal Rate Of Return	PV (B-C) C at 3%
A	-100	110	0	0.10	0.07
C	-100	0	115	0.07	0.08
D	-100	106	0	0.06	0.03
E	- 50	52	0	0.04	0.01
F	-200	2	208	0.02	-0.01

The proposals are listed in declining order of internal rates of return, yet at the prevailing 3% discount rate, Proposal C is superior.

Stress the point that alternatives A,B,C, and D are all legitimate proposals since their internal rates of return are all higher than the adopted discount rate. Proposal E's internal rate of return is less than the adopted discount rate and thus is not economically efficient.

(d) Sum up the practical importance of discounting benefits and costs into present value and that not choosing the proper discount rate can easily bias the decision.

- Typically choosing a high discount rate will introduce bias in favor of rejecting projects since the benefit stream is proportionally weighted further in the future than the cost stream.

- Choosing a low discount rate will introduce bias in the opposing direction.

3.4. Exercise 2: Criteria for Evaluation (page VI.5.14)

3.4.1. Ask the participants to read Exercise 2 in their student manuals, think about the questions at the end, and to jot down their ideas on paper. (Allow about 10 minutes).

3.4.2. Discussion of questions. The issues of scale and comparability of projects are at issue here. If five regional facilities could be built then clearly this would yield both the highest benefit-cost ratio and excess benefits.

3.4.3. Emphasize:

(a) The need to have comparable alternatives which are being comparatively evaluated (thus need to refer back to objectives).

(b) The flexibility allowed and/or a cost constraint for the project must be taken into account to decide which criterion to use and hence which alternative is preferred.

3.5. Case Study and Scenario 1: Simple Cost-Benefit Analysis (page VI.5.15)

3.5.1. Ask each participant to read Case Study 1 (allow about 10 minutes). Stress the importance of separating costs and benefits (or not to "double-count") in reading the case study.

3.5.2. After the participants have read the case study, ask if there are any questions about (i) the validity of the procedure, (ii) the inclusion of all relevant costs and benefits. The fact that time-savings is the only considered benefit of the new link may be worthy of discussion. Point out that the cost items have been separated prior to discounting since the items have different designated useful lives.

3.5.3. Ask the participants to read Scenario 1 and to solve the problem. (Allow about 15-20 minutes).

3.5.4. Solution to Scenario 1:

(a) Separate the two sections of the link and compare each proposed section with only the relevant existing section:

(b) Section I:

$$B_n - B_o = \tfrac{1}{2}[(0.1002 \times 1.4) - (0.0877 \times 0.9)](2500 + 2000)(365)$$

$$= \tfrac{1}{2}[0.1403 - .0789)(4500)(365)]$$

$$= 50.424$$

$$C_n - C_o = (0.0872)(35{,}000) + 0.0619(13{,}000) + 0.0665$$
$$(225{,}000) + 783 - 1540$$
$$= 3052 + 805 + 14{,}962 + 783 - 1540$$
$$= 18{,}062$$

$$\frac{\Delta B}{\Delta C} = \frac{50{,}424}{18{,}062} = 2.79$$

(c) Section II

$$B_n - B_o = \tfrac{1}{2}[(0.1061 \times 1.1) - (0.1040 \times 0.8)](2500 + 2000)(365)$$
$$= \tfrac{1}{2}[0.1167 - 0.0832)(4500)(365)$$
$$= \tfrac{1}{2}(0.0335((4500)(365)$$
$$= 27.511$$

$$C_n - C_o = 0.0872(38{,}000) + 0.0619(24{,}000) + 0.0665$$
$$(230{,}000) + 720 - 1210$$
$$= 3313 + 1485 + 15{,}295 + 783 - 1210$$
$$= 19{,}603$$

$$\frac{\Delta B}{\Delta C} = \frac{27{,}511}{19{,}603} = 1.40$$

(d) Alternative decisions
(i) Build only Section 1
(ii) Build only Section 2
(iii) Build both Sections 1 and 2
(iv) Do not build any sections.

(e) Decision Analysis

Since each new section alone would be justified on the basis of economic efficiency, alternative (iv) can be eliminated. One can then argue from the geometry that both sections should be built (since there is no cost constraint given), without needing additional data to do another analysis in which both sections are considered together. This approach to structuring the problem is a simple form of branch and bound decision-making. This entails being able to hierarchically disaggregate the whole problem into several discrete sub-problems, but such that there are no important negative interaction costs among the sub-problems at any level of the hierarchy (in this case there are only two levels). Discuss this as a practical strategy for doing cost-benefit analysis for certain kinds of problems.

(f) Marginal vs. Average Benefit-Cost Ratio

We can approach the problem above in a different way. If we had to pick the alternative in (d) above with the highest benefit-cost ratio, we would choose (i) build section II only (ratio = 2.79). Yet after this would be built, the benefit-cost ratio of new Section II (1.40) would justify building it too, if, again, there would be no negative interaction costs of linking section II with section I. This illustrates the difference between "marginal" thinking and "average" thinking in cost-benefit analysis: "average" thinking would result in just building section I; marginal thinking would result in both sections being built. Cost-benefit analysis is based upon "marginal" thinking. This same point can be illustrated with numerous other examples of projects with increments of investment or scale.

(g) Other points to re-emphasize from Case Study 1

(i) Decomposition of cost items when they have different project lives or would have different discount rates.

(ii) Net savings in costs are represented as benefits; benefits and costs are often duals in the same problem and while one can consider each to be a negative of the other, one must be careful so as to not "double-count" (in an accounting sense).

(iii) Watch for interaction effects among alternative courses of action.

3.6. Case Study and Scenario 2: Simple Cost-Effectiveness Analysis (VI.5.23)

3.6.1. Before instructing the participants to read Case Study 2, outline the following differences between cost-benefit and cost-effectiveness analysis. The rudimentary difference should have been briefly described in the Overview section above.

(a) Whereas cost-benefit analysis uses a criterion of efficiency - "the most bang for the buck", cost-effectiveness uses the criterion of effectiveness - "an acceptable level of performance at the least cost."

(b) Put another way, the criterion of efficiency maximizes the level of performance among alternatives subject to a total cost constraint; effectiveness seeks the alternative which minimizes total cost but subject to an acceptable level of performance.

(c) More practically, cost-effectiveness analysis avoids the need for estimating benefits (often troublesome) and transforming all benefits into dollar units.

(d) Cost-effectiveness analysis allows various measures of performance to be kept in their "natural" units, and qualitative measures can be incorporated into the calculus.

3.6.2. Now ask the participants to read Case Study 2, and to pay particular attention to the different kinds of effectiveness measures that were used. (allow about 10 minutes). Ask if there are any questions before proceeding to the Scenario.

3.6.3. Ask the participants to read Scenario 2 and to solve the problem. (If they can not do the calculation, ask them to structure the problem as if they were given the individual cost items).

3.6.4. The solution - see Table 3.6

(a) The calculations for noise standards, span width and U.S.A. bonus are all straight forward. The time penalty calculations are more intricate. Most participants will not know how to do this section, and the instructor may choose to "gloss over this" and just accept the travel time differentials as given.

(b) Travel time calculations

(i) In general one divides the average 1 mile trip into three segments: acceleration, maximum speed, deceleration. One then calculates the elapsed time for each segment.

(ii) Safeage

Mean acceleration rate = 3.3 miles/hour/second

Maximum speed = 50 miles/hour

Time to reach maximum speed (acceleration time)

$= \frac{50}{3.3} = 15.0$ seconds

Acceleration distance

$= 25 \text{ m.p.h.} \times \frac{1}{60} \times \frac{1}{4} \text{ minute} = \frac{25}{240}$ miles

Deceleration distance $= \frac{25}{240}$ miles

Distance at maximum speed $= \frac{240}{240} - \frac{25}{240} - \frac{25}{240} = \frac{190}{240}$ miles

Time at maximum speed $= \frac{190}{240}$ miles $\div$ 50 miles/hour $= \frac{19}{1200}$ hours

$= \frac{19}{1200} \times 3600$ seconds/hour $= 57$ seconds

Total trip time = 57 seconds + 2(15 seconds) = 87 seconds.

(iii) Quorail

Mean acceleration rate = 3.0 miles/hour/second

Maximum speed = 60 miles/hour

Time to reach maximum speed = 20 seconds

Acceleration distance $= 30 \text{ miles/hour} \times \frac{1}{60} \times \frac{1}{3} \text{ minute} = \frac{1}{6}$ mile

Deceleration distance $= \frac{1}{6}$ mile

Distance at maximum speed = 2/3 mile

Time at maximum speed = 2/3 miles $\div$ 60 miles/hour $= \frac{1}{90}$ hour

$= \frac{1}{90} \times 3600 = 40$ seconds

Total trip time = 40 seconds + 2(20 seconds) = 80 seconds.

Table 3.6

SOLUTION TO SCENARIO 2

	Additional Standards	Safeage	Durorail	Skybus	Alweg
	Noise	0	External 88→81 6,030,000	External 85→81 1,154,000	Internal 81→75 2,251,000
	Span Width	5 ft. 2,500,000	2.5 ft. 1,250,000	0	0
	Total Costs	42,555,000	37,875,000	34,274,000	34,711,000
	USA Bonus	4% 1,702,200	3% 1,136,250	5% 1,713,700	1% 357,110
Benefits	Time Savings	87 sec. 2,500,000	80 sec. 6,500,000	107 sec. 0→92 sec.	90 sec. 1,000,000
Revised	Revised Net Costs	38,352,800	30,238,750	32,560,300	33,353,870

↑
Still
Preferred

(iv) Alweg Monorail
Mean acceleration rate = 2.8 miles/hour/second
Maximum speed = 50 miles/hour
Time to reach maximum speed = 18.0 seconds (approx.)
Acceleration distance = 25 miles/hour x $\frac{1}{3600}$ x 18 = 1/8 mile
Decelaration distance = 1/8 mile
Distance at maximum speed = 3/4 mile
Time at maximum speed
= 3/4 mile ÷ 50 miles/hour = $\frac{3}{200}$ hours
= $\frac{3}{200}$ hour x 3600 seconds/hour = 54 seconds
Total elapsed time = 54 seconds +2(18 seconds) = 90 seconds

3.6.5. Discussion of the structuring of the problem solution in Table 3.6.

(a) The U.S.A. bonus must be based on the total capital costs <u>before</u> adding time savings.

(b) Time savings are relative to the slowest alternative and thus represent <u>cost</u> savings or benefits.

(c) The problem is not a pure cost-effectiveness analysis--measures of effectiveness have been converted into dollar benefits. (Ask the class what the solution would look like if the problem were retained as a more or less pure cost-effectiveness analysis.

(d) What is the dollar value of time savings? (Explain that this is a frequent benefit itme in cost-benefit analysis, and is often problematic. Many economists use the hourly wage level as a measure of the opportunity cost of travel. Other economists feel that this value is too high.

(e) How does one estimate the true social costs of noise, including health damage (physical and mental), structural stress on buildings, etc.?

3.7. <u>Case Study and Scenario 3 -- The Morganville - LTIC Program</u>. (page VI.5.26)

3.7.1. Rationale. This case study and scenario place emphasis upon evaluating alternative on-going programs rather than capital facility projects. Thus while present-value techniques are not as important, the issues of indirect costs and benefits, externalities (of spill-over effects), and the <u>distribution</u> of the various costs and benefits become central. In addition, this case study and scenario pose the problem of carefully defining the objectives of the programs--is it to reduce unemployment or alleviate poverty? The evaluation of each program category should depend upon which objective is chosen, but the case study purposely keeps the objective ambiguous.

3.7.2 Ask the participants to carefully read the case study and to jot down on paper any logical errors or omissions in the analysis. (Allow 15-20 minutes).

3.7.3. Some questions for discussion:

(a) Is the claim of efficient use of society's resources justified?

(b) Would employers be subsidized for the total costs of job-training?

(c) Should firms be financing part of the training programs themselves (in the name of efficiency)?

(d) Does the estimate of benefits properly include the multiplier effects of the investment?

(e) What relevant cost and benefit items may have been omitted in the analysis (e.g., displacement of private sector agencies, additional costs to marginal businesses due to upward pressure on wages, displacement of jobs from presently employed, skilled labor, costs of "over-training"). Which of these are justified? How should one deal with these items in the analysis? (At this point the instructor should be discussing the general problem of dealing with indirect costs/benefits and externalities).

3.7.4. Ask the participants to now read Scenario 3 and to answer the questions posed. (Allow about 25-30 minutes).

3.7.5. Discussion of key questions in Scenario 3.

(a) Based upon the data given, and using poverty-level B, the average member of each of the categories of LTIC trainees without training would have an income below the poverty line. The earnings associated with training, however, were insufficient to push the average earnings above the poverty line (male on-the-job trainees as a category came closest to crossing the threshold.)

(b) Using poverty line definition A, the average male on-the-job trainee would not be considered below the poverty line without training, although the average trainee in each other category would be below. The earnings associated with training would push the average trainee in these categories above the poverty line.

(c) Since the poverty line definitions are so arbitrary (whether to multiply minimum adequate food budgets by 1.67 or 3.0, or the designation of what the minimum adequate food budget actually should be), can one make a sensible evaluation of whether the antipoverty programs were distributionally effective?

(d) Should effectiveness of the program be judged according to whether the incomes of the trainees are raised above the poverty line (however defined), and no value placed upon any income increase in earnings due to training? How would the latter be operationalized in the analysis? (Note the differences but easy transferability between cost-benefit and cost-effectiveness analysis in this scenario). Can cost-benefit analysis address distributional questions or merely allocative ones?

3.8. Case Study 4: Sensitivity Analysis of Cost-Effectiveness (page VI.5.31)

3.8.1. Briefly explain the rationale of sensitivity analysis:

(a) To what degree does the value of the evaluation criterion depend upon a particular quantitative or qualitative value of a coefficient or parameter that has been assumed in the analytic procedure?

(b) How does the numerical value of the evaluative criterion change when a particular parameter, coefficient or key assumption changes in value (as a result of new information, better estimation procedures, changes in the state of the world, etc.)?

(c) Ideal mathematical form of a sensitivity coefficient: $\frac{\Delta Y}{\Delta C}$

where ΔY represents the change in the output, or level of the evaluation criterion (e.g. benefit-cost ratio), and ΔC represents a unit or incremental change in a particular parameter or coefficient.

3.8.2. Ask the participants to read Case Study 4. Ask if there are any questions about the model or why it is a measure of cost-effectiveness.

3.8.3. Depending on the remaining time and the interests of the class, Scenario 4 may be skipped, left as an exercise to be optionally done after the workshop, or done in class. If done in class, allow about 30 minutes to answer the questions.

3.8.4. The solution:

(a) $X = \frac{A + B}{D+E-C}$

$A = \$20,000/\text{journal}$

$B = \frac{\$7.15 + \$5.81}{2} = \$6/48/\text{journal}$ (assuming 50% of journals are stored in the reserve room - any reasonable % is allowed)

$C = \$0.93/\text{request}$ (with file copy)

$D = \frac{628(\$2.89) + 374(\$1.31) + 196(\$4.12)}{1198}$

using a weighted sum with weights corresponding to requests from various sources in 1976.

$= \$2.60/\text{request}$

$E = 0.0$

$\therefore X = \frac{20.00 + 6.48}{2.60 - 0.93} = 15.86$

Critical number of requests = 16.

(b) If subscription price increases \$1/journal, increases to \$16.46 so $\frac{\Delta Y}{\Delta C}$ = 0.60 requests/\$. Thus the critical number of requests is relatively insensitive to changes in subscription prices.

(c) If the salary clerk's salary increases from \$0.07/min. to \$0.09/min;

(i) The handling costs of owning a journal increases from \$6.48 to \$6.86,

(ii) The cost of obtaining an article from the Rhoidville Library shelf increases (with file copy) from \$0.93 to \$1.02.

(iii) The cost of obtaining an article from the State Library Clearing house increases from \$2.89 to \$2.97.

(iv) The cost of obtaining articles from the adjacent county library increases from \$1.31 to \$1.38.

(v) The cost of obtaining an article from the State University Library increases from \$4.12 to \$4.20.

$\therefore$ D increases from \$2.60 to \$2.67

$$\therefore X = \frac{20.00 + 6.86}{2.67 - 1.02} = 12.68$$

$\therefore$ X increases 16.28 - 15.86 = 0.42 requests with an increase of \$0.02/minute in the serial clerk's salary.

The critical number of requests is very insensitive to changes in the serial clerk's salary. (Explain mathematically why, if not obvious to the class.)

(d) If the price of purchasing an article from the State University Library increases from \$4.12 to \$8.24, D increases from \$2.60 to \$3.27.

$\therefore$ X <u>decreases</u> to 11.32 requests.

(e) Time delay costs change from \$0.50/day to \$0.75/day

(i) At \$0.50/day, E = 628(10.0) + 374(4.0)

$$E = \frac{628(10.0) + 374(4.0) + 196(16.0)}{1198} (0.50)$$

E = 9.109 (0.50) = \$4.55

$$X = \frac{20.00 + 6.48}{2.60 + 4.55 - 0.93}$$ = 4.26 requests per year to justify subscription

(ii) At \$0.75/day, E = 9.109(0.75) = \$6.83

$$X = \frac{20.00 + 6.48}{2.60 + 6.83 - 0.93} = 3.12 \text{ requests/year}$$

Thus the critical number of requests decreases drastically when time delay costs are included, and moreover, X is relatively sensitive to changes in time delay costs.

3.8.5. Discussion. Examples of different models for sensitivity analysis for different problems might be appropriate.

4.0 Lecture Material - Some Practical Elements in the Use of Cost-Benefit and Cost-Effectiveness Analysis

4.1 Estimating future benefits

(a) Entails projection of future technology
(b) Entails projection of changes in tastes
(c) Entails projection or organizational changes (supply)
(d) Entails forecasting future socio-economic settings, including income, prices

- Because future benefits are difficult to estimate, many analysts will only claim that their estimate is a plausible lower bound. This is a deliberate conservative bias.

- Benefit measurements are quantifications of the extent to which desirable effects occur (or will occur). In order to know what is desirable, we must have well-defined objectives and goals for the organization.

4.2 Techniques for estimating costs

(a) Use of unadjusted past and current data applied to the future (e.g., linear extrapolation)
(b) Preparation of "internal engineering" estimates
(c) Use of vendor estimates
(d) Statistical estimation (e.g. multiple regression, other functions).
(e) Special cost-models built for the particular problem.

4.3 Coping with Uncertainty and Risk

(a) Difference between uncertainty and risk.
  (i) Risk - known probabilities of future states.
  (ii) Uncertainty - unknown probabilities of future states.

(b) Some reasons for existence of uncertainty and risk
  (i) Changes in the economy including prices, income, interest rates on capital
  (ii) Discovery of new sources of supply
  (iii) Technological innovations

(c) Methods for coping with uncertainty and risk
(i) Cut-off period - will not take on a program unless the investment can be recovered in X years.

(ii) Build a premium into the discount rate: $i + p = i'$ where p is the premium and i is the normal discount rate.

(iii) Downward revision of expected future benefits and upward revision of expected future costs (inputs).

(iv) Subjective probability - estimate:

upper limit

most likely

lower limit

- The instructor may wish to have a concrete example in mind to illustrate the difference between risk and uncertainty and how to deal with each.

4.4 Costs and Quality of Information

(a) Good information is expensive to obtain, and there is a trade-off between getting better information to perform better analysis and the costs of obtaining the better information.

(b) Kinds of information

(i) Continuous scale
(ii) Interval scale
(iii) Ordinal scale
(iv) Qualitative

(c) Units of measurement

(i) Performance measurements (quantity of output)
(ii) Target quartities (e.g., expressed as % change)

4.5 Ask the participants if they have any other questions on the general practical aspects of cost-benefit and cost-effectiveness analysis.

4.6 Stress the limitations of a two-day workshop for learning the practical aspects. Important, though, that the participants become <u>sensitive</u> to the more likely problem areas and issues which have been the most troublesome or most dubious elements/assumptions in cost-benefit and cost-effectiveness analysis, and hence will not be likely to be "sold a bill of goods" or "taken to the cleaners" when presented with an analyst's work.

5.0 Exercise 3: Group Problem Design and Analysis (page VI.5.39)

5.1 The participants should now be ready to undertake a prototype evaluation analysis themselves. This exercise should provide the opportunity to structure the design of an evaluation analysis to conform to a concrete or hypothetical problem of the participants choice. It will also provide an opportunity for the participants to follow through the analysis with actual data when they return to their agencies.

5.2 Ask the participants to form groups of three (two is acceptable but probably not as effective in terms of group self-learning) according to the individual functional area interests. If there is a notable difference in experience/ability among the participants, attempt to arrange the membership of the groups as equitably as possible.

5.3 Assuming that the instructor had already asked the participants to think about the definition of the problem, the participants will be ready to articulate the goals and objectives to be achieved in solving the problem. Direct the participants to Worksheet A and to articulate the above and then design a set of alternative programs/courses of action to achieve the goals/objectives. As a consultant to the groups, stress the importance of articulating operational goals/objectives and specific, well-defined set of alternatives.

5.4 Participants now go to Worksheets B and C where they must identify all relevant costs and benefits. These items must all be measurable in some way. (If cost-effectiveness rather than cost-benefit analysis is chosen, measure of effectiveness (performance) are substituted for benefit items. This portion of the analysis will take a significant amount of time, and likely will consume the remaining time in the workshop.) Worksheet D should still be distributed however for the participant's future use.

5.5 Ask the participants a final time for general questions on the framework of the cost-benefit/cost-effectiveness analysis. If desired, leave your address so that the participants may be able to consult with you on their final group project or for additional references.

6.0 Workshop Evaluation

If a participant evaluation of the workshop is desired or required, ask the participants to do this now and either complete before leaving (preferred) or mail the completed evaluation to you. A questionnaire already designed by the instructor with sufficient copies to distribute may be preferred to a free-format evaluation.

COST-BENEFIT AND COST-EFFECTIVENESS ANALYSIS

Participant/Student Manual

Prepared by Harvey Goldstein

Module Number Five
of
POLICY/PROGRAM ANALYSIS AND
EVALUATION TECHNIQUES Package VI

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Package VI

TABLE OF CONTENTS

COST-BENEFIT ANO COST-EFFECTIVENESS ANALYSIS: AN OVERVIEW

As the need to develop more precise ways to evaluate the efficacy of a public project, or to choose among alternative projects to meet some designated objective arose it became important to be able to systematize the estimation of the relevant costs and benefits that would be derived from the given project. This is what cost-benefit and cost-effectiveness analysis attempt to do. They can be useful techniques of project evaluation but can also be easily misused--either by people who do not fully understand the underlying assumptions of the techniques, or by people who conveniently ignore or misrepresent key elements in the analytic process in order to "scientifically" justify their own particular preferences when these preferences would not be justified on efficiency or effectiveness grounds. It is thus important for the practitioner to understand each of the essential elements in the cost-benefit and cost-effectiveness analytic process and to be aware of the limitations and shortcomings of these analytic techniques.

Brief History of the Use of Cost-Benefit Analysis

Cost-benefit analysis is not a "new" technique born of modern computer technology and systems-thinking. In a rudimentary sense cost-benefit thinking was manifest when homo-sapiens first decided to compare the positive and negative aspects of a decision. In the Bible we can point to Noah's use of cost-benefit analysis when deliberating on what animals and materials to bri in the ark knowing that the ark had a limited amount of space ar at everything left off would be killed or destroyed in the floo

As a modern, systematic way of comparing benefits and costs, though, cost-benefit analysis is generally acknowledged to have started with the River and Harbor Act of 1902 where it was established that the improvement of a project had to be weighted against the ultimate cost.[1] In the early 1930's the Roosevelt Administration wanted to extend the New Deal to develop the nation's natural resources for dealing with some of the problems associated with the economic depression. In this regard an estimation of the social costs and benefits of development projects were included as well as the private (indivudual) costs and benefits, making it possible that projects with substantial intangible social benefits would not be evaluated disadvantageously.[2]

In 1936, cost-benefit analysis became even more institutionalized through federal legislation. The Flood-Control Act of 1936 established that the Federal government should improve navigable waters for flood-

control purposes "if the benefits to whomever they may accrue are in excess of the estimated costs . . ."[3] This was an important guideline because it extended the scope of the analysis to include those who indirectly benefited from a project or who indirectly suffered costs. From this time on, governmental use of cost-benefit analysis tended to place more emphasis on the indirect and intangible benefits and costs and social scientists began to devote more attention to developing better techniques for measuring these factors.[4]

In 1950 the Subcommittee on Costs and Benefits of the Federal Inter-Agency River Basin Committee developed a primer to show how cost-benefit analysis could be used in evaluating water-resource projects. This publication outlined the acceptable principles and procedures for determining benefits and costs for the projects and represents the last stage in the institutionalization of cost-benefit analysis into the Federal bureaucracy.[5]

Definition of Cost-Benefit Analysis

What, then, precisely is cost-benefit analysis? According to A. R. Prest and R. Turvey it is a practical way of assessing the desirability of projects, where it is important to take a long view (in the sense of looking at the farther future as well as the nearer future) and wide view (in the sense of taking into account side-effects of various kinds on various persons, industries, regions, etc.); i.e., it implies the enumerating and evaluation of all relevant costs and benefits."[6]

Basically, then, cost-benefit analysis is the process of calculating the ratio between all the relevant benefits project and all the relevant costs of each alternative for the purpose of determining which alternative would yield the highest return (benefits) on the total investment (costs).

Thus one can look at cost-benefit analysis as a process composed of several discrete steps. According to the Report to the Federal Inter-Agency River Basin Committee,[7] these steps are: (1) the establishment of need; this may be obvious to some, but an articulation of the nature of demand for the desired benefits of the project should be identified and then carried through the entire analysis. This step can also be interpreted as the setting of goals and/or objectives; (2) the estimation of each of the project's relevant benefits and costs in standardized units so that they can be meaningfully compared for alternative projects; (3) establishment of the scope of project development--the scale of the project should be determined as different allowable scales will, in general, yield different decisions as to which alternative is most preferred; (4) development of the most economical means of realizing project purposes--all the elements of the project as well as the project as a whole should be the most efficient means of accomplsihing the given objective(s).

To compare several projects one should compare the ratio of benefits to costs for each of the projects. If all of the relevant costs and benefits have been accounted for and properly discounted,[8] then this benefit-cost ratio would be a reasonable criterion on which to decide the relative priority of each of the several projects.

Goals and Objectives

Step (1) above mentions the need for establishing goals in the process of cost-benefit analysis and the importance of keeping these firmly in mind throughout the analysis.

Objectives are sometimes used interchangeably with goals but it is preferable for objectives to mean the operational articulation of goals. That is, objectives are the measurable and quantifiable statements of the verbalized goals. When there are several objectives to be achieved in a project (and there usually are) then these different objectives should be ranked and weighted in such a way that they reflect the priority of each goal in comparison to the others.[9] This is particularly important if among the several goals there are conflicting ones.

Advantages and Limitations of Cost-Benefit Analysis

The principal advantage of cost-benefit analysis is that it provides a better understanding of the implications of embarking upon alternative courses of action by forcing the analyst to examine the structure of the costs, constraints, and benefits of each alternative. If one attempts to go beyond this in the analytic process, i.e., to let the result of the analysis make the decision for the decision-maker, then there may be some serious problems. Although cost-benefit analysis is a scientific approach to evaluating alternatives, it is not an exact scientific tool nor is it value-free. It must be remembered that in the design and implementation of the analysis, human judgement is relied upon, and moreover, there may be other criteria besides efficiency and effectiveness (such as equity) that should be considered before a final decision is made.

Inherent within cost-benefit analysis, however, there are limitations. As in any social inquiry, there is a limit to the number of factors that can be included in the analysis and thus we never actually include all of the relevant benefits and costs for methodological reasons. Moreover, since only measurable benefits and costs can be included in the analysis (in cost-benefit analysis, per se, all must be converted to dollars; cost-effectiveness analysis relaxes this requirement), the analyst invariably must exclude certain intangible effects such as aesthetics, psychological factors, etc.[10] Related to this is the difficulty of estimating future benefits and costs; there will always be a certain measure of error in trying to predict the future. The use of discounting adjusts the estimates of future benefits and costs to present-day values but the estimates must still be made before-hand, and they can, in hind-

sight, be bad estimates. The benefit-cost ratio can, under these circumstances not serve as a reasonable guide to decision-making.

Cost-Effectiveness Analysis

Cost-effectiveness is very similar to cost-benefit analysis and many times no distinction is made; the former is subsumed under the umbrella of the latter. There are some differences, however. Edward S. Quade defines cost-effectiveness as "a comparison of alternate courses of action in terms of their costs and their effectiveness in attaining some specific objective."[11]

Instead of proceeding to find the most efficient way to expend a certain level of resources in trying to maximize a set of objectives (as cost-benefit does), cost-effectiveness attempts to find the least-cost method for achieving an acceptable level of performance or results. Thus more emphasis is placed upon the articulation of goals and objectives in cost-effectiveness analysis. There are two principal tasks involved here. The first is the identification of the total costs of each alternative if each of the alternatives were to meet some specified level of performance. The second is the articulation of indicators of effectiveness. In constructing indicators of effectiveness, the analyst "lays out" all of the dimensions of the desired performance and sets minimal levels of acceptability. An alternative is "effective" then if it meets the minimum level of performance; it is cost-effective" if it meets the minimum level of performance at the least cost of all the alternatives available.

Two of the major advantages of cost-effectiveness over cost-benefit analysis are that (1) the goals and objectives must be explicitly articulated and that (2) all degrees of quality of information on "benefits" are allowable in the analysis. Thus the analyst does not have to compress all "benefits" into a single number expressed in dollars, but effectiveness is considered in terms of a number of dimensions and non-cardinal measures can be used in these dimensions.

Externalities and Spillover Effects

An important concept to consider when enumerating the various relevant costs and benefits of alternative projects is that of externality. An externality, according to Paul Samuelson is "an effect to one or more persons that emanates from the action of a different person or firm."[14] That is, a cost or benefit is incurred by a 3rd party as a result of a transaction between two other parties, and the 3rd party is not directly involved in the transaction. A classic example of a positive externality is the lighthouse. A person builds a lighthouse to protect his boat but at the same time the lighthouse's light protects everyone else's boats in the vicinity, while they do not share in the cost of providing the protection (building and maintaining the lighthouse and consuming the electricity).

A negative externality occurs when the 3rd party incurs a cost rather than a benefit. When a firm decides to discharge its wastes into a stream, it is imposing a real cost on the people and firms that are located downstream and use the water. This cost can be seen in that recreational activities downstream may have to be curtailed; fishermen's livelihoods are threatened; municipalities taking water from the stream may have to send it through a more expensive purification system before the water is suitable for drinking, etc.

Spillover effects are actually externalities but usually refer to the specific geographical, or spatial effects of externalities. Slum housing, because of proximity, will have a deleterious effect of the value of well-maintained housing on the same block or in the same general neighborhood. These external effects are not transmitted through the market so it is usually methodologically difficult to account for these in the identification and calculation of all relevant costs and benefits. Nevertheless, externalities often can be considerable, and omission of them will lead to drastic errors in decision-making.

Related to the problem of externalities is that of considering project overlap. If there is a package of projects to be considered, in addition to analyzing the costs and benefits of each individual project alternative, one must consider the additional costs and/or benefits that would occur due to project interaction. Projects that complement and benefit one another have positive spillover effects. Those that conflict (act in opposition to each other) have negative spillover effects. These effects should definitely be considered in the benefit-cost calculus when a combination of projects are under consideration.

Threshold Analysis[13]

Threshold analysis was developed by B. Malisz in Poland after observing the failure of more conventional physical planning evaluation systems. It deals with the problem of physical limitations to development such as topography, in-place land uses, and the current available technology. These limitations are called thresholds. This is not to say that these thresholds can not be overcome, but there are relatively very large costs involved in crossing the threshold, and thus there will tend to be less development in the threshold area.

Development thresholds have a marked effect upon urban development patterns and so can be important for the planner to consider when laying out a plan for future physical development. Threshold analysis then attempts to identify and define these thresholds and to evaluate the costs of overcoming them. If the costs imposed by the threshold can be estimated, then these costs can be included in the benefit-cost ratio while the feasible region of alternatives will have been greatly enlarged.

Cost-Benefit and Cost-Effectiveness Analysis and Other Urban Management Techniques

Used in conjunction with other techniques, cost-benefit and cost-effectiveness analysis can be a valuable tool for the planning and programming of public projects.

Planning-Programming-Budgeting[14] links cost-benefit analysis and hierarchial goal formulation. In PPB, objectives that are to be met are defined and then programs, sub-programs and elements are designed and delineated. Then each of these can be evaluated using cost-benefit and/or cost-effectiveness analysis to determine if the objectives are being efficiently/effectively met. This information on program performance is then fed back and the original objectives and/or program design can be reviewed, and different priorities can be set.

Performance auditing can provide estimates as to whether a program is achieving the objectives for which it was instituted. It can tell us if the inflows and outflows of a project are equivalent to those that were predicted by cost-benefit analysis. It is important to do this because a project on paper is often not the project which actually gets implemented. Additional construction costs, time delays, mismanagement of the project, or simply misunderstandings can serve to increase the costs of a project significantly.

While cost-benefit and cost-effectiveness analysis attempt to estimate the future costs and benefits for the useful life of the project, unanticipated changes in population distribution, income, exogenous economic forces, government policy, tastes, and technology will upset these estimations and result in erroneous benefit-cost ratios. Long-range forecasting techniques, used in conjunction with cost-benefit and cost-effectiveness analysis, can reduce the errors in the perdiction of the future.

Finally, management-by-objectives (MBO) is designed to better identify and evaluate the objectives of an organization and to provide more employee participation in goal formulation. This, when combined with the evaluation of costs and benefits, should provide for a more efficient organizational framework. The people that implement the project will better know what problems are most likely to ensue and can thus provide better information to analysts so that recalculations of costs can be done most accurately. Also, mistakes and misunderstandings of organizational objectives and thus the best means for accomplishing these objectives would be diminished.

Conclusions

Cost-benefit and cost-effectiveness analyses, especially when used with other techniques, can be useful tools in project evaluation and of which planners and administrators should be knowledgeable.

This overview has been written as an introduction to some of the basic concepts underlying these techniques, as an exposure to the classes of problems which these techniques can usefully address, and as a warning to the practitioneer that limitations are inherent in their applications. The Cost-Benefit and Cost-Effectiveness Module should be considered suited to allowing the planner or administrator to intelligently and critically read a report containing the application of these techniques and allow him/her to decide whether the recommendations of the report are reasonable or justifiable or whether gross improper use of the techniques have led to misrepresentation of the relative merits of the alternatives. The module is not suitable for "how to do it" as a much longer training period would be necessary for the practitioneer to be able to design and fully implement an analysis specific to a complex problem situation. Nevertheless this module should be an excellent primer for those who wish to become fully skilled in the art and science of project evaluation.

ENDNOTES

1. Richard J. Hammond, Benefit-Cost Analysis and Water Pollution Control, Food Research Institute, Stanford, California, 1960, p. 4.

2. Ibid.

3. Flood Control Act of 1936, Quoted by Lawrence G. Hines in Environmental Issues, W. W. Norton & Co., N. Y., N. Y., 1973, p. 111.

4. Ibid.

5. Report to the Federal Inter-Agency River Basin Committee - Proposed Practices for Economic Analysis of River Basin Projects. Prepared by the Subcommittee on Benefits and Costs, May 1950, Gool Printing Office, Washington, D. C.

6. A. R. Prest and R. Turvey, Cost Benefit Analysis; A Survey, The Economic Journal, December, 1965, London, England, pp. 683.

7. Report to the Federal Inter-Agency River Basin Committee, op, cit., p. 13.

8. See glossary under discount-rate, present-value technique.

9. Morris Hill, Planning for Multiple Objectives, Monograph Series #5, Regional Science Research Institute, 1973, p. 5-6.

10. Edward S. Quade in Cost Effectiveness Analysis - Washington Operations Research Council. Edited by Thomas A. Goldman, Praeger, Washington, D. C., 1967, pp. 1-2.

11. Edward S. Quade, op. cit., p. 8.

12. Paul A. Samuelson, Economics, 8th Edition, McGraw-Hill Book Co., 1970, p. 453-454.

13. J. Kozlowski and J. T. Hughes, Threshold Analysis, The Architectural Press, London, England, p. 14.

14. Trevor Newton, Cost-Benefit Analysis in Administration, George Allen and Unwin L.T.D., London, England, pp. 237-239.

ANALYSIS OF DECISION TO ATTEND*

The following brief questionnaire is designed to help you describe the problem solving process you went through in deciding to attend this program. It is intended to increase your awareness of the learning questions that influence your decision to attend as well as to provide a starting point for sharing with staff and participants the kinds of needs and concerns you and others bring to workshop. The design for sharing your answers to the questionnaire during the first meeting is such that your responses can remain anonymous unless you choose to identify yourself in some way as you answer the questions.

1) Describe in a few sentences or phrases the problems or felt needs that brought you to this program. What questions are you seeking to answer?

Which of the following three phrases best characterizes how you feel about these needs right now?

My needs are critical and specific. I need to come away from this program with specific action plans to satisfy them.

My needs are less pressing and more general. I am here to discover and explore.

Some of both of the above.

2) What made you decide to come to this specific program? What have you heard about it? What features of it most attracted you? Again, answer briefly in a few sentences or phrases.

*Adapted from David A. Kolb, Building A Learning Community, NTDS Training Pamphlet #6.

Which of the following statements best characterizes your decision to attend this program?

I freely chose to come myself with no external prossure to attend this program.

I was basically sent here by forces or events outside of my control.

Some of both of the above.

3) What are your expectations about the workshop?

The best thing that could happen for me in the workshop is:

The worst thing that could happen to me is:

4) What are the resources and set of experiences which you bring to this workshop which the group as a whole may benefit from?

Exercise 1
THE USE OF PRESENT-VALUE TECHNIQUES IN COST-BENEFIT AND COST-EFFECTIVENESS ANALYSIS

Present-value technique is appropriate to any evaluation procedure when a stream of benefits and/or costs is distributed over time. Thus not only is the technique applicable to evaluating alternative capital expenditure projects but also to program proposals when program benefits can be expressed in terms of dollars.

We use the present-value technique to compare dollar values of benefits and costs when they occur at different points in time. Since we value objects in use now more than their future use, a dollar in use now is worth more than a dollar in use a year from now. For example, if we had a choice between having $100 now or $100 a year from now, most of us would select the former. If the choice were between $100 now and $110 one year from now, we may have a more difficult decision. If we were indifferent between these, then we would have an individual discount rate of 10%. But at any rate, to be unbiased in our evaluation procedure, it is desirable to express all dollar values as standard at one point in time. Somewhat arbitrarily, we generally choose to standardize all dollar values in the present-time, and thus we employ present-value techniques to translate all future dollar values into present dollar values.

The obverse of this discussion is the existence of an investment opportunity rate. This rate expresses the going highest return on public or private investments; any investment which yields a rate of opportunity costs - returns foregone. This rate is operationally difficult to measure. We instead use the minimum cost of capital facing the organization. Thus the organization would not rationally choose an investment which did not promise a rate of return at least as high as the cost of obtaining capital. Otherwise the capital could earn a higher rate of return remaining in the bank or some other guaranteed investment program (municipal bonds, etc.). It is then, at least operationally, the minimum cost of capital which is used as the discount rate for employing present-value techniques. The following example illustrates the procedure and uses of the present-value technique in project evaluation.

Example

Consider two alternate proposals to provide emergency health care facilities in a large metropolitan area.

Proposal I involves building a new centrally-located facility in a low-income area; the capital investment (front-end) costs have been estimated to be $15.0 million with annual operating costs = $1.0 million over an assumed 30 year life.

Proposal II involves using existing physical structures in three different locations. The capital investment here would be only $5.0 million in primarily renovation but the annual operating costs would be $2.0 million

for all three facilities. Assuming all other factors (including economic benefits) are equal, which proposal should be chosen on efficiency grounds if the discount rate were 6% and if the discount rate were 12%?

Analysis

a. at 6% discount rate

(i) Present value lifetime cost of Proposal I
= $15.0 million + present value of stream of costs equal to $1.0 million/year over 30 years.

(ii) Present value lifetime cost of Proposal II
= $5.0 million + present value of stream of costs equal to $2.0 million/year over 30 years.

(i) Present value = $15.0 million + (p.v. factor x $1.0 million)
= $15.0 million + (13.77 x $1.0 million)
= $15.0 million + $13.77 million
= $28.77 million

(ii) Present value = $5.0 million + (p.v. factor x $2.0 million)
= $5.0 million + (13.77 x $2.0 million)
= $5.0 million + $27.54 million
= $32.54 million

b. at 12% discount rate

(i) Present value lifetime cost of Proposal I
= $15.0 million + (p.v. factor x $1.0 million)
= $15.0 million + (8.06 x $1.0 million)
= $15.0 million + 8.06 million
= $23.06 million

(ii) Present value lifetime cost of Proposal II
= $5.0 million + (p.v. factor + $2.0 million)
= $5.0 million + (8.06 x $2.0 million)
= $5.0 million + $16.12 million
= $21.12 million

The analysis shows that the choice of the most efficient proposal is a function of the discount rate used. With a discount rate of 6%, Proposal I is the most cost-efficient alternative. An analysis using the 12% discount rate, however, yields Proposal II as the best choice on efficiency grounds.

Questions

a. Explain why the discount rate affects the two alternative proposals differentially.

b. Which alternative would you choose if the discount rate were 8% but the useful lifetime were only 20 years?

PRESENT VALUE OF $1 RECEIVED ANNUALLY FOR N YEARS

Years (N)	1%	2%	4%	6%	8%	10%	12%	14%	15%	16%	18%	20%	22%	24%	25%	26%	28%	30%	35%	40%	45%	50%
1.....	0.990	0.980	0.962	0.943	0.926	0.909	0.893	0.877	0.870	0.862	0.847	0.833	0.820	0.806	0.800	0.794	0.781	0.769	0.741	0.714	0.690	0.667
2.....	1.970	1.942	1.886	1.833	1.783	1.736	1.690	1.647	1.626	1.605	1.566	1.528	1.492	1.457	1.440	1.424	1.392	1.361	1.289	1.224	1.165	1.111
3.....	2.941	2.884	2.775	2.671	2.577	2.487	2.402	2.322	2.283	2.246	2.174	2.106	2.042	1.981	1.952	1.923	1.866	1.816	1.696	1.589	1.491	1.407
4.....	3.902	3.808	3.630	3.465	3.312	3.170	3.037	2.914	2.855	2.798	2.690	2.589	2.494	2.404	2.362	2.320	2.241	2.166	1.997	1.849	1.720	1.605
5.....	4.853	4.713	4.452	4.212	3.993	3.791	3.605	3.435	3.352	3.274	3.127	2.991	2.864	2.745	2.689	2.635	2.532	2.436	2.220	2.035	1.876	1.737
6.....	5.795	5.601	5.242	4.917	4.623	4.355	4.111	3.889	3.784	3.685	3.498	3.326	3.167	3.020	2.951	2.885	2.759	2.643	2.385	2.168	1.983	1.824
7.....	6.728	6.472	6.002	5.582	5.206	4.868	4.564	4.288	4.160	4.039	3.812	3.605	3.416	3.242	3.161	3.083	2.937	2.802	2.508	2.263	2.057	1.883
8.....	7.652	7.325	6.733	6.210	5.747	5.335	4.968	4.639	4.487	4.344	4.078	3.837	3.619	3.421	3.329	3.241	3.076	2.925	2.598	2.331	2.108	1.922
9.....	8.566	8.162	7.435	6.802	6.247	5.759	5.328	4.946	4.772	4.607	4.303	4.031	3.786	3.566	3.463	3.366	3.184	3.019	2.665	2.379	2.144	1.948
10.....	9.471	8.983	8.111	7.360	6.710	6.145	5.650	5.216	5.019	4.833	4.494	4.192	3.921	3.682	3.571	3.465	3.269	3.092	2.715	2.414	2.168	1.965
11.....	10.368	9.787	8.760	7.887	7.139	6.495	5.937	5.453	5.234	5.029	4.656	4.327	4.035	3.776	3.656	3.544	3.335	3.147	2.757	2.438	2.185	1.977
12.....	11.255	10.575	9.385	8.384	7.536	6.814	6.194	5.660	5.421	5.197	4.793	4.439	4.127	3.851	3.725	3.606	3.387	3.190	2.779	2.456	2.196	1.985
13.....	12.134	11.343	9.986	8.853	7.904	7.103	6.424	5.842	5.583	5.342	4.910	4.533	4.203	3.912	3.780	3.656	3.427	3.223	2.799	2.468	2.204	1.990
14.....	13.004	12.106	10.563	9.295	8.244	7.367	6.628	6.002	5.724	5.468	5.008	4.611	4.265	3.962	3.824	3.695	3.459	3.249	2.814	2.477	2.210	1.993
15.....	13.865	12.849	11.118	9.712	8.559	7.606	6.811	6.142	5.847	5.575	5.092	4.675	4.315	4.001	3.859	3.726	3.481	3.268	2.825	2.484	2.214	1.995
16.....	14.718	13.578	11.652	10.106	8.851	7.824	6.974	6.265	5.954	5.669	5.162	4.730	4.357	4.033	3.887	3.751	3.503	3.283	2.834	2.489	2.216	1.997
17.....	15.562	14.292	12.166	10.477	9.122	8.022	7.120	6.373	6.047	5.749	5.222	4.775	4.391	4.059	3.910	3.771	3.518	3.295	2.840	2.492	2.218	1.998
18.....	16.398	14.992	12.659	10.828	9.372	8.201	7.250	6.467	6.128	5.818	5.273	4.812	4.419	4.080	3.928	3.786	3.529	3.304	2.844	2.494	2.219	1.999
19.....	17.226	15.678	13.134	11.158	9.604	8.365	7.366	6.550	6.198	5.877	5.316	4.844	4.442	4.097	3.942	3.799	3.539	3.311	2.848	2.496	2.220	1.999
20.....	18.046	16.351	13.590	11.470	9.818	8.514	7.469	6.623	6.259	5.929	5.353	4.870	4.460	4.110	3.954	3.808	3.546	3.316	2.850	2.497	2.221	1.999
21.....	18.857	17.011	14.029	11.764	10.017	8.649	7.562	6.687	6.312	5.973	5.384	4.891	4.476	4.121	3.963	3.816	3.551	3.320	2.852	2.498	2.221	2.000
22.....	19.660	17.658	14.451	12.042	10.201	8.772	7.645	6.743	6.359	6.011	5.410	4.909	4.488	4.130	3.970	3.822	3.556	3.321	2.851	2.498	2.222	2.000
23.....	20.456	18.292	14.857	12.303	10.371	8.883	7.718	6.792	6.399	6.044	5.432	4.925	4.499	4.137	3.976	3.827	3.559	3.325	2.854	2.499	2.222	2.000
24.....	21.243	18.914	15.247	12.550	10.529	8.985	7.784	6.835	6.434	6.073	5.451	4.937	4.507	4.143	3.981	3.831	3.562	3.327	2.855	2.499	2.221	2.000
25.....	22.023	19.523	15.622	12.783	10.675	9.077	7.843	6.873	6.464	6.097	5.467	4.948	4.514	4.147	3.985	3.834	3.564	3.329	2.856	2.499	2.222	2.000
26.....	22.795	20.121	15.981	13.003	10.810	9.161	7.896	6.906	6.491	6.118	5.480	4.956	4.520	4.151	3.988	3.837	3.566	3.330	2.856	2.500	2.222	2.000
27.....	23.560	20.707	16.330	13.211	10.935	9.237	7.943	6.935	6.514	6.136	5.492	4.964	4.524	4.154	3.990	3.839	3.567	3.331	2.856	2.500	2.222	2.000
28.....	24.316	21.281	16.663	13.406	11.051	9.307	7.984	6.961	6.534	6.152	5.502	4.970	4.528	4.157	3.992	3.840	3.568	3.331	2.857	2.500	2.222	2.000
29.....	25.066	21.844	16.984	13.591	11.158	9.370	8.022	6.983	6.551	6.166	5.510	4.975	4.531	4.159	3.994	3.841	3.569	3.332	2.857	2.500	2.222	2.000
30.....	25.808	22.396	17.292	13.765	11.258	9.427	8.055	7.003	6.566	6.177	5.517	4.979	4.534	4.160	3.995	3.842	3.569	3.332	2.857	2.500	2.222	2.000
40.....	32.835	27.355	19.793	15.046	11.925	9.779	8.244	7.105	6.642	6.234	5.548	4.997	4.544	4.166	3.999	3.846	3.571	3.333	2.857	2.500	2.222	2.000
50.....	39.196	31.424	21.482	15.762	12.234	9.915	8.304	7.133	6.661	6.246	5.554	4.999	4.545	4.167	4.000	3.846	3.571	3.333	2.857	2.500	2.222	2.000

Source: From tables computed by Jerome Bracken and Charles J. Christenson. Copyright © 1961 by the President and Fellows of Harvard College. Used by permission.

Exercise 2
CRITERION FOR EVALUATION:
Excess Benefit or Benefit-Cost Ratio?

The Rhoidville Public Library Association is in a quandry. It has a choice between building a new wing on its existing centrally-located facility (Proposal A) or purchasing a book mobile (Proposal B). An economic analyst in the Rhoidville Planning Department was asked to prepare an estimate of the benefits and costs of each proposal so that the head librarian could make a recommendation to the Board of Directors at the next monthly meeting.

The analyst identified and estimated all of the relevant costs and benefits over the life of each project, respectively, and appropriately discounted these using a discount rate provided by the Finance Director's office. The discounted costs and benefits were as follows (as presented to the head librarian):

	Discounted Costs ($)	Discounted Benefits ($)
Proposal A	100,000	150,000
Proposal B	20,000	50,000

Now the head librarian, while not versed in the art of cost-benefit analysis, had a great deal of native intelligence. He reasoned that since the difference of benefits and costs for Proposal A = $50,000 and the difference between benefits and costs for Proposal B = $30,000, that Proposal A was the best choice.

Well, one of the members of the Board of Directors, having had some economics in college, remembered that decisions should be made on the "margin", and this meant calculating the benefit-cost ratio. The scoreboard at that point looked like the following:

	Discounted Costs	Discounted Benefits	B - C	B/C	$\frac{B-C}{C}$
Proposal A	100,000	150,000	50,000	1.5	0.5
Proposal B	20,000	50,000	30,000	2.5	1.5

There was a deadlock at the meeting: other than these two individuals, no one else could decide which proposal was preferred because no one could decide which criterion to use.

What criterion would you use? Can you think of any guidelines for deciding which criterion should be applied in a given situation?

CASE STUDY 1
Simple Cost-Benefit Analysis

Mr. Homer R. B. Rhoid, chief transportation planner for the city of Morganville, has contracted an engineering firm to prepare a design for the relocation of a length of a state-highway bypass. The existing link would be abandoned if a new, alternative route could be shown to be more economical than the present one; if it could allow more vehicles to use the link with less traffic congestion.

At the present time traffic on the existing link averages 1,500 vehicles/day (v.p.d.). Projections based upon the expected growth of Morganville within the next twenty years indicate that there would be a demand of 2,000 v.p.d. on the present link in 1996. The tentatively planned relocation of the link would result in an estimated generation of 2,500 v.p.d. The extra 500 v.p.d. would be a result of induced land development due to the presence of the new link. The traffic in both cases would be composed mostly of passenger cars with only a small (5-10%) fraction composed of trucks.

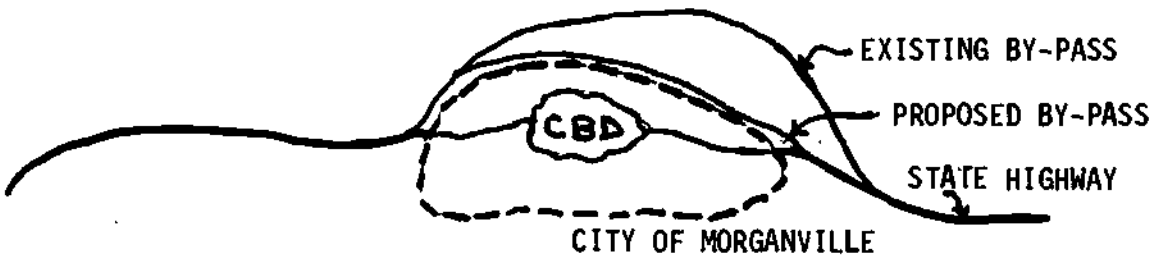

Figure 1

The proposed alternative link would have a pavement width of 20 feet (compared with 18 feet on the existing link). This factor, together with improved alighment and grades, permits distinction between free and normal operations.

The results of the engineers' study is shown in the following table. The table has attempted to identify the salient variables and to estimate the values of these variables so that a rational decision could be made by Rhoid as to whether to recommend building a new link.

TABLE 1.1

Variable	Existing Link	Proposed Link
1. Future volume (v.p.d.)	2,000	2,500
2. 30 Highest hourly volume (v.p.d.)	375	450
3. Service volume, level D (v.p.d.)	450	715
4. Ratio (2./3.)	0.83	0.63
5. Type of operation	Normal	Free
6. Design Speed (m.p.h.)	50	60
7. Running Speed	35	42

TABLE 1.1 (continued)

	Variable	Existing Link	Proposed Link
8.	No. lanes	2	2
9.	Length (miles)	2.5	1.5
10.	Grade class (%)	0-5	0-3
11.	Surface and condition	Paved-good	Paved-good
12.	Curvature	50%-4°	Negligible
13.	Unit cost ($/vehicle mile)	.1024	.901
14.	Estimated pavement life (yrs).	---	20.
15.	Estimated rights of way life (yrs.)	---	60.
16.	Estimated life, other (yrs.)	---	40.
17.	Pavement cost ($)	---	66,000
18.	R.O.W. cost ($)	---	33,000
19.	Other cost ($)	---	451,000
20.	Annual pavement cost ($)	---	5,290
21.	Annual R.O.W. cost ($)	---	1,740
22.	Annual other costs ($)	---	26,290
23.	Total annual capital cost ($)	---	33,320
24.	Maintenance cost ($/mile)	1,100	880

The curvature on the new facility would be generally flat. The existing link, however, has a relatively large number of curves which limits the maximum design speed to about 50 m.p.h. The calculated unit cost can be found in Row 13 of Table 1.1. Based upon the data generated by the engineers' study, Rhoid and his staff have decided to conduct a cost-benefit analysis of the two alternative plans. Essentially their methodology will attempt to measure the relative benefits and costs of building the new link as opposed to keeping the existing link.

The net economic benefits of the proposed new facility over the existing one can be described by equation 1:

$$B_n - B_o = 1/2(C_oI_o - C_nI_n)(V_n + V_o)(365) \qquad (1)$$

where

B_n = annual vehicle operating and time benefit for the proposed roadway.

B_o = annual vehicle operating and time benefit for the existing roadway.

C_oI_o = total cost of a trip over the existing roadway.

C_nI_n = total cost of a trip over the new roadway.

V_n = annual average daily volume estimated for the new roadway.

V_o = annual average daily volume observed for the existing roadway.

The total annual highway cost B given by

$$C = CRF_{in}K_1 + CRF_{in}K_2 + CRF_{in}K_3 + M \qquad (2)$$

where

C = total annual highway cost

K_1, K_2, K_3 = capital costs of each item:

Pavement costs = K_1

Right-of-way costs = K_2

Other capital costs = K_3

CRF_{in} = capital recovery factors for a known rate of interest, i, and amortization of total cost of each of the above items based on its average expected life, N.

M_n = the annual cost for the maintenance of the proposed link.

M_o = the annual cost for the maintenance of the existing link

The general equation which Rhoid used for calculating the benefit-cost ratio was

$$\frac{\Delta B}{\Delta C} = \frac{B_n - B_o}{C_n - C_o} = \frac{1/2\ (C_oI_o - C_nI_n)(V_n + V_o)\ (365)}{CRF_{in}K_1 + CRF_{in}K_2 + CRF_{in}K_3 + M_n - M_o} \qquad (3)$$

With the aid of a fact calculator, one of Rhoid's planning technicians did the arithmetic for the numerators:

$$B_n - B_o = 1/2[(0.1024)(2.5) - (.0901)(1.50)](2500 + 2000)(365)$$
$$= \$99,250. \qquad (4)$$

The average annual unit maintenance cost on the existing route was estimated to be $1100/mile or a total of $2750. The average annual unit maintenance cost of the proposed route was estimated to be $880/mile or a total of $1320.

The total estimated cost of the proposed route (less maintenance costs) was calculated to be $550,000 but this had to be disaggregated by the individual items (K_1, K_2, K_3) since the life expectancy of each of these separate items was different. The prevailing local opportunity cost of capital was 5%. The appropriate capital recovery factor ($CRF_{.05,N}$) was then selected from Table 2 for each of the items, and turn out to be 0.0802, 0.0528, and 0.0583, respectively. With this information Rhoid, himself, calculated the annual capital cost of the proposed alternative route to be $33,320.

The benefit-cost ratio for the proposed alternative was then directly found to be

$$\frac{\Delta B}{\Delta C} = \frac{99,250}{33,320 + 1320 - 2750} = 3.11. \qquad (5)$$

Rhoid's analysis indicated that the estimated annual user benefits from rerouting the bypass would exceed three times the annualized costs of the venture, and thus recommended to the city manager that the venture be undertaken as soon as possible - before further inflation would raise the total costs of the project or the interest rates went up.

In the meantime, however, an ambitious member of Rhoid's staff, while working on his own, made a hunch that user demand would not go as high as 2500 vehicles per day unless there were uncontrolled develop-

TABLE 1.2 Capital Recovery Factors

N Years	Rate of Interest, in percent (i) 1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1	1.0100	1.0150	1.0200	1.0250	1.0300	1.0350	1.0400	1.0450	1.0500	1.0550	1.0600
2	0.5075	0.5113	0.5150	0.5188	0.5226	0.5264	0.5302	0.5340	0.5378	0.5416	0.5454
3	0.3400	0.3484	0.3567	0.3501	0.3535	0.3569	0.3603	0.3638	0.3672	0.3707	0.3741
4	0.2563	0.2594	0.2626	0.2658	0.2690	0.2723	0.2755	0.2787	0.2820	0.2853	0.2886
5	0.2060	0.2091	0.2121	0.2152	0.2183	0.2215	0.2246	0.2278	0.2310	0.2342	0.2374
6	0.1725	0.1755	0.1785	0.1815	0.1846	0.1877	0.1908	0.1939	0.1970	0.2002	0.2034
7	0.1486	0.1515	0.1545	0.1575	0.1605	0.1635	0.1666	0.1697	0.1728	0.1760	0.1791
8	0.1307	0.1336	0.1365	0.1395	0.1425	0.1455	0.1485	0.1516	0.1547	0.1579	0.1610
9	0.1167	0.1196	0.1225	0.1255	0.1284	0.1314	0.1345	0.1376	0.1407	0.1438	0.1470
10	0.1056	0.1084	0.1113	0.1143	0.1172	0.1202	0.1233	0.1234	0.1295	0.1327	0.1359
11	0.0965	0.0993	0.1022	0.1051	0.1081	0.1111	0.1141	0.1172	0.1204	0.1236	0.1268
12	0.0888	0.0917	0.0945	0.0975	0.1005	0.1035	0.1065	0.1097	0.1128	0.1160	0.1193
13	0.0824	0.0852	0.0881	0.0910	0.0940	0.0971	0.1001	0.1033	0.1065	0.1097	0.1130
14	0.0769	0.0797	0.0826	0.0855	0.0885	0.0916	0.0947	0.0978	0.1010	0.1043	0.1076
15	0.0721	0.0749	0.0778	0.0808	0.0838	0.0868	0.0899	0.0931	0.0963	0.0996	0.1030
16	0.0679	0.0708	0.0737	0.0766	0.0796	0.0827	0.0858	0.0890	0.0923	0.0956	0.0989
17	0.0643	0.0671	0.0700	0.0729	0.0759	0.0790	0.0820	0.0854	0.0887	0.0920	0.0954
18	0.0610	0.0688	0.0667	0.0697	0.0727	0.0758	0.0790	0.0822	0.0855	0.0889	0.0923
19	0.0581	0.0609	0.0638	0.0688	0.0698	0.0729	0.0761	0.0794	0.0827	0.0861	0.0896
20	0.0554	0.0582	0.0611	0.0641	0.0672	0.0704	0.0736	0.0769	0.0802	0.0837	0.0872
21	0.0530	0.0559	0.0588	0.0618	0.0649	0.0680	0.0713	0.0746	0.0780	0.0815	0.0850
22	0.0509	0.0537	0.0566	0.0596	0.0627	0.0659	0.0692	0.0725	0.0760	0.0795	0.0830
23	0.0489	0.0517	0.0547	0.0577	0.0608	0.0640	0.0673	0.0707	0.0741	0.0777	0.0813
24	0.0471	0.0499	0.0529	0.0559	0.0590	0.0623	0.0656	0.0690	0.0725	0.0760	0.0797
25	0.0454	0.0483	0.0512	0.0543	0.0574	0.0607	0.0640	0.0674	0.0709	0.0745	0.0782
26	0.0439	0.0467	0.0497	0.0528	0.0559	0.0592	0.0626	0.0660	0.0696	0.0732	0.0769
27	0.0424	0.0453	0.0483	0.0514	0.0546	0.0579	0.0612	0.0647	0.0683	0.0719	0.0757
28	0.0411	0.0440	0.0470	0.0501	0.0533	0.0566	0.0600	0.0635	0.0671	0.0708	0.0746
29	0.0399	0.0428	0.0458	0.0489	0.0521	0.0554	0.0589	0.0624	0.0660	0.0698	0.0736
30	0.0387	0.0416	0.0446	0.0478	0.0510	0.0544	0.0578	0.0614	0.0651	0.0688	0.0726
31	0.0377	0.0406	0.0436	0.0467	0.0500	0.0534	0.0569	0.0604	0.0641	0.0679	0.0718
32	0.0367	0.0396	0.0426	0.0458	0.0490	0.0524	0.0559	0.0596	0.0633	0.0671	0.0710
33	0.0357	0.0386	0.0417	0.0449	0.0481	0.0516	0.0551	0.0587	0.0625	0.0663	0.0703
34	0.0348	0.0378	0.0408	0.0440	0.0473	0.0507	0.0543	0.0580	0.0617	0.0656	0.0696
35	0.0340	0.0369	0.0400	0.0432	0.0465	0.0500	0.0536	0.0573	0.0611	0.0650	0.0690
36	0.0332	0.0361	0.0392	0.0425	0.0458	0.0493	0.0529	0.0566	0.0604	0.0644	0.0684
37	0.0325	0.0354	0.0385	0.0417	0.0451	0.0486	0.0522	0.0560	0.0598	0.0638	0.0679
38	0.0318	0.0347	0.0378	0.0411	0.0445	0.0480	0.0516	0.0554	0.0593	0.0633	0.0673
39	0.0311	0.0341	0.0372	0.0404	0.0438	0.0474	0.0511	0.0549	0.0588	0.0628	0.0669
40	0.0305	0.0334	0.0365	0.0398	0.0433	0.0468	0.0505	0.0543	0.0583	0.0623	0.0665
41	0.0229	0.0328	0.0360	0.0393	0.0427	0.0463	0.0500	0.0539	0.0578	0.0619	0.0661
42	0.0293	0.0323	0.0354	0.0387	0.0422	0.0458	0.0495	0.0534	0.0574	0.0615	0.0657
43	0.0287	0.0317	0.0349	0.0382	0.0417	0.0453	0.0491	0.0530	0.0570	0.0611	0.0653
44	0.0282	0.0312	0.0344	0.0377	0.0412	0.0449	0.0487	0.0526	0.0566	0.0608	0.0650
45	0.0277	0.0307	0.0339	0.0373	0.0408	0.0445	0.0483	0.0522	0.0563	0.0604	0.0647
46	0.0272	0.0303	0.0335	0.0368	0.0404	0.0441	0.0479	0.0518	0.0559	0.0601	0.0644
47	0.0268	0.0298	0.0330	0.0364	0.0400	0.0437	0.0475	0.0515	0.0556	0.0598	0.0641
48	0.0263	0.0294	0.0326	0.0360	0.0396	0.0433	0.0472	0.0512	0.0553	0.0595	0.0639
49	0.0259	0.0290	0.0322	0.0356	0.0392	0.0430	0.0469	0.0509	0.0550	0.0593	0.0637
50	0.0255	0.0286	0.0318	0.0353	0.0389	0.0426	0.0465	0.0506	0.0548	0.0591	0.0634
60	0.0222	0.0254	0.0288	0.0324	0.0361	0.0401	0.0442	0.0485	0.0528	0.0573	0.0619
70	0.0199	0.0232	0.0267	0.0304	0.0343	0.0385	0.0427	0.0472	0.0517	0.0563	0.0610
80	0.0182	0.0215	0.0252	0.0291	0.0331	0.0374	0.0418	0.0464	0.0510	0.0558	0.0606
90	0.0169	0.0203	0.0240	0.0280	0.0323	0.0367	0.0412	0.0459	0.0506	0.0554	0.0603
100	0.0159	0.0194	0.0232	0.0273	0.0316	0.0362	0.0408	0.0456	0.0504	0.0553	0.0602

Source: J. W. Dickey, Metropolitan Transportation Planning (New York: McGraw-Hill Book Company, 1975).

ment along the link, which the staff member felt certain would not be tolerated. Thus, the staff member reasoned, the link could be redesigned from an engineering point of view such that it could be built at a lower cost but along the same route as the engineering consultants had advocated.

The staff member proposed an alternative design which allowed a volume of 2300 v.p.d. and whose unit cost amounted to 10.18¢/vehicle-mile, but whose capital costs were $70,000, $5000, and $451,000 for pavement costs, right-of-way costs and other costs, respectively.

Performing the calculations to compute the benefit-cost ratio of the staff member's brainchild:

1. Benefits

$$B_n - B_o = 1/2[(0.1024)(2.5) - (0.1018)(1.5)](2300 + 2000)(365) = \$81,065$$

2. Annualized Capital Costs

$$C_n = 0.0802\ (70,000) + 0.0528(5,000) + 0.0583(300,000) = 23,360$$

3. Benefit-Cost Ratio

$$\frac{\Delta B}{\Delta C} = \frac{81,065}{23,360 + 1320 - 2750} = 3.70.$$

The benefit-cost ratio, lo and behold was higher than that for the consultants' design.

Rhoid, for his part was suspicious since he had made the decision to hire the engineering consultants, plus he was uncomfortable with the ambitions of his young, bright, staff member. Rhoid decided that he should calculate a benefit-cost ratio which compared his staff member's proposal with that of the consultants. Since the consultants design costs $20,000 more than the staff-members', Rhoid was implicitly asking if the additional funds needed for the higher priced design could be justified in terms of the additional benefits it would bring to the users.

Rhoid let n_1 designate the consultants' design, n_2 the staff member's design.

Thus:

$$B_{n_1} - B_{n_2} = 1/2[(0.1018)(1.5) - (.0901)(1.5)](2500 + 2300)(365) = \$15,400$$

$$C_{n_1} - C_{n_2} = 33,320 + 1,320 - 23,360 - 1320 = \$9,960$$

$$\frac{\Delta B}{\Delta C} = \frac{\$15,400}{\$9,960} = 1.55.$$

Rhoid's suspicions were justified. The extra expenditure for the more costly proposal, on paper, gave a 55% greater return. Since Morganville had the necessary funds to go with the more expensive proposal, the City Council, acting on Rhoid's recommendation, voted to follow the consultant's advice. The ambitious young staff member quit his job and started a consulting firm of his own.

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* The above case study was adapted from materials in J. W. Dickey, senior author, Metropolitan Transportation Planning (New York: McGraw Hill Book Company, 1975).

SCENARIO 1
Simple Cost-Benefit Analysis

Homer Rhoid used a cost-benefit calculus to justify on ecomonic efficiency grounds the recommended design made by the engineering consultants. If the proposed rerouting could have been decomposed as a design problem, however, perhaps a different decision, using the same calculus, might have been reached.

Suppose that the 1.5 mile stretch could be seen as two stretches each of about half the distance either of which would be built alone and connected to the already existing road network (by-pass). See Figure 1.

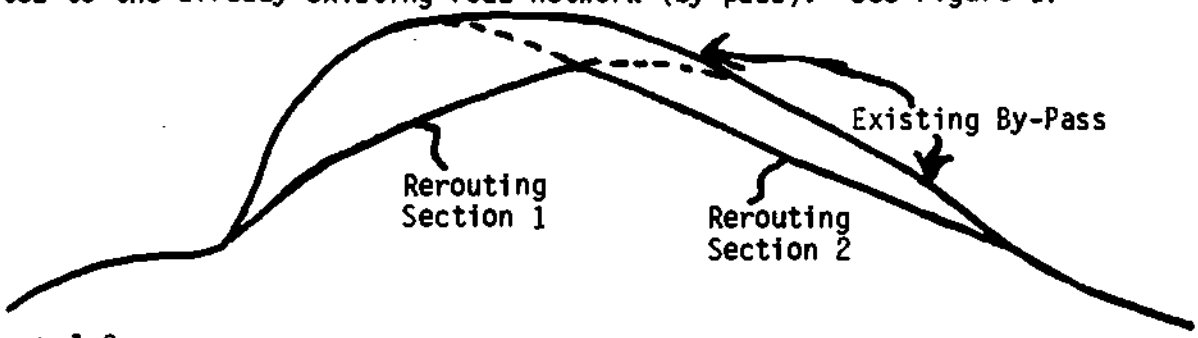

Figure 1.2

This would be a desirable view of the design problem, if, for instance, there was a large amount of uncertainty as to the total resources available, i.e., there might not be enough appropriation to build the entire stretch but enough for a portion of it. Alternatively, the right-of-way costs may be concentrated in one section of the proposed rerouting and hence it may be economical to use the existing by-pass for that section.

Let's suppose we had the following information for the existing by-pass by each section, and also the estimates of costs and performance of the proposed by-pass, also <u>by section</u>.

TABLE 1.3 EXISTING BY-PASS

	Variable	Section 1	Section 2
1.	Future volume (v.p.d.)	2000	2000
2.	Length (miles)	1.4	1.1
3.	Design speed (m.p.h.)	50	50
4.	Running speed	37	34
5.	Unit cost ($/vehicle-mile)	0.1002	0.1061
6.	Service volume, level D (v.p.d.)	450	450
7.	Maintenance cost ($/mile)	1100	1100

TABLE 1.4 PROPOSED BY-PASS

		Section 1	Section 2
1.	Future volume	2500	2500
2.	Length	0.90	0.80
3.	Design speed	60	60
4.	Running speed	45	40
5.	Unit cost ($/vehicle-mile)	0.0877	0.1040
6.	Service volume	700	700
7.	Estimated pavement life (yrs.)	20.0	20.0
8.	Estimated R.O.W. life (yrs.)	60.0	60.0
9.	Estimated life, other (yrs.)	40.0	40.0
10.	Pavement cost ($)	35,000	38,000
11.	R.O.W. cost ($)	13,000	24,000
12.	Other capital costs ($)	225,000	230,000
13.	Maintenance costs ($/mile)	870	900

The prevailing interest rate is 6%. On the basis of economic efficiency, would you build both sections of the proposed by-pass, only one (which one?), or neither? (Hint: consider the interaction effects between the existing and proposed by-pass if only one section of the proposed by-pass is built.)

CASE STUDY 2*
Simple Cost-Effectiveness Analysis

The Urban Mass Transit Agency in the Department of Transportation, Washington, D. C. has been eager to give 100% financial support for demonstration projects in new technology, rapid transit systems. DOT has contacted Homer Rhoid, Chief Transportation Planner in Morganville to find out if Morganville would be interested in having Federal transportation funds for mass transit. There was no hesitancy on Rhoid's part so a team from DOT travelled to Morganville to meet the famous Rhoid and explore which of four systems would be most suitable as the Morganville Rapid Transit Demonstration Project. The four alternatives were: (1) the Safeage Monorail; (2) the Electric Railway (Duorail); (3) the Westinghouse Skybus; and (4) the Alweg Monorail. The DOT officials put two constraints on the choice process: (i) the system had to be finished in two years; and (ii) the system needed to have a capacity of 7500 persons per hour (pph). Rhoid was told to make a decision within thirty days as to which system the city would use.

Rhoid met with his staff and told them that he wanted an evaluation done which would reveal (a) the quality of service which each system could give; (b) the likely environmental effects of each alternative system; and (c) the estimates of the capital and operating costs of each system. The staff, with the valuable assistance of people at DOT, was able to construct Table 2.1 with the information as shown.

The only notable differences on measures of effectiveness among the four appeared to be:

(a) The skybus had a slightly lower maximum speed and deceleration rate.
(b) The Safeage monorail, hanging below the guideway, would require a taller structure and also a major structure on the ground level.
(c) Switching would be easiest for the duorail.
(d) The duorail and the skybus require the least diameter tunnel.
(e) The Safeage monorail could have the longest elevated beam span but also the widest.
(f) The duorail was found to be somewhat louder than the others.

Rhoid was in a quandry: no one alternative dominated the others in effectiveness measures. The duorail was, however, significantly cheaper to build and operate than the other three.

Thus, in the absence of any "weighting" scheme, Rhoid selected the duorial system and informed DOT officials of his decision.

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* This case study was adapted from materials in J. W. Dickey, senior author, Metropolitan Transportation Planning, (New York: McGraw Hill Book Company, 1975).

Table 2.1

EFFECTIVENESS AND COST CHARACTERISTICS FOR FOUR POSSIBLE RAPID TRANSIT SYSTEMS FOR MORGANVILLE

Effectiveness Measures	Safeage Monorail	Duorail	Skybus	Alweg Monorail
Could be built in 2 years	Yes	Yes	Yes	Yes
Route Capacity of at least 7500 pph	Yes	Yes	Yes	Yes
Maximum Speed (mph)	50	60	50	50
Mean acceleration/deceleration (mph) sec	3.3	3.0	2.5	2.8
Car Capacity (persons)	173	279	120	360
Height of guideway above ground (ft)	over 16.5	16.5	16.5	16.4
Beam Span (ft.)	104	60	60	65
Width of Elevated Span (ft.)	30.0	27.5	19.8	15.5
Use of Ground Level	Suspended	On Ground	On Ground	On Ground
Tunnel Diameter (ft.)	17.0	15.6	14.0	18.3
Switching	Slow	Fast	?	Slow
Noise Level (internal) dB (A)	68	71	?75	81
Noise Level (external) dB (A)	81	88	?85	80
Total Car Requirements for:				
2,000 pph	15	9	22	14
4,000 pph	30	18	44	28
6,000 pph	45	27	66	42
Train Headway (min.) at:				
2,000 pph	2.65	2.84	2.87	3.64
4,000 pph	2.65	2.84	2.87	2.76
6,000 pph	2.65	2.84	2.87	2.44

Cost Measures	Safeage Monorail	Duorail	Skybus	Alweg Monorail
Total Capital Costs ($) (At 6,000 design hour capacity)	40,055,000	30,595,000	33,120,000	33,460,000
Annual Operation & Maintenance Costs (At 6,000 design hour capacity)	1,020,000	705,000	900,000	880,000
Total Annual Costs ($)	3,675,000	2,665,000	3,065,000	3,045,000

SCENARIO 2
Cost-Effectiveness Analysis

D.O.T. officals have just handed down revised standards for new technology rapid transit systems. These new standards include:

- maximum external noise levels of 81 decibels and internal noise levels to 75 decibels.
- elevated span width no greater than 25 feet (greater than this amount limits route flexibility and creates a greater disruptive effect in the neighborhoods).
- maximum use of U.S. made components.
- minimize travel time.

Homer Phoid must now take another look at his selection of a rapid transit system. Please help him determine whether the Duorail is still preferred, or some other system should now be chosen in view of the new constraints and minimum levels of effectiveness.

The following information will help you in your determination:

(1) The cost of reducing the noise levels for the Duorail is $400,000 for the first decibel reduction and grows with each successive decibel reduction by a factor of 1.25 from the previous cost. For the Skybus and Alweg monorail the initial decibel reduction will cost $200,000 with successive reductions increasing in cost by a factor of 1.25 also.

(2) A 0-5% bonus or reduction in total capital costs before deductions for time savings (next item) will be achieved for each 10% of these costs which are American-made products. The percentage of American components (by $) are: Safeage Monorail 80%, Duorail 60%, Skybus 100%, and Alweg Monorail 20%.

(3) Travel time should be estimated over a distance of one mile between stops. The estimated total dollar benefit from a one second time saving between stops one mile apart for all transit users combined is estimated to be $500,000 over the life of the investment.

(4) Every foot wider than 25 feet of an elevated span will be assessed an additional $500,000/ft. to cover the costs of community disruption.

CASE STUDY 3*
The Morganville - LTIC Program

In an effort to help communities achieve a balance between its demand and supply of labor skills and also to reduce the incidence of local poverty, a program called Labor Training in the Community (LTIC) was concocted by the Feds. Homer Rhoid's smarter and younger sister read somewhere that the Feds were looking for a depressed area to try out the new program. Ms. felt that Morganville was as good a labor market as any for receiving freebies from Washington, so as Director of the Anti-Poverty Program, applied and received the contract award for Morganville.

A choice had to be made, however, between two alternative administrations of the program, and both alternatives were to be "tested" in Morganville in an attempt to discover which would be more cost-efficient. The two alternatives were: (1) On the Job Training, in which individuals were to be first hired by the particular firms and then provide the training commensurate with the skills demanded; (2) Institutional Training, in which individuals would have their skills upgraded, before hiring by employers. In this case the LTIC would make a contract with an appropriate public or quasi-public educational institution which specialized in vocational training.

After the first 18 months of administrating both alternative programs, a survey was designed to elicit information from employers about those trainees who either were given OJT from the firm and subsequently worked in a normal capacity at the same firm, or had attended the Institutional Training Program and subsequently placed with the local firms.

The Allocative Benefits of Training

The program evaluators in Washington devised a measure of the present-value of the benefits which the alternative administrations of the LTIC program conferred upon the community (allocative benefits). This measure was:

$$V_a = \sum_{N=A}^{64} \frac{Y_a P_n (1 + X)^{N-A+\frac{1}{2}}}{(1 + R)^{N-A+1}} \qquad (1)$$

where V_a = present value of all allocative training benefits from the average age of trainees at the end of the training period (A) through retirement (65).
Y_a = annual increase in earnings associated with the training.
P_n = number of survivors at age N.
R = rate of discount used to convert future earnings to their present values
X = annual increase in earnings levels due to rising productivity.

* This case study was adapted from materials in David O. Sewell, "The MITCE Project as Judged by Efficiency and Distributional Investment Criteria," in Benefit Cost Analysis 1971, A. Harberger et. al.eds., (Chicago: Aldine-Atherton, Inc., 1972).

The evaluators used a social rate of discount = 10% since this was the figure which the Office of Management and Budgeting (OMB) had issued as a guideline for federal agencies to use in all discounting procedures involving public investment funds. After making several adjustments in the formula to allow for data limitations, the following figures were obtained for the present value of the allocative benefits associated with training by administrative program and by sex of trainee, and also for the LTIC program as a whole:*

Table 3.1 Allocative Benefits Associated with Training

Category	Benefits (dollars)/trainee
Female, On-the-Job	8,113
Male, On-the-Job	4,014
Male, Institutional	4,396
All LTIC Trainees	4,623

The Allocative Costs of Training

The following classes of costs for the program were identified by the evaluators of LTIC (per trainee) for the Morganville experiment:

(1) The LTIC Contract Costs. LTIC was not directly engaged in training its clients. The LTIC personnel in Morganville recruited workers for on-the-job and institutional training, checked their progress during training, and then attempted to find jobs for them when the recruits had completed their training. These costs were of a "overhead" nature in relation to the training process. While a good portion of this work could be viewed as initial costs (which subsequently would lower the costs of training in the period after the experimental period, the evaluators decided that it would be too difficult to separate the items of initial cost from the ongoing "overhead costs".

(2) Direct Course Costs of Institutional Training. The costs covered such items as salaries of instructors, materials used in the courses, expenditures to maintain and repair equipment, janitorial costs, and capital equipment and costs of physical, structural alteration necessary for the particular institutions to offer the courses which LTIC requested.

(3) Direct Course Costs of On-the-Job Training. These costs were subsidies to employers so as to provide incentives for the firms to take part in the LTIC program. A dollar amount per trainee was paid to every employer who hired LTIC clients.

(4) Indirect Costs of Training. An allowance had to be made for administrative costs incurred by several Federal agencies, which included the Bureau of Employment Security, Bureau of Apprenticeship and Training, both of the Department of Labor, and the Office of Educational of DHEW. These costs were "averaged" for each of the categories of trainees.

* Previous research had indicated that the women who had received institutional training did not, on the average receive higher earnings, and thus this category was not considered in the evaluator's analysis.

The various components and the total allocative costs of the training program are given in Table 3.2.

Table 3.2 Allocative Costs/Trainee

Item	Costs/Female OTJ Trainee	Costs/Male OTJ Trainee	Costs/Male Insti-tutional Trainee	Average for all Clients
LTIC Contract Costs	1105.9	1105.9	1105.9	
On-the-Job Direct Costs	68.3	106.8		
Institutional Direct Course Costs			546.4	
Indirect Federal Costs	13.2	20.7	86.7	
Total Allocative Costs/ Trainee	1187.4	1233.4	1739.0	1320.

Allocative Benefit-Cost Ratio From Training

With allocative benefits and allocative costs of the training sponsored by LTIC calculated, it was now possible to calculate the benefit-cost ratio in a rather straightforward way for the various categories and for the LTIC program as a whole:

Table 3.3 Allocative Benefit-Cost Ratios per LTIC Trainee

Item	On-the-Job Training for Women	On-the-Job Training for Men	Institutional Training for Men	Training for all LTIC Clients
Present value of allocative benefits	8113	4014	4396	4623
Allocative costs	1187	1233	1739	1320
Allocative benefit-cost ratio	6.8	3.3	2.5	3.5

Table 3.3 clearly reveals that based upon the experience in Morganville, the LTIC program as a whole was an efficient use of society's resources, i.e. the average LTIC trainee contributed more to society's output than the cost to society for the training. The benefit-cost ratios also revealed that in allocative terms, on-the-job skill instruction represented a more efficient use of society's resources than institutional training. But the reasons for the superiority of on-the-job training varied by sex of the client: for women, the superiority originated on the benefit side; for men, the superiority originated on the cost side. Finally, the benefit-cost ratios showed that on-the-job training for women was twice as efficient as O-T-J training for men and 2.7 times as efficient as institutional training for men.

With publication of the evaluation report, which contained the results above along with a discussion of the methodology which the evaluators employed, there was a considerable uproar from various groups who objected to the conclusions. Was this surprising?

SCENARIO 3

Indirect and External Costs and Benefits and Distributive Effectiveness of Job Training

In Case Study 3 the evaluators of the LTIC program explicitly labelled the benefits and costs of the program as "allocative benefits" and "allocative costs." Allocative in this sense refers to the efficiency criterion in which it must be determined whether the program raised the aggregate output of society by more than the "allocated" expenditures of society for the training. An alternative way, of asking the same question is, in the case of the LTIC, did society have to make any sacrifices in total output in the process of raising the incomes of the poor. There is an altogether different class of questions that can be asked in the evaluation process, however, which the "allocative" criterion does not address. These are the distributional effects of the LTIC program, and of which several vociferous citizen-planners of Morganville were more than mildly concerned. In particular, we would want to know, since LTIC is an anti-poverty program, whether the increases in earnings associated with training accrued to people who would otherwise have been poor, and if so, whether the earning increases were sufficiently large to lift the LTIC clients out of the "poverty class."

Suppose we adopt two alternative sets of poverty lines (both of which have been used by various government researchers for policy design. Both of these poverty lines indicate the dollar income necessary for a family to provide itself with the necessities of life. In the calculation of the two guidelines used here, the minimum-adequacy food budget was estimated for households of various compositions, and this figure was multiplied by a factor which represented the reciprocal of the percentage of a poor family's income which was spent on the minimum-adequate diet. For poverty line A this factor was 3.0 and for poverty line B the factor was 1.67. (The figure of 3.0 was obtained by observing that food expenditures make up roughly 1/3 the income of the average family; the figure of 1.67 was obtained by observing what percentage of a family's income goes for food for those families which are at the margin of adequate nutrition). Of course, both sets of poverty lines vary by the size of the household, i.e., the number of dependents per trainee, which varied between the group of female trainees and male trainees. In addition, criterion B's poverty line varied by sex of head of household.

The poverty lines, as calculated in the manner described above, can then be compared with the average annual earnings levels after training for each of the several training categories.

Table 3.4

POVERTY LINES AND INCREASES IN EARNING LEVELS
ASSOCIATED WITH TRAINING[1]

Training Category	Poverty Lines in Annual Income A	B	Average Annual Earnings Levels Without Training	With Training
Female on-the-job	3600	4682	2202	3714
Male on-the-job	4426	6236	5036	5804
Male Institutional	4426	6236	4146	5004
All LTIC Trainees[2]	4426	5754	3946	4812

[1]All dollar amounts have been converted to 1976 prices.

[2]The poverty line for all LTIC trainees following criterion B was derived by assigning a weight of .69 to the poverty line for a family of 4 headed by a male and a weight of .31 to the poverty line for a family of 3 headed by a female. These weights reflect the proportions of males and females in the sample.

Based upon the information contained in case Study 3 and the data provided in Table 3.4, how would you evaluate the distributive effects of the LTIC programs? Is there sufficient information for you to make an evaluation? If not, what kind of information would you need? What additional considerations should these be in the evaluation of this analysis?

CASE STUDY 4

Sensitivity Analysis of Cost-Effectiveness

The public library of Rhoidville has been recently faced with some difficult decisions regarding whether to renew their subscriptions to journals which were infrequently needed or whether to borrow an issue from a larger library and photocopy articles which were requested.

A staff librarian who had had some university training in management techniques was asked by the head librarian to design a cost-effective system for decision-making for all journal subscriptions.

The first task was performing a cost analysis for each of the two alternatives of obtaining journal articles: (a) journal subscription, (b) borrowing and photocopying.

The staff librarian, Jack Biblio, identified three major cost items to be considered in obtaining an article from a journal owned by the library: (i) subscription price, (ii) journal handling and storage costs, and (iii) handling cost for each article requested. The cost of obtaining an article from outside sources included: (i) the cost of a time delay to the user who must often wait up to as much as several weeks to see the article he (she) needs; and (ii) the cost to the library of ordering the photocopied article (handling and copying fees).

Biblio translated the above costs into a simple mathematical formulation which enabled one to learn how many requests/year for articles in a journal justified obtaining a subscription. This formulation follows:

(1) $$\frac{\text{Purchase price/year + handling costs/year}}{\text{No. requests/year}} + \text{handling cost per request from shelf} = \text{cost of ordering article from outside}$$

The equation says that there is a point at which the cost to maintain a journal for one year plus the cost of ordering articles from the journal on the shelf (borne by the librarians) just equals the cost of ordering an article photocopied and sent from an outside source. This point is determined by the number of requests for a particular journal in a year. Solving the equation for this "critical" number tells Biblio whether he should suggest that the library subscribe: if the number of actual requests exceeds this "critical" number of requests, the subscription is justified.

For instance, if the

Purchase price for the journal/year	=	$20.00
Handling cost/year	=	16.00
Handling cost/request obtained from shelf	=	1.00
Average cost of ordering article from outside	=	5.00
Critical number of requests	=	X

Then:

(2) $$\frac{20.00 + 16.00}{X} + 1.00 = 5.00$$

and,

(3) $X = \frac{20 + 16}{5-1} = 9$

That is, there would need to be at least nine requests for articles from a given journal for the library to be justified to have a subscription.

Biblio, however, did not include the costs of time delay to the user if the library had to obtain an article from "outside". If these costs were included, we would then have the following general model:

(4) $\frac{A + B}{X} + C = D + E$

where:

A = subscription price of the journal/year
B = handling cost/year
C = handling cost/request obtained from the shelf
D = average dollar costs of ordering the requested article from outside
E = time delay costs to user
X = critical number of requests

and thus:

(5) $X = \frac{A + B}{D + E - C}$

This model could now be used by Biblio when any of the above costs changed (as, in general, each cost element would) for any particular journal or could be used for a sensitivity analysis. That is, how sensitive is the critical number X, to changes in any of the cost parameters. This kind of information can be very useful to the library administration for planning its future facilities when a particular journal is not being considered but general policy toward journal subscriptions are being discussed.

SCENARIO 4
Sensitivity Analysis of Cost-Effectiveness*

Biblio has developed the following model, as described in Case Study 4, for the undertaking sensitivity analyses for a rational policy of journal subscriptions:

(1) $\frac{A + B}{X} + C = O + E$

(2) $X = \frac{A + B}{O + E - C}$

The following information was collected and tabulated by Biblio on requests for journal articles in the Rhoidville Public Library during the first six months of 1976:

Total number of filled requests	3132
Sources for articles	
Shelf of Rhoidvelle Library	1040
File of previously obtained items	794
State library clearinghouse	628
Adjacent county public library	374
State University Library	196

Table 4.1 Handling Costs of Owning a Journal Title One Year

Tasks	Minutes Per Title		Cost/Minute	Cost/Title	
	Reserve Room	Stacks		RR	Stacks
Professional Supervision	33.3	33.3	$0.12	$4.00	$4.00
Clerical					
Unwrapping Journals	2.0	2.0			
Logging In	10.4	10.4			
Shelving (unbound)	6.3	2.6			
Claiming missing	2.0	2.0			
	20.7	17.0	0.07	1.45	1.19
Storage @ $5/sq.ft.				1.70	.62
TOTAL				7.15	5.81

*The tables used in this scenario have been adapted from Margaret Phillips, "Cost Analysis of a Document Retrieval System," unpublished paper, Smith, Kline and French Laboratories, Philadelphia, Pa., June, 1969.

Table 4.2 Cost to Obtain an Article from Rhoidville Public Library Shelf

Tasks	Minutes/Request		Cost/Minute	Cost/Request	
	File Copy	No File Copy		File Copy	No File Copy
Professional					
Fill out request form	.88	.88			
Keep statistic	.26	.26			
Find locations	.43	.43			
	1.57	1.57	.12	.19	.19
Clerical					
Pull journals from shelf	1.27	1.27			
Find journals not on shelf (23%)	1.37	1.37			
Prepare requests for duplication	1.34	1.34			
Match article with request	.22				
File file copy	.28				
	4.48	3.98	.07	.31	.28
Duplicating cost @ $0.07/page, 6.4 pp/request				.43	.22
TOTAL				.93	.69

Table 4.3 Cost to Obtain a Copy of an Article from the State Library Clearinghouse

Tasks	Minutes/Request		Cost/Minute	Cost/Request	
	File Copy	No File Copy		File Copy	No File Copy
Purchase price/ article				2.00	2.00
Professional					
Fill out request form	.88	.88			
Keep statistics	.26	.26			
Find locations	.43	.43			
	1.57	1.57	.12	.19	.19
Clerical					
Type order forms	1.08	1.08			
Match order with request	.39	.39			
Prepare for duplicating	.81				
Mail to user	1.22	1.00			
File library copy	.28				
	3.78	2.47	.07	.26	.17
Duplicating @ $0.07/page, avg. 6.4 pp/ request, 1 copy				.44	
TOTAL				2.89	2.36

Table 4.4 Cost to Obtain a Copy of an Article from the Adjacent County Library

Tasks	Minutes/Request		Cost/Minute	Cost/Request	
	File Copy	No File Copy		File Copy	No File Copy
Professional					
Fill out request form	.88	.88			
Keep statistics	.26	.26			
Find locations	.43	.43			
	1.57	1.57	.12	.19	.19
Clerical					
Order journals by phone	.88	.88			
Prepare request for duplicating	1.34	1.34			
Mail to user	1.22				
File library copy	.28				
	3.72	2.22	.07	.26	.16
Duplicating cost @ $0.07/page, 6.4 pp/request, 2 copies				.86	.44
TOTAL				1.31	.79

Table 4.5 Cost to Obtain a Copy of an Article from the State University Library

Tasks	Minutes/Request		Cost/Minute	Cost/Request	
	File Copy	No File Copy		File Copy	No File Copy
Purchase price/ article @ 6.4 pp/article, $0.50/page				3.20	3.20
Professional					
Fill out request form	.88	.88			
Keep statistics	.26	.26			
Find locations	.43	.43			
	1.57	1.57	.12	.19	.19
Clerical					
Type order forms	1.40	1.40			
Match order with request	.39	.39			
Prepare for duplicating	.81				
Mail to user	1.22	1.00			
File library copy	.28				
	4.10	2.79	.07	.29	.20
Duplicating, @ $0.07/page, 6.4 pp/request, 1 copy				.44	
TOTAL				4.12	3.59

Table 4.6 Cost to Obtain Copy of Article from R.P.L. File

Tasks	Minutes/Request		Cost/Minute	Cost/Request	
	File Copy	No File Copy		File Copy	No File Copy
Professional					
Fill out request form	.88				
Keep statistics	.26				
Find locations	.43				
	1.57		.12	.19	
Clerical					
Pull from file	.28				
Prepare for duplicating	.81				
Mail to user	1.22				
File file copy	.28				
	2.59		.07	.18	
Ouplicating cost, @ $0.07/page, 6.4 pp/request, 1 copy				.44	
TOTAL				.81	

In addition, Biblio had also noted the average length of time of delay that it took from the request to fulfillment of the request from each of the outside sources:

	Days
State Library Clearinghouse	10.0
Adjacent County Library	4.0
State University Library	16.0

Assume the average annual subscription price/journal = $20.00.

Now, without considering the time delay costs and given the preceding information, and assuming that a file copy is also requested, (1) how does the critical number of requests vary with the average annual journal subscription cost? (2) If the serial clerk's salary increases from $0.07/minute to $0.09/minute, how does the critical number of requests change? (3) If the price of purchasing an article from the State University Library doubles, how sensitive is the critical number of requests to justify subscription?

(4) Now, include true delay costs and assume they change from $0.50/day to $0.75/day, how does the critical number of requests change?

Exercise 3

GROUP PROBLEM DESIGN AND ANALYSIS

You are asked to devise a problem in which one of the evaluation techniques discussed in this workshop (or a related one) would be used in its solution. If you can make a relation to a problem encountered in your agency, the exercise will probably be of greater benefit to you than a completely hypothetical problem. After carefully articulating the problem statement, you should then systematically proceed with a series of analytic/evaluative procedures which will yield a solution.

For a problem which lends itself to cost-benefit analysis, for example, the following steps should be considered after the problem is articulated:

(1) An operational statement of the goals or objectives which the organization is trying to achieve with the given project.

(2) Articulation of a set alternative projects or courses of action to meet goals/objectives in (1).

(3) The identification and specification of <u>all</u> relevant costs and benefits associated with the project (alternatives).

(4) Translation of the cost and benefit items to streams of costs and benefits.

(5) Selection of the appropriate discount rate and application of it to the cost and benefit streams.

(6) Calculation of benefit-cost ratio and project selection.

(7) Sensitivity analysis of the analytic procedure: is the particular solution highly sensitive to a chosen parameter or an assumption you have made in the analysis which may not be highly accurate?

(8) Does the solution of the problem satisfy the stated goals/objectives in (1)? What items/issues might you have overlooked or ignored?

(9) Can the alternative solution chosen by practically implemented? If not, what items have you overlooked?

A Glossary of Frequently-Used Terms in Cost-Benefit and Cost-Effectiveness Analysis

Amortization:	a. gradual reduction of a debt through periodic payments covering the interest and part of the principal. b. a method of recording the decline from its original value of some facility over the estimated life of the facility.
Annuity:	a payment made at some regular interval for a specified or unspecified length of time.
Asset:	a property or right that has a value to the given owner. Current or liquid assets can readily be converted to cash, while fixed assets (e.g., equipment, buildings) are less easily converted to money.
Benefit-cost ratio:	a ratio used in cost-benefit analysis which expresses the value, or benefits, created by a project to the costs of the project. When the benefits exceed the costs (the ratio > 1), the ratio suggests that the project is a worthwhile one.
Capital:	the stock of goods used to carry out a project. Buildings, equipment, raw materials and various forms of money stocks are types of capital distinct from direct land and labor inputs involved in the immediate project activity. Capital costs is the money value of a class of elements in the total cost stream of a project.
Consumer surplus:	the difference between the total amount of money an individual (or group) would be prepared to pay for some good and the amount he (she) actually has to pay. This is considered a net benefit when a project would enable a consumer of a given service to get what he (she) wants for less money than he (she) would otherwise be willing to pay.
Cost-benefit analysis:	the identification and calculation of all the relevant costs and benefits of alternative projects used for evaluation of these alternatives or future decision-making among them. An attempt should be made to identify indirect as well as direct benefits and costs, as well as the various social benefits and costs in addition to the financial items.

Cost of capital: the cost of obtaining capital in the form of money credit, to be used for financing a given project. Often the cost of capital is expressed as the going interest rate and is commonly a surrogate for the discount rate.

Cost-effectiveness analysis: the identification of the relevant costs of alternative projects which meet a specified minimum level of performance, or effectiveness. The least-cost alternative would be the most preferred choice. More generally this technique is more concerned with the performance standards of alternative programs than with the most efficient alternative as in cost-benefit analysis.

Cost-revenue ratio: a ratio comparing the costs of a public project with the revenues (taxes) which would be generated by such a project.

Demand curve: a graphical presentation showing in what quantities a good or service will be bought at differing prices with all other influences remaining constant. Typically, as the price rises, the quantity demanded falls; as price drops, quantity demanded rises.

Depreciation: a reduction in the value of an asset due to use and/or obsolescence.

Diminishing returns: describes the situation when each additional unit input to a system brings about successively less and less amount of additional output and when everything else remains constant.

Discount rate: the society's or an individual's rate of time preference, commonly expressed as the interest rate. Since we generally would prefer to have a given asset in the present rather at some time in the future, we "discount" future benefits and costs of an investment stream so that all items can be expressed in present value terms. For instance, if we are indifferent between $100 now and $110 one year from now, then the social rate of discount is 10%, and the $110 is appropriately "discounted" to $100 which is its present value.

Economic rent: when an input into the production of a good or service earns more than the minimum to keep that input from being used in an alternative use, the excess payment is called economic rent. When the supply of an input is limited, such as the case with urban land, the economic rent may be considerably large.

Effectiveness: a process or activity is effective when a given desired performance level is reached. The most effective activity among alternatives is that which achieves the desired level of performance at lowest cost.

Efficiency: an activity is efficient when the additional outputs accruing from an additional unit of input are maximized. The most efficient alternative among many is that activity which would yield the largest additional output with an additional unit of input among all the possible alternatives.

Elasticity: the responsiveness of one variable to a change in the value of another variable. For instance, the (price) elasticity of demand for some item measures the percentage change in quantity demanded relative to a percentage change in the price of that item.

Equilibrium: the state of a system in which all forces affecting that system are in balance. An economic system is said to be in equilibrium when consumers wish to purchase the same amount the producers wish to sell, and no more, at a given, equilibrium price.

Externalities (external effects, spillover effects): the effects of the production or consumption of a good or service upon a third party otherwise not involved in the transaction. Typically the producer of such effects does not accept responsibility for these effects, and further they are not transmitted through the market, and hence remain unpriced. Externalities can be either positive (benefits) or negative (costs). Freely discharge pollution is a classic example of a negative externaltiy released on a community.

Factors of production: all the various inputs to a production process wherein they are combined in a particular way to produce goods and services; land, labor, capital.

Human capital: the investment in education and skills for the purpose of increasing the productivity of the labor force.

Marginal efficiency of investment: the return to an activity (output) from the last unit of investment (input).

Marginal cost: the additional cost of producing an additional unit of output.

Market economy: a type of economic organization in which supply and demand determine the production and distribution of goods and services by means of forces internal to the market system. Competition and pricing are fundamental aspects of this type of economy.

Market failure: a situation where the market does not perform its essential function of the allocation of scarce resources in an efficient manner. There can be many reasons for market failure. Two of the most important are the existence of imperfect competition or the existence of externalities.

Multiplier: the ratio of a change in total income (or "benefits") for an area to the amount of initial investment that causes this change. The multiplier shows how small initial expenditures can generate much larger impacts. Often used in impact analysis to analyze the transmission of an initial "shock" throughout a system such as a local economy.

Net benefits: the algebraic difference between project costs and benefits.

Opportunity cost: the cost of any item in terms of the most desired alternative. The use of any resource implies "opportunities foregone" for using that resource in an alternative activity. Thus a resource which is not being used in the most efficient manner and for the highest use is said to be incurring opportunity costs to society.

Pareto-optimality (efficient): a situation that exists when no one actor can be made better off (higher utility level) without making at least one other actor worse off (lower utility level). A situation (social state) is not Pareto-optimal if it is possible by engaging in a transaction to make at least one of the actors in an economic system better off without making any other actor worse off. Pareto-optimal situations are aimed for in cost-benefit frameworks, but are not attainable if there exist either imperfect competition or externalities.

Present value discounted: In a stream of benefits and costs for a project, future benefits and costs are appropriately "discounted" to their present value. A given future benefit or cost has less value in the present, and thus a proper evaluation of alternative projects must be based on a dollar standard which is invariant to the nature of a particular stream. Present value dollars by convention is chosen to be this standard. PVO is independent of the effects of inflation.

Productivity:	the amount of output produced per unit of input (factors of production) when the same amount of a factor input produces more output than in a previous period, all other factors held the same, then we would say that the productivity of that factor has increased.
Program budgeting:	a technique of budgeting wherein expenditures are classified primarily by programs (and sub-programs) which are designated to meet certain designated objectives. The emphasis then is on budgetary elements that relate to objectives rather than the objects of expenditure.
Rate of return:	the ratio of profits to initial outlay (investment) for a project.
Social benefits:	the value of the gains from investment to a community that may be secondary to the primariy purpose of the investment project and/or may not be accountable as private benefits accruing to individuals.
Social capital:	the total stock of capital in a community, which includes public facilities such as schools, transport facilities, etc.
Social costs:	costs which do not appear in the accounts of a private organization, but may be absorbed by the community, e.g., congestion, pollution, crime, and other burdens on public facilities.
Transfer earnings:	the amount that an input in production must be paid to keep it from moving to some other use. Transfer earnings are equal to the amount an input could earn in the best paid alternative use.
Value added:	the money value created by some action on a good or service purchased from another producer. Value added is calculated by subtracting from the sellers price the cost of his raw or intermediate materials.

Selected References Related to Cost-Benefit/Cost-Effectiveness Analysis and Project Evaluation

I. General and Background Readings

P. Dasgupta, et. al., Guidelines for Project Evaluation (New York: United Nations, 1972).

R. Dorfman, ed., Measuring Benefits of Governmental Investments (Washington: The Brookings Institution, 1965).

M. A. Goldberg, "On the Inefficiency of Being Efficient," Environment and Planning, Vol. 7, No. 8, December, 1975.

R. Haveman and J. Margolis, ed., Public Expenditures and Policy Analysis (Chicago: Markham, 1971).

M. Hill, "A Goals-Achievement Matrix for Evaluating Alternative Plans," Journal of the American Institute of Planners, January, 1968.

R. Layard, Cost-Benefit Analysis: Selected Readings (Baltimore: Penguin Books, 1974).

I. M. D. Little, A Critique of Welfare Economics (London: Oxford University Press, 1958).

A. Maass, et. al, Design of Water Resources System (Cambridge, Mass.: Harvard University Press, 1962).

J. Maciaiello, Dynamic Benefit-Cost Analysis (Lexington, Mass.: Lexington, Books, 1974).

L. Merewitz and S. H. Sosnick, The Budget's New Clothes (Chicago: Markham, 1971).

E. Mishan, Cost-Benefit Analysis (New York: Praeger, 1976).

T. Newton, ed., Cost-Benefit Analysis in Administration (London: George Allen and Unwin Ltd., 1972).

C. Schultze, The Politics and Economics of Public Spending (Washington: The Brookings Institute, 1976).

B. A. Weisbrod, "Income Redistribution Effects and Benefit-Cost Analysis," Problems in Public Expenditure Analysis. S. B. Chase, ed.(Washington: The Brookings Institute, 1968).

II. Housing and Urban Renewal

S. Awerlach, Policy Evaluation for Community Development: Decision Tools for Local Government (New York: Praeger, 1976).

D. Capazza, "Measuring the Benefits of Urban Improvements," The Annals of Regional Science, Vol. IX, No. 2, July, 1975.

J. DeSalvo, "A Methodology For Evaluating Housing Programs," Aldine Annual, 1971 (Chicago, Aldine-Atherton, 1971).

N. Lichfield, "Cost-Benefit Analysis in Urban Redevelopment: A Case Study," Papers and Proceedings of Regional Science Association, Vol. 16, 1966.

T. Newton, "Urban Redevelopment and the Social Cost of Slums," Cost-Benefit Analysis in Administration (London: George Allen and Unwin Ltd., 1972).

J. Rothenberg, Economic Evaluation of Urban Renewal (Washington: The Brookings Institute, 1967).

III. Environmental Quality, Energy, and Natural Resources

Battelle Memorial Institute and Pacific Northwest Laboratory, Evaluation of Municipal Sewage Treatment Alternatives (Springfield, Va.: National Technical Information Service, 1974).

Bershire County (Mass.) Regional Planning Commission, Evaluation of Power Facilities: A Reviewer's Handbook, 1974.

J. W. Brown, Models and Methods Applicable to Corps of Engineers Urban Studies (Visksburg, Miss.: U.S. Army Corps of Engineers, Waterways Experiment Station, 1974).

C. Cicchett, et. al., "Benefits or Costs? An Assessment of the Water Resources Council's Proposed Principles and Standards," Aldine Annual, 1972 (Chicago: Aldine Atherton, 1972).

M. Hill and M. Schecter, "Optimal Goal Achievement in the Development of Outdoor Recreation Facilities," Studies in Regional Science, 1970.

R. Mack and S. Meyers, "Outdoor Recreation," Measuring Benefits of Government Investments. R. Dorfman, ed. (Washington: The Brookings Institution, 1965).

T. Newton, "The Benefits of Recreation: A Survey and Case Study," Cost-Benefit Analysis in Administration (London: George Allen and Unwin Ltd., 1972).

IV. Transportation

American Association of Highway Officials, Road User Benefit Analyses for Highway Improvements (Washington: American Association of Highway Officials, 1960).

T. J. Batchelor, A Benefit-Cost Analysis of a Freeway System With Respect to an Average Real Estate Equity (Springfield, Va.: National Technical Information Service, 1974).

J. W. Dickey, senior author, Metropolitan Transportation Planning (New York: McGraw-Hill Book Company, 1975).

J. M. English, ed., Cost-Effectiveness, the Economic Evaluation of Engineered Systems (New York: Wiley, 1969).

A. Harrison and S. Holterman, "Economic Appraisal of Transport Projects and Urban Planning Objectives," Aldine Annual, 1973 (Chicago: Aldine-Atherton, 1973), pp. 214-238.

N. Lichfield, "Cost-Benefit Analysis in Planning: A Critique of the Roskill Commission," Aldine Annual, 1971 (Chicago: Aldine-Atherton, 1971), pp. 378-404.

H. Mohring and M. Harwitz, Highway Benefits: An Analytical Framework (Evanston, Ill.: Northwestern University Press, 1962).

H. Mohring, "Urban Highway Investments," Measuring Benefits of Government Investment. R. Dorfman, ed. (Washington: The Brookings Institution, 1965) pp. 231-288.

National Cooperative Highway Research Program, Methods For Evaluating Highway Safety Improvements, (Washington: National Academy of Sciences, Transportation Research Board, 1976).

National Cooperative Highway Research Program, Report No. 156, Transportation Decision-Making: A Guide to Social and Environmental Considerations (Washington: National Research Council, Transportation Research Board, 1975).

The Rand Corporation, Measurement and Evaluation of Transportation System Effectiveness (Springfield, Va.: Federal Clearinghouse, PB-185 772, 1969).

A. J. Robson, "Cost-Benefit Analysis and the Use of Urban Land for Transportation," Journal of Urban Economics, Vol. 3, No. 2, April, 1976.

H. Van der Tak and Anandarpu Ray, "The Economic Benefits of Road Transport Projects," Aldine Annual, 1972 (Chicago: Aldine-Atherton, 1972), pp. 132-172.

V. Employment, Manpower and Human Capital

For an annotated bibliography in manpower and human capital, see W. D. Wood and H. F. Campbell, Cost-Benefit Analysis and the Economics of Investment in Human Resources (Kingston, Ont.: Industrial Relations Centre, Queen's University, 1970), pp. 1-15 and pp. 125-189.

S. Barsby, Cost-Benefit Analysis and Manpower Programs (Lexington, Mass.: Lexington Books, 1972).

J. Goldstein, "The Effectiveness of Manpower Training Programs: A Review of Research on the Impact on the Poor," Aldine Annual, 1972 (Chicago: Aldine-Atherton, 1972), pp. 321-337.

R. Haveman, et. al., "Earnings Supplementation Plans for 'Working Poor' Families: An Evaluation of Alternatives," Aldine Annual, 1973 (Chicago: Aldine Atherton, 1973), pp. 291-318.

T. Newton, "Urban and Rural Planning, Location, and Regional Employment," Cost-Benefit Analysis in Administration (London: George Allen and Unwin Ltd., 1972).

E. W. Stormsdorfer, Review and Synthesis of Cost-Effectiveness Studies of Vocational and Technical Education (Monticello, Ill.: Council of Planning Librarians, 1973).

VI. Economic and Social Development

N. Caiden and A. Wildavsky, Planning and Budgeting in Poor Countries (New York: Wiley, 1974).

P. Dasgupta, et. al., Guidelines for Project Evaluation (New York: United Nations, 1972).

A. Harberger, "On Measuring the Social Opportunity Cost of Labour," Aldine Annual, 1971 (Chicago: Aldine-Atherton, 1971), pp. 79-99.

I. M. D. Little and J. Mirrless, Project Appraisal and Planning for Developing Countries (London: Heineman Educational Books, 1974).

S. Marglin, Public Investment Criteria: Benefit-Cost Analysis for Planned Economic Growth (Cambridge, Mass.: M.I.T. Press, 1967).

E. Mishan, "Cost-Benefit Rules for Poorer Countries," Aldine Annual, 1971 (Chicago: Aldine-Atherton, 1971).

A. Papandreou and U. Zohar, Project Selection for National Plans: National Planning and Socioeconomic Priorities - A Two Volume Series (New York: Praegar, 1974).

VII. Social Service Delivery Systems

For an annotated bibliography see W. D. Wood and H. F. Campbell, Cost-Benefit Analysis and the Economics of Investment in Human Resources (Kingston, Ont: Industrial Relations Centre, Queens University, 1970), pp. 189-197.

R. Ackoff, "Toward Quantitative Evaluation of Urban Services," Public Expenditure Decisions in the Urban Community. H. Schaller, ed. (Washington: Resources for the Future, 1963).

R. Chinitz and C. Tiebart, "The Role of Cost-Benefit Analysis in the Public Sector of Metropolitan Areas," The Public Economy of Urban Communities. J. Margolis, ed. (Washington: Resources for the Future, 1965).

B. S. Cooper and N. L. Worthington, Comparison of Cost and Benefit Incidence of Government Medical Care Programs, Fiscal Years 1966 and 1969 (Washington: U.S. Department of Health, Education and Welfare, Social Security Administration, Office of Research and Statistics, 1974).

K. A. Fox, ed., Economic Analysis for Educational Planning: Resource Allocation in Non-Market System (Baltimore: Johns Hopkins University Press, 1972).

W. Hanson, "Rates of Return to Investment in Schooling in the United States," Economics of Education, M. Blaug, ed. (Oxford, N.Y.: Pergaman Press, 1966), pp. 137-155.

H. Heinemann and E. Sussna, "Criteria for Public Investment in the Two-Year College," Aldine Annual, 1971 (Chicago: Aldine-Atherton, 1971), pp. 212-225.

N. Lichfield and J. Margolis, "Benefit-Cost Analysis as a Tool in Urban Government Decision-Making," Public Expenditure Decisions in the Urban Community. H. Schaller, ed. (Washington: Resources for the Future, 1963).

N. Lichfield, "Cost-Benefit Analysis in Urban Expansion," Regional Studies, September, 1969.

Metropolitan Council of the Twin Cities, Metropolitan Investment Framework: Development Guide Chapter, 1975 (Saint Paul, Minn.: The Council, 1975).

S. Nagel, Minimizing Costs and Maximizing Benefits in Providing Legal Services to the Poor (Beverly Hills, Calif.: Sage Publications, 1973).

C. P. Newhouse and W. Schwartz, "Policy Options and the Impact of National Health Insurance," Aldine Annual, 1974 (Chicago: Aldine-Atherton, 1974), pp. 128-166.

D. Shoup, "Cost Effectiveness of Urban Traffic Law Enforcement," Aldine Annual, 1973 (Chicago: Aldine-Atherton, 1973), pp. 188-213.

W. C. Sze and J. C. Hopps, ed., Evaluation and Accountability in Human Service Programs (Cambridge, Mass.: Schenkman Publishing Co., 1974).

U. S. Public Health Service, Economic Effects from Public Health Services (Washington: Department of Health, Education and Welfare, U. S. Public Health Service).

B. Weisbrod, "External Effects of Investment in Education," Economics of Education. M. Blang, ed., (Oxford, N. Y.: Pergaman Press, 1966), pp. 156-182.

Worksheet for Free-Format Group Project

Worksheet A

Operational Set of Goals/Objectives

Alternative Projects/Courses of Action

Worksheet B	Cost-Items		
Alternative A	Alternative B	Alternative C	Alternative D

Worksheet C	Benefit Items		
Alternative A	Alternative B	Alternative C	Alternative D

Worksheet
D

STREAM OF BENEFITS AND COSTS
(FILL IN ESTIMATES)

ALTERNATIVE:

Benefit Item	Time Period 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1.																				
2.																				
3.																				
4.																				
5.																				
6.																				
7.																				
8.																				
9.																				
10.																				
Costs Item:																				
1.																				
2.																				
3.																				
4.																				
5.																				
6.																				
7.																				
8.																				
9.																				
10.																				