

Cost - Effectiveness Analysis
and
Cost - Benefit Analysis
of
Information Systems

A Tutorial Presented at the American Society
for Information Science Annual Meeting, Washington
D.C. October 1972. Sponsored by the Special
Interest Group on Costs, Budgeting, and Economics

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Tutorial Outline

- I. Introduction
- II. Examples of Cost-Effectiveness and Cost-Benefit Analysis
- III. Systems Analysis
 - Concept of the black box
 - Steps in the systems analysis process
 - Relationship of systems analysis to cost-effectiveness and cost-benefit analysis
- IV. Definitions of Cost-Effectiveness and Cost-Benefit
- V. Cost Analysis
- VI. General Problems in Measuring Effectiveness and Benefit
 - Quality Considerations
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Outdoor recreation

Education

University library

Public library

XIII. Cost-Benefit Analysis

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Interest Rates

Project Life

XIV. Limitations of the Methodology

I. Introduction

- A. This tutorial is designed to introduce to you the concepts of cost-effectiveness analysis, cost-benefit analysis and some of the ideas underlying welfare economics.
- B. Topics to be covered include
 1. Examples of cost-effectiveness (CE) studies
 2. Examples of cost-benefit (CB) studies
 3. Concepts of systems analysis and how they relate to the problem
 4. Definitions of CE and CB
 5. A very brief discussion of cost analysis. This was covered extensively last year by Doug Price.
 6. We will then discuss the environment within which the decisions are made (Government)
 7. General measurement problems relating both to effectiveness and benefit measures
 8. Effectiveness measures
 9. Principles of CE analysis
 10. Welfare Economics Concepts
 11. Benefit measures
 12. Principles of CB analysis
 13. Limitations of the CE, CB Methodology

- C. The overall objective of the tutorial will be to familiarize you with the concepts, discuss their applicability, show problem areas, and encourage you to try them yourselves.
- D. The current state of the art in this field is that much has been done in application of the techniques to Defense, water resources, education, recreation, etc. But very little has been done in applying the methodology to information service related activities.
 - 1. In the course of the discussion we will point out the relevant library related material
- E. You should all have in your possession a copy of the handout for the tutorial. The handout contains a number of items:
 - 1. An overall outline of the tutorial
 - 2. A detailed outline of each of the topics
 - 3. A bibliography
 - 4. Copies of each of the slides that I will be using to illustrate the material

II. Examples of Cost-Effectiveness and Cost-Benefit Analysis

- A. Before we submerge ourselves in the details of how to perform CE and CB analyses, let us go over a few examples of the type of analysis that we are interested in.
1. We will discuss later what makes one study a CE study and the other a CB study
- B. Examples of CE studies
1. Military example. Assume that it is required to determine the optimal way in which forces are to be deployed to a geographical point. A number of possibilities are feasible including various types of airbyts or sealifts. The decision involves the best strategy. [Hovey, p. 117]
 2. Information retrieval example. Assume we are designing an information retrieval system and one of the aspects under investigation is the indexing language. We need to decide on the type of vocabulary control that we will exercise, whether a thesaurus will be used, how vocabulary growth will influence our decision, etc. All these within the context of a measure of effectiveness and a measure of cost. [Lancaster].

C. Examples of CB Studies

1. Building a new subway: Construction of the 'Victoria Line' in London. Involved examination of:
 - a. cost savings in terms of fares saved
 - b. Time savings by shorter rides, less surface congestion, less use of other lines
 - c. Other benefits: increased comfort, reduced stress, brought about by new line
 - d. Construction costs. [Mishan, p. 10-12]
2. Preventing High School Dropouts [Weisbrod study as described by Hovey, p. 129]
 - a. Cost per dropout prevented includes:
 - (1) Direct prevention costs (the project itself)
 - (2) Additional instruction costs (because they stayed in school)
 - b. Internal benefits per dropout prevented
 - (1) Increased present value of lifetime income
 - (2) Improved self esteem of student
 - c. External benefits per dropout prevented.
(not qualified).
 - (1) Increased productivity
 - (2) Increased social and political consciousness
 - (3) Decreased social costs (crime)

(4) Decreased social administrative costs

(5) Inter-generation benefits

3. Library example [Hamburg, Ramist, Bommer] Determine what the benefits are from library service

- a. Cost analysis of components of providing service
- b. Benefit analysis in terms of objectives for public library (also University library)

(1) Library materials objective

- (a) variety of subject matter
- (b) meeting research needs
- (c) good organization of material
- (d) good distribution of material

(2) Objectives relating to process of communicating with user

- (a) Encourage reading of socially significant material
- (b) Interpreting materials
- (c) Expressing ideas
- (d) Providing information
- (e) Entering into the educational, civic, and cultural activities of community groups

(3) Objectives related to the end result of library use

- (a) Individual self development
- (b) Increased reading enjoyment and ability

- (c) Human understanding
- (d) Better family and community members
- (e) Aid in daily occupations
- (f) Consumer and health education
- (g) Creative use of leisure time
- (h) Culture
- (i) Creative and spiritual capacities

c. The problem, of course, is to quantify these benefits
More about this later

III. Systems Analysis

- A. The problems that we have briefly discussed in the previous section, in addition to being studies of the application of Cost-Effectiveness and Cost-Benefit analysis, are also problems that would be solved by systems analysis.
- B. What then is the relation between systems analysis and Cost-Effectiveness and Cost-Benefit analysis? Let us begin with some definitions and broadly indicate how the concepts interrelate.
- C. Definition of a system:
 - 1. A group of people, operations, and procedures brought together to perform a specific activity
 - 2. A system is made up of sets of components that work together for an overall objective [Churchman]
- D. Definition of systems analysis: A formal procedure for examining a complex process or organization, reducing it to its component parts and relating these parts to each other and to the unit as a whole in accordance with an agreed upon performance criterion.
- E. The major conceptual idea in systems analysis can be thought of in terms of the black box.



The issue is how to design the black box in order to achieve the desired transformation from input to output

- F. There are a number of stages in the systems analysis process
1. Determination of the objectives of the system. This has to do with determining the output of the system or the goals or objectives of the system. What is to be accomplished.
 2. Determination of the Constraints on achieving the objective
These include time, budget, manpower, technology, political, etc.
 3. Analysis of the system including analysis of the alternatives.
This is done with the objectives and constraints in mind.
A number of tools and methodologies can be employed.
 - a. Interviews
 - b. Flowcharts
 - c. Decision tables
 - d. Sampling
 - e. Models
 - f. Cost analysis
 - g. Operations Research

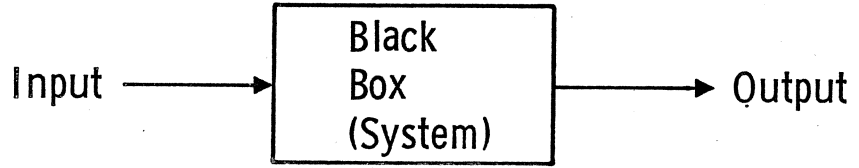
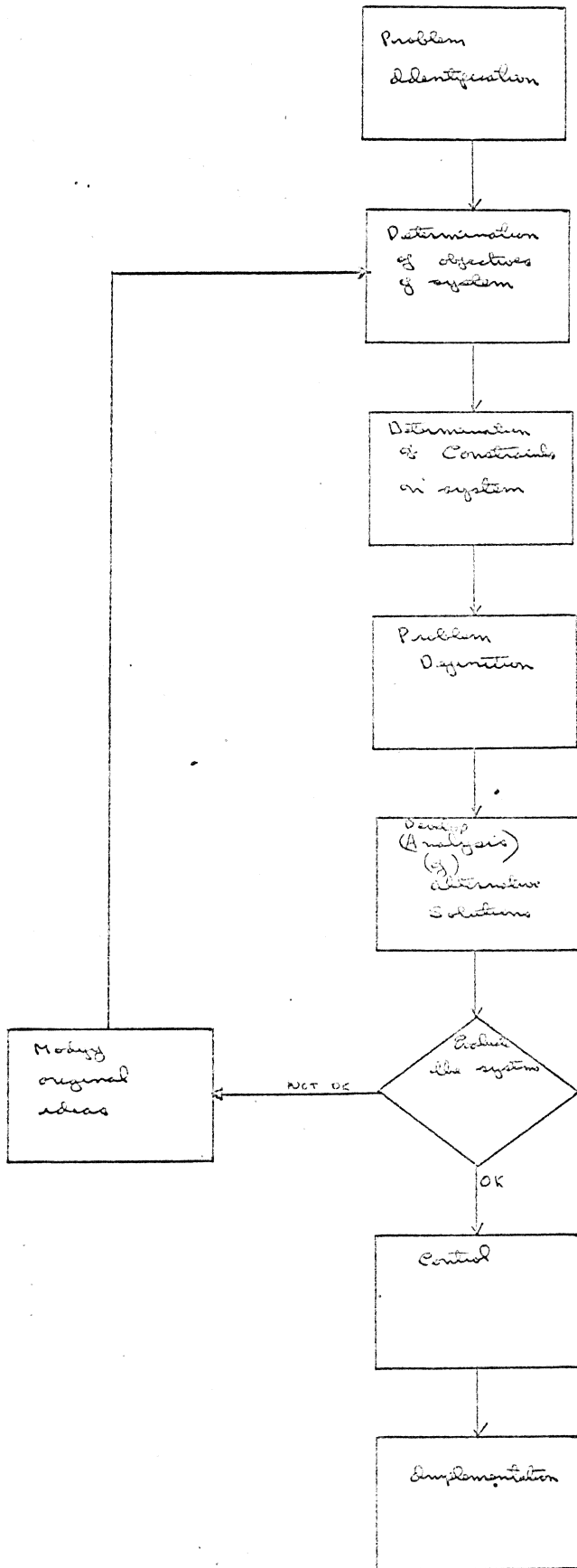


Figure 1

Systems Analysis
Overview



Necessary and sufficient conditions for existence of a problem.

What the system is to accomplish. Ranked list.

What is the problem.
Learn system in terms of its components

Is the system satisfactory?
What other ways to ~~can~~ accomplish objectives
 $I \rightarrow \square \rightarrow 0$ as long as we get the I + 0 the box can do anything. Change I + 0

Table 2.1

STEPS IN THE DESIGN PROCESS

	Kline-Lifson	Hall	Asimow	Rosenstein-English	Gosling	Alger and Hays	Affel	Churchman, Ackoff, and Arnoff
System design process	Problem solving	Design process	Anatomy of design	Design process	Recognizing	Engineering design process	System engineering process	Phases of operations research
Information gathering and organizing (need)		Information collection and organization; identification of need		Description of input and environment				
Formulation of value model	Problem definition, selecting objectives	Analysis of problem situation	Identification of system variables; criteria development	Measure of value (system worth)				Formulating the problem
Synthesis of alternative solutions	Systems synthesis	Synthesis of solution	Synthesis	Formation of system models				Constructing mathematical model
Analysis and/or test	Systems analysis							Deriving solution from model
Evaluation	Systems analysis	Evaluation and decision	Test and evaluation	Realization				Testing model and solution derived from it
Decision	Selecting the best system		Decision	Optimization				Establishing controls over solution
Optimization (iteration)		Optimization (revision)	Optimizing (iteration)					
Communication	Communicating results	Implementation	Communication and implementation	Description of outputs				Putting solution to work; implementation

Figure 2

KLINE-LIFSON	HALL	ASIMOV	ROSENSTEIN-ENGLISH	GOSLING	ALGER & HAYS	AFFEL	CHURCHMAN-ACKOFF & ARNOFF
SYSTEM DESIGN PROCESS	PROBLEM SOLVING	DESIGN PROCESS	ANATOMY OF DESIGN	DESIGN PROCESS	ENGINEERING DESIGN PROCESS	SYSTEM ENGINEERING PROCESS	PHASES OF OPERATIONS RESEARCH
INFORMATION GATHERING AND ORGANIZING (NEED)			INFORMATION COLLECTION AND ORGANIZATION IDENTIFICATION OF NEED	DESCRIPTION OF INPUT DESCRIPTION OF ENVIRONMENT	RECOGNIZING		
FORMULATION OF A VALUE MODEL	PROBLEM DEFINITION SELECTING OBJECTIVES	ANALYSIS OF PROBLEM SITUATION	IDENTIFICATION OF SYSTEM VARIABLES CRITERIA DEVELOPMENT	MEASURE OF VALUE (SYSTEM WORTH)	SPECIFYING	PROBLEM DEFINITION: SELECTING SYSTEM CRITERIA	FORMULATING THE PROBLEM
SYNTHESIS OF ALTERNATIVE SOLUTIONS	SYSTEMS SYNTHESIS	SYNTHESIS OF SOLUTION	SYNTHESIS	FORMATION OF SYSTEM MODELS	PROPOSING OF SOLUTIONS	SYSTEM SYNTHESIS	CONSTRUCTING A MATHEMATICAL MODEL
ANALYSIS AND/OR TEST	SYSTEMS ANALYSIS		TEST AND	REALIZATION	EVALUATING	SYSTEM ANALYSIS	DERIVING A SOLUTION FROM THE MODEL
EVALUATION		EVALUATION AND DECISION	EVALUATION		ALTERNATIVES		TESTING THE MODEL AND THE SOLUTION DERIVED FROM IT
DECISION	SELECTING THE BEST		DECISION	OPTIMIZATION	DECIDING ON A SOLUTION		ESTABLISHING CONTROLS OVER THE SOLUTION
OPTIMIZATION (ITERATION)	SYSTEM	OPTIMIZATION (REVISION)	OPTIMIZING (ITERATION)				
COMMUNICATION	COMMUNICATING RESULTS	IMPLEMENTATION	COMMUNICATION AND IMPLEMENTATION	DESCRIPTION OF OUTPUTS	IMPLEMENTING	IMPLEMENTATION	PUTTING THE SOLUTION TO WORK: IMPLEMENTATION

TABLE 3-1
STEPS IN THE DESIGN PROCESS

4. Evaluation of the alternatives
 5. Selection of an alternative. This is the decision making aspect of the analysis.
- G. From this very brief sketch of the systems analysis process, a number of points emerge:
1. Systems analysis is a form of the scientific method
 2. The types of problems that we are discussing can be viewed as systems analysis problems
 3. Cost-Effectiveness and Cost-Benefit analysis are two possible tools that can be used to analyze the problems. They are aids to the decision making process.
 4. By using the systems analysis framework, we make explicit the importance of establishing the objective of the system before we do any analysis. This is particularly important as we shall see later in defining measures of effectiveness and benefit.

- H. When can the tools of systems analysis, cost-effectiveness and cost-benefit analysis be applied to library and information service problems?
1. The objective of these approaches is to encourage quantitative thinking about problems. We want to replace intuitive analysis with these tools when possible.
 2. Specific examples of the applicability of the techniques to library problems:
 - a) Planning problems. Planning is the process of making policy projections and determining courses of action for the future. Planners can be aided by systems analysis, cost-effectiveness and cost benefit analysis by using the tools to give analyses of future situations just as they are used to give analyses of present situations.

- I. How are the tools of cost-effectiveness and cost-benefit analysis relevant to U.S. governmental agencies? Are these methods only useful outside a governmental environment or is the reverse true?
 1. The system of planning-programming - budgeting currently in use in federal agencies is a methodology which attempts to integrate costs of programs with their effectiveness.
 2. Many services that are procured by the government are done so through competitive bidding. These bids must show cost-effectiveness.
 3. Some agencies, such as the National Technical Information Service, charge for their products and services. These organizations must be cost effective to keep charges as low as possible.
 4. Funding cuts have been made on the basis of inability to show cost-effectiveness. National Science Foundation has been cut because it can't show cost-effectiveness
 5. Federal government is the single biggest sponsor of information programs so that cost-effectiveness from the standpoint of the Office of Management and Budget is very important.

IV. Definitions

- A. Up to this point we have informally talked about cost effectiveness and cost-benefit analysis by way of example. In this chapter we will present some definitions that have been proposed for the two concepts and then synthesize the distinctions between CE and CB.
- B. Definitions of cost-effectiveness analysis
 - 1. A method of analysis.
 - 2. Involves comparison of the cost of an alternative with the level of effectiveness achieved at the cost.
 - 3. The concept of effectiveness refers to a measure which indicates the degree to which an objective or goal is being met.
 - a. Effectiveness is also defined as a number designed to indicate the operational state of some part of the system.
 - 4. In cost-effectiveness analysis the measure of effectiveness is expressed in physical units such as commuters transported, fatalities prevented, housing units provided, number of documents retrieved, number of records searched in a file, number of bombers over target, number of lives saved, etc. [partially from Hovey, p. 131]

C. Definitions of cost-benefit analysis:

1. Another method of analysis.
2. Involves comparison of the cost of an alternative with the level of benefit achieved at the specified cost level.
3. Benefits have the following definitions:
 - a. Understood in the most comprehensive sense to include all additions to social welfare that can in Pigou's words, 'be brought into relation with the measuring rod of money.' [Mishan, p. 181]
 - b. All incidental effects on society that arise either in the building or operation of a project are to be added or subtracted from social benefit.
[Mishan, p. 182]
4. In cost-benefit analysis the units of output are converted to a monetary value. One quantifies benefits by converting program outputs into dollar values.
5. Examples of the quantification of benefits:
 - a. In hydro-electric power studies one prices the output of the new facility in terms of what it would cost to buy the power elsewhere.
 - b. Highway studies convert the time saved by individuals into money benefits.

- c. In calculating the benefit from the drop-out program one uses future earning power as a measure of benefit.
- d. In arriving at the benefit from a publication one tries to assess the value of the information to the individual and society.

Cost Effectiveness	Cost Benefit
Input measured in dollars	Input measured in dollars
Output measured in units of X	Output measured in dollars
Specific	General
Internal	External

Figure 3

Cost Effectiveness	Cost Benefit
Input measured in dollars	Input measured in dollars
Output measured in units of X	Output measured in dollars
Specific	General
Internal	External

- D. To summarize the distinction between the two concepts, in both cost-effectiveness and cost-benefit analysis the input is evaluated in terms of dollars. In cost-effectiveness analysis output is not evaluated in terms of dollars while in cost-benefit analysis output is evaluated in terms of dollars.
- E. "Ultimately the question boils down to determining the value of the output. How much are irrigation water and better achievement test scores worth? Because it does seek to answer such questions as these, cost-benefit analysis is inherently a more powerful aid to decision making than is cost-effectiveness analysis. It is also harder to perform." [Hovey, p. 55]
- F. As can be seen from the previous discussion, there is an element of social welfare involved in cost-benefit analysis. More than just one individual is involved. Because of this the concepts of Welfare Economics must be reviewed. We will do this in a later chapter.
- G. There are a number of scales on which one could view the analysis techniques of cost-effectiveness and cost-benefit.
1. General vs. specific. Cost-effectiveness is more specific than cost-benefit.
 2. Internal vs. external. Here we are referring to the use made of the technique. Internal meaning a technique used

for internal evaluation of an operation or company.
Cost-effectiveness would be internal and cost-benefit
would be external.

3. If one looks at a scale of purity ranging from classical theory of the firm at one end and operations research at the other end, then some would say cost-effectiveness and cost-benefit are in the middle [Niskonen, p. 17]
Others would say that there is no difference between operations research and CE or CB. [Quade, Report #P4557]
- H. Before moving on can we say anything about the analogies between cost-effectiveness, cost-benefit and other ratios? One view is that the cost-benefit ratio might be analogous to the businessman's calculations of the ratio of sales to cost of goods sold, or of a profit-sales ratio, except that the value of output used in a cost-benefit computation is the social rather than market value. [Dorfman, p. 7]
- I. Finally, it should be made clear that these definitions are by no means the final or precise word. They are approximations.

V. Cost Analysis

- A. If it has not been made explicit by now, cost effectiveness analysis compares costs to measures of effectiveness and cost-benefit analysis compares costs to measures of benefits. The common ingredient of both types of analysis is cost.
- B. Before I tell you what I am not going to tell you about costs, let me tell you about the classic recipe, floating around in economic circles, for horse and rabbit stew. It goes something like this: add one horse to the stew and then add one rabbit. Somehow the stew always tastes like horseflesh.
1. Last year this special interest group on Costs, Budgeting, and Economics sponsored a tutorial on Cost Analysis given by Doug Price. Stand up Doug. That's the horse part of the horse and rabbit stew. Talk to him about costs.
 2. This year the easy way out would be for me to talk mostly about costs and save fifteen minutes for benefits and effectiveness. But those characters in the wings are wise to me.
 3. The net result is that I will not be talking about costs at all and concentrating on the other aspects of the problem.

Real Costs for Information Managers

by

Douglas S. Price, Deputy Director

ERIC Processing and Reference Facility

Keynote Address

National Library Week Symposium III

April 20 - 21, 1972

Minneapolis, Minnesota

Sponsored by the Minnesota Chapters

of

Special Libraries Association

American Society for Information Science

LIST OF FIGURES*

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2	Building Block Assembly	4
3	Building Block Assembly	4
6	Summary Report Format (Simplified)	4
9	Input Products	6
10	Functional Labor Costs	7
11	Input Allocations	10
12	Output Products	13

*These figures were extracted from a longer work.
The numbers were not changed.

Good morning.

Several weeks ago, I read something which strikes me as being the perfect keynote statement for this symposium. It is simply this: "A manager who doesn't know his costs is no manager at all." John Wilson said that in his chapter on costs for the next volume of the Annual Review. I doubt if many people would take issue with his position as stated. After all, we all know how much we have spent and what revenues or ^Ubudget allocation we had to work with, so we know whether we are in the black or the red. But is this enough? Even if we know how our expenditures were distributed among labor, overhead, materials, services, and facilities, do we have enough information to manage? I submit that we do not. Management of an information function requires much more detailed knowledge of what we are spending, how, and what we are getting for our money. This may seem like another obvious statement, but the question of how we collect this detailed information and put it together in a meaningful, useful fashion is not so obvious. Because of the variations in our workloads, the idea of unit costing is very attractive, but unit costs -- in themselves -- are not necessarily more meaningful. In fact, they can be quite misleading. The most common method of determining unit costs in the past has been to divide total expenditures by the number of documents processed. Surely, this gives you a unit cost, but is it any more meaningful than the budget figures? Suppose you spent \$450,000 in one year and processed 12,000 documents, so your unit cost was \$37.50. What information does this figure provide as a basis for management action? In a word, none. There is no structure or detail to the number.

Of course, you can go to the other extreme and send someone out into the shop with a stop watch to time all the functions, multiply by rates, and get all the structure you want. But, again, is this information useful? What

about nonproductive time? And non-labor costs? And the manager? Are you going to time him? Besides, who do you know who can work normally when someone is standing over him with a stop watch?

The use of numbers obtained by either method for management decisions is fraught with risk. In the first case, there isn't enough detail, and in the second, the costs are unlikely to be either accurate or complete. But, in order to manage an information function intelligently, the manager must have the complete picture, and it must be an intelligible picture, with enough structure and detail to permit him to zero in on the real problems. Is there a way to give him this? The answer is, yes.

Over the last six or seven years, a system for building block cost analysis of information systems has been developed. This system -- which incidentally, is new only in its application to information systems -- is designed to provide the information system manager with precisely the information he needs to manage.

Building block costing rests on a couple of basic premises which we should examine --

First, the most effective display of information systems costs is in terms of unit costs. However, it must be recognized that -- in the real world -- it is highly unlikely that a single production count is going to be a useful measure of an entire information system. What you have to do is attempt to break the system up into smaller subunits, each of which is measurable by a single, coherent, countable unit of production. These are then individually unit costed by collecting real costs and real production over a period of time. To find the cost of an end item or deliverable article, you take the appropriate number of each kind of subunit that went into the end item, multiply each by its unit cost and add these together.

Analogous situations exist in the automobile and aircraft industries, where --

I am told -- they can deliver a whole year's production with no two vehicles or aircraft being exactly alike. A given airframe, for instance, may be equipped with varying proportions of first and coach class seats; a cargo framework; or fuel tanks, while a given seat design may be used in any number of different airframes.

The second premise is that unit costs are meaningful only in a framework which includes all costs of the system. Since some information system activities are inherently incapable of being unit costed, this means some method of distribution or allocation has to be applied. Accomplishing this on a rational basis takes some doing.

At this point, let me show you an example of building block cost analysis and how it can help you manage.

Oversimplifying for the purposes of illustration, let us assume an information activity which: collects a series of reports, many of which have author abstracts; prepares surrogates; enters them into a computer system; and produces a monthly abstract journal, in which the abstract section is photocomposed and the indexes are produced on a chain printer. Printing is by offset. Ignoring for the moment other uses to which the computer file may be put, let's assume that he spends \$449,400 per year and processes 12,000 accessions through the system. This works out to a unit cost per accession of \$37.45. Looking at this figure in isolation, a manager might well decide that processing is costing too much and try to crack the whip over his people to get more production; or cut down on the quality or size of abstracts to get the cost down.

However, building block cost analysis would provide him with information something like Figure 1. As you can see there are five building blocks which make up this simplified system. Each issue has 700 accessions with author abstracts, and 300 for which abstracts had to be prepared. This results in 150 photocomposed pages for the abstract section and 200 computer printer pages of

TOTAL COST \$449,400

ACCESSIONS PROCESSED 12,000

UNIT COST \$37.45

	<u>PER ISSUE</u>	<u>ANNUAL 12 ISSUES</u>
700 ACCESSIONS TO FILE, WITH AUTHOR ABSTRACTS @ \$8.00	\$ 5,600	\$ 67,200
300 ACCESSIONS TO FILE, IN-HOUSE ABSTRACTS @ \$15.00	4,500	54,000
150 PHOTOCOPIED PAGES @ \$5.00	750	9,000
200 CHAIN PRINTER PAGES @ \$1.75	350	4,200
1,750,000 PAGES REPRODUCED (350 x 5,000 COPIES) @ \$15.00 PER 1,000	<u>26,250</u>	<u>315,000</u>
	\$ 37,450	\$ 449,400

WITH 4,500 PAID SUBSCRIPTIONS, ANNUAL COST PER SUBSCRIPTION = \$99.87
 AVERAGE COST PER ACCESSION = \$37.45

FIGURE 1. EXAMPLE OF BUILDING BLOCK ASSEMBLY

indexes. A 5,000-copy print run gives us close to 2 million pages per issue for printing. The cost per issue and the annual cost are shown. Note that the average cost per accession is still \$37.45. We also show the average cost per paid subscription. You can see from the unit costs that in-house abstracting adds \$7.00 per item to 30% of the thruput. If you assume brilliant methods analysis and a heroic training effort (both of which will cost money), you might be able to reduce the added cost to \$4.00 without damaging the quality too badly. This would save you \$3.00 per item abstracted, \$900.00 per issue, and \$10,800 per year, which just might defray the cost of the analysis and training.

On the other hand, look at the print run -- 5,000 copies, but only 4500 paid subscriptions. Do you really need 500 extra copies? By cutting the overrun to 250 copies, you can, at virtually no cost, reduce your costs by over \$1,300.00 per issue and nearly \$16,000.00 per year. (See Figure 2). Or take another tack. Photocomposition of the indexes can conservatively reduce the number of pages in the indexes by one-third. Suppose you spent \$25,000.00 for programming to photocompose the indexes. You will have increased your per issue page preparation costs by \$320.00, but will have reduced your printing costs by \$4703.00 per issue for a net savings of \$4383.00 per issue. Over the year, this amounts to a saving of over \$50,000.00 (See Figure 3) for a net in the first year of more than the investment in programming. Note also, that by these two actions we have reduced the average unit cost by \$5.69 without touching the input processing cost!

You can see how valuable this kind of display would be to a manager, but what I have shown you so far has been out of context, so let's try to put it back into context so I can show you how these numbers are obtained.

Figure 6 is a greatly simplified sample of a summary report. An actual report would have a great many more lines and columns. I have a sample of an actual report here, but you can see that if I tried to put it on the screen, you wouldn't be able to read it. However, this will establish the pattern, and we

	<u>PER ISSUE</u>	<u>ANNUAL 12 ISSUES</u>
700 ACCESSIONS TO FILE, WITH AUTHOR ABSTRACTS @ \$8.00	5,600	67,200
300 ACCESSIONS TO FILE, IN-HOUSE ABSTRACTS @ \$15.00	4,500	54,000
150 PHOTOCOMPOSED PAGES @ \$5.00	750	9,000
200 CHAIN PRINTER PAGES @ \$1.75	350	4,200
1,662,500 PAGES REPRODUCED (350 x 4,750 COPIES) @ \$15.00 PER 1,000	<u>24,938</u>	<u>299,256</u>
	TOTAL \$ 36,138	\$ 433,656
	SAVINGS OVER FIGURE 1: \$ 1,312	\$ 15,744

WITH 4,500 PAID SUBSCRIPTIONS, ANNUAL COST PER SUBSCRIPTION = \$96.37

AVERAGE COST PER ACCESSION = \$36.14

FIGURE 2. BUILDING BLOCK ASSEMBLY

	<u>PER ISSUE</u>	<u>ANNUAL 12 ISSUES</u>
700 ACCESSIONS TO FILE, WITH AUTHOR ABSTRACTS @ \$8.00	5,600	67,200
300 ACCESSIONS TO FILE, IN-HOUSE ABSTRACTS @ \$15.00	4,500	54,000
284 PHOTOCOMPOSED PAGES @ \$5.00	1,420	17,040
1,349,000 PAGES REPRODUCED (284 x 4,750 COPIES) @ \$15.00 PER 1,000	<u>20,235</u>	<u>242,820</u>

TOTAL	\$ 31,755	\$ 381,060
SAVINGS OVER FIGURE 2	4,383	52,596
LESS EXPENSES		(25,000)
NET SAVING 1ST YEAR		27,596

WITH 4,500 PAID SUBSCRIPTIONS, ANNUAL COST PER SUBSCRIPTION = \$84.68
 AVERAGE COST PER ACCESSION = 31.76

FIGURE 3. BUILDING BLOCK ASSEMBLY

PROD. CLASS	DESCRIPTION	UNITS	DIRECT COSTS	INTERNAL ALLOCATIONS & TRANSFERS	SUBTOTAL	EXTERNAL BURDENS	TOTAL COSTS
	TOTAL COSTS		\$125,000	\$ -	\$125,000	\$25,000	\$150,000
	GENERAL COSTS		25,000	(25,000)	-	-	-
	AD HOC ACTIVITIES		15,000	3,750	18,750	3,750	22,500
	INPUTS		30,000	7,500	37,500	7,500	45,000
	OUTPUTS		35,000	8,750	43,750	8,750	52,500
	COLLATERAL SERVICES		20,000	5,000	25,000	5,000	30,000

FIGURE 6. SUMMARY REPORT FORMAT (SIMPLIFIED)

can look at some of the details later.

The first column headings are fairly straightforward. Product Class simply provides a place to identify each line entry by the tag(s) used to collect its costs, and Description is self-explanatory. Units would not be applicable to the line entries shown, but would be an essential for any line entry where you are calculating unit costs. Direct Costs would, in a real report, certainly be shown in more detail -- at least to the level of Direct Labor, Fringe, and Other Direct Costs, with a subtotal. Note that Fringe (i.e., Vacation, Holiday, Pension, Insurance, etc.) which is a kind of burden, is included here among direct costs. This is because unlike most other burdens, it really is a percentage of the base against which it is applied. The division of Other Direct Costs into its components would be determined by your situation. If you had heavy computer involvement, you would probably want to show this as a separate column. Similarly, Printing or a large subcontract affecting a number of products might also be separately displayed.

Internal Allocations & Transfers represents the distribution of costs which cannot be directly associated with production. In this simplified report, we have simply allocated General Costs across the other costs on the basis of total direct costs shown in the previous column.

Turning our attention now to the lines, we encounter the crux of this report, the Total Costs line, which must show class by class, every dollar spent during the period being reported. The only other point to note is that the total for the allocations columns will always be zero; they do not change total costs, only redistribute them.

The remainder of the lines we show here would appear as subtotals, if at all, on a real report. What I have chosen to show here are the five general categories of activities which are typical of information systems. Let's look at these for a moment.

General Costs are the essentially fixed costs of operating an information system, and would include such things as the manager and his staff, rent, utilities, etc. They would also include the costs of system development and maintenance, including computer programming, if you use a computer.

Ad Hoc Efforts - Include the innumerable special studies and tasks with which almost any information operation is deluged over the course of a year. Usually, these get buried in the burdens, but they should be separately identified, if only to show management how useful you are.

Inputs - Include all the activities which are concerned with building a base and maintaining it, e.g. Acquisitioning, Cataloging, Abstracting, Indexing, Update, etc.

Outputs - Include all the activities which draw on the data base to produce products for sale or delivery to the customer(s), e.g. Publications, Indexes, Searches, SDI, etc.

Collateral Services - Include activities which are "spin^o-offs" from the input/output activities, but are not necessarily dependent on them, e.g. producing microfiche of the documents or duplicating copies on request.

The significance of these categories lies in the fact that a valid building block activity will be wholly contained within one -- and only one -- of them. Further, while Inputs, Outputs, and Collateral Services can usually be unit costed, Burdens cannot, in and of themselves be unitized. However, to display real costs, they must be incorporated into the unit costs, usually by a process of allocation. The treatment of Ad Hoc Efforts will vary depending upon the organization. In a service center, they should be displayed separately, and carry a share of Burden costs. In a commercial operation, they would ultimately have to be included in the burden, but provision should be made for separate display

DESCRIPTION	UNITS	DIRECT LABOR	FRINGE	COMPUTER USAGE	OTHER DIRECT COSTS	TOTAL DIRECT COSTS
ACQUISITIONS	N.A.	\$20,000	\$4,000	-	\$2,000	\$26,000
RECEIVING & INPUT	26,000 DOCUMENTS	52,000 2.00	10,400 0.40	-	15,600 0.60	78,000 3.00
ACCESSIONS TO FILE						
a. CLASS A - ANNOUNCED	12,000 ACCESSIONS	117,000 9.75	23,400 1.95	21,000 1.75	18,600 1.55	180,000 15.00
b. CLASS B - INDEXED	5,000 ACCESSIONS	31,000 6.20	6,200 1.24	6,250 1.25	6,550 1.31	50,000 10.00
c. CLASS C - CATALOGED	2,000 ACCESSIONS	7,200 3.60	1,440 0.72	2,000 1.00	1,360 0.68	12,000 6.00
AUTHORITY FILE UPDATES						
a. INDEXING VOCABULARY	120 TERMS	1,800 15.00	360 3.00	720 6.00	120 1.00	3,000 25.00
b. CORPORATE SOURCES	240 SOURCES	1,200 5.00	240 1.00	720 3.00	240 1.00	2,400 10.00

FIGURE 9. INPUT PRODUCTS

so that the extent of such activities can be measured and, if appropriate, changed

Let's go down to Inputs and look at these in some detail as illustrative of how the building block costs are arrived at. Figure 9 shows a possible set of Input products. This is probably more detail than you would normally use, but I need all of these to illustrate some points about the building block concept.

Figure 9 also displays for each product by cost element, the total cost for the period and, except for Acquisitions, a unit cost which is obtained by dividing the dollar cost for the element by the units shown in the Units column of the report. This juxtaposition enables the manager to assess both the unit cost and the dollar impact at a glance.

Let's look at the products I have chosen to represent here. Acquisitions is not unit costed for several reasons. Primarily this is because there is little value in an average unit cost for this activity. On one hand, the attempt to acquire a single document may require considerable research and several follow-up letters, with ultimate failure. On the other, a single form letter or coupon may result in the acquisition of many documents. Also, there may be -- and usually is -- a considerable time lag between the exertion of the effort and the response. Add to this the difficulty of distinguishing between documents which arrive as a result of acquisitions effort and those which arrive because people know you exist, and you have a hopeless situation. You can eventually arrive at a unit cost of sorts, but we will get to that later.

Receiving and Input, however, is a readily measurable function. Since this is all of the activities from the point the document hits your receiving station through the decision to process it in a certain way, this is readily measurable by a count of the incoming documents. Note that in the example, the number of units is greater than the total number of accessions to file. This illustrates the point that processing duplicates and rejects also costs money. The valid measure of this effort is not how many accessions may eventually be added to

the file, but how many documents have to be processed through these operations.

Under Accessions to File, we have three substantially different kinds of Inputs. Class A is presumed to be current significant material which warrants announcement in an abstract journal and perhaps SDI treatment. The announcement will include cataloging data, an abstract, and indexing for both publication and machine retrieval. Class B is older or less significant material, which is entered into the system only for machine retrieval. It is catalogued and indexed only. Class C is administrative material which is entered into the system for control purposes only. It is cataloged only.

This array is, I suspect, more complex than you would commonly encounter, but I will need the detail to illustrate some points further on.

You will note that, in Class A, I have not displayed a distinction between items which have author abstracts, and those which must be abstracted in-house. The reason for this is that, at the delivery point as Accessions to File, they are substantially indistinguishable. The only significant difference between them is the amount of labor required to get them to that point -- and that occurs only in document analysis. To illustrate this point, and show how the system can make this distinction, let's look at Figure 10 for a moment. This is a functional analysis of labor costs for each of the inputs. The first line shows the overall cost and unit cost by function for the total of Class A labor, using the total production volume of 12,000 units as the divisor. This reconciles the functional entries to the direct labor costs in Figure 9. The second line shows the functions which are common to both author and in-house abstract accessions to give a total labor unit cost of common functions of \$6.25. It should be apparent that to the cataloger or the keyboard operator, for instance, it is irrelevant whether or not the item carries an author abstract. The next two lines display the overall and unit costs of the two significant functions -- Indexing and Indexing/Abstracting -- using their respective production volumes as divisors.

These yield unit costs of \$2.00 and \$6.00 per item respectively. Adding the common unit costs to each of these gives us labor unit costs for Author Abstract Items of \$8.25 and for In-House Abstract items of \$12.25. Note that we have not separated abstracting per se as a separate function. It is uneconomical to have one person review the document for the purpose of preparing an abstract and have someone else review it for the purpose of indexing -- and if you have one person doing both tasks, it is irrational to expect him to divide his time appropriately.

While we are on Figure 10, I might point out that the cataloging unit costs for all three classes are the same, since cataloging is cataloging. In the real world, these would probably not be identical, but they should track pretty closely. Class B shows indexing and editing costs somewhat below the Author Abstract items of Class A because there is no indexing for publication, and there is less material to edit. Keying, however, should be substantially lower, because the abstract will probably be more than half the volume of keying a Class A item. Class C shows no indexing, of course, and somewhat lower other costs because of this.

Returning to Figure 9, we find the Authority File Updates divided into two areas; Indexing Vocabulary; and Corporate Sources. A glance at the unit costs -- which, although imaginary, are not too unrealistic -- will show why these are separated from the straight processing and from each other. There is a secondary reason, in that the volume of these activities -- particularly, the vocabulary -- has very little relationship to the input volume. Typically, during start-up, when processing volume is relatively low, vocabulary additions are quite voluminous, but as volume increases, and the base is built, the need for additional vocabulary terms drops off quite sharply. In the example, the Indexing vocabulary is presumed to be a hierarchically-structured thesaurus, requiring the determination of broader and narrower terms, synonyms, etc., while a Corporate Source entry only requires determination that it is in fact a new source and not a variation of an

Description	A Production Quantity	FUNCTIONS								I Total Direct Labor
		B Cataloging 21	C Indexing 22	D Abstract Indexing 23	E Initial Edit 24	F Keying 31	G Print-Out Edit 25	H Clerical 11		
CLASS A TOTAL	12,000	21,000 1.75	15,000 1.25	27,000 2.25	15,000 1.25	24,000 2.00	12,000 1.00	3,000 0.25	117,000 9.75	
CLASS A COMMON	12,000	21,000 1.75	See Below	See Below	15,000 1.25	24,000 2.00	12,000 1.00	3,000 0.25	75,000 6.25	
CLASS A INDEX AUTHOR/ABSTRACT	7,500		15,000 2.00						15,000 2.00	
CLASS A INDEX AND IN-HOUSE ABSTRACT	4,500			27,000 6.00					27,000 6.00	
CLASS B INDEXED	5,000	8,750 1.75	9,000 1.80		5,000 1.00	4,000 0.80	3,750 0.75	500 0.10	31,000 6.20	
CLASS C CATALOGED	2,000	3,500 1.75			1,500 0.75	1,000 0.50		200 0.10	7,200 3.60	

Notes: 1. The figures in column A (Quantity Produced) and column I (Total Direct Labor) are identical with column A (Quantity Produced and Units) and column B (Direct Labor) of Sheet 1 for the corresponding Product Line Entries.

FIGURE 10. FUNCTIONAL LABOR COSTS

existing one, and requiring only a single line entry, with perhaps a code.

At this point, we are tracking seven different products (or classes of cost) for Inputs, but only three of these, the Accessions to File, are "deliverable" items in the sense that they are significant additions to the data base which will increase its value. The other four products only support these "deliveries". Therefore, their cost must be reflected in the final cost of the items delivered or added to the data base. This is where the allocation and transfer technique which I mentioned earlier, comes into play.

Let's look at a few of the various ways in which this can be done. I use that phrasing to remind you that allocation is inherently an arbitrary process. There is no universal "right way". Even similar situations may require different treatment in different systems. The only criteria are rationality and usefulness. Figure 11 illustrates some approaches we have found useful. To keep the process as simple as possible, the Management Allocation and the Systems Maintenance Allocation should be applied in that order before all others. The Management Allocation is the internal burden mentioned earlier and is usually applied as a percentage of Direct Costs. The factor is determined by dividing the Direct Costs of Management by the total of all other Direct Costs. In the example, this factor is 0.5 (or 50%) which is not too unrealistic if Management includes rent, utilities and maintenance costs. But look at those numbers. That Management Allocation has a terrific impact on your unit costs. If you could reduce it to 40% by, for example, dispensing with unneeded floorspace, or services, or even people -- or, of course, by increasing your base -- you would achieve the same effect on the unit cost of announced items alone as you would by eliminating in-house abstracting! Systems Maintenance (which is defined as computer systems maintenance) is allocated on the base of computer usage rather than Direct Costs so that it burdens only those products which make use of the computer. Remember

DESCRIPTION	UNITS	TOTAL DIRECT COSTS	ALLOCATIONS						REVISED TOTAL DIRECT	
			MANAGEMENT NOTE 1	SYSTEMS MAINT. NOTE 2	ACQUISITIONS NOTE 3	INPUT NOTE 4	INDEX. VOCAB. NOTE 5	CORP. SOURCES NOTE 6		
ACQUISITIONS	N.A.	26,000	13,000		(39,000)					
RECEIVING AND INPUT	26,000 Docmts.	78,000 3.00	39,000 1.50				(117,000) //4.50//			
ACCESSIONS TO FILE										
a. CLASS A - ANNOUNCED	12,000 Accessns.	180,000 15.00	90,000 7.50	4,200 0.35	29,008 2.42		73,895 6.16	3,278 0.27	2,365 0.20	382,746 31.90
b. CLASS B - INDEXED	5,000 Accessns.	50,000 10.00	25,000 5.00	1,250 0.25	8,058 1.61		30,789 6.16	1,366 0.27	985 0.20	117,448 23.49
c. CLASS C - CATALOGED	2,000 Accessns.	12,000 6.00	6,000 3.00	400 0.20	1,934 0.96		12,316 6.16		394 0.20	33,044 16.52
AUTHORITY FILE UPDATES										
a. INDEXING VOCABULARY	120 TERMS	3,000 25.00	1,500 12.50	144 1.20				(4,644) //38.70//		
b. CORPORATE SOURCES	240 SOURCES	2,400 10.00	1,200 5.00	144 0.60					(3,744) //15.60//	

- NOTES:
1. (a) 50% of Total Direct
 2. (a) 20% of Computer Usage
 3. To Classes A.B.&C. by Total Direct
 4. To Classes A.B.&C. by Volume
 5. To Classes A.&B. by Volume
 6. To Classes A.B.&C by Volume

FIGURE 11. INPUT ALLOCATIONS

that both of these allocations are applied across the whole system and we are looking here at only a portion, the Inputs.

With the Acquisitions allocations, we come to the specific Internal transfers for Inputs, and we can discuss some of the reasoning we have applied to specific allocations. The first thing to note is that the amount being allocated must include all previous allocations. In the example, the previous allocation to Acquisitions was the Management Allocation, so the amount to be allocated is \$39,000 -- \$26,000 in Direct Costs and \$13,000 Management Allocation. We have chosen to allocate Acquisitions on the basis of Total Direct Costs. The allocation pool (\$39,000) is divided by the sum of the Total Direct Costs of the three Accessions to File products (\$242,000) to obtain a factor of 0.16. This is then applied to the Total Direct Cost of each line entry to obtain the allocation for each. This procedure applies nearly three quarters of the Acquisition cost to the Class A accessions. You could, of course, make this allocation on the basis of volume processed. In this case, you would divide the allocation pool (\$39,000) by the total production (19,000) to obtain a factor (or more correctly a unit cost) of \$2.053. This is then multiplied by the production figure for each line entry to obtain the dollar allocation. The unit cost would then be constant for all three Classes. This procedure reduces the burden on Class A accessions by about \$4,000 and increases the other two by about \$2,000 each. This is perfectly valid (i.e. conforming to the rules), but is it rational? If you remember the definitions of the classes, I think you will agree that it is not. In this particular case (and I can't emphasize that too strongly), the main thrust of Acquisitions would be to acquire the most current, most significant documents, i.e. Class A. Should we then let Class A carry the entire load? Again, no. Inevitably, there will be fall-out from the Acquisitions effort which will benefit the other two classes, so they should carry a part, albeit a small one, of the load.

The negative entry -- shown in parentheses () -- zeroes out both the line and the column to maintain the arithmetic integrity of the report.

The Input Allocation, on the other hand, is a different story. We have been showing unit costs for Receiving and Input all along, and for this operation, a document is a document, without regard to which class of accession it may become. However, the unit cost of the allocation pool (shown in brackets) is not the unit cost we use for the allocation. The new unit cost is calculated by dividing the pool by the total Accessions to File or 19,000 rather than the 26,000 documents used heretofore. This results in a higher unit cost, which distributes the cost of duplicates and rejects equitably among the accession classes.

The difference between the unit cost for the product itself and that for allocation becomes dramatic when we examine the allocation of the Indexing Vocabulary costs. The unit cost for this allocation pool is large enough to be frightening by itself, but look what happens when we allocate it. The unit cost per indexed accession to file comes down to only \$0.27 which is of minor importance. This illustrates the point that high unit costs of subsidiary products can be tolerated if their volume -- hence the total dollar impact -- is small with respect to the main product line(s). This allocation also illustrates the limitation of allocations to benefitting products. Since Class C accessions are not indexed, they do not carry any of the burden of the indexing vocabulary updates.

However, a Class C accession is as likely to generate a new corporate source as is a Class A or B accession, so the Corporate Source pool is allocated (again, on the basis of volume) to all three accession classes. Here also, there is a dramatic difference between the unit cost of the pool, and the unit cost of allocation because of the relatively small volume.

If we were displaying the costs and allocations for the entire system, the top line total for the last column, Revised Total Direct, should be precisely the same

number as the top line total for the first column, Total Direct Costs, to verify the validity of the allocations.

If we were to carry these products out to the end, we would add in succeeding columns the external burdens such as general and administrative costs, marketing, and profit (or fee), with a total cost column as the last entry.

You can now see, I think, how the building block costs are arrived at. Outputs would be treated in a similar fashion, except that they are usually not quite so complicated. However, there are usually more of them. Figure 12 is a listing of possible outputs of an information system in four general classes: Publications Pages; Magnetic Tapes; Searches; and Duplication/Publication. Note that for several of these, a number of possible units are shown. This is because what you can count will depend on your system, and the way things are costed.

Now I have spent a good deal of time explaining building block cost analysis because I believe it offers the key to effective cost analysis and control for information systems -- and these are absolutely essential in today's environment. What I haven't told you -- and obviously can't in the time we have -- is how to put this to work for your system. Even if our time was unlimited, I really couldn't do that. Installing building block costing is for the foreseeable future a do-it-yourself project. Since each system is unique, the building block structure has to be designed specifically for it. There is some help available in the form of the text for the tutorial "Collecting and Reporting Real Costs of Information Systems" which was presented by the Special Interest Group on Costs, Budgeting, and Economics at the ASIS Annual Meeting in November. This text is available from ASIS headquarters at \$6.00 a copy. Incidentally, I'm not plugging it for myself. ASIS gets all the income.

For most of the last 20 years, I have been hearing and reading about how impossible it is to analyze and control costs of information systems, because of their unique nature. Only in the last couple of years has the literature re-

OUTPUT PRODUCTSUNITS

1 PUBLICATION PAGES

- | | |
|----------------------------|--------------------|
| a. PHOTOCOMPOSED | PAGES |
| b. COMPUTER-ONTO-MICROFILM | PAGES/FRAMES/FICHE |
| c. COMPUTER PRINTER | |
| (1) CAMERA READY | PAGES |
| (2) LISTINGS | PAGES |
| (a) UPPER CASE ONLY | PAGES |
| (b) UPPER/LOWER CASE | PAGES |

OR, ALTERNATIVELY

- | | |
|----------------|-------|
| (a) TWO-PART | PAGES |
| (b) THREE-PART | PAGES |
| (c) ETC. | PAGES |

2 MAGNETIC TAPES

- | | |
|------------------------|-------------------------------------|
| a. PUBLICATIONS FORMAT | TAPE REELS/RECORDS/CHARACTERS/PAGES |
| b. DATA BASE COPIES | TAPE REELS/RECORDS/CHARACTERS |
| c. PROGRAMS | TAPE REELS/RECORDS/CHARACTERS |

3 SEARCHES

- | | |
|----------------------|-------------------------------------|
| a. CURRENT AWARENESS | HIT/PROFILE PER ACCESSION CHECKED/? |
| b. RETROSPECTIVE | SEARCH/HIT/PAGE |
| c. MANUAL | SEARCH/HOUR/? |
| d. PUBLICATION | SEARCH/HIT |

4 DUPLICATION/PUBLICATION

- | | |
|----------------------|--------------|
| a. PLATE PREPARATION | PLATE/? |
| b. PRINTING | PAGE COPY/? |
| c. BINDING | COPY/? |
| d. DISTRIBUTION | COPY/ISSUE/? |

FIGURE 12. OUTPUT PRODUCTS

flected any real concern with costs and efforts to analyze and control them. I am sure you will agree that we can no longer afford such superstitions.

Building block costing has been proved in actual use in real information systems. If you are going to manage an information function, I suggest you give it careful consideration.

VI. General Problems in Measuring Effectiveness and Benefit

- A. In succeeding chapters we will discuss specific measures of effectiveness, and then benefit, applicable to information services. In this section a discussion of some general methodological problems in developing measures will be examined.
- B. Let us return to our systems analysis framework for a moment. Recall that in the black box analogy:



the system is designed to achieve a desired output. The process of cost-effectiveness and cost-benefit analysis involves an evaluation of the system or alternative systems to determine how well the objectives of the system are being met.

1. Development of an effectiveness or benefit measure involves a careful scrutiny of the goals and objectives in order to be able to quantify them.
2. Before talking about specific measures it is important to have a clear understanding of how objectives should be established.

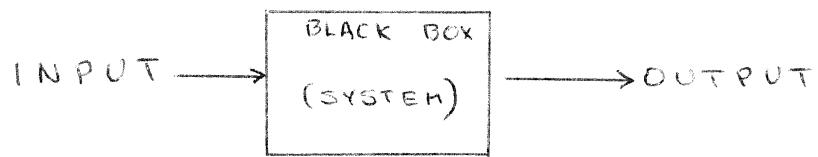


Figure 2

- C. As an example of establishing objectives, consider the case of the information needs of individuals. [Patrick and Cooper]
1. Assume our objective is to provide information to individuals. Then it may be possible to express the objective quantitatively in terms of (e.g.) amount of information transferred, specific socio-economic groups reached, or types of information needs satisfied.
 2. It would be incorrect to automatically assume that an existing institution, such as a library, is the correct one to satisfy the need for information. Thus the objective of the system could not be stated in terms of, say, circulation without proxy that the library is the correct institution.
 3. Continuing with the same line of reasoning, one could not use published library goals statements as a criterion for evaluation because these are indirectly related to the information need problem.
 4. Finally, library standards could not be used because there is no conclusive evidence that the standards are based on individual needs.

D. Another general consideration in the measurement of effectiveness and benefit has to do with assessing the quality of the product or service. [Hirsch]

1. One needs to make explicit the quality of the product in the measure.
2. It is necessary to state the quality if the measure is going to be used to compare different services.
3. Want to know the quality if for no other reason than to make adjustments in production and price indices.
4. Steps in determining the quality of service units.

[Hirsch, p. 246].

- a. Define the service unit.
- b. Identify the quality.
Characteristics of service units.
- c. Estimate the money value and money-cost of characteristics.

5. Examples of the determining quality of service units.

[Hirsch, p. 247-8]

- a. Define service unit.
 - (1) Residential refuse collection - refuse collection and disposal per household per week in pounds.
 - (2) Water supply: cubic foot of water delivered to place of use.

- (3) Street cleaning: square foot of street cleaned.
- (4) Library: use Meier's measure of item use days as partial measure.
- b. Identification of quality characteristics.
 - (1) Water supply: quality characteristics include hardness, temperature, color, taste, odor, mineral content, bacteria count.
Delivery process characteristics: pressure, reliability, rapid repair, correct metering, etc.
 - (2) Library service: book is basic unit.
 - (a) Quality characteristics: selection, physical condition of books themselves.
 - (b) Secondary quality characteristics: availability of books when requested, good reading room facilities, help to children in selecting books, reference service and location of library.
- 6. Library standards are not a measure of quality because they have not been formulated with information needs in mind.
- 7. Could use Delphi to establish goals.

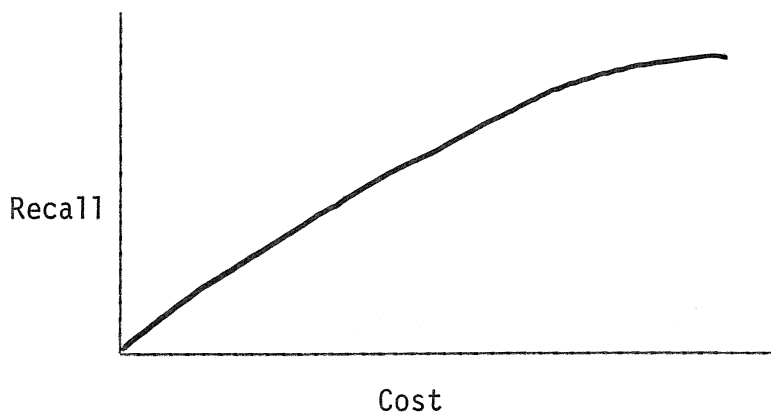
E. Uncertainty.

1. One wants to consider that not all estimates will be equally reliable and of equal certainty.
2. Two types of uncertainty [Fisher, p. 12]
 - a. Uncertainty about the state of the world in the future. Major factors here are technological uncertainty, strategic context uncertainty, uncertainty about the enemy and his reactions.
 - b. Statistical uncertainty. Has to do with probabilistic occurrences of events. Use simulation to analyze.
3. Sensitivity analysis. Manipulate certain key parameters of a model to see the effect on the result. Use to counter the uncertainty about the state of events in the future.

Not the same
simulation
sensitivity

VII Cost Effectiveness Analysis

- A. In our discussion of the methodology of systems analysis we saw that the systems approach involves analyzing and designing systems. Cost-Effectiveness analysis is presented here as a tool to aid in the systems analysis process.
- B. The concept underlying cost-effectiveness analysis is that in any systems analysis or design one can not perform the analysis without considering the cost of a system, the effectiveness of the system, and the trade-off between cost and effectiveness.
- C. Consider a simple example of evaluating an information retrieval system. Suppose we measure the effectiveness of the system by the recall ratio. Also let us presume we can calculate the cost per search. Then we can perform a simple cost-effectiveness analysis by comparing the recall with the cost to obtain that recall level. As a next step we can redesign the system based on what we know about the cost-recall relation.



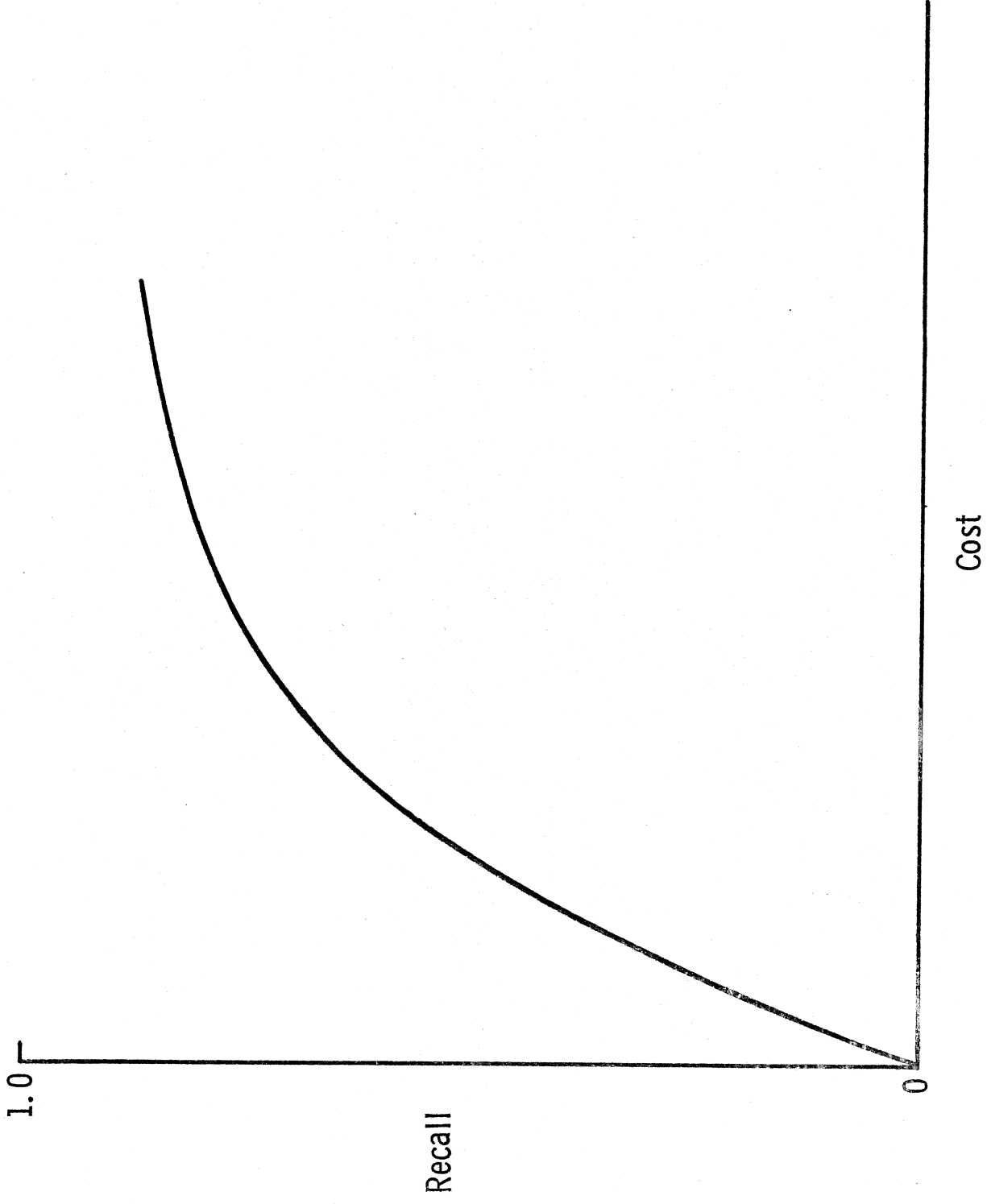
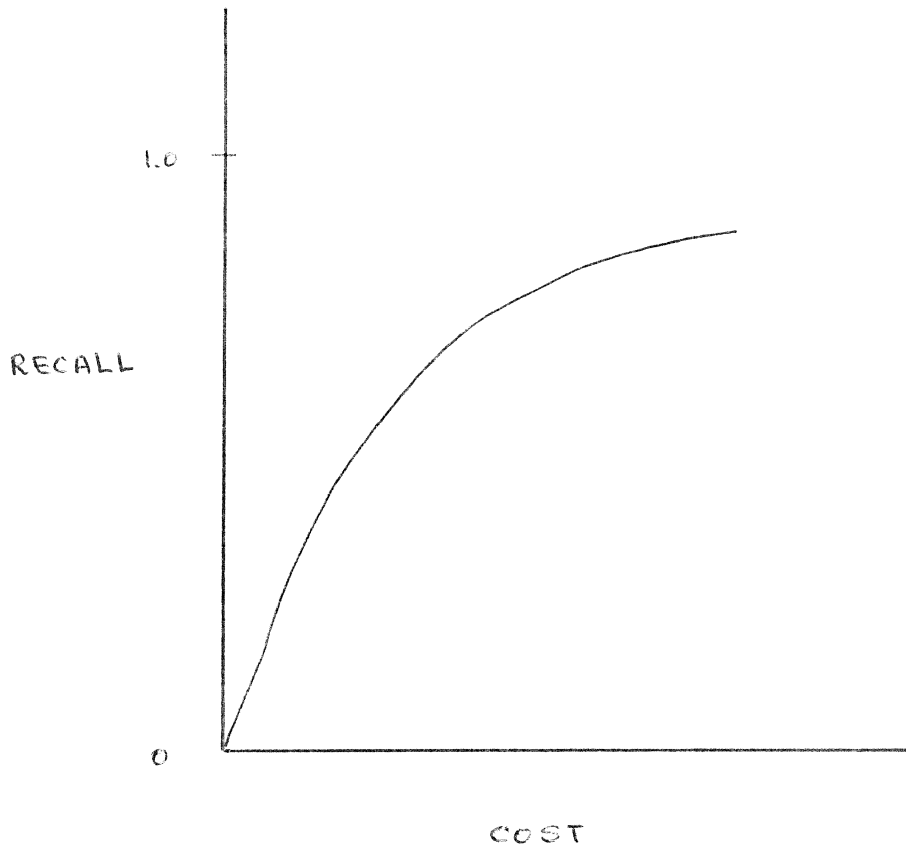


Figure 4



Example of Cost-Effectiveness analysis of a retrospective search system

[King, Donald W. and Nancy W. Caldwell Westat Research March 1971 APA]

1. Objective was to explore the factors that affect the choice among alternative systems for retrospective searching.
2. Measure effectiveness by search accuracy. Perfect search accuracy implies that searches yield all relevant documents and no nonrelevant materials. Measure accuracy by recall (proportion of relevant documents retrieved) and fallout (proportion of nonrelevant documents retrieved).
3. A large fallout implies high costs, since each retrieved document adds to processing, output, screening and mailing costs.
4. Cost model: 3 types of costs
 - a) Fixed costs associated with each subsystem.
 - b) Variable costs dependent on the number of items input to the system.
 - c) Variable costs dependent on the number of searches conducted.
5. Cost model

$$C = C_1 + C_2 + C_3 + C_4 + C_5 \\ + X_1(C_6 + X_5C_7) + X_2[C_8 + C_9 + X_3(C_{10} + C_{11} + C_{12}) + X_4C_{13}],$$

where:

- X_1 = number of items input,
- X_2 = number of searches conducted,
- X_3 = number of items retrieved per search,
- X_4 = number of items mailed per search,
- X_5 = number of terms in authority list,

- C_1 = fixed cost associated with computing,
- C_2 = fixed cost associated with screening,
- C_3 = fixed cost associated with input,
- C_4 = fixed cost associated with user/system interface,
- C_5 = fixed cost associated with mailing results,
- C_6 = total input cost per item,
- C_7 = total file loading cost per item per term,
- C_8 = fixed cost of mailing per search,
- C_9 = fixed cost of user/system interface per search,
- C_{10} = computer retrieval cost per item retrieved,
- C_{11} = computer printing cost per item retrieved,
- C_{12} = screening cost per item retrieved,
- C_{13} = mailing cost per item mailed, and
- C = total annual cost.

TABLE 3

Cost per Search, per Item Retrieved, and per Relevant Item Retrieved for Alternative Retrospective Search Systems, Subsystems, and Recall Levels (Demand = 1,000)

Recall level and cost (\$) for each	Written request			Telephone request		
	Batch processing	On-line index	On-line abstract	Batch processing	On-line index	On-line abstract
No screening -- mail titles to users						
.40 Search Item retrieved	212.00	117.00	252.00	216.00	121.00	256.00
Relevant item retrieved	6.60	4.30	1.10	6.70	4.50	9.80
.60 Search Item retrieved	11.20	6.20	13.30	10.80	6.00	12.80
Relevant item retrieved	213.00	117.00	252.00	217.00	121.00	256.00
.80 Search Item retrieved	3.30	2.30	6.00	3.30	2.30	6.00
Relevant item retrieved	7.40	4.00	8.70	7.50	4.20	8.80
Search item retrieved	216.00	135.00	252.00	220.00	138.00	256.00
Relevant item retrieved	1.70	1.30	3.20	1.70	1.40	3.20
Search item retrieved	5.70	3.50	6.60	5.60	3.50	6.60
Relevant item retrieved	230.00	152.00	279.00	233.00	156.00	282.00
Search item retrieved	.60	.70	1.60	.60	.70	1.60
Relevant item retrieved	4.80	3.20	5.80	4.80	3.20	5.80
No screening -- mail abstracts to users						
.40 Search Item retrieved	215.00	119.00	254.00	219.00	123.00	258.00
Relevant item retrieved	6.70	4.40	10.20	6.80	4.60	9.90
.60 Search Item retrieved	11.30	6.20	13.40	11.50	6.20	12.90
Relevant item retrieved	219.00	122.00	256.00	223.00	125.00	260.00
.80 Search Item retrieved	3.40	2.40	6.10	3.40	2.40	6.00
Relevant item retrieved	7.60	4.20	8.80	7.70	4.30	9.00

TABLE 3 (cont)

Recall level and cost (\$) for each	Written request		
	Batch processing	On-line index	On-line abstract
.80 Search Item retrieved	228.00	144.00	2
Relevant item retrieved	1.80	1.40	
.60 Search Item retrieved	6.00	3.80	
Relevant item retrieved	266.00	173.00	2
.80 Search Item retrieved	.70	.80	
Relevant item retrieved	5.60	3.60	
Tight screen on titles --			
.40 Search Item retrieved	218.00	123.00	
Relevant item retrieved	72.67	41.00	
.60 Search Item retrieved	72.67	41.00	
Relevant item retrieved	220.00	126.00	
.80 Search Item retrieved	44.00	25.20	
Relevant item retrieved	44.00	25.20	
.80 Search Item retrieved	226.00	149.00	
Relevant item retrieved	32.29	21.29	
.60 Search Item retrieved	37.67	24.83	
Relevant item retrieved	251.00	179.00	
.80 Search Item retrieved	25.10	19.89	
Relevant item retrieved	31.38	22.38	

User costs depend on the user/system interface (written requests versus telephone requests). Typical costs for these are given in Table 2B.

TABLE 2B
Search Costs Dependent on User/System Interface

Search	Written request	Telephone request
C ₄ - staff, rent, other overhead	\$500 ^a	\$500 ^a
C ₉ - staff, equipment	\$11.25/search.	\$15.00/search

^aAmortized over 4 years.

Screening can be performed on titles or abstracts, which yield substantially different costs. Typical costs for these are given in Table 2C.

TABLE 2C
Screening Costs

Screen	Titles	Abstracts
C ₂ - staff, rent, equipment, other overhead	\$4,000 ^a	\$32,000 ^a
C ₁₂ - staff	\$.04/item retrieved	\$.125/item retrieved

^aAmortized over 4 years.

Finally, mailing costs also depend on whether titles or abstracts are sent to the user. Typical mailing costs are given in Table 2D.

TABLE 2D
Mailing Costs

Mailing	Titles	Abstracts
C ₅ - staff, rent, equipment, other overhead	\$250 ^a	\$250 ^a
C ₈ - preparation, staff materials	\$.20/search	\$.35/search
C ₁₃ - postage, materials	\$.002/item sent	\$.10/item sent

^aAmortized over 4 years.

An example is given to illustrate the following:

1. System processes include batch tight screening on abstracts, number of items input (X₁) is 1
2. number of searches (X₂) is 4,000
3. number of items retrieved per search is 80% prior to screening
4. recall level is 80% prior to screening
5. number of items mailed per search at 80% and after-screening is 1
6. number of terms in authority list is 1

The model is:

$$\begin{aligned}
 C &= C_1 + C_2 + C_3 + C_4 + C_5 + X_1(C_6 + X_2) \\
 &+ X_2[C_8 + C_9 + X_3(C_{10} + C_{11} + C_{12})] \\
 &= \$131,000 + \$32,000 + \$5,500 + \$500 \\
 &+ 100,000[.575 + (1,000)(\$-0.00003)] \\
 &+ 4,000[0 + \$15.00 + 126(\$-0.05 + \$ \\
 &= \$169,250 + \$61,250 + \$161,032 \\
 &= \$391,532
 \end{aligned}$$

The average cost per search is then \$97 retrieved document is \$4.40 (\$97.90/22) retrieved is \$4.60 (\$97.90/21).

Using the cost model, the following in the preceding example for demand level emphasized again that these cost estimates from scanty information available from estimates should be very useful for gross the effect of such factors as demand on serve as a benchmark to assess potential

Discussion

Table 3 gives the cost per search, per relevant item retrieved for 1,000 relevant items. Table 4 gives the same information for three cost measures.² As the search processing system becomes more competitive probably the most feasible. Of course, the incremental costs necessary to achieve

²One should not generalize this cost search costs can be reduced considerably to a broader range of other services or

7. Cost-effectiveness analysis involves making tradeoff analysis between various types of screening:

- a) Tight screening on abstracts
- b) Loose screening on titles
- c) Loose screening on abstracts
- d) Tight screening on titles
- e) No screening

Also involved are various types of delivery systems:

- a) Mail abstracts to user
- b) Mail titles to user

Also the type of processing:

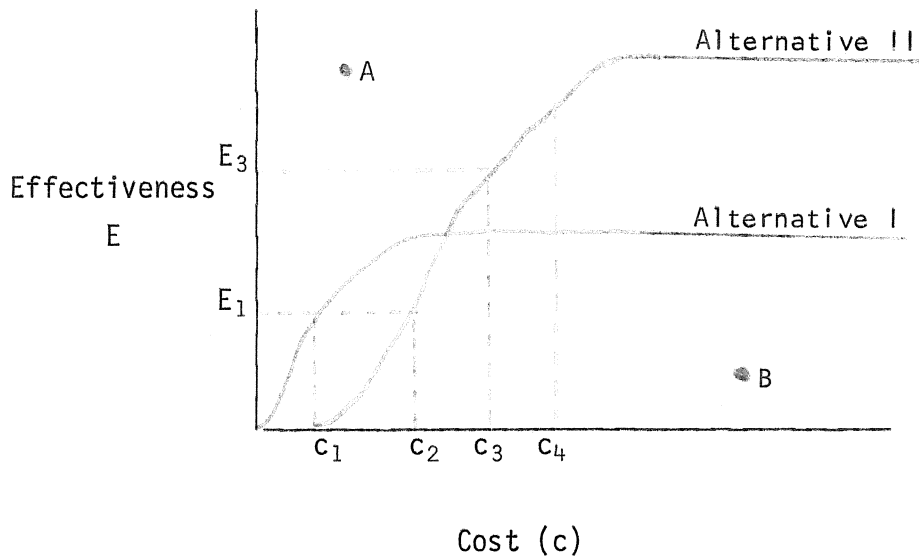
- a) Batch processing
- b) On-line index
- c) On-line abstract

And the recall level and cost for each of these factors.

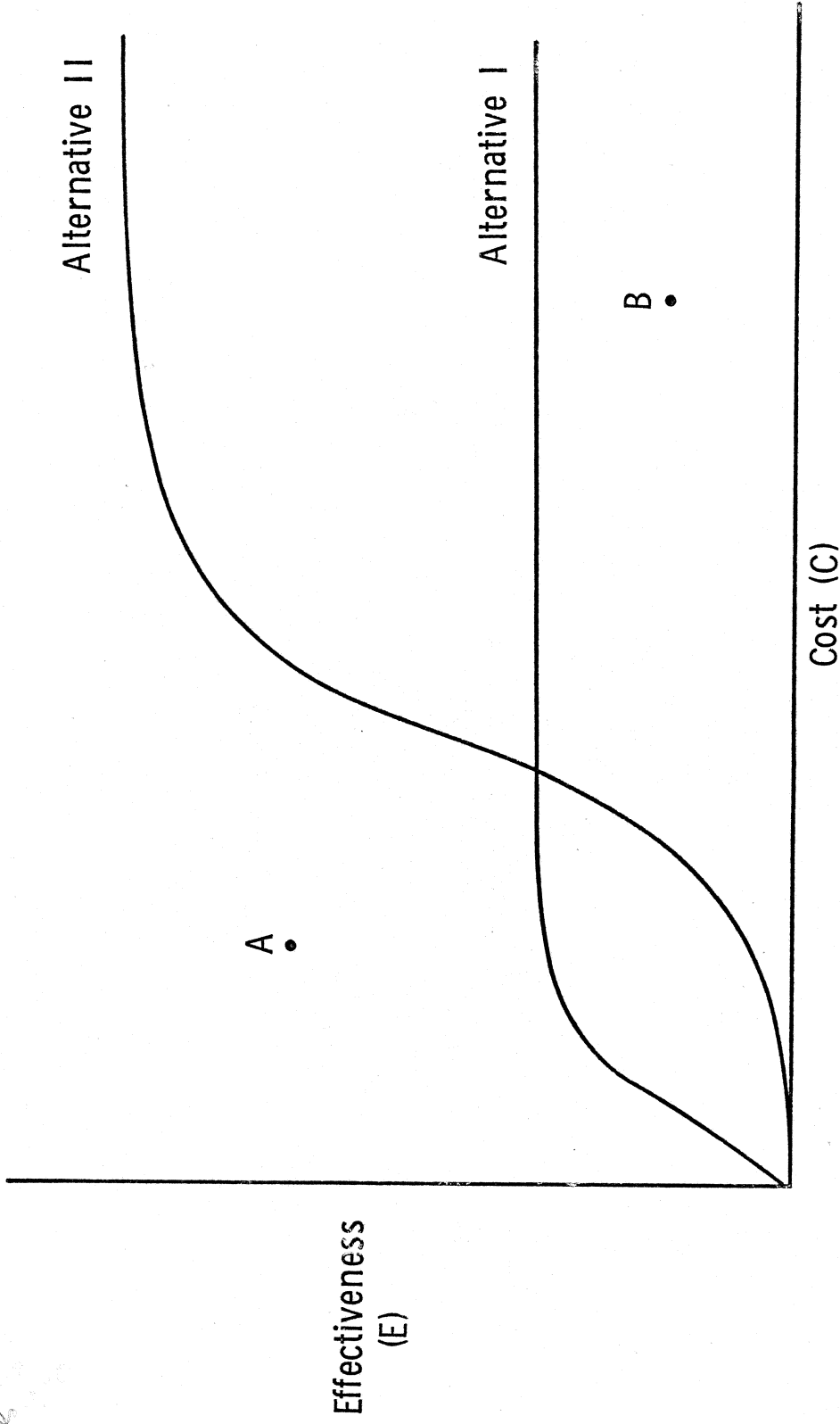
VIII. Cost-Effectiveness Analysis - Funding Considerations

- A. This chapter discusses some of the approaches used in performing a cost-effectiveness analysis.
- B. Two principal conceptual approaches to the problem.
[Fisher, p. 10].
 - 1. Fixed effectiveness approach. "For a specified level of effectiveness to be attained in the accomplishment of some given objective, the analysis attempts to determine that alternative (or feasible combination of alternatives) which is likely to achieve the specified level of effectiveness at the lowest economic cost."
 - 2. Fixed budget approach. "For a specified cost level to be used in the attainment of some given objective, the analysis attempts to determine that alternative (or feasible combination of alternatives) which is likely to produce the highest effectiveness."
- C. The selection of a cost level or of an effectiveness level involves examining interrelationships. Certain problems can arise if this is not done carefully. [Attaway, pp. 56-58]
 - 1. Overspecification of criteria. Both the required cost and effectiveness should not be specified. This overspecifies

the criterion, and can result in asking for alternatives that are either unobtainable (point A) or underdesigned (point B).

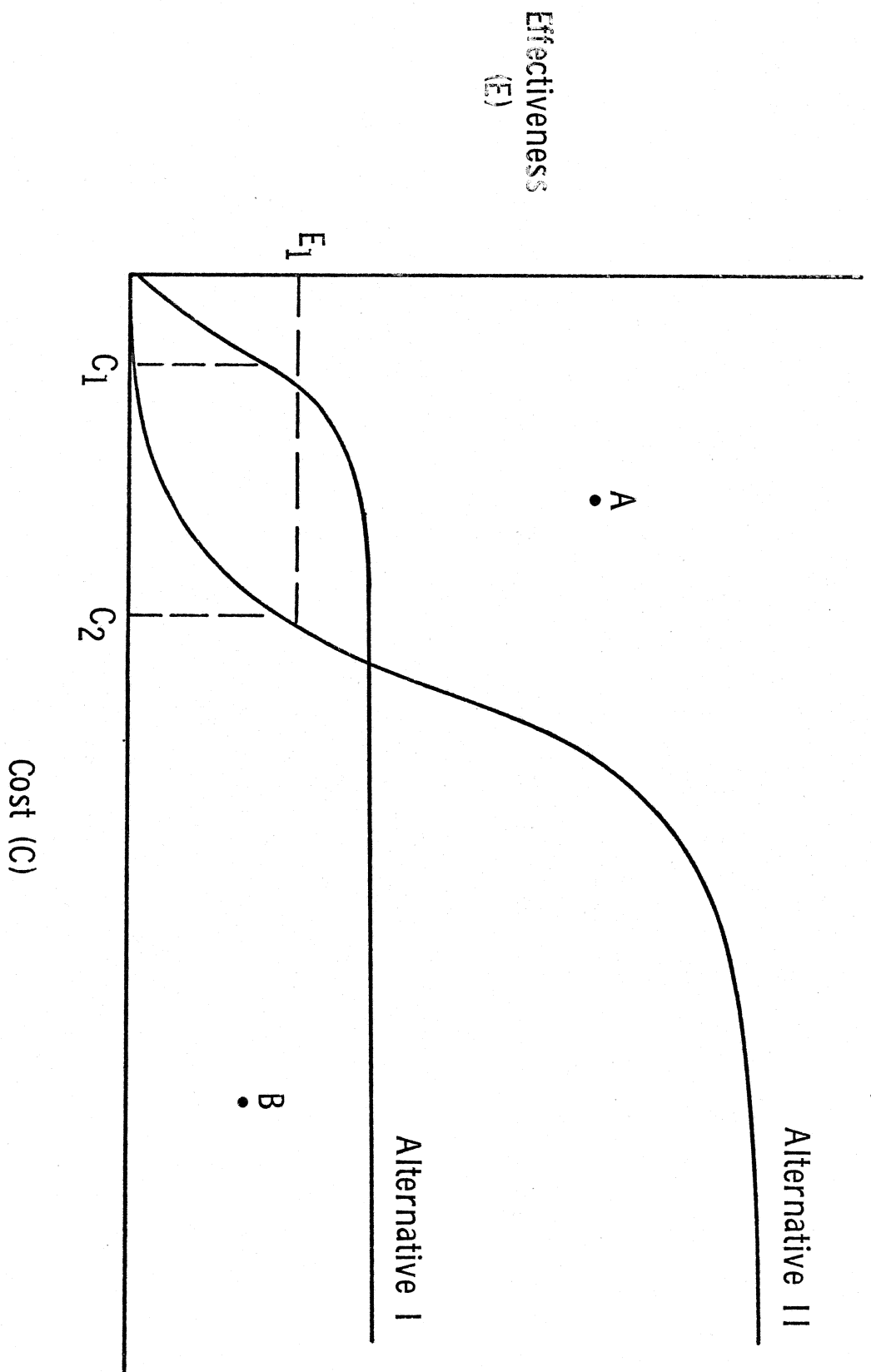


2. If E_1 is adequate then select Alternative I at a third of the cost of II.
3. If cost constraint c_2 is exercised then pick I.
4. If want new level of E_3 , no matter what the cost then pick II.
5. If C_3 is reasonable to pay, then for a little more money C_4 get more effectiveness.
6. Dominance. When an alternative is more effective at every cost. Alternative III is said to dominate I and II at all



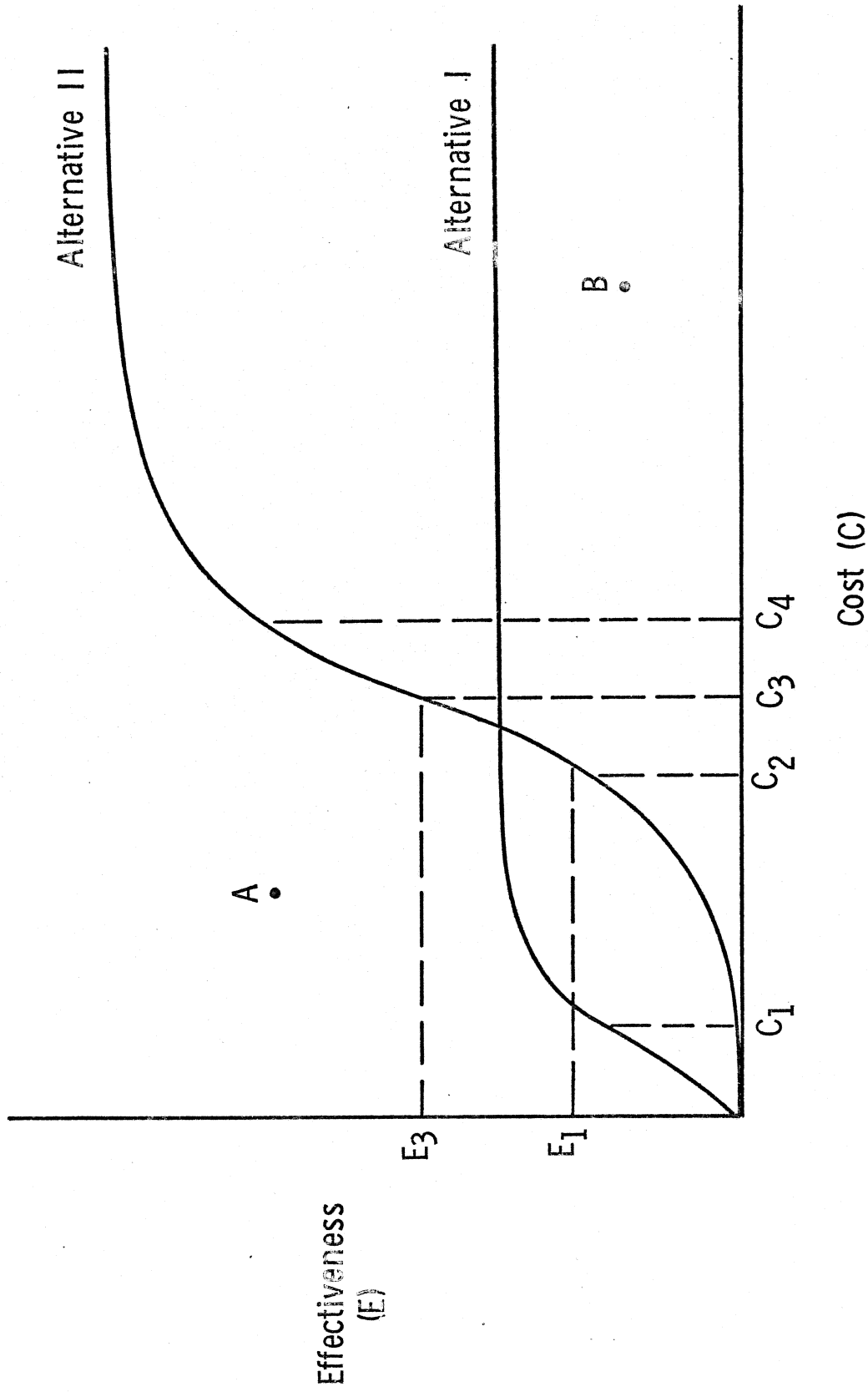
Source: [1]

Figure 5a



Source: [1]

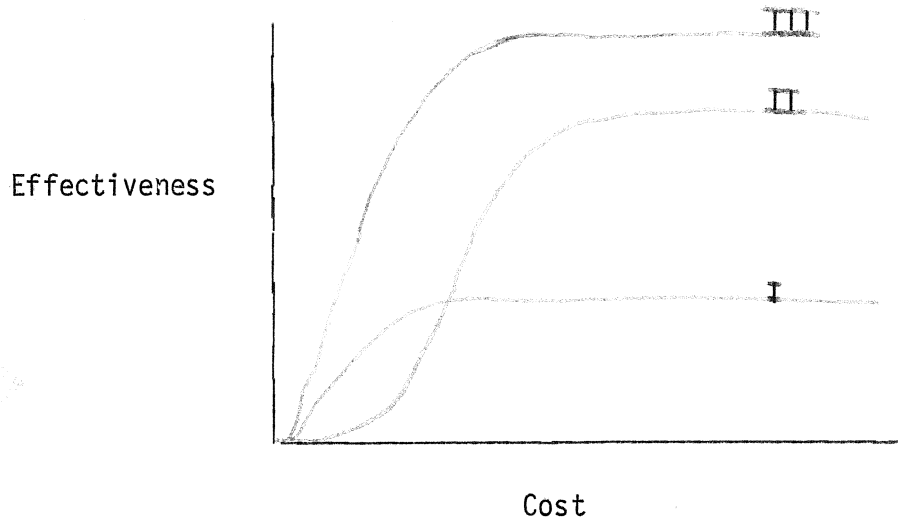
Figure 5b

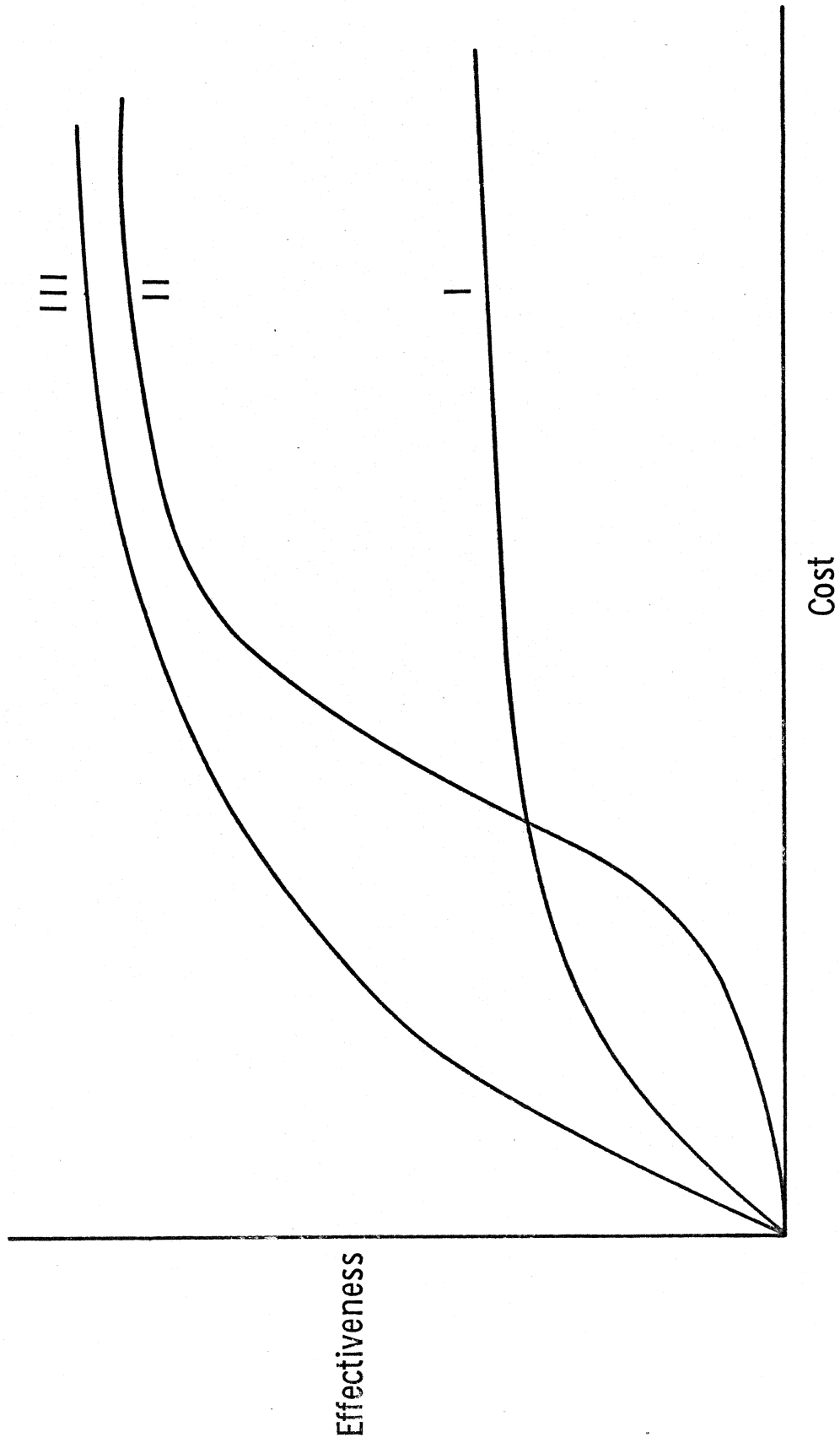


Source: [1]

Figure 5c

levels of cost and effectiveness.





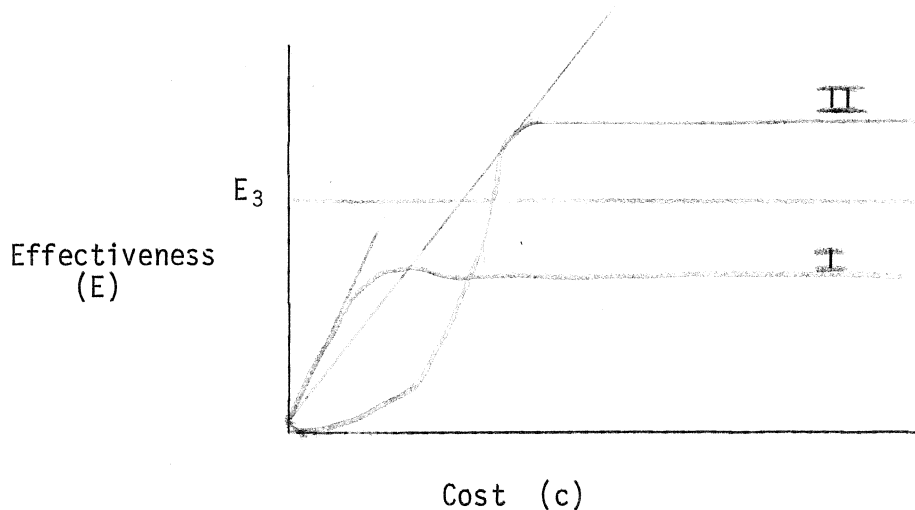
Source: [1]

Figure 6

D. Maximizing effectiveness relative to cost. We want to pick an alternative system or policy in which the ratio of effectiveness to cost is greatest.

1. This seems to be a workable criterion since in general we want to increase effectiveness and decrease cost.
2. Graphically the effectiveness - cost ratio for either alternative is the slope of the line from the origin to the curve.

[Attaway, p. 57-8]



- (a) Based on the graph we would select alternative I since the slope is greatest.
- (b) Note however that if E_3 is the minimum level of effectiveness for the program, then one must choose II.
- (c) The point to be made is that unless the decision maker is

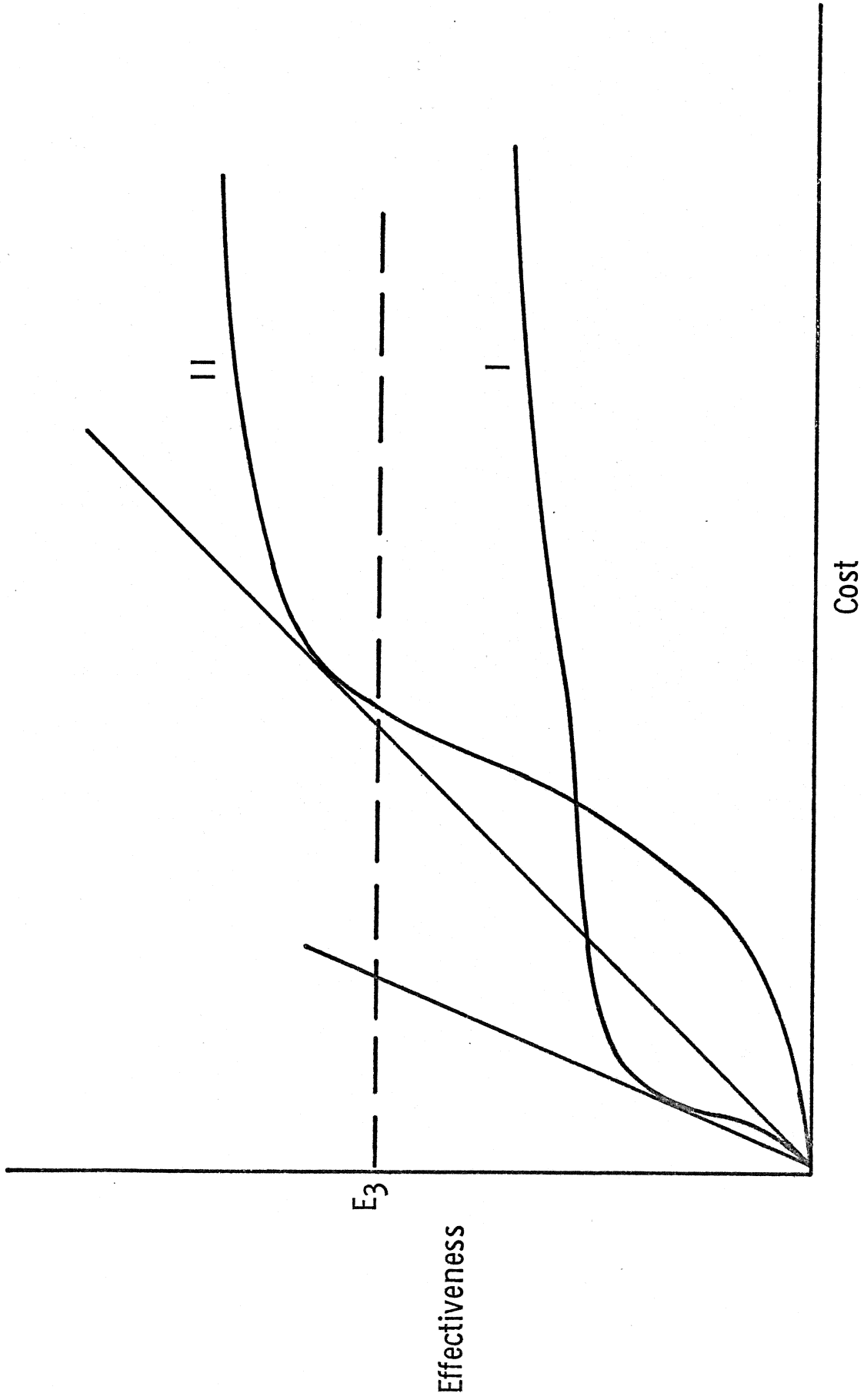
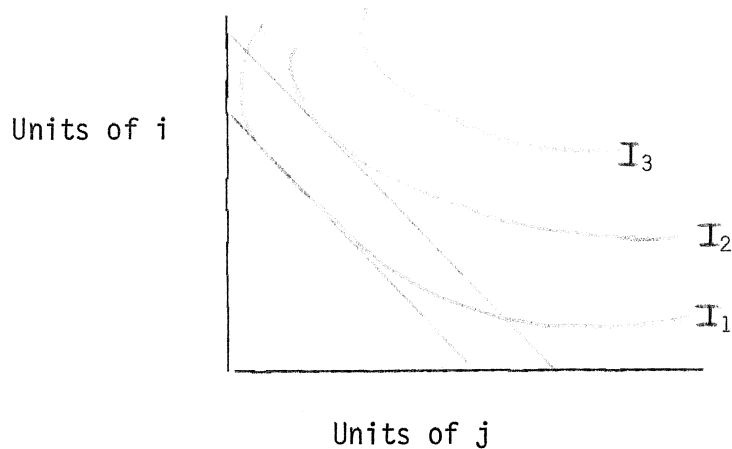


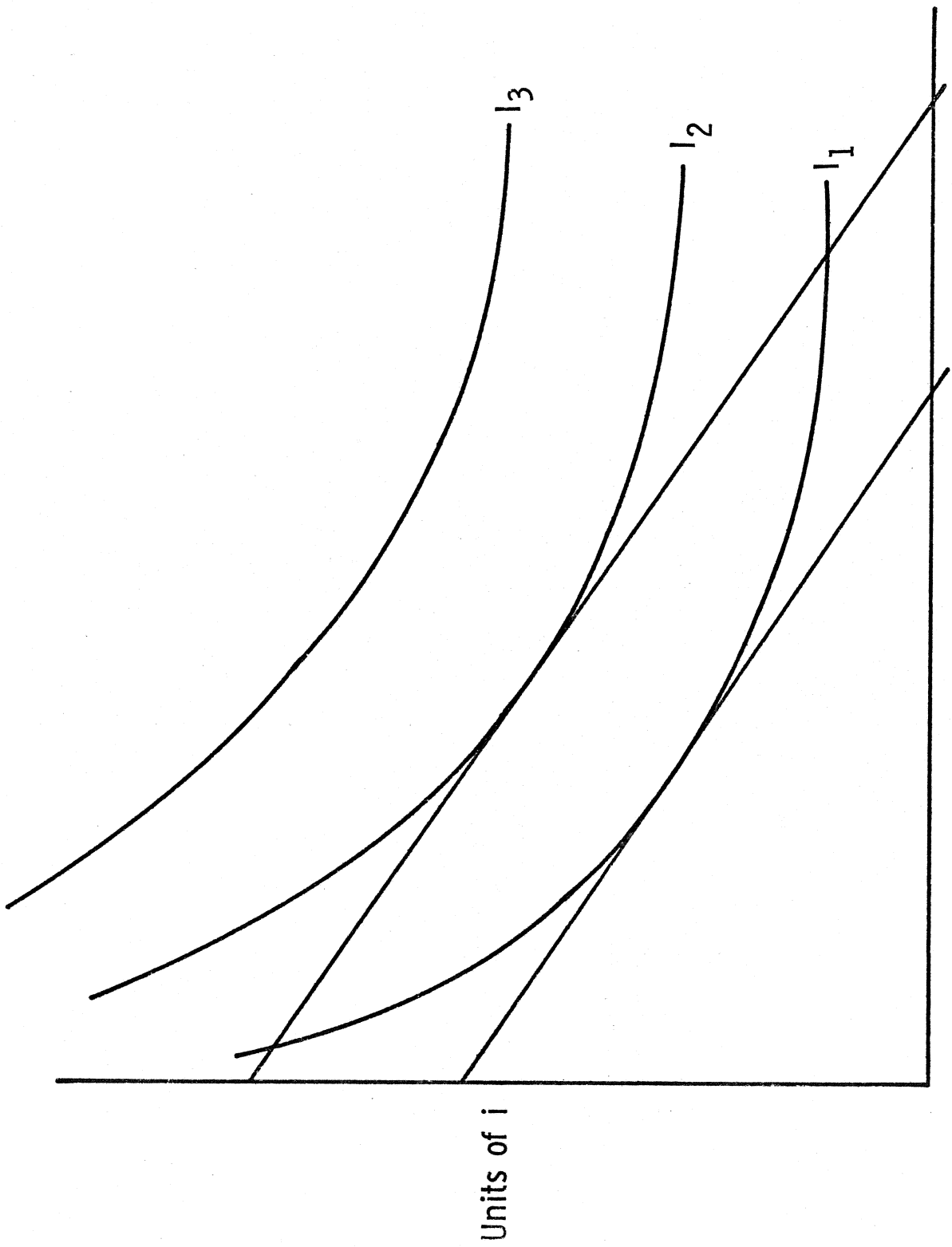
Figure 7

completely unconcerned about absolute levels of effectiveness and cost, then a criteria such as this, which suppresses them, must be avoided.

E. Indifference Curves. Assume we are interested in the question of resource allocation. We have two systems and want to see the tradeoff between the resources used and the level of effectiveness.



1. The indifference curves describe the manner in which alternative systems can be exchanged while maintaining the effectiveness constant.
 2. In order to achieve a higher level of effectiveness one has to increase the budget so as to move to a higher indifference curve.
 3. The optimal point at which to operate is the point of tangency of the cost curve and the indifference curve.
- [Seiler, p. 81] The cost curve describes the manner



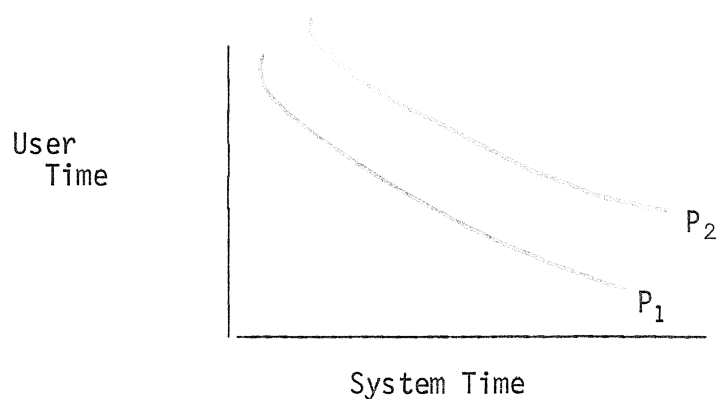
Units of j

Units of i

Figure 8

in which the alternative systems can be exchanged in terms of procurement for a given constant budget.

4. At the point of tangency of the cost curve and the indifference curve, any further exchange of one alternative for the other cannot increase the effectiveness.
 5. Any part other than tangency would be non optimal since it requires a higher budget.
 6. An isocline is defined by the points of tangency of the cost and indifference curve. It shows the expansion path of the change in a firm's optimum combination of inputs i and j as the firm's budget for inputs increases.
- F. An application of indifference curves to information retrieval systems analysis.
1. Consider the case of allocating resources between the effect that a user will spend interacting with an information system and the effort a system will expend



For a given level of performance there will be a specified quantity of time that the user and system have to spend in negotiation. For higher performance a higher budget will be required.

G. Probabilistic Cost-Effectiveness analysis [Seiler, p. 91]

Measures of Effectiveness

- A. In the previous discussion we have outlined some examples of cost-effectiveness analysis and also have illustrated the concept of a trade-off between cost and effectiveness. In this chapter we summarize the ideas behind selection of a measure of effectiveness and present a number of measures that have been proposed.
- B. In our previous discussion we defined a measure of effectiveness as a number designed to indicate the operational state of some part of the system. [Morse, LQ, p. 15]
- C. There are many conceptual problems in selecting a measure of effectiveness. We have noted some of these problems earlier:
 - 1. The measure should reflect the quality of the product or service.
 - 2. The measure should take into account uncertainty in measurement and the state of the environment.
- D. Another problem in developing a measure of effectiveness is that inherent in the systems analysis methodology.
 - 1. The systems analysis methodology involves analysis of a system usually by dividing it into its component parts and analyzing each part separately. This procedure implies that for each sub-system there will be an objective. It also implies that one should be able to formulate measures of effectiveness for each sub-system.
 - 2. Thus not only should one have measures of effectiveness for the overall system, but its components as well.

E. General classification of measures of performance [Seiler]

1. Performance (?)
2. Availability
3. Reliability
4. Survivability

F. Measures of performance related to information retrieval systems.

1. We mentioned earlier the recall and fallout ratios. Suffice it to say that there are a number of such ratios based on four quantities:
 - a. Relevant documents retrieved.
 - b. Non relevant documents retrieved.
 - c. Relevant but not retrieved.
 - d. Non relevant documents not retrieved.
2. Among the ratios based on these values are recall, precision, generality, concentration, specificity, noise, etc.
3. After viewing the permutations and combinations used to calculate the ratios, one can only conclude that there is no theoretical basis for any of the measures.
4. If we are to move forward in the evaluation of retrieval systems and services, we must go beyond these ratios and develop new measures of effectiveness.
5. One approach might be to determine the value of the information to an individual.

Look up the concept
in change literature
as a measure
of... measures

Retrieval Effectiveness Contingency Tables

	Relevant	Not Relevant	
Retrieved	a	b	a + b
Not Retrieved	c	d	c + d
	a + c	b + d	a + b + c + d

Figure 9a

Number of Documents in each of Four Categories

Retrieval Effectiveness Contingency Tables (Cont)

	Relevant	Not Relevant	
Retrieved	V_1	K_1	
Not Retrieved	K_2	V_2	

Figure 9b

Value (V) and Cost (K); per Document Falling into each of the Four Categories

Figure 2

Retrieval Effectiveness Contingency Tables

	Relevant	Not Relevant	
Retrieved	a	b	a + b
Not Retrieved	c	d	c + d
	a + c	b + d	a + b + c + d

Figure 2a

Number of Documents in each of Four Categories.

	Relevant	Not Relevant	
Retrieved	V_1	K_1	
Not Retrieved	K_2	V_2	

Figure 2b

Value (V) and Cost (K); per Document Falling into each of the Four Categories.

Table 2a

Overall Measures of Retrieval Effectiveness

Name / Author	Standard Notation	Authors' Notation
Effectiveness Rees [103]	$\frac{a}{a+c} + \frac{d}{b+d}$	$\frac{a}{a+c} + \frac{d}{b+d}$
Effectiveness NSF [134]	$\frac{a}{a+b} \cdot \frac{a}{a+c}$	-
Composite Measure Salton [111] (1)	-	$\frac{\sum_{i=1}^n i}{\sum_{i=1}^n r_i} + \frac{\sum_{i=1}^n \ln i}{\sum_{i=1}^n \ln r_i}$
(2)	-	$1 - 5(R_{\text{norm}}) + P_{\text{norm}}$
Measure of Merit Verhoff [136]	$V_1 a - K_1 b - K_2 c + V_2 d$	$\alpha AP_1 - \beta AP_1 - \gamma \overline{AP}_1 + \delta \overline{AP}_1 $
Effectiveness Goffman [48]	$V_1 a - K_1 b$	$\alpha \mu_I(A) - \beta \mu_{I'}(A)$
Value Function Good [49]	$\alpha(\sqrt{a} - \sqrt{c}) - \beta b$	$\alpha(\sqrt{n_R} - \sqrt{n_{RD}}) - \beta n_{IS}$

Table 2b

Overall Measures of Retrieval Effectiveness

Name / Author	Standard Notation	Authors' Notation
Efficiency Swets [129], [130]	$\frac{M_{F_p}(z_i) - M_{F_{\bar{p}}}(z_i)}{O_{F_p}(z_i)}$	same
Search Effectiveness Dale [29]	$\frac{\sum_{j=1}^n \frac{A_j}{j}}{N}$	same
Retrieval Score Swanson [128]	$R - K_1 I$ $I = (a+b) - (a+c)R$	$R - \rho I \quad (I = N - LR)$
Retrieval Score Borko [15]	$R - K_1 \frac{b}{a+b}$	$r - \rho i$ $r = S/T; i = M/N$

Table 1
Measures of Retrieval Effectiveness

Name / Author	Standard Notation	Authors' Notation
Generality Ratio Cleverdon [25]	$\frac{a+c}{a+b+c+d} \cdot 1000$	$\frac{1000C}{N}$
Concentration Ratio Fairthorne [40]	$\frac{a+c}{a+b+c+d}$	$\frac{C}{N}$
Non Relevant Doc. Ratio Mooers, Fels [42]	$\frac{b}{b+d}$	-
Specificity Rees [103]	$\frac{d}{b+d}$	$\frac{d}{b+d}$
Resolution Factor Perry [101]	$\frac{a+b}{a+b+c+d}$	$\frac{m}{n}$
Elimination Factor Perry [101]	$\frac{c+d}{a+b+c+d}$	$\frac{m-n}{n}$
Noise Factor Perry [101]	$\frac{b}{a+b}$	$\frac{n-w}{m}$
Omission Factor Perry [101]	$\frac{c}{a+c}$	$\frac{x-w}{x}$
Distillation Fairthorne [40]	$\frac{ad-bc}{(a+b)(c+d)}$	$\frac{RN-CL}{L(N-L)}$
Discrimination Fairthorne [40]	$\frac{ad-bc}{(a+c)(b+d)}$	$\frac{RN-CL}{C(N-C)}$

G. Other measures related to information systems have been proposed by Lancaster [JASIS, 22:1 (January-February 1971) p. 12].

1. Coverage of the system.
2. Ability to retrieve wanted items (recall).
3. Ability to avoid retrieval of unwanted items (precision).
4. Response time of system.
5. Amount of effort required from user.

- H. Another set of measures of effectiveness related to evaluating journal publication programs has been suggested by Joe Kuney of the American Chemical Society. The variables include:
1. Subscription sales (prices).
 2. Response to sales promotion.
 3. Retained subscriptions (renewal rate).
 4. Reader surveys.
 - a. Value (perceived)
 - b. Amount read (time spent on journal)
 - c. Currency of reading (how soon after receipt)
 - d. Demographic relationships
 - 1) Age
 - 2) Education - degree
 - 3) Geographic location
 - 4) Employment (industry, government, academic)
 5. Manuscripts submitted and rejected
 6. Citations
 7. Pages published
 8. Time between receipt of publication and publication
 9. Advertising

I. Measures of effectiveness related to libraries. One very extensive set of measures has been collected by Evans, Borko and Ferguson [Bulletin of the Medical Library Association,

They divide measures into six major categories

1. Accessibility
2. Cost
3. User Satisfaction
4. Response time
5. Cost/Benefit ratios
6. Use

I. Accessibility

1. Number of services and degree of services provided various classes of users.
2. Ratio of services requested to services available.
3. Ratio of holdings to total user population (actual and potential).

II. Cost

1. Staff size.
2. Staff skill and characteristics.
3. Unit cost.
4. Ratio of book budget to users.

III. User Satisfaction

1. User satisfaction with services rendered.
2. Number of user activities in library.
3. Percentage of items in collection as listed in some checklist.

4. Percentage of items in collection by type of materials (books, serials, reports, etc.).
5. Percentage of items in collection by type of material compared to various classes of users.
6. Quality-value of items in collection based on expert opinion.
7. Ratio of documents used to materials requested.

IV. Response Time

1. Speed of services.
2. Ratio of number of services offered to average response time for all services.
3. Ratio of response time (to secure document) to total time document is of value.

4. Ratio of holdings to response time.

V. Cost/Benefit Ratio

1. Ratio of services provided to total cost.
2. Ratio of total service expenditures to users (actual and/or potential).
3. Ratio of item cost to item value or utility.
4. Ratio of a given service (including overhead cost) to response time cost.

VI. Use

1. Gross use of services (reference questions answered, bibliographies completed, etc.).
2. Ratio of actual users to potential users.
3. Total library use (attendance figures, circulation, etc.).
4. Ratio of a given service to total number of users.
5. Ratio of total use for all services to total number of services provided.
6. Percentage of materials used by type and by class of users (student, teacher, researcher, etc.).
7. Ratio of documents circulated to various classes of users.
8. Ratio of documents circulated to number of users.
9. Ratio of total use to total holdings.
10. Item-use-day (a measure based on the number of items used in a twenty-four hour period).

IX Economic Issues

- A. Once we step beyond cost-effectiveness analysis and start to think about cost-benefit analysis we must considerably enlarge our perspective. We become concerned with values of individuals, with societal objectives and with the role of government in the process of satisfying individual needs.
- B. As a prerequisite to our discussion of welfare economics it is important to discuss some general economic concepts relevant to the topic. The motivation behind the discussion is to make us aware of the overall objectives of the economy not just the objectives of a single firm or library or information retrieval system.
- C. Basic economic decisions that must be made if individual wants are to be satisfied [Due, pp. 3-4]
 - 1. Decisions about allocation of resources among various products.
 - 2. The extent to which output is used for immediate consumption or for further production.
 - 3. The particular technique of production to be used.
 - 4. The distribution of output of society to its members must be decided.
- D. Methods of solving the allocation problems [Due, p. 4]
 - 1. Pure convention or custom

2. Government
 3. Market mechanism
- E. The accepted goals of the economy [Due, pp. 7-9]
1. Maximize individual freedom of choice
 2. Optimize standards of living in terms of available resources. If this optimum is to be reached three requirements must be met
 - a. Optimum efficiency in the use of resources
 - b. Direction of production in terms of consumer preferences. The relative outputs of the various goods must be such that, given the pattern of distribution of income the marginal social benefit from the production of each commodity is equal to the marginal social cost resulting from the production of the commodity
 - (1) Marginal social benefit - gain to individuals from the acquisition of the last unit of the commodities
 - (2) Marginal social cost - real cost to society resulting from the production of additional units, the cost taking the form primarily of sacrifice of output of other goods
 - c. In order to have optimal resource allocation, we need to make sure:

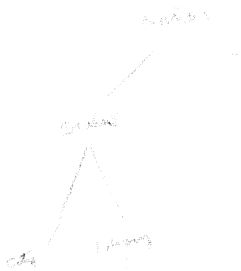
- (1) Prices of all commodities are equal to marginal cost of production
 - (2) All real costs to society from the production of the goods appear as costs to the business firms producing them *(e.g. transportation)*
 - (3) Benefits from the consumption of the goods accrue solely to the persons acquiring them and not to others as well
- d. Employment of all factor units whose owners wish to have them employed at prevailing factor prices
3. Distribution of income in conformity with currently accepted standards of equity

X. Concepts of Welfare Economics

A. We are concerned with welfare economics because we are concerned with determining what is right and wrong with our economic system from the standpoint of values and goals. This is necessary because of our interest in benefits

B. Definition of Welfare Economics:

"Welfare economics is that branch of economics which concerns itself with the principles by which alternative economic arrangements may be ranked in terms of social welfare." [Mishan in Encyclopedia of Social Science, "Welfare Economics"]



Welfare economics is a branch of economics that deals with the distribution of resources and the well-being of society. It is concerned with the principles by which alternative economic arrangements may be ranked in terms of social welfare.

- C. Given our interest in values we now must ask questions related to why various economic units perform certain tasks. Particularly from a public library viewpoint we are interested in why governments undertake certain activities [Due, p. 419-420]
1. Are there substantial social or indirect benefits? External economics beyond direct benefit? (We will discuss this in detail in a moment). If yes then private provision of service will result in inadequate output compared to the optimal quantity
 2. Can the government provide the service more efficiently than private enterprise? In the U.S. assume private production more efficient than governmental ^{production} because of the project motive and the absence of political interference
 3. Does monopoly result with private enterprise, and is the attempt to regulate the monopoly unsuccessful
 4. Do the circumstances warrant the undertaking by government of the risk of failure of the enterprise? With respect to education and highways, the case for government operation is almost universally accepted

- D. Collective Goods. One of the important concepts of welfare economics has to do with collective goods
1. A collective good is made freely available to all without charge: [Dorfman, p. 4-5]
 - a. To charge would be cumbersome
 - b. Use is not voluntary or even clearly definable
 - c. Collective goods are not sold because there is no market price in appraising their value. Library?
 2. Examples of situations where it is infeasible or not desirable to charge:
 - a. Can't charge every shipmaster who sees a lighthouse, or
 - b. Every householder whose door a patrolman passes, or
 - c. Every housewife when a health officer inspects a food market
 - d. Every library user?
 3. Collective goods (with rare exceptions) can't be provided by private firms because they do not induce a flow of income to the provider
 4. Common collective goods include:
 - a. National defense
 - b. Civil and criminal justice
 - c. Streets
 - d. Most highways

- e. Recreation facilities
 - f. Libraries
 - g. Some findings of scientific research
5. In connection with the concept of collective goods one wants to ask the next question - when is it feasible to charge for a service versus levying a general tax to support the service. There are a number of considerations. [Due, p. 422-424]
- a. Will the use of the charge method facilitate determination of the optimum amounts of the service to supply? Objections to the use of taxes is that it can not insure that the individual attains an optimum balance between public and private sector outputs
 - (1) The usefulness of a charge in facilitating optimum adjustment of output depends in part upon the extent to which the charge prevents waste of the service - produce more than is justifiable or prevent someone with a greater need from obtaining it.
 - b. Can the charges be collected without costs to the government and the user being substantially greater than the cost of collecting taxes. Making all roads toll roads is no good

- c. Does the use of the charge method result in a distribution of burden which is regarded by the community as equitable? Is it more equitable to make all persons pay for these services which they receive or provide these services free of charge and cover the costs by taxation.

XI Measures of Benefit

- A. We have seen that the distinction between cost-effectiveness and cost-benefit analysis has to do with placing a dollar value on output in benefit analysis. In this chapter we discuss some of the concepts of quantifying benefits and present examples that have appeared in the literature.
- B. Before proceeding further let us remember our general discussion of measurement problems presented earlier. We noted that any measure of effectiveness and/or benefits needs to account for:
1. The quality of the product or service.
 2. The uncertainty involved in measurement.
- C. Another problem related to measurement and valuation of benefits has to do with intangible factors.
1. Some costs and benefits (such as scenic effect of building electric transmission lines) cannot be quantified, and others, although they can be quantified, cannot be valued in any market sense (e.g., a reduction in lives lost). Such costs and benefits are called intangibles. [Prest and Turney, p. 696].
 2. In other words an intangible is something that cannot be readily translated into the common denominator that is being used. [McKean, Efficiency, p. 58].

3. Intangibles will mar the neatness of any analysis.
4. Ways of treating intangibles. [McKean, Efficiency, p. 62-3]
 - a. Ignore them. If can not convert to common denominator them forget about them. Not recommended.
 - b. Try and accurately define what can not be measured.
 - c. Show the minimum dollar value that one must attach to the intangibles. Suppose project A cost \$1 million and yields \$2 million plus preservation of salmon fishing in the watershed. B costs \$1 million and yields \$3 million. If one chooses A, he must be attaching a value of at least \$1 million to the salmon fishing. If this comes to \$1,000 per salmon (and he sticks the project A) then he must think rather highly of the sport. This brings out explicitly the minimum value implicit in the project.

- D. In the next sections of this chapter we will discuss some of the problems involved in measuring benefits and describe economic concepts that can be used in the analysis. Among the topics to be discussed are:
1. Factors affecting an individual's assessment of benefits.
 2. The concept of external economies.
 3. Valuation of external economies.
 4. The concept of secondary benefits.
- E. In order to arrive at a measure of benefit we need to examine closely the factors that affect gains and costs of an individual. McKean [p. 202] lists a number of factors:
1. Material comfort for a person - rational man not economic man.
 2. Desire for prestige.
 3. Power.
 4. Security.
 5. Avoidance of difficult decisions.
 6. Probability of success - no action if no likelihood of success.
 7. Loyalties and attitudes.

E. External Economics. In this section we are concerned with...
 "costs and benefits which accrue to bodies other than the one sponsoring a project and the equally wide issue of how far the sponsoring body should take them into account." [Prest and Turvey, p. 688].

1. Mishan, p. 101 notes the synonymy in the concept. "External effects, an abbreviation for External Economies and Dis-economies - sometimes referred to as 'externalities', more picturesquely as 'neighborhood effects', somewhat rapidly as 'side effects', and more suggestively as 'spillover effects', or briefly, as 'spillovers' - first appeared as 'external economies' in Alfred Marshall's Principles in connection with a competitive industry's downward - sloping supply curve."
2. Examples of spillovers. [Mishan, p. 102]
 - a. Adverse effects on flora, fauna rainfall and social of cutting down trees of a forest.
 - b. Effect on mosquito population of creating artificial lakes.
 - c. Pleasure given by erection of a beautiful building.
 - d. Offense of erection of a tasteless building.
 - e. Congestion of additional traffic on crowded road.
 - f. Noise and pollution arising from operation of industry.
 - g. Loss of life resulting from increased air or ground traffic.

3. Example of spillover effect in library service.
 - a. Library service directly benefits the individual receiving the service - be it a reference question or the supply of a book to the patron or the comfort of a reading room.
 - b. Since the individual gets part of the benefit it is possible for private enterprise to sell a small quantity of library service.
 - c. There is a gain to society from providing some level of library service to the population.
 - d. By analogy with Due's discussion of education [p. 14], library service helps generate greater skills and larger potential output and facilitates economic development. "An educated citizenry is likely to provide a more discerning electorate and greater political stability."
 - e. Although some persons will pay for education (library service) low income families will not do so. Thus total education (library service) received will be less than optimum unless provided free of charge.
4. Characteristics of spillover effects (external economies)
[Mishan, p. 102-107]
 - a. Incidental or unintentional nature of effect produced.
 - b. Usually no knowledge of consequence.
 - c. Plant owner wants profit. If makes it, not concerned with smoke produced by plant.

- d. Person is influenced not only his his own possessions (flowers, stocks) but others as well.
- e. Unlimited number of external effects.
 - (1) Attractive short-skirted women may generate adverse external effects on other women and favorable external effects on men.
 - (2) A cigar smoked in the presence of non-smokers has adverse external effects.

F. Valuation of spillovers (external economies). [Mishan, p. 114-5]

1. "In principle, the method of valuing spillover effects for a cost-benefit analysis is straightforward. Any particular spillover effect associated with a given project is but one among any number of consequences affecting the welfare of different people in the community. We must consider, therefore, only the difference made to their welfare by the spillover effect in question."
2. Any i^{th} person made better off on balance by the spillover effect would offer a maximum positive sum V_i rather than go without it. Any i^{th} person made worse off on balance would require some minimum sum V_i to induce him to put up with the spillover, such sum to be prefixed by a minus sign. Called compensating variations.
3. Each spillover is conceived of as a sum of money to be paid or to be received to restore welfare to original pre-spillover level. The spillovers are added together algebraically to the excess benefits of the project (positive or negative).

- Handwritten note: 10/10/10
Part of International
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- F. Secondary Benefits. A secondary benefit is one that results in increased income chiefly to local producers resulting from the project. [McKean, p. 208].
1. Example of a canal in India [Prest and Turvey, p. 708]
 - a. Canal water used for washing, bathing and watering cattle.
 - b. Silt is deposited at outlet heads which requires cleaning.
 - c. Excess water makes some land untillable.
 - d. Canal divides area into two parts. Take time to get across.
 2. Two kinds of secondary benefits [Prest and Turvey, p. 689-90]
 - a. Stemming secondary benefits. Build water system. Grain production increases. 48% as a result of water system.
 - b. Induced secondary benefits. Extra profits made from activities which sell to farmers.
 - c. Do not need to worry about secondary benefits unless market prices do not reflect marginal social costs and benefits.

- I
- E. Valuation of costs and benefits. A major issue that needs to be examined is how to place a value on benefits and costs [Prest and Turvey, pp. 690-695].
1. The relevant prices. When dealing with costs and benefits that can be expressed in terms of money, need to consider future prices of the items.
 2. Non-marginal changes.
 - a. With exceptions below, market prices are used to value the costs and benefits of a project.
 - b. Difficulties arise when investment projects are large enough to influence these prices.
 - c. In order to know how changes in output affect price - measure area under demand curve for which the price remains unchanged. See if this area covers range under study.
 3. Market imperfections.
 - a. Need to consider situations where monopolistic elements influence output. Watch out for it when valuing costs and benefits at market price.
 - b. Public authority in its pricing may not set prices at market level and thus resource allocation will not be efficient.
 - c. Watch out for factors such as wages which include rent element.

- e. Above are all examples of the inapplicability of investment decision rules derived from a perfectly competitive situation to a world where competition doesn't hold.
 - f. Correct levels of cost or benefits or correct future levels of cost or benefit.
4. Taxes and controls
- a. Imperfect competition constitutes only one case of divergence between market price and social cost or benefit.
 - b. Another is that of taxes on expenditure. Measure taxed inputs at their factor cost rather than market value.
 - c. Tariff protection influences factors.
5. Unemployment.
- a. A divergence of social cost from private cost occurs when there is unemployment. When there is excess supply at current market price of any input, that price overstates the social cost of using that input.
 - b. Use of market values to ascertain direct costs and benefits of a project overstates social costs and underestimates its total benefits (by the amount of 'induced benefits').
 - c. Let central government correct problem.
6. In the previous chapter we discussed collective goods. Now the issue is to determine how to value them.
- a. Market prices can not be used to value benefits which are not capable of being marketed.

- b. Some good and services supplied by government are of a collective nature in sense that the quantity supplied to any one member of the relevant group cannot be independently varied.
- c. Want to get consumers to tell how much of a collective good they want. But rational thing for any individual consumer to do is understate his demand, on the theory that his cost will decrease but quantity will not.

· Examples of Cost-Benefit
Analysis

- G. Example of assessing benefits of outdoor recreation [Mack and Myers].
1. Definition. "leisure time activity undertaken in a relatively nonurban environment characterized by a natural setting for the privacy purposes of enjoyment and physical or mental well-being."
 2. Three characteristics of outdoor recreation.
 - a. Immediate enjoyment.
 - b. Long-term benefits for the individual.
 - c. Benefits to the nation as a whole.
 3. What are government's responsibility in the field.
 - a. Paternal interest in individual well-being.
 - b. Third party interest in recreation and conservation. No supply and demand, thus government steps in.
 - c. Interest in efficient supply of resources.
 4. Decisions about resource allocation
 - a. How many dollars to spend?
 - b. How much on outdoor recreation vs. other public purposes.
 - c. How to optimize aggregate utility of all outdoor expenditures.
 5. A measure is useful in proportion to:
 - a. The percent of total benefit that it adequately calibrates.
 - b. Its capacity to uncover and expose aspects of benefits it does not measure.

- c. General acceptability.
 - d. Its power to improve administrative or legislative action because of a capacity to focus debate on well-considered notions of the public weal.
6. Dollar measure. Can one use the dollar as a measure of benefit? There are certain theoretical limitations of market prices.
- a. Price fails to reflect benefits of recreation and conservation to the nation as a whole. Spillover effects.
 - b. Price won't reflect utilities that people fail to appreciate. Price reflects a portion of utility.
 - c. The problem is to arrive at total or average benefit from data that reflects benefit at the margin. Hard to do. How to cope with consumer surplus.
 - d. If we provide free recreation then generate consumer surplus in connection with public recreation. Depresses price of private recreation.
7. Indirect approaches to measurement. Four categories of study.
- a. Cross volume of business generated as a result of the availability of outdoor recreation opportunities.
 - b. Estimated value of the gross expenditure on outdoor recreation added to local business alone.

- c. Demand for outdoor recreation, measured by the willingness of users to pay specified sums of money for travel and recreation areas.
 - d. Measurement of consumer's surplus resulting from the provision of recreation at no or low cost to persons who would otherwise be willing to pay relatively large sums for such opportunities.
8. One concept that has been adopted is that of merit-weighted user-days. It is a function of the number of people expected to use a park and the lengths of time of their stays. This is weighted to take into account that some user-days are better than others. ^{Local} ~~Local~~ judgments are involved.
- a. A day spent by child in wilderness has more lasting value than adult picknicking in a crowded noisy park.
 - b. Marginal utility of additional recreation declines as larger amounts are made available.
 - c. Equity requires government to provide relatively more recreational opportunities for those who need them most and can least afford them.
9. In the development of the concept of merit weighted user days, Mock and Myers [pp. 89-93] , consider five characteristics of the measures.
- a. Performance criteria.

- (1) Conservation as a public purpose.
 - (2) Government policy about providing cheap recreation at price lower than private.
 - (3) Government provision of recreation as a means of setting standards for private provision.
 - (4) Public policy with respect to encouraging private recreation.
 - (5) Charge of price
 - (6) Provision of a standard for people who can't afford to pay.
- b. Quality standards.
- (1) Maintenance of a designated standard of care for grounds and equipment.
 - (2) Develop facilities in order to increase use.
 - (3) Physical use standards to control overcrowding of low density areas.
- c. Character of the recreation afforded.
- (1) Have well balanced variety of facilities.
- d. Distributive justice - provisions should bear proper resemblance to need.
- (1) Geographic distribution of areas with respect to accessibility for after-work, weekend, vacation use.
 - (2) Distribution among people of various ages, education, and previous experience.

(3) Distribution among people of different incomes and consequently, different opportunities to use private facilities.

e. Requirements for future generations.

(1) Meet requirements of the future by a variety of means appropriate to the uncertainty that surrounds prediction.

10. Then take each parcel of land and weight it with respect to the extent that it satisfies each of the evaluation criterion.

H. Example of assessing the benefits of education [Hersch, p. 252-253]

1. Education accruing to a pupil attending public school per day (or year) appears to be a useful measure of service. Pupil direct beneficiary although we also recognize that his present and future family, his employer, as well as society at large, are potential beneficiaries.
2. Measurement of costs is in terms of salaries of administrators; principles, librarians, teacher/pupil ratio, etc.
3. Measurement of benefits involves three dimensions.
 - a. Dimensions of quality assessment.
 - (1) Knowledge in standard subjects.
 - (2) Knowledge in special and optional subjects.
 - (3) Ability to reason.
 - (4) Intellectual curiosity.
 - (5) "Creativity".
 - (6) Social Poise.
 - (7) Emotional stability.
 - (8) Physical health.
 - b. Variables that influence quality.
 - (1) Caliber of teaching staff and teaching load.
 - (2) Caliber of school administration.
 - (3) Grouping and class size.

(4) Teaching program.

(5) Length of school year and day.

c. Measures of value of quality of education.

(1) Lifetime earnings from various education qualities.

(2) Native ability or inherent intelligence.

(3) Home environment.

(4) Motivation or ambition to learn.

4. Studies find a correlation of quality as measured by before - after IQ with expenditure per pupil.

I. Example of analysis of benefits for a library environment - Hamburg.

One of the most interesting attempts to analyze benefits has been done by Morris Hamburg at the Wharton School of the University of Pennsylvania.

1. The basic problem, as Hamburg sees it, is to allocate resources in such a way that benefits are maximized.
2. Another basic problem is to define in a measurable way what the outputs of a library are.
3. The study concerns benefits measurement for public and university libraries.
4. Public library objectives.
 - a. Formal education objective: supplement, enrich, and further develop educational programs of schools and colleges.
 - b. Informal education objective.
 - (1) Library materials.
 - (2) Process of communicating with user.
 - (3) End result of library use.
 - c. Library materials objectives.
 - (1) Variety of subject matter.
 - (2) Point of view.
 - (3) Media.
 - (4) Meeting of research needs.

- (5) Good organization of materials to make them easily and temptingly available.
- (6) Good distribution of materials.
- d. Objectives relating to the process of communicating with the user.
 - (1) Encourage reading of socially significant materials.
 - (2) Interpreting materials.
 - (3) Expressing ideas.
 - (4) Providing information.
 - (5) Entering into the educational, civic, and cultural activities of community groups.
- e. Objectives related to the end result of library use.
 - (1) Individual self development.
 - (2) Increased reading enjoyment and ability
 - (3) Human understanding.
 - (4) Better family and community members.
 - (5) Aid in daily occupations.
 - (6) Consumer and health education.
 - (7) Creative use of leisure time.
 - (8) Culture.
 - (9) Creative and spiritual capacities.

5. University Library Objectives.

- a. One difference between university and public library objectives is that the population of potential users of a university library is relatively more homogeneous and operates at more intellectual and reading levels than the public at large.
- b. Another difference: While public libraries respond to societal objectives of the entire community, the university library's objectives relate to those of the parent institution.
- c. University library objectives involve meeting teaching and research needs. Meet reading, reference, and research needs of users.

6. Development of Library Performance Measures

- a. Stated objectives do not yield criteria for evaluating alternative policies. Can't tell how well objectives are being met because the objectives are not developed that way.
- b. Serious problem involved in getting good measure.
 - (1) How to measure individual self-development.
 - (2) How much of the changes in cultural creative or spiritual capacities of individuals can one attribute to the library.

(3) If we could measure stated objectives, we would face serious difficulties in using these measures as criteria for evaluating library programs. This difficulty results from the interrelatedness of the objectives and the conflict between them.

(a) A particular book serves a variety of purposes to the same person or different people. Growth, use in leisure, group activities.

(b) Allocation problem results. Introduce new library program which results in increased usage of the library. Can not tell which of the objectives were being met because of interdependencies.

(4) Conflict between objectives. Acquire materials vs. communicating with users. Limited funds.

(5) Library contributes to helping individual meet societal objectives. Can not tell how much library contributed.

7. One possibility in the measurement problem is to take a step back from ultimate benefits and concentrate on the exposure of individuals to documents of recorded human experience.

a. Ignore evaluation in terms of facilities

b. Other measure are available for libraries emphasizing use rather than promotion of use:

- (1) Proportion of user demands satisfied.
- (2) Average time to get document or information to the user.
- (3) Note that these are really effectiveness measures (MC].

J. Library Benefits - Goddard. Another paper dealing with public and school library benefits was written by Haynes C. Goddard and published in Library Quarterly, July 1971.

1. Goddard suggests that benefits can be divided into three categories.
 - a. Education
 - b. Information
 - c. Recreation
2. Education benefits
 - a. 75% of public library circulation is accounted for by school-age children. Thus education is a major function of public libraries.
 - b. Economics of education suggests these are external or collective benefits of education. Technological progress and rising levels of economic welfare are correlated with levels of educational achievement.
 - c. Thus public library is an important adjunct to, or input into, the education process
 - d. A percentage of external benefits should be traced to the library. There is no empirical evidence about this.
3. Information
 - a. Very little is known about the benefits of this.
 - b. Many varieties of information.

c. If information used in education then previous section applies. If information used in operation of a business then it is input to the firms production function and it is private not social in nature.

4. Recreation

a. Not clear if there are externalities or collective benefits associated with recreation and leisure-time reading.

b. Have to decide this in the allocation of resources. If no externalities then do not support publically.

5. A problem with the framework proposed is that it is hard to tell which category the benefits flow from. Thus one needs to consider explicitly in the framework

a. The materials that are used.

b. The socioeconomic status of the library users.

6. Social Benefits by Demand Class. Idea is to classify the various economic uses of the library and relate these to individuals who are responsible for library use. One possible classification of library users is given below.

a. School-age children, adolescents, and those involved in education.

(1) If material borrowed is for education, then service is a public good.

(2) If an adult not in a culturally and economically disadvantaged minority group, then only private benefits. Public support is not called for - a prior

(3) Argues that in order to maximize social benefits one should not provide for other than educational needs because of scarce resources and availability of material for other readers in other places (bookstores).

- b. Disadvantaged Minority Groups. Overlap with school age children possible. If so put in that category. Should provide service to this category.
- c. The Business Community. Business community has low demand. Libraries are providing private benefits for which the business community should be willing to pay.
- (1) One exception might be professional groups such as lawyers or doctors. Social benefits are generated.
- (2) Some economics of scale.
- d. Civic and Cultural Associations. Difficult to see many collective public benefits from these activities. They are like recreation. Since no external benefits (perhaps economics of scale - symphony) a misallocation of resources is involved to support the function.
- (1) League of Women Voters, PTA may be exception.
- (2) Tentative conclusion.
- e. Service to Government. Government activity implies public goods and social benefits. Support the activity.
- f. Leisure-time pursuits. Defined as a private good. Not provided free.
- g. Elderly and Infirm Persons. Economic analysis not extendable to this category.

*Not included in final
Pub Community Prog Book
Not included in final
Community & Public Services*

- K. Library Benefits - Lancaster. As part of his discussion of cost-effectiveness, Lancaster in the Journal of the American Society for Information Science (January-February 1971) lists five possible criteria that could be used for measuring benefits of an information system.
1. Cost savings in using this system as compared with the costs of finding needed information elsewhere.
 2. Avoidance of loss of productivity (of engineers for example) that would result if information sources were not readily available.
 3. Improved decision-making or reduction in the level of personnel required to make decisions.
 4. Avoidance of duplication or waste of engineering or research effort that has either been done before or has been proved infeasible by earlier investigators.
 5. Stimulation of invention (a serendipity factor) For example, an industrial current-awareness service might easily justify itself economically by suggesting possible new products, new applications for existing products, possible markets for industrial waste, or less expensive methods of fabrication.
 6. Lancaster suggest that there are various levels of benefits.

L. Other examples.

M. Conclusions

1. It is by no means clear that we have arrived at anything close to a good set of measures of benefit of information service.
2. The papers that have been discussed are good beginnings in the analysis.
3. It is up to us to continue.

XII Cost-Benefit Analysis

- A. In some disciplines, the practice of cost-benefit analysis has become so refined that books are published describing how to calculate benefits, what is or is not a secondary benefit, what interest rates should be used for discounting, etc.
1. One such manual is called the "Green Book" and is used for water resources work. Its full title is: Proposed Practices for Economic Analysis of River Basin Projects, Report to the Federal Inter-Agency River Basin Committee Prepared by the Subcommittee on Benefits and Costs. May 1950. *(Fuller was the author)*
 2. The information science world is just beginning its use of cost-benefit analysis of information systems. Perhaps in the future a codification of the procedures used in the analysis will be possible. *Probably the subject*
- B. The problem that we are discussing in this chapter is that of the mechanism for cost-benefit analysis.
1. In previous sections we have talked about the problem of developing measures of benefit and cost.
 2. Now we want to use the measures to evaluate projects and compare alternatives - to perform the mechanics of the process.
 3. We will cover several topics:
 - a. Investment criteria.
 - b. Selection of alternatives.
 - c. Interest rates
 - d. Project life.

C. For purposes of explanation, let us assume that we are involved in a cost-benefit analysis related to the construction of library buildings. Assume we have three possible sites for the building and we now want to know which to pick.

1. Previously we have made cost calculations and have determined the amount of money that will have to be invested to construct the facility, purchase the building, maintain it, pay salaries and expenses.
2. In addition assume that we have also conducted a benefit study connected with each library design. The study has taken into account the location of the building, the proportion of various types of clientele that will be served at each physical location, the benefits resulting from the different planned collection mixes, and the benefits from the type of reference service that will be provided.
3. The result of the analysis is that for a given time period, say perhaps 5, 10 or 15 years we know each year the costs that are involved in operating the library and the benefits accruing to the library.
4. We will call the projects A and B and present some hypothetical numbers to illustrate the techniques. We assume for simplicity that we are examining a stream of benefits and costs for three years.

A			B	
Year	Benefits	Cost	Benefits	Cost
1	5	100	25	100
2	50	75	75	40
3	100	25	85	20

Figure 10

A

B

Year	Benefits	Cost	Benefits	Costs
1	5	100	25	100
2	50	75	75	40
3	100	25	85	20

5. The objective of the analysis that follows will be to examine the stream of benefits and costs to see which is best. The calculations will involve a number of steps. [Mobasher in UCLA Course 885.7 March 1968 English and Klein: Cost-Effectiveness: The Economic Evaluation of Engineered Systems]
 - a. Identification of different parts of the project and measurement of their costs
 - b. Identification and measurement of the significant consequences of the project, i.e., benefits
 - c. Consideration of the time context of the investment and time pattern of the occurrence of the benefits
 - d. Translation and aggregation of benefits and costs to a common point of time, for example, the present
 - e. Establishment of a criterion and its application to find the optimum scale of development and the ranking of the project.
6. Several factors will be involved in the cost analysis:
 - a. Calculating primary costs
 - b. Calculating associated costs. These include costs to users to take advantage of changes in technology, resource availability, etc.
 - c. Translation of market costs into social costs
7. Benefit analysis will include:
 - a. Determination of the types of benefits derivable from the project
 - b. Measurement of benefits
 - 1) Willingness to pay
 - 2) Least cost alternative
 - 3) With and without project
 - c. Secondary benefits

8. Also to be considered in the project analysis will be the time context
 - a. Time interval
 - b. Economic life of the project
9. Once the benefits and costs have been determined, consideration will have to be given to the evaluation of the stream over time. This involves consideration of:
 - a. Interest rates
 - b. Social rates of discount
 - c. Evaluation criteria

D. Investment Criteria

1. Before embarking on a discussion of investment criteria, it should be noted that this is another area in which cost-benefit analysis borrows from other disciplines.
 - a. We saw previously that the concepts of welfare economics are used because of the collective nature of the information supplied.
 - b. In the discussion of investment criteria, we are employing techniques that financial managers have been using for a long while in project selection.
2. There are a number of investment criteria that can be used and we briefly review each of them.
3. Cut-off period. [Mishan, p. 185-6] Choose a period of time within which money invested must be fully recouped. Justify this criterion on the basis that if a product or method is not protectable by patent it will be copied by the competitor in two or three years. One shortcoming is that if returns are not expected in the first few years ~~but~~ later on, worthwhile projects would be rejected.
4. Pay-off period. [Mishan, pp. 186-7] Instead of choosing an arbitrary cut-off period, we may rank the investment options according to the number of years necessary to recoup the initial outlay.

5. Present Discounted Value. The methodology that is most frequently used in evaluating the merits of particular projects involves comparing a stream of benefit values and cost values over time.
- The technique used is to determine what the value today is of expenditures and benefits in the future.
 - The decision that has to be made is one of selecting a particular project over another based on the benefits and costs stream.
 - One other factor is needed to perform the calculations and that is the discount rate or interest rate.
 - We are all familiar with the concept of interest rates. We put \$100 in the bank at 5% per year and at the end of the first year have \$105. At the end of the second year we have \$110.25 (\$105 + \$2.25). This is the same concept only in reverse that is used in calculating the present discounted value of an investment.
 - We return to our example of the library building to illustrate the discounting technique. The calculations assume a discount rate of 5%. *return to the problem of building a library*
 - The formula for computing the present value of a stream of benefits is

$$B = \frac{b_1}{(1+i)} + \frac{b_2}{(1+i)^2} + \dots + \frac{b_n + s}{(1+i)^n}$$

- A similar formula is used for costs

$$C = \frac{c_1}{(1+i)} + \frac{c_2}{(1+i)^2} + \dots + \frac{c_n}{(1+i)^n}$$

Present Value of a Stream of Benefits

$$B = \frac{b_1}{(1+i)} + \frac{b_2}{(1+i)^2} + \dots + \frac{b_n + s}{(1+i)^n}$$

Present Value of a Stream of Costs

$$C = \frac{C_1}{(1+i)} + \frac{C_2}{(1+i)^2} + \dots + \frac{C_n}{(1+i)^n}$$

Where

B = present value of a stream of benefits b_1, b_2, \dots, b_n

s = salvage value

i = discount rate

C = present value of a stream of costs C_1, C_2, \dots, C_n

Figure 11

h. For project A the calculations are as follows:

$$B = \frac{5}{1+.05} + \frac{50}{(1+.05)^2} + \frac{100}{(1.05)^3}$$

$$B = 5(.952) + 50(.907) + 100(.864)$$

$$B = 4.76 + 45.25 + 86.40$$

$$B = 136.41$$

$$C = 100(.952) + 75(.907) + 25(.864)$$

$$C = 95.20 + 68.00 + 21.60$$

$$C = 184.80$$

i. For project B the calculations are:

$$B = 25(.952) + 75(.907) + 85(.864)$$

$$B = 23.80 + 68.00 + 73.50$$

$$B = 165.30$$

$$C = 100(.952) + 40(.907) + 20(.864)$$

$$C = 95.20 + 36.20 + 17.28$$

$$C = 148.68$$

Financial Tables
PRESENT VALUE $1/(1 + i)^n$

Periods n	Rate		
	.04 (4%)	.045 (4½%)	.05 (5%)
1	.9615 3846	.9569 3780	.9523 8095
2	.9245 5621	.9157 2995	.9070 2948
3	.8889 9636	.8762 9660	.8636 3760
4	.8548 0419	.8385 6134	.8227 0247
5	.8219 2711	.8024 5105	.7835 2617
6	.7903 1453	.7678 9574	.7462 1540
7	.7599 1781	.7348 2840	.7106 8133
8	.7300 9021	.7031 8513	.6768 3936
9	.7025 8674	.6729 0443	.6446 0892

Figure 12

Financial Tables

PRESENT VALUE $1/(1+i)^n$ (Continued)

Periods n	Rate i				
	.035 (3 1/2%)	.04 (4%)	.045 (4 1/2%)	.05 (5%)	.055 (5 1/2%)
1	.9661 8337	.9615 0846	.9569 3780	.9523 8055	.9478 6730
2	.9335 1370	.9288 5321	.9242 9995	.9197 2954	.9152 6242
3	.9019 4271	.8972 8336	.8927 1650	.8882 3739	.8837 1335
4	.8714 4223	.8667 8419	.8622 6134	.8577 0247	.8532 1671
5	.8419 7317	.8373 2711	.8328 3165	.8283 2617	.8238 1070
6	.8135 0093	.8089 5332	.8044 2874	.7999 1510	.7954 0535
7	.7859 0063	.7814 0321	.7769 2211	.7724 1159	.7679 0181
8	.7594 1153	.7549 0321	.7504 2211	.7459 1159	.7414 0181
9	.7337 3097	.7292 0321	.7247 2211	.7202 1159	.7157 0181
10	.7089 2881	.7044 0321	.6999 2211	.6954 1159	.6909 0181
11	.6849 4571	.6804 0321	.6759 2211	.6714 1159	.6669 0181
12	.6617 8337	.6572 0321	.6527 2211	.6482 1159	.6437 0181
13	.6394 0415	.6349 0321	.6304 2211	.6259 1159	.6214 0181
14	.6177 8179	.6132 0321	.6087 2211	.6042 1159	.5997 0181
15	.5965 0062	.5920 0321	.5875 2211	.5830 1159	.5785 0181
16	.5767 0501	.5722 0321	.5677 2211	.5632 1159	.5587 0181
17	.5572 0378	.5527 0321	.5482 2211	.5437 1159	.5392 0181
18	.5383 6114	.5338 0321	.5293 2211	.5248 1159	.5203 0181
19	.5201 5569	.5156 0321	.5111 2211	.5066 1159	.5021 0181
20	.5025 6588	.4980 0321	.4935 2211	.4890 1159	.4845 0181
21	.4855 7090	.4810 0321	.4765 2211	.4720 1159	.4675 0181
22	.4691 5053	.4646 0321	.4601 2211	.4556 1159	.4511 0181
23	.4532 8563	.4487 0321	.4442 2211	.4397 1159	.4352 0181
24	.4379 3713	.4334 0321	.4289 2211	.4244 1159	.4199 0181
25	.4231 4681	.4186 0321	.4141 2211	.4096 1159	.4051 0181
26	.4088 3767	.4043 0321	.3998 2211	.3953 1159	.3908 0181
27	.3950 1222	.3905 0321	.3860 2211	.3815 1159	.3770 0181
28	.3816 5332	.3771 0321	.3726 2211	.3681 1159	.3636 0181
29	.3687 4813	.3642 0321	.3597 2211	.3552 1159	.3507 0181
30	.3562 7821	.3517 0321	.3472 2211	.3427 1159	.3382 0181
31	.3442 3035	.3397 0321	.3352 2211	.3307 1159	.3262 0181
32	.3325 8071	.3280 0321	.3235 2211	.3190 1159	.3145 0181
33	.3213 4271	.3168 0321	.3123 2211	.3078 1159	.3033 0181
34	.3104 7665	.3059 0321	.3014 2211	.2969 1159	.2924 0181
35	.2999 7680	.2954 0321	.2909 2211	.2864 1159	.2819 0181
36	.2898 3272	.2853 0321	.2808 2211	.2763 1159	.2718 0181
37	.2800 3161	.2755 0321	.2710 2211	.2665 1159	.2620 0181
38	.2705 6194	.2660 0321	.2615 2211	.2570 1159	.2525 0181
39	.2614 1250	.2569 0321	.2524 2211	.2479 1159	.2434 0181
40	.2525 7247	.2480 0321	.2435 2211	.2390 1159	.2345 0181
41	.2440 3137	.2395 0321	.2350 2211	.2305 1159	.2260 0181
42	.2357 7910	.2312 0321	.2267 2211	.2222 1159	.2177 0181
43	.2275 6530	.2230 0321	.2185 2211	.2140 1159	.2095 0181
44	.2201 0231	.2156 0321	.2111 2211	.2066 1159	.2021 0181
45	.2126 5113	.2081 0321	.2036 2211	.1991 1159	.1946 0181
46	.2052 3737	.2007 0321	.1962 2211	.1917 1159	.1872 0181
47	.1985 1663	.1940 0321	.1895 2211	.1850 1159	.1805 0181
48	.1918 0646	.1873 0321	.1828 2211	.1783 1159	.1738 0181
49	.1853 2024	.1808 0321	.1763 2211	.1718 1159	.1673 0181
50	.1790 5337	.1745 0321	.1700 2211	.1655 1159	.1610 0181

For project A the calculations are as follows:

$$B = \frac{5}{1 + .05} + \frac{50}{(1 + .05)^2} + \frac{100}{(1 + .05)^3}$$

$$B = 5 (.952) + 50 (.907) + 100 (.864)$$

$$B = 4.76 + 45.25 + 86.40$$

$$B = 136.41$$

$$C = 100 (.952) + 75 (.907) + 25 (.864)$$

$$C = 95.20 + 68.00 + 21.60$$

$$C = 184.80$$

Figure 13a

For project B the calculations are:

$$B = 25 (.952) + 75 (.907) + 85 (.864)$$

$$B = 23.80 + 68.00 + 73.50$$

$$B = 165.30$$

$$C = 100 (.952) + 40 (.907) + 20 (.864)$$

$$C = 95.20 + 36.20 + 17.28$$

$$C = 148.68$$

Figure 13b

For project A the calculations are as follows:

$$B = \frac{5}{1+.05} + \frac{50}{(1+.05)^2} + \frac{100}{(1+.05)^3}$$

$$B = 5(.952) + 50(.907) + 100(.864)$$

$$B = 4.76 + 45.35 + 86.40$$

$$B = 136.41$$

$$C = 100(.952) + 75(.907) + 25(.864)$$

$$C = 95.20 + 68.00 + 21.60$$

$$C = 184.80$$

For project B the calculations are:

$$B = 25(.952) + 75(.907) + 85(.864)$$

$$B = 23.80 + 68.00 + 73.50$$

$$B = 165.30$$

$$C = 100(.952) + 40(.907) + 20(.864)$$

$$C = 95.20 + 36.28 + 17.28$$

$$C = 148.68$$

6. The Internal Rate of Return. The rate of discount which makes the present value of the benefits exactly equal to the present value of the costs. Put otherwise, the internal rate of return is that rate of discount which makes the present value of the entire stream-benefits and costs - exactly equal to zero.

[Mishan, p. 198]

a. Here the idea is to solve for the discount rate.

E. Selection of Alternatives. Once we have a number of different criterion we can use to develop rules that can be used to select alternative projects given the measures.

1. Prest and Turvey have synthesized the issue in a succinct manner. [Prest and Turvey, p. 703].

"We believe that the most common maximand where projects involve only costs and benefits expressed in terms of money is the present value of benefits less costs."

2. "Where no projects are interdependent or mutually exclusive, where starting dates are given and where no constraints are operative the choice of projects which maximises the present value of total benefits less total costs can be expressed in any of the following four equivalent ways:

- a. "select all projects where the present value of benefit exceeds the present value of costs;
- b. "select all projects where the ratio of the present value of benefits to the present value of costs exceed unity;
- c. "select all projects where the constant annuity with the same present value as benefits exceeds the constant annuity (of the same duration) with the same present value as costs;
- d. "select all projects where the internal rate of return exceeds the chosen rate of discount."

3. Notation for the above criteria:

Let c_1, c_2, \dots, c_n = series of prospective costs in years
1, 2, 3, . . . n.

c = constant annuity with some present value

as c_1, c_2, \dots, c_n .

b_1, b_2, \dots, b_n = series of prospective benefits in years 1, 2,
. . . n.

b = constant annuity with some present value as b_1, b_2, \dots, b_n .

s = scrap value.

i = appropriate rate of discount for annual compounding.

r = internal rate of return

4. The selection rules are written as follows

(corresponding to 2 a - d above):

Select projects where

$$\text{a. } \frac{b_1}{(1+i)} + \frac{b_2}{(1+i)^2} + \dots + \frac{b_n + e}{(1+i)^n} >$$

$$\frac{c_1}{(1+i)} + \frac{c_2}{(1+i)^2} + \dots + \frac{c_n}{(1+i)^n}$$

$$\text{b. } \frac{b_1}{(1+i)} + \frac{b_2}{(1+i)^2} + \dots + \frac{b_n + s}{(1+i)^n} > 1$$

$$\frac{c_1}{(1+i)} + \frac{c_2}{(1+i)^2} + \dots + \frac{c_n}{(1+i)^n}$$

c. $b > c$

d. Select projects where $r > i$ where r is given by

$$\frac{b_1}{(1+r)} + \frac{b_2}{(1+r)^2} + \dots + \frac{b_n - c_n}{(1+r)^n} = 0$$

5. Returning to our calculations in the previous example, we would reject project A and accept project B.
6. The internal rate of return would be calculated iteratively until the value equals zero.

F. One issue in the analysis of alternatives using cost-benefit analysis has to do with division of benefit by cost or subtraction of cost from benefit. We quote Mishan [p. 234] for one view.

"... If we adopted the $(B' - K')$ method of ranking, we tacitly suppose that the alternative investment streams are of exactly the size given: no increase is possible. If, however, we adopt the $(B' - K') / K'$ method of ranking, we tacitly suppose the opposite; that either stream can be increased in any proportion. Where neither of these suppositions are true, we should not repose confidence in either method of ranking."

- G. Interest Rates. Up to this point in our discussion of how to perform the evaluation of projects, we have assumed that we know the proper discount or interest rate to use. Unfortunately this is usually not the case and in fact the selection problem is a very difficult one
1. There are many interest rates available for us to use.
 - a. Government borrowing rate.
 - b. Commercial borrowing rate.
 - c. Cost of capital.
 - d.
 - e.
 2. Prest and Turvey note several problems in determining the interest rate [pp. 697-700].
 - a. Want to select an interest rate with which to discount net benefits.
 - b. Another problem is to determine whether market rates bear any relation to marginal productivity of investment.
 - c. Two difficulties:
 - 1) How to actually determine the social rate of discount.
 - 2) Different rates of interest will be used in public and private sectors. Which one to pick.
 - d. The Social Opportunity Cost Rate.
 - 1) Could use rate at which government borrows money.
 - 2) Question of whether this rate actually equals interest rate.
 - e. Adjustment for uncertainty.
 - 1) Public investment projects are not free from uncertainty.
 - 2) Allowance for uncertainty can be made:

- a) In the assessment of annual levels of benefit and costs.
 - b) In the assumptions about length of life.
 - c) In the discount rate.
- f. Principles vs. practice
- 1) In practice not much consideration of future changes in interest rates.
 - 2) 4-8% rates are common
3. Mishan [p. 191] has several comments on the interest rate problem:
- a. The correct rate of interest is that which reflects society's rate of time preference. (If for example, society is indifferent between having \$100 million today and \$106 million next year, the social rate of time preference is 6% per annum)
 - b. Rate is valid only for quantity used to arrive at it.
 - c. Rate is valid only for time period used to arrive at it.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

March 27, 1972

CIRCULAR NO. A-94
Revised

TO THE HEADS OF EXECUTIVE DEPARTMENTS AND ESTABLISHMENTS

SUBJECT: Discount rates to be used in evaluating time-distributed costs and benefits

1. Purpose. This Circular prescribes a standard discount rate to be used in evaluating the measurable costs and/or benefits of programs or projects when they are distributed over time.

2. Rescission. This Circular replaces and rescinds Office of Management and Budget (OMB) Circular No. A-94 dated June 26, 1969.

3. Scope.

a. This Circular applies to all agencies of the executive branch of the Federal Government except the U.S. Postal Service. The discount rate prescribed in this Circular applies to the evaluation of Government decisions concerning the initiation, renewal or expansion of all programs or projects, other than those specifically exempted below, for which the adoption is expected to commit the Government to a series of measurable costs extending over three or more years or which result in a series of benefits that extend three or more years beyond the inception date.

b. Specifically exempted from the scope of this Circular are decisions concerning water resource projects (guidance for which is the approved Water Resources Principles and Standards), the Government of the District of Columbia, and non-Federal recipients of Federal loans or grants.

c. The remaining exemptions derive from the secondary nature of the decisions involved; that is, how to acquire assets or proceed with a program after an affirmative decision to initiate, renew, or expand such a program using this Circular. Thus:

(1) This Circular would not apply to the evaluation of decisions concerning how to obtain the use of real property, such as by lease or purchase.

c. Expected annual effects means an objective, non-monetary measure of program effects expected for each of the years a program or project is in operation. When dollar value cannot be placed on the effects of comparable programs or projects, an objective measure of effects may be available and useful to enable the comparison of alternative means of achieving specified objectives on the basis of their relative present value costs. These effects should be estimated for each year of the planning period and are not to be discounted.

d. Discount rate means the interest rate used in calculating the present value of expected yearly costs and benefits.

e. Discount factor means the factor for any specific discount rate which translates expected cost or benefit in any specific future year into its present value. The discount factor is equal to $1/(1+r)^t$, where r is the discount rate and t is the number of years since the date of initiation, renewal or expansion of a program or project.

f. Present value cost means each year's expected yearly cost multiplied by its discount factor and then summed over all years of the planning period.

g. Present value benefit means each year's expected yearly benefit multiplied by its discount factor and then summed over all years of the planning period.

h. Present value net benefit means the difference between present value benefit (item g) and present value cost (item f).

i. Benefit-cost ratio means present value benefit (item g) divided by present value cost (item f).

Attachment A contains an example that illustrates calculation of the present value information.

5. Treatment of inflation. All estimates of the costs and benefits for each year of the planning period should be made in constant dollars; i.e., in terms of the general purchasing power of the dollar at the time of decision. Estimates may reflect changes in the relative prices of cost and/or benefit components, where there is a reasonable basis for estimating such changes, but should not include any forecasted change in the general price level during the planning period.

ATTACHMENT A
Circular No. A-94
Revised

SAMPLE FORMAT FOR DISCOUNTING DEFERRED COSTS AND BENEFITS

Assume a ten-year program which will commit the Government to the stream of expenditures appearing in column (2) of the table below and which will result in a series of benefits appearing in column (3). The discount factor for a 10 percent discount rate is presented in column (4). Present value cost for each of the ten years is calculated by multiplying column (2) by column (4); present value benefit for each of the ten years is calculated by multiplying column (3) by column (4). Present value costs and benefits are presented in columns (5) and (6), respectively.

Year since initiation, renewal or expansion	Expected yearly cost	Expected yearly benefit	Discount factor for 10 percent	Present value cost [Col. (2) x Col. (4)]	Present value benefit [Col. (3) x Col. (4)]
(1)	(2)	(3)	(4)	(5)	(6)
1	\$10	\$0	0.909	\$9.1	\$0.0
2	20	0	0.826	16.5	0.0
3	30	5	0.751	22.5	3.8
4	30	10	0.683	20.5	6.8
5	20	30	0.621	12.4	18.6
6	10	40	0.564	5.6	22.6
7	5	40	0.513	2.6	20.5
8	5	40	0.467	2.3	18.7
9	5	40	0.424	2.1	17.0
10	5	25	0.386	1.9	9.7
				\$95.5	\$117.7

The sum of column (5) is present value cost: \$95.5
The sum of column (6) is present value benefit: \$117.7

Present value net benefit is the difference between present value total benefit and present value total cost:
\$117.7 - \$95.5 = \$22.2.

The benefit-cost ratio is $117.7/95.5 = 1.23$.

NOTE: For more difficult discounting problems, a recommended reference is Principles of Engineering Economy, by Eugene L. Grant and W. G. Ireson, Ronald Press Company, 1960.

ATTACHMENT B
Circular No. A-94
Revised

DISCOUNT FACTORS

<u>Year since initiation, renewal or expansion</u>	<u>Discount factors*</u>	<u>Year since initiation, renewal or expansion</u>	<u>Discount factors*</u>
1	0.909091	26	0.083905
2	0.826446	27	0.076278
3	0.751315	28	0.069343
4	0.683013	29	0.063039
5	0.620921	30	0.057309
6	0.564474	31	0.052099
7	0.513158	32	0.047362
8	0.466507	33	0.043057
9	0.424098	34	0.039143
10	0.385543	35	0.035584
11	0.350494	36	0.032349
12	0.318631	37	0.029408
13	0.289664	38	0.026735
14	0.263331	39	0.024304
15	0.239392	40	0.022095
16	0.217629	41	0.020086
17	0.197845	42	0.018260
18	0.179859	43	0.016600
19	0.163508	44	0.015091
20	0.148644	45	0.013719
21	0.135131	46	0.012472
22	0.122846	47	0.011338
23	0.111678	48	0.010307
24	0.101526	49	0.009370
25	0.092296	50	0.008519

*The discount factors presented in the table above implicitly assume end-of-year lump-sum costs and returns. When costs and returns occur in a steady stream, applying mid-year discount factors may be more appropriate. Present value cost and benefit computed from this table can be converted to a mid-year discounting basis by multiplying them by the factor 1.048809.

For example, if the present value cost of a series of annual expenditures computed from the above table is \$1,200.00, the present value cost on a mid-year discounting basis is \$1,200.00 x 1.048809 or \$1,258.57.

Project A

Discount Discount Rate	Benefit	Cost	B/C Ratio
2½%	145.4	192.2	0.757
5%	136.4	184.8	0.740
7½%	128.4	177.9	0.724
10%	120.9	171.7	0.705

Project B

Discount Rate	Benefit	Cost	B/C Ratio
2½%	174.8	154.3	1.13
5%	165.3	148.7	1.11
7½%	156.5	143.7	1.09
10%	158.6	139.0	1.14

PROJECT A

<u>Discount Rate</u>	<u>Benefit</u>	<u>Cost</u>	<u>B/C Rate</u>
2- $\frac{1}{2}$ %	145.4	192.2	0.757
5%	136.4	184.8	0.740
7- $\frac{1}{2}$ %	128.4	177.9	0.724
10%	120.9	171.7	0.705

PROJECT B

<u>Discount Rate</u>	<u>Benefit</u>	<u>Cost</u>	<u>B/C Rate</u>
2- $\frac{1}{2}$ %	174.8	154.3	1.13
5%	165.3	148.7	1.11
7- $\frac{1}{2}$ %	158.5	143.7	1.09
10%	156.6	139.0	1.14

FIGURE 14

H. Project Life. The final topic that we need to discuss is the life of a project. The selected life of the project will influence whether the project is accepted or not.

1. Estimation of length of life is a subjective process. It depends on:

[Prest and Turvey, p. 690]

a. Physical life.

b. Technological changes.

c. Shifts in demand.

d. Emergence of competing products.

2. One way to see effect of varying project lives is to use sensitivity analysis for various discount rates and various project time spans.

XII Limitations of the Methodology

- A. We have now completed a brief survey of the methodology of cost-effectiveness and cost benefit analysis. It is useful to take a step backward and see the possible limitations of the approaches.
- B. A useful framework for analysis of the limitations has been proposed by Aaron Wildovsky. He suggest four environments that put the problems in perspective. [p. 371]
1. Pure efficiency - concerned with meeting the objective at the lowest cost or obtaining the maximum amount of the objective for a specified amount of resources.
 2. Mixed efficiency - modify objectives to suit the cost of achieving them.
 3. Limited efficiency - both pure and mixed efficiency are limited in the sense that they take for granted the existing structure of the political system and work within its boundaries.
 4. Total efficiency - alter the machinery for making decisions. After resources and objectives. Pursue efficiency into the heart of the political system.
 5. Wildovsky suggests that cost-benefit analysis involves more than notions of just pure efficiency. [One should remember that total system - that is, use the systems approach].

C. Quade [In: Goldman, p. 8-11] has suggested a number of limitations of the approach:

1. Human judgment is involved.
2. Adherence to the party line (bias in outlook).
3. Time and money constraints prevent full analysis.
4. Measures of effectiveness are approximate.
5. No satisfactory way to predict the future.

D. Assumptions of the methodology of cost-benefit analysis. [Widovsky, pp. 373-374].

1. Cost-benefit analysis based on values related to full employment. Market imperfections work against validity of results.
2. Assume a given income distribution to start with. Government action influences it. Economists should not change the distribution unless politically authorized.
3. Whose welfare is cost-benefit analysis promoting? Inter-personal utility comparison problems.
4. Do not have an objective welfare function to use to guide policy so as to benefit everyone.

E. Limitations on the utility of cost-benefit analysis [Waldovsky, pp. 375-377].

1. Certain projects are not amenable to cost-benefit analysis.
 - a. When there are many diverse types of benefits from a project and/or many different beneficiaries it is difficult to list them

all and avoid double counting. This is why it is easier to apply cost-benefit analysis to limited purpose projects than multi-purpose ones.

- b. Difficult to apply in fields in which benefits are widely diffused.
 - c. Difficult to apply in fields where there are large divergencies between accounting and economic costs or benefits.
 - d. Difficult to apply to projects involving comparisons of different branches of economic activity.
 - e. Techniques are more applicable in the public - utility area than in the social - services area of government. [Prest and Turvey, p. 729-731].
2. If calculations are to be made useful, it is necessary to simplify.
 3. One makes a guess when cost and benefits are important but cannot be quantified. The issue of recreational and aesthetic value in benefits must be considered. Could include in appendix so as not to bias the calculations.
 4. Do sensitivity analysis to see how project life and interest rate affect project.
 5. Interest rate needs to be selected. Interest rate should measure opportunity cost of private capital that could be used to produce wealth elsewhere in the economy.
 - a. If the Corps of Engineers raised interest (or discount) rates from $2\frac{5}{8}$ to 4, 6, or 8% then 9, 64 and 80% of the projects would have benefit-cost ratios less than unity. Discount rate is a very important choice.

- F. Prest and Turvey [pp. 728-729] point out a number of problems in cost-benefit analysis, all related to evaluating benefits.
1. How to measure surpluses of a product or service so as to price or produce correctly. This causes consideration of:
 - a. Measurability of utility.
 - b. Issue of constant marginal utility of money across an individual's demand curve.
 - c. Inter-personal utility comparisons.
 2. We need to go beyond measurements of benefits on the basis of market prices and make allowances for imperfections, externalities and so on.
 3. How to choose appropriate discount rate.
 4. How to include uncertainty in the analysis.

G. Concluding comments

1. If we decide that cost-effectiveness or cost-benefit analysis is not adequate, are there any other alternatives we should consider? [Prest and Turvey, p. 730].
2. In the process of performing the analysis we will clarify the way in which the system operates and understand its objectives.

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