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ECONOMIC ANALYSIS· OF INFORMATION SYSTEM

by

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Economic Analysis of Information System

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ABSTRACT

This paper examines the utilities of present value analysis, discounted payback analysis, uniform annual cost, benefit-cost ratio, savings investment ratio, internal rate of return, and break even analysis, as economic analysis techniques. These techniques are analyzed using comparative four-way data sets that have front-loaded and back-loaded costs and front-loaded and back-loaded benefits. The findings of this analysis are then summarized in a matrix that scores the category of utility for each technique. An expert system (COSTEX) is then developed using the Intelligence Compiler expert system shell. This system directs MIS managers in the selection of appropriate techniques of analysis for a given set of economic analysis contingencies. The Basic Economic Analysis Decision Support (BEADS) system is also developed to provide users with both a decision support framework and a tutorial on the methodologies and virtues of each of the economic analysis techniques.

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I. INTRODUCTION

Decision making is a major activity of both private and public organizations. Expansion versus modernization, buying versus making, and action versus inaction are just a few examples of decisions that face institutions regularly. The success or failure of an organization is directly related to its ability to make these decisions correctly. Unfortunately, critical decisions are often made without the proper analysis.

Over the years, many different techniques have been developed to help organizations with their decisions. Such techniques often deal with decisions in complex quantifiable terms. Because of this, many managers shy away from decision making algorithms, choosing to use their gut instincts instead. Decisions based on such information can prove to be costly if not crippling to the organization.

To analyze potential investment decisions, organizations must first be able to understand and classify the criteria on which to base decisions. Different types of decisions can result in different problems, have different effects, and require different analysis tools.

Because of the large number of economic analysis tools in existence, decision makers must be familiar with large numbers of analysis techniques and their associated properties. If for example, an organization's emphasis is on rate of return,

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decision makers might find it more beneficial to measure alternatives using analysis techniques that calculate rate of return vice user satisfaction.

Once appropriate analysis techniques have been selected, decision makers must also be able to use them properly. Inexperienced decision makers could easily become confused and frustrated by the many computations and variables associated with some techniques. If care is not taken in these circumstances, costly economic analysis errors could occur.

As the role of information systems increase in public and private sectors, so does the amount of capital expenditure. Some of the largest expenditures that organizations make today are on their information systems. For this reason, it has become essential for decision makers to carefully evaluate potential investments in information technology. Improper choices in this area could literally destroy an organization's ability to function.

A. EXAMINATION OF ANALYSIS TECHNIQUES

To assist decision makers in their increasingly important role, a number of economic analysis techniques will be examined in detail. Strengths and weaknesses of each technique will be identified, and properties of the different techniques will be grouped into a matrix format. After these techniques have been fully reviewed and categorized, they will be used to design expert system and decision support

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system applications. These applications will assist decision makers choose and use the economic analysis techniques in a more timely and effective manner.

II. LITERATURE REVIEW

A. DEFINITIONS

Why are there so many different economic analysis
techniques used for evaluating information systems? To answer
this question, the definition of an information system must be
determined. Lucas (1982), suggests that an information system
may be defined as a set of procedures that provide information
for decision making and organizational control. Banbury
(1975), offers that an information system is simply any system
that provides information for decision making. From these
general definitions, it is clear that information systems can
take on many forms. These systems can range from simple
manual procedures to complex automated processes. They also
may differ in the type and amount of information they provide.
The basic functions of an information system, however, are
fairly standard. Lucas (1982), briefly outlines these
functions as data collection, data storage, data processing,
output, and information use.

It is also necessary to define exactly what economic
analysis means. Stermole (1984), defines economic analysis as
the systematic evaluation of the profit potential or effects
of investment alternatives. Another definition is offered by
Stevens (1979) and describes economic analysis as the methods

by which sound economic decisions are made. These economic decisions fall into three major areas:

1. Investment decisions that deal with the evaluation of alternatives under consideration.

2. Financing decisions that are concerned with how the alternatives will be financed.

3. Dividend decisions that determine how the benefits of an alternative will be utilized.

Stevens (1979), elaborates on this definition by pointing out that it is possible to use the term 'economic analysis' interchangeably with managerial accounting, economics, and finance. Van Horne (1983), reinforces this by defining financial management in terms of the same three decision areas. Though definitions of economic analysis may vary, its purpose is clearly to help organizations in making sound decisions.

Economic analysis is most beneficial when the decisions facing an organization require capital expenditures. Making versus buying, renting versus building, expanding versus consolidating, and automating versus staying manual are decisions that confront organizations regularly. The amount of capital that organizations are spending on such decisions is also increasing. Levy and Sarnat (1982), point out that total U.S. capital expenditures on plant and equipment increased tenfold between 1950 and 1980. Quirin and Wriginton (1981) describe capital expenditures of this type as future-oriented in that organizations invest capital to receive some type of benefit later.

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Benefits can take on many manifestations. Increasing profits, decreasing waste, improving productivity, and increasing quality, are examples of possible benefits an organization may hope to achieve through capital expenditures. The success or failure of an organization is often directly related to its ability to evaluate and make these expenditures wisely. Despite this fact, Bierman and Smidt (1984) point out that many managers still make critical decisions by gut feelings, or rules of thumb that have no scientific foundation.

B. EXPENDITURES FOR INFORMATION

Investments in information system technology have also increased at an impressive rate. Lucas (1992) points out that, from their inception, formal organizations rely on some type of information system. Though these systems can take on many forms, Lucas states that the information explosion of the last decade has substantially increased the importance of computer-based information systems. Strassman (1985), points out that information work represents over two-thirds of the United State's labor expenditures.

As computer-based information systems become more complex and integrated, the amount of capital invested in them can rise dramatically. Strassman (1985), states that in 1982, 33.4% of all producers' durable equipment investments were for computer equipment. He also goes on to predict that in the 1990's, annual information system expenditure budgets in the

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United States will total as much as 10% of the GNP. Despite this prediction, however, Strassman (1985) stresses that there is little concrete evidence that shows information system technology is a profitable investment. One case study that he considers valid, examined the returns on assets of 138 wholesalers. Each company was classified as either a heavy computer user, a moderate computer user, or a non-user. The average ROA for heavy users was 8.8% while the average ROA's moderate users and non-users were 9.8% and 11.3% respectively. Strassman (1985), also points out that despite test results such as these, the overwhelming consensus in industry is that information system investments are inherently profitable. It is because of this general belief that information technology has become such a major expenditure.

Successful selection and implementation of these systems can result in many benefits for an organization, while improper selection or misuse of information systems can result in financial ruin. A poorly selected information system can cripple an organization. Losses in efficiency, profit, customer satisfaction, and quality are just a few examples of the possible damages.

Despite all that is at stake when choosing potential information systems, Lucas (1982) points out that often managers and administrators do not take the impact of a computer-based information system seriously. Concerning the successes of computer systems, Allen (1982) states:

No technology has promised so much to organizations of all types, and probably no technology has been the source of so much disappointment and frustration.

Strassman (1985), also suggests that the advantages of information technology are matched by its potential disadvantages. For these reasons it is essential that organizations thoroughly evaluate all potential alternatives before committing capital.

C. CHOOSING ANALYSIS TECHNIQUES

Quirin and Wriginton (1981) describe the basic steps of economic analysis as consisting of the evaluation of benefits and costs, and converting these evaluations into some measure of desirability. They also state that for an analysis technique to be suitable, it must conform to the following principles:

1. The "bigger-the-better" principle: Other things being equal, bigger benefits are preferable to smaller benefits.

2. The "bird-in-the-hand" principle: Other things being equal, early benefits are preferable to later benefits.

If this is the overall goal of economic analysis techniques, why do so many different techniques exist? It seems that a single analysis tool could handle this objective easily. Unfortunately, this is not so. Quirin and Wrigin (1981) state:

A systematic review of the literature on capital-expenditure decisions will reveal a bewildering variety of suggested criteria on which to base them.

They also point out that one of the major reasons for conflicts between analysis techniques may be the multiplicity of goals sought by the organization. Levy and Sarnat (1984), illustrate the diversity of organizational goals by listing some of the more common goals as follows:

1. Maximization of profits

2. Survival of the firm

3. Maximization of sales

4. Achieving a satisfactory level of profits

5. Achieving a target share

6. Some minimum level of employee turnover

7. 'Internal peace' or no ulcers for management

8. Maximization of salaries.

From this partial list, it is easy to see that a goal for one organization could be completely contradictory to the goals of another.

Abdelsamad (1971) suggests that the methods used to evaluate capital expenditures should reflect management's policies and ways of thinking. After interviewing key top managers of six major organizations, Abdelsamad compiled the following list of what they considered the key problems associated with economic analysis:

1. Estimates in general, and estimates of benefits in general.

2. Difficulty of translating the expected benefits into dollar figures.

3. Improper disclosure of alternative courses of action.

4. Unexpected later costs which cannot be forecasted.

5. Qualitative information not subject to quantitative analysis.

6. The difference in background and interests of top management and board of directors.

7. Price level changes and how they could be properly treated.

8. The multitude and variety of assumptions made by analysts and evaluators.

9. The lack of unified and consistent treatment of the topic in literature.

From this list, it is easy to see the many factors involved in economic analysis considerations.

Stermole (1984), states that it is possible for an alternative to look acceptable from an economic perspective, while proving to be unacceptable from a financial or intangible perspective. To have a clear picture of the costs and benefits associated with a project it is necessary to consider it from all applicable perspectives. He stresses that the financial and intangible analysis factors are just as important as the economic factors and should never be underestimated. Abouchar (1985), states that traditional cost-benefit analysis cannot be applied to all projects, and emphasizes the fact that cost-benefit analysis should not be performed without consideration of other financial perspectives like budget constraints, profit maximization, and overall welfare.

Garrison (1988) groups capital expenditures into two broad categories. The first category of decisions are screening

decisions. In this category, projects under consideration are compared to certain standards of acceptance. Preference decisions are the second category and relate to decisions that select from several competing alternatives. Economic analysis techniques will be chosen based on the category into which the decision falls and the measurement requirements of the organization.

Choosing between different information technologies may be one of an organization's most important decisions. When evaluating alternative information systems, it is essential that the organization have the most complete picture possible. To obtain this picture, it is necessary for an organization to select evaluation techniques that can measure the alternatives in terms of its goals and policies. It is also essential that these techniques conform to the decision at hand. Organizations that require specific payback periods on investments should use techniques that rank alternatives by payback time. Organizations that require a specific rate of return should center decisions around other methods. Many times it will be necessary for organizations to use several techniques so that all economic, financial, and intangible factors can be evaluated.

D. OVERVIEW OF TECHNIQUES

Different analysis techniques can be used to evaluate alternatives from different perspectives. Following chapters

will deal with each of the following techniques in greater detail:

1. Net Present Value

2. Uniform Annual Cost

3. Savings Investment Ratio

4. Benefit/ Cost Ratio

5. Discounted Payback Analysis

6. Break-Even Analysis

7. Internal Rate of Return.

E. NET PRESENT VALUE

Garrison (1988), points out that business investments are usually long term in nature. Factors such as inflation and interest make the immediate receipt of a benefit more valuable than a future receipt of the same benefit. Beirman and Smidt (1984), elaborates on this fact by stating:

> The present value of $100 payable in two years can be defined as that quantity of money necessary to invest today at compound interest in order to have $100 in two years.

Therefore, it is necessary for analysis tools to emphasize the time value of money. This philosophy also adheres to Quirin and Wiginton's "Bird-in-the-hand" principle.   If an organization has a set of alternatives where everything is equal except for the costs, discounting the projects' costs to their present value can be used to determine desirability. In this situation, the alternative with the lowest present cost value would be preferable. Garrison (1988), also points out that by discounting a project's costs, then its benefits, and

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finally calculating the difference between the two, a project's desirability can be obtained. In this scenario, an information system would be considered feasible if the present value of its benefits were greater than the present value of its costs. In all cases, however, Net Present Value techniques tend only to deal with the monetary benefits of an alternative. If the organization wishes to analyze other types of costs and benefits associated with a perspective information system, additional techniques must be incorporated into the analysis procedure.

F. UNIFORM ANNUAL COST

Many times, however, it will be necessary to compare alternative information systems with differing economic lives. The Uniform Annual Cost (UAC) method will make this possible. Zimmerman (1980) points out that this technique involves putting all life cycle costs and receipts for an alternative in terms of an average annual expenditure. Quirin and Wiginton (1981) refer to this method as the Uniform Annual Series (UAS), and show that it can be used to measure an information system's costs as well as its benefits. In this technique, the present value of a projects costs or benefits are calculated and summed. This figure is then divided by the cumulative discount factor corresponding to the economic life of the project. The result is the average annual cost or the average annual income of the proposal. The system exhibiting

the highest annual income or the lowest annual cost is considered to be preferable.

G. SAVINGS/INVESTMENT RATIO

Different projects can also be ranked according to their Savings/Investment Ratios (SIR). Zimmerman (1980) describes this ratio as the relationship between an information system's savings and the investment required. The SIR represents the savings that occur from the investment of each dollar. It is computed by dividing the present value of the prospective system's savings by the present value of the investment required. An SIR should be greater than one to be considered favorable. For example, a system having an SIR of 1.32 will generate $1.32 of savings for each dollar invested. Projects with the highest SIR among the alternatives would be considered the most favorable.

H. BENEFIT COST RATIO

Many times, alternative projects yield benefits that are difficult to compare. One information system might increase output while another system might improve quality. To compare such alternatives, it necessary to rank them on a relative scale. Zimmerman (1980) describes the Benefit Cost Ratio (BCR) as an alternative's benefits divided by its costs. The resulting number represents the benefits obtained per unit of cost. By using this technique, alternatives can be ranked based on any number of benefits. One way to rank alternatives

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using this method is to divide the system's discounted benefits by its average annual costs (UAC). The result is simply the ratio of a project's benefits and costs. Stermole (1984), suggests that a project is favorable if the result of this calculation is greater than one. Quirin and Wiginton (1981), point out that Benefit Cost Ratios of this type are also referred to as profitability indices. VanHorne (1983), expresses Benefit Cost Ratios as a project's discounted net cash flows divided by the initial cash outlay. Like Stermole, VanHorne concludes that as long as the result is greater than one, the investment is acceptable.

Benefit Cost Ratios may also be used to measure non-monetary and non-quantifiable benefits. As stated previously, the benefits of an alternative may take such forms as increased output or increased throughput. Zimmerman (1980), shows that a form of the BCR can be applied to determine a project's cost-effectiveness. This is done simply by dividing the non-monetary benefit by the project's UAC. As before, the resulting figure will represent a ratio between the alternative's costs and its perceived benefits. In this case, however, the ratios may be substantially smaller than one. Alternatives with the higher BCR's are considered to be the most cost effective systems.

Often, new information systems can benefit organizations by increasing quality, worker retention, or efficiency. To rank these benefits using the BCR technique, the analyst must

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first convert them to a quantifiable form. This is done by applying weights to the intangible benefits according to how critical they are. Benefits are then rated on some scale of reliability. This rating is then multiplied by the weight to produce a figure representing the relative quantifiable measure of the benefit. This number may then be used in the BCR formula to rank the project's cost-effectiveness.

I. PAYBACK ANALYSIS

Zimmerman (1980), describes Payback Analysis as determining the period of time between initial investment in a system and the point in time at which payback occurs. Stevens (1979), describes the method as determining the number of years required for a project's incoming cash flows to recover the project's investment costs. Abdelsamad (1970), points out that this is accomplished by estimating the yearly cash flow of a project. In his dissertation, Abdelsamad goes on to describe two basic methods of calculating simple payback and when they should be used. The first method consists of dividing the initial investment by the average annual cash flows. This method is useful when cash flows are considered to be roughly equal each year of the project. When cash flows change from year to year, however, he recommends that payback be calculated by subtracting each estimated yearly flow from the initial investment figure. Merret and Sykes (1972), state that basic payback analysis is a popular decision making tool among organizations because of its simplicity and clear cut

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results. Levy and Sarnat (1982), however, emphasize that the simple payback method has some serious defects. One problem is that the payback method only considers cash flows up to the payback period; receipts and costs of later project years are totally ignored. For this reason, Levy and Sarnat point out that it is possible for a project to be chosen based on its payback period, when in actuality later year costs make it an unwise decision. Another problem with simple payback is that it does not take the time value of money into account. This, in turn, could result in underestimating a system's payback period.

J. DISCOUNTED PAYBACK ANALYSIS

In an effort to correct these shortcomings Zimmerman (1980), describes a modified version of simple payback analysis known as discounted payback analysis. This technique incorporates the time value of money as well as the project's terminal value. To calculate the discounted payback period of an information system, first subtract the present value of the project's terminal value from the present value of the investment. This figure is then divided by the annual income or savings provided by the alternative to come up with a cumulative discount figure. To determine the discounted payback period, simply look this figure up on a cumulative discount table and match it with the corresponding time period. It may be necessary to interpolate in some instances to achieve an exact time period.

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It should be noted that payback analysis, discounted or not, does not determine the least costly alternative. It is simply a measure of which system will pay back the investment the quickest. Abdelsamad (1970), stated that payback is less a measure of risk than it is a measure of how long capital is invested with risk. To get the full and accurate picture of a system's desirability it is essential that other analysis techniques, such as payback analysis and benefit cost ratios, should be used along with the payback method.

K. BREAK-EVEN ANALYSIS

It is a possibility that an information system will have certain variable costs in addition to the fixed investments required. In cases such as this, Break-Even Analysis could prove to be a useful tool. Garrison (1988), describes the break-even analysis as finding the point where a project's total expenses equals its total revenue. At this point the decision maker will be indifferent as to whether a project should be undertaken. Zimmerman (1980) and Van Horne (1983), describe it as finding the value of a variable at which the decision maker is indifferent between alternatives. Break-even analysis differs from the payback method in that it measures the level of some variable factor such as units produced, man hours, or raw materials used. To apply this method, Stevens (1979), explains that the following assumptions must first be made:

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1. Profit and gross income are both linear functions
   of production/output

2. Production and sales volume are equal

3. All variables are known with certainty

4. Fixed costs are independent of the production/output
   rate.

Stevens continues by pointing out that variable costs are
proportional to some level of production or system operation.
Information systems require the input of some resource to
operate. Resources such as direct labor, material, direct
supplies, or direct maintenance are often variable costs
associated with information systems. As the use of an
information system increases so, too, will these costs. The
rate at which they increase can directly effect the economic
desirability of the information systems being evaluated.
Stermole (1984), points out that break-even analysis of a
system can be accomplished with simple algebra. The standard
format for this calculation is:

$$VC(X) + FC = TC$$

Where: VC is the variable cost per unit of measure
       FC are the fixed costs
       TC is the total cost of the system/alternative

The result of this equation is simply the amount of
variable costs at which the alternative's costs are equal to
the total costs. If this total cost figure represents the
costs of a competing system, the answer would show the level
of variable costs at which the two projects break-even. By

expressing two alternatives, sharing the same variable costs, in the above form and setting them equal to each other, it is possible to determine the point at which their total costs are equal. This method is quite useful when comparing similar information system alternatives.

Zimmerman (1980), shows that it is also possible to account for the time value of money by multiplying the equations by the cumulative discount factor that corresponds to the number of years the system will operate. The result of this calculation will be discounted to present value. Discounted break-even analysis is most useful when the alternatives being compared have uneven cash flows over their economic lives.

The objective in break-even analysis, as it applies to information systems evaluation, is simply to determine the point at which systems being considered cost the same. Increasing operation beyond this point will make one alternative the most desirable, while decreasing operation will make the other choice optimal.

L. INTERNAL RATE OF RETURN

Beirman and Smidt (1984), define Internal Rate of Return (IRR) as the discount rate that equates the present value of an investment's proceeds with the present value of its outlays. An investments proceeds are considered to be the cash benefits resulting from the investment for as long as it is owned. Beirman and Smidt also point out that the word

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internal is used because the market value of the investment is only considered when it is purchased and when it is sold. Thus the IRR is based on internal information. Garrison (1988), calls IRR the Time Adjusted Rate of Return and defines it as the true interest yield promised by a project over its life. Quirin and Wiginton (1981), state that IRR is often referred to as the Marginal Efficiency of Capital and the Rate of Return Over Cost. Regardless of the name, however, its purpose and calculation are the same. Garrison (1988), describes the calculation of IRR as consisting of two basic steps. In the first step, the factor of the time-adjusted rate of return is calculated using the following formula:

Investment in project / Annual cash flow = factor

The second step in the process is to look this factor up in a present value table. The rate that corresponds to the factor in the table is the project's IRR. If a project's cash flows are not even, however, the IRR must be calculated on a trial-and-error basis. This can become quite tedious and can often be better done using a computer application program such as Lotus 123. Once the IRR is calculated, it is compared with whatever rate of return is required by the organization. If it is equal to, or higher than, this rate the investment is considered economical. IRR is often favored by organizations because it ranks potential projects and investments by a concrete rate of return. Garrison (1988), points out,

however, that in most circumstances the net present value method may be preferable. This is mainly due to the fact that NPV can be calculated easily without any trial-and-error iterations.

When comparing information system alternatives, it may be helpful to express the alternatives in terms of their IRR. This is especially useful when an organization requires any investment to provide a specific rate of return. In these situations IRR can be used as an effective screening tool to eliminate alternatives that do not meet the required rate.

M. METHODOLOGY

In order to study how data are interpreted by each of the different economic analysis techniques discussed, a data set was developed that represents a series of system alternatives. Each economic analysis technique will be applied to that data. The results of the different techniques will be evaluated and compared to each other to determine how each analyzed the data set and contributed to the overall picture.

In each chapter, the data set will be slightly modified to accommodate the varying decision scenarios. The different scenarios that will be looked at are the following:

1. Front-end load alternatives

2. Rear-end load alternatives

3. Steady load alternatives

4. Mixed alternatives.

Front-end load alternatives have the bulk of their cash flows in the earlier years of their economic lives. Because these flows occur earlier, their impact on the alternative's desirability is much greater than that of later life cash flows. This is true because the time value associated with the earlier cash flows is much higher.

Back-end load alternatives are the opposite of front-end load alternatives. They produce larger cash flows later in a project's economic life. Because these larger cash flows occur later in a project's economic life, they are more heavily discounted and do not affect the desirability of the alternative as much as earlier cash flows.

Steady-flow alternatives are projects that distribute cash flows evenly across their economic lives. Rather than paying a lump sum at the beginning or end of a project, payments are made at steady intervals throughout the project's duration. Cash inflows are also arranged in this manner.

In some situations it will be necessary to compare alternatives with unlike cash flows. One alternative, for example, might require full payment in advance, while another alternative might require payment throughout its economic life. Situations such as this will be studied as mixed alternatives. By looking at these various types of alternatives and determining how the different economic analysis techniques represent them, it will be possible to understand the value and relevance of various economic

analysis procedures. It will also assist in understanding when, and in what combination, analysis tools should be used in order to make the best decision. After the results of each technique have been analyzed, all of the results will be placed into a grid. This grid may then be used to compare the results of each technique. This information will also be used to develop an economic analysis expert system and decision support system.

N. DATA SET

The basic data set that we will use to evaluate the economic analysis techniques, will consist of the following three hypothetical information systems:

	STATUS QUO	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.	5 yrs.
Initial Cost	0	$11,500	$12,000
Operating Cost	$200/yr.	$120/yr.	$80/yr.
Maintenance	$4,000/yr.	$500/yr.	$500/yr.

The first system is the current or status quo system. The other two systems represent proposed systems that might replace the status quo. The initial cost of the status quo system is considered to be zero because it is a sunk cost. The numbers that are used in the data set may, at times, seem impractical or unrealistic, but, are being used to show a property of the analysis techniques being evaluated.

O. SUMMARY

If organizations require information to survive, then their information systems are often their most critical system. To keep up with the increasing flow of necessary information, many organizations have automated their information systems with costly computing and data processing equipment. When selecting this equipment, organizations are often faced with many alternatives. Selecting the improper system for the job can cripple an organization financially as well as operationally. To overcome this potential disaster, decision makers have turned to a series of economic analysis techniques to assist them in choosing the optimal information system. Analysis techniques such as net present value, uniform annual cost, savings/ investment ratio, break-even analysis, benefit cost ratios, payback periods, and internal rates of return are designed to offer the user a specific perspective of the decision at hand. Often, it will be necessary for decision makers to use a combination of these tools in order to get the full picture of an alternative's desirability. Economic analysis techniques should be chosen based on how well they represent an organizations goals and values.

The technique must be relevant to the decision at hand. For example, comparing alternatives with equal economic lives, using the uniform annual cost method is a waste of time.

Additionally, the use of internal rate of return would be unnecessary if a specific rate of return is not required on investments.

III. PRESENT VALUE TECHNIQUE

The data set developed previously, will be used to examine the present value technique. For this analysis, assume that management has determined that the current system is unacceptable, and must be replaced. Assume also, that the benefits of the alternative systems are equal. To decide which of these two alternatives is preferable, management will discount the cost of each alternative to its present value using a 10% discount rate. According to Zimmerman (1980), present value analysis is accomplished by discounting each alternative's cost to their present value. The alternative with the lowest discounted cost is considered to be favorable. Present value analysis computations for the two alternatives of the data set follows:

	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.
Initial Cost	$11,500	$12,000
Operating costs	$120/yr.	$80/yr
Cost of Maintenance	$500/yr.	$500/yr.

ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	11,500	620	620	620	620	620
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	11,500	591.48	537.54	488.56	444.54	404.24
TOTAL PV						$13,966.36

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	12,000	580	580	580	580	580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	12,000	553.32	502.86	457.04	415.86	378.16
TOTAL PV						$14,307.24

The initial cost of Alternative One is $11,500 and is paid once at the beginning of the project's economic life. Maintenance and operating costs total $620 and are paid each year of the alternative's life. Each of these costs are then discounted by the 10% discount factor that corresponds to each year of the project's life (Appendix A). The present values of each cash flow are summed to get the total present value of $13,966.36 for alternative one. The calculations for alternative two are accomplished in the same manner, to arrive at a present value of $14,307.24 for its costs. Comparing the present values of the two alternatives' costs, we see that Alternative One has the lowest total cost and is, therefore, preferable to Alternative Two.

In both alternatives, the bulk of the costs occur in the earlier years of their economic lives. After the first year, 82% of Alternative One's costs and 84% of Alternative Two's

costs have been incurred. Because of this uneven
distribution, both alternatives fit the definition of front-
end load alternatives.

To further study how the distribution of a project's costs
can affect its present value, a change was made in the data
set. Assume that the initial payments of the alternatives are
not due until the final periods of their economic lives. The
calculations of this new scenario follow:

ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	0	620	620	620	620	12,120
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	0	591.48	537.54	488.56	444.54	7902.24
TOTAL PV						$9,964.36

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	0	580	580	580	580	12,580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	0	553.32	502.86	457.04	415.86	8,202.16
TOTAL PV						$10,131.24

The present values of both alternatives have dropped.
This is because the bulk of the alternatives' costs have been
redistributed to the ends of their economic lives. The final
year of Alternative One, now contains 79% of the project's
total costs. Similarly, Alternative Two incurs 81% if its

total costs in year 5. Because of this new distribution, both projects fit the definition of back-loading.

Instead of paying the $11,500 immediately in Alternative One, it is paid five years later. By applying the year 5 discount factor of .652 we see that the present value of $11,500 paid five years from now is only $7,498. By applying the same discount factor to Alternative Two's $12,000 payment in year five, we find that it also has a much lower present value of $7,824. The drop in the present values of the projects' costs, underscores the effects of the time value of money. Garrison (1988), points out that the longer an organization must wait to spend or receive a dollar, the more unlikely the transaction becomes. If Alternative One was paid for up front, it would have a present value cost of $11,500. If, however, this sum was not required until year five, the organization could invest $7,498 at 10% interest, in order to pay for the alternative.

In this scenario Alternative One is still the preferable project. However, shifting the bulk of a project's cash flows to later in its economic life, alters its present value. To understand further the ramifications of this fact, compare the front-loaded version of Alternative One to the back-loaded version of Alternative Two.

ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	11,500	620	620	620	620	620
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	11,500	591.48	537.54	488.56	444.54	404.24
TOTAL PV						$13,966.36

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	0	580	580	580	580	12,580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	0	553.32	502.86	457.04	415.86	8,202.16
TOTAL PV						$10,131.24

In this new scenario, Alternative Two is the preferred project because of its lower discounted total cost. This shows the power that the distribution of an alternative's cash flow has on its desirability. In this example, when the cash flows of both projects were distributed in the same manner, Alternative One was favorable. If, however, the alternatives have opposite distributions, Alternative Two has the lower present cost.

It is also possible that payment for these projects might not be in the form of one lump sum. Often, organizations ease the burdens of large cash outflows by spreading payments incrementally over time. The scenario is modified again, by assuming that the initial payment will be paid in six equal installments:

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ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	1917	2537	2537	2537	2537	2537
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	1917	2420.3	2199.6	1999.2	1819	1654.1
TOTAL PV						$12,009.20

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	2000	2580	2580	2580	2580	2580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	2000	2461.3	2236.9	2033	1849.9	1682.2
TOTAL PV						$12,263.30

Again, Alternative One was favored. However, notice that the present values of the costs of both alternatives have changed once again. In this scenario, the costs are lower than the front-loaded scenarios and higher than the back-loaded scenarios.

The scenarios that have been examined demonstrate how net present value analysis can be used to determine project desirability. They also point out two major factors that come into play when using this technique. The first factor is simply the size and number of cash flows associated with an alternative. Simply put, the greater the cash outflows a project requires, the less preferable it may become. The second factor, is the distribution of an alternative's cash flows over its life. From the previous examples, we have seen the effect that the time value of money has on a project's

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desirability. One strength of the net present value method, is its ability to differentiate between projects with different cash flow distributions. These two factors combined, make the present value method a useful analysis tool. It needs to be emphasized, however, that net present value techniques tend only to deal with the monetary factors of decision making.

In these examples, potential non-monetary cost factors could have easily arisen. The failure of net present value analysis to deal with such factors, may make it an inappropriate tool for scenarios where non-monetary elements are influential in a decision. In such circumstances, measuring alternatives strictly from a net present value perspective could be misleading.

A. SUMMARY

The present value method of economic analysis, provides the user with a powerful decision making tool. Taking the time value of money into account, this technique provides the decision maker with an alternative's costs stated in terms of their present value. Present value analysis not only takes the size of a project's cash flows into account, but also considers when they occur.

A major weakness of present value analysis, is its inability to take non-monetary and qualitative factors into account. In situations such as this, it may be prudent to use alternate techniques to arrive at a clearer picture.

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IV. UNIFORM ANNUAL COST

Sometimes it is necessary to compare alternatives with different economic lives. To use the present value method in this situation, the economic lives of the alternatives have to be made equal. This is done by either extending the alternative with the shorter life or by shortening the alternative with the longer economic life. Alternatives are then compared as if they had equal economic lives. Depending on how the alternatives are manipulated, this technique can become cumbersome.

According to Zimmerman (1980), the best tool for such a calculation is the uniform annual cost method (UAC). This method is specifically designed to place alternatives with different economic lives on an equal footing. Calculating a project's UAC is simply a matter of dividing the present value of its costs by the cumulative discount factor corresponding to its economic life. As Zimmerman (1980) points out, there are several assumptions that must be made prior to choosing this technique. First, it must be assumed that all project costs are uniform and recurring. It must also be assumed that the benefits of the alternatives being compared are equal. Finally, requirements are considered ongoing, with no end in sight. The result of the UAC calculation represents the discounted annual cost required for each alternative. The

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project with the lowest UAC is favored. To see how UAC ranks alternatives with different economic lives, the economic lives of the projects in the basic data set are altered as follows:

	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	4 yrs.	5 yrs.
Initial Cost	$11,500	$12,000
Operating costs	$120/yr.	$80/yr
Cost of Maintenance	$500/yr.	$500/yr.

Because Alternative One has been shortened to four years, the present value of its costs are recalculated as follows:

ALTERNATIVE ONE:

Year	0	1	2	3	4
Cash Flow	11,500	620	620	620	620
PV Factor	1.0	.954	.867	.788	.717
Present Value	11,500	591.48	537.54	488.56	444.54
TOTAL PV					$13,562.12

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	12,000	580	580	580	580	580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	12,000	553.32	502.86	457.04	415.86	378.16
TOTAL PV						$14,307.24

Comparing the present values of Alternatives One and Two, it initially appears as if Alternative One is the most favorable with a present value of $13,562.12. However,

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because the projects being compared have differing economic lives, these present value figures have little relative meaning. In order to compare these alternatives, their UAC's are calculated. To calculate the UAC for these alternatives, the cumulative discount factor that corresponds to each project's economic life must be found. On the discount table located in appendix A, the factor 3.326 corresponds to the four year project and 3.977 corresponds to the five year project. The UAC for each alternative is calculated as follows:

ALTERNATIVE ONE: $13,562.12 / 3.326   = $4,077.60

ALTERNATIVE TWO: $14,307.24 / 3.977   = $3,597.50

Alternative One has annual costs of $4,077.60 while Alternative Two has annual costs of $3,597.50. In this scenario, Alternative Two is actually preferred. By using the UAC economic analysis technique it is possible to look at the two alternatives on a relative scale. As seen in this example, basing such decisions on their total discounted costs can be misleading.

Because the uniform annual cost technique is based on the present value of a project's costs, it is also sensitive to the time value of money, as well as the way the payments are distributed. To illustrate this fact examine the following scenarios:

ALTERNATIVE ONE   (Back-load):

Year	0	1	2	3	4
Cash Flow	0	620	620	620	12120
PV Factor	1.0	.954	.867	.788	.717
Present Value	0	591.48	537.54	488.56	8690.04
TOTAL PV					$10,307.62

ALTERNATIVE TWO   (Front-load):

Year	0	1	2	3	4	5
Cash Flow	12,000	580	580	580	580	580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	12,000	553.32	502.86	457.04	415.86	378.16
TOTAL PV						$14,307.24

ALTERNATIVE ONE: $10,307.62 / 3.326   = $3,099.10

ALTERNATIVE TWO: $14,307.24 / 3.977   = $3,597.50

By making Alternative One a back-load alternative, its UAC drops, making it the preferred system.   This shows the technique's responsiveness to the distribution of a project's cash flows.   Thus, the UAC method can be used to effectively evaluate alternatives regardless of their economic lives or cash flow distributions.

Up to this point, only alternatives with unequal economic lives have been evaluated using UAC. To illustrate the effect UAC analysis has on alternatives with equal economic lives, consider the following:

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	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.
Initial Cost	$11,500	$12,000
Operating costs	$120/yr.	$80/yr
Cost of Maintenance	$500/yr.	$500/yr

Recall from previous calculations, that the present values of the alternatives' costs were:

ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	11,500	620	620	620	620	620
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	11,500	591.48	537.54	488.56	444.54	404.24
TOTAL PV						$13,966.36

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	12,000	580	580	580	580	580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	12,000	553.32	502.86	457.04	415.86	378.16
TOTAL PV						$14,307.24

To calculate the UAC for these alternatives, the cumulative discount factor that corresponds with each project's economic life must be found. On the discount table located in the appendix, the factor 3.977 corresponds to a five year project. For the final calculation, divide the present value of each project's costs by this figure:

ALTERNATIVE ONE: $13,966.36 / 3.977   = $3,511.78

ALTERNATIVE TWO: $14,307.24 / 3.977   = $3,597.50

From these calculations, it is determined that, Alternative One has an annual cost of $3,511.78 and Alternative Two has an annual cost of $3,597.50. In this situation, Alternative One would be considered preferable. It should be noted, however, that because both of these alternatives have equal lives, their uniform annual costs will always be directly proportional to their present values. This is made evident by the fact that they are both divided by the same cumulative discount figure. Thus, it pointless to use the UAC technique in these situations, unless annual costs are required for other calculations.

A. SUMMARY

The uniform annual cost method of financial analysis, provides users with a useful tool for ranking alternatives having different economic lives. If a set of alternatives have equal lives, however, use of this technique, though valid, might prove to be redundant with present value analysis.

Because the UAC method is based on an alternative's present value analysis, it incorporates the time value of money into the final result. For this reason, UAC is sensitive to different dispersions of costs throughout a project's economic life.

V. SAVINGS/INVESTMENT RATIO

The savings/investment ratio (SIR), is calculated by dividing the present value of a project's savings by the present value of its investments. Zimmerman (1980), defines the resulting number as the relationship between future cost savings and the investment required to generate these savings. For an alternative to be considered desirable it must possess an SIR of over one. Savings/investment ratios deal only with a project's costs and can be used to rank possible alternatives on a relative scale of desirability. To better understand the principles of this method, the savings/ investment ratio for the data set is calculated as follows:

	STATUS QUO	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.	5 yrs.
Initial Cost	0	$11,500	$12,000
Operating Cost	$200/yr.	$120/yr.	$80/yr.
Maintenance	$4,000/yr.	$500/yr.	$500/yr.
PV(savings)/PV(initial investment) = SIR			

ALTERNATIVE ONE SAVINGS:

Year	0	1	2	3	4	5
Cash Flow		3580	3580	3580	3580	3580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	0	3145.3	3103.9	2821	2566.9	2334.2
TOTAL PV SAVINGS					$13,971.26	

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ALTERNATE TWO SAVINGS:

Year	0	1	2	3	4	5
Cash Flow		3620	3620	3620	3620	3620
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	0	3453.5	3138.5	2852.6	2595.5	2360.2
TOTAL PV SAVINGS					$14,400.30	

ALTERNATIVE ONE SIR: $13,971.26 / $11,500   =   1.21

ALTERNATIVE TWO SIR: $14,400.30 / $12,000   =   1.20

Alternative One has an SIR of 1.21 while Alternative Two has an SIR of 1.20.   Alternative One's SIR shows that for every dollar invested in the alternative over its economic life, one dollar and twenty one cents in benefit will be received.   Because Alternative One has the higher of the two SIR's it is considered to be the preferable system.   It should be pointed out, however, that because both alternatives have SIR's over one, they are both considered to be acceptable as investments.   In these situations, it may be useful to rank alternatives based on their respective SIR's.   Alternative Two may also have other non-monetary benefits that make it preferable to Alternative One. As with present value analysis and UAC methods, these benefits are not considered by the SIR technique.   Bearing this in mind, it may be useful to use other techniques in addition to the SIR , in order to get a full picture of the alternatives.

Because the SIR methodology is based on the present value of a project's savings, it is also sensitive to the

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distribution of the project's cash flows. Savings occurring later in a project's economic life will be less certain and will have a smaller present value. This will, in turn, cause the present value of a project's savings to drop thereby reducing its SIR. To better demonstrate exhibit this fact, assume that Alternative One has a one year lead time. The new present value for the alternative's savings is as follows:

ALTERNATIVE ONE SAVINGS:

Year	0	1	2	3	4	5	6
Cash Flow		0	3580	3580	3580	3580	3580
PV Factor	1.0	.954	.867	.788	.717	.652	.592
Present Value	0	0	3103.9	2821	2566.9	2334.2	2119.7
TOTAL PV SAVINGS						$12,945.70	

Because of the one year lead time, savings occur one year later than those of the original data set. This, in turn, causes the discounted savings to drop to $12,945.70. The new SIR for the alternative is then calculated as follows:

ALTERNATIVE ONE SIR: $12,945.70 / $11,500 = 1.13

The new SIR for Alternative One has now decreased from 1.21 to 1.13, and as a result, Alternative Two would be preferred. Adding the lead time to Alternative One caused its annual savings to become somewhat back-loaded. As previously seen, back-loaded cash flows are more heavily discounted than those occurring earlier in the project's life. For this

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reason, the $3,580 savings in year 6 is worth less than it would have been had it occurred in year one. Because the total discounted savings of the project drops while its initial cost remains the same, the project's SIR also drops.

If the savings of the alternative had been moved up a year, it would have increased the project's front-load. Because the future savings of the project would occur earlier, they would be discounted less. This in turn, would cause the value of the alternative's discounted savings to rise. The result would be a higher SIR. An illustration of this follows:

ALTERNATIVE ONE SAVINGS:

Year	0	1	2	3	4	5
Cash Flow	3580	3580	3580	3580	3580	0
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	3580	3145.3	3103.9	2821	2566.9	0
TOTAL PV SAVINGS						$15,217.10

ALTERNATIVE ONE SIR: $15,217.10 / $11,500 = 1.32

By moving $3,580 in savings up to year zero, Alternative One's SIR can be increased to 1.32, once again making it the favorable alternative. Because year zero represents the present, the corresponding $3,580 is not discounted. This increases the project's total discounted savings. Because the value of the project's savings increases while its initial cost remains constant, the SIR increases.

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By changing the distribution of Alternative One's cash flows, it has been possible to cause the project's SIR to vary between 1.13 and 1.32. This shows the impact that the time value of money has on the SIR technique.

A. SUMMARY

The savings/investment ratio can be a useful economic analysis tool for ranking projects based on their cost savings. Organizations may use this technique to compare and rank projects with different economic lives as well as different cash flows. Because SIR analysis is based on a project's savings, it gives the decision maker a different view of the alternatives than present value analysis and UAC analysis do, and can be used to supplement these techniques. Like present value analysis and UAC analysis, however, the SIR methodology is based on discounted cash flows, putting all savings in terms of present dollars. It is also similar to present value analysis and UAC analysis, in that, it does not consider the non-monetary benefits of a project. If a project has many such benefits, it may be necessary to use other analysis techniques along with SIR in order to get the full picture.

VI. DISCOUNTED PAYBACK ANALYSIS

Simple payback analysis provides the decision maker with the time frame required for an investment to pay for itself. Because of its simple concept and clearly defined output, simple payback has become a popular analysis technique. As Abdelsamad (1970) points out there are two basic ways of calculating a project's simple payback period. The first way is used for projects that have equal cash flows over their economic lives, and consists of dividing the alternative's investment by its average annual cash flows. The second method is used for projects that have uneven cash flows and consists of subtracting each annual cash in-flow from the total initial investment. In either case, the result will be the number of periods required for the project's investment costs to be recouped.

The primary problem with the above method is that it does not take the time value of money into account. Because of this oversight, cash flows in the distant years of a project's life can be overestimated causing inaccurate calculation of the payback period. Zimmerman (1980), points out that to compensate for this inaccuracy, it is useful to use a modified version of simple payback analysis, known as discounted payback analysis. In this modified version, the time value of

the project's investment as well as its cash flows are taken into account.

To calculate the discounted payback period of an alternative, divide the present value of the alternative's investment by the resulting annual savings. The result of this calculation is then looked up in a 10% cumulative discount table (Appendix A). The corresponding period number on the chart will represent the project's discounted payback period. To better illustrate this technique consider the following example of discounted payback analysis:

	STATUS QUO	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.	5 yrs.
Initial Cost	0	$11,500	$12,000
Operating Cost	$200/yr.	$120/yr.	$80/yr.
Maintenance	$4,000/yr.	$500/yr.	$500/yr.

ALTERNATIVE ONE:

PV Initial investment   = $11,500(1.0) = $11,500

Annual savings   = $3,580

Present value factor   = $11,500 / $ 3,580 = 3.2

Discounted payback period =   3.83 years

ALTERNATIVE TWO:

PV Initial investment   = $12,000(1.0) = $11,500

Annual savings   = $3,620

Present value factor   = $12,000 / $3,620 = 3.31

Discounted payback period = 3.99 years

In this example, Alternative One's Investment will be paid back in 3.83 years while Alternative Two's investment will be paid back in 3.99 years. Based on discounted payback analysis, Alternative One is the preferred alternative.

To understand the difference between discounted and simple payback analysis, it is important to note that the simple payback periods for each of the alternatives were equal to their respective present value factors. This is true because the alternatives' initial investments were paid in the present. This fact makes the present value factor equations identical to Abdelamad's procedure for calculating simple payback. Inspection of these figures reveals that Alternative One's simple payback period was only 3.2 years, over a half a year shorter than its discounted payback period. Likewise, Alternative Two's simple payback period was 3.3 years, once again, over half a year shorter than its discounted payback period. In this example, it can be seem that simple payback analysis tends to underestimate a project's payback period, by not accounting for the time value of money. These underestimates could prove to be costly to organizations investing millions of dollars in information technology. For this reason, discounted payback analysis is considered to be the preferred method.

Because discounted payback analysis takes the time value of money into account, the dispersion of certain cash flows can affect its outcome. To better understand this fact,

recalculate the payback periods of the two alternatives, but, this time assume that Alternative Two is back-loaded, and that its initial payment will occur in the last period. Calculations for this example follow:

	STATUS QUO	ALTERNATIVE ONE	ALTERNATIVE TWO (Back-Load)
Economic life	5 yrs.	5 yrs.	5 yrs.
Initial Cost	0	$11,500	$12,000
Operating Cost	$200/yr.	$120/yr.	$80/yr.
Maintenance	$4,000/yr.	$500/yr.	$500/yr.

ALTERNATIVE ONE:

PV Initial investment   = $11,500(1.0)   = $11,500

Annual savings   = $3,580

Present value factor   = $11,500 / $ 3,580   =   3.2

Discounted payback period   =   3.83 years

ALTERNATIVE TWO (Back-Load):

PV Initial investment   = $12,000(.652)   = $7,824

Annual savings   = $3,620

Present value factor   = $7,824 / $3,620   =   2.16

Discounted payback period   =   2.43 years

In this example, the $12,000 initial payment of Alternative Two is moved to year 5. By multiplying the initial payment by the appropriate discount factor, the present value of the payment is found to be $7,824. Thus, moving the initial payment from the present to 5 years in the

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future, decreases its present value by $4,176. This decrease, in turn, causes the discounted payback period of the project to drop to 2.43 years. Increasing Alternative Two's back-load has made it the preferable alternative according to the discounted payback periods. If the initial payment of Alternative One was also shifted to the last year, its payback period would drop in a similar manner to 2.34 years, once again making it the preferred alternative.

Discounted payback analysis, however, does not determine the least costly alternative. Its only function is to measure the time required for investments to pay for themselves. It should be noted that payback analysis does not take cash flows occurring after the payback period into account. This fact could result in an alternative with the most desirable payback period, actually being a poor choice. It is also important to stress the fact that alternatives with the shortest payback periods may not always the preferable alternative.

As with present value analysis and uniform annual cost analysis, discounted payback analysis only considers monetarily quantifiable variables. Costs and benefits that are more qualitative in nature, cannot be measured with such a technique. In situations involving alternatives with many qualitative costs and benefits, discounted payback analysis alone could prove to be inaccurate and misleading to the decision maker. However, if an organization's management has specific payback period requirements for its investments, this

technique could prove beneficial in initially screening out
bad alternatives. To get the full picture of an alternative's
desirability, however, discounted payback analysis should be
used in concert with other analysis techniques.

A. SUMMARY

Because discounted payback analysis takes the time value
of money into account, it is far superior to simple payback
analysis. By discounting a project's investment to its
present value, discounted payback periods are sensitive to
back-loading as well as front-loading. This makes the
methodology good for comparing alternatives with different
cash flow distributions and economic lives.

This technique, however, does not determine an
alternative's cost. It simply measures the amount of time
required for an alternative to pay for itself. It also fails
to take cash flows occurring after the payback period into
account.

Another limitation of discounted payback analysis, is its
inability to take non-quantifiable costs and benefits into
account. Alternatives that have many such variables should
not be chosen solely on present value analysis. In certain
circumstances, however, present value analysis can be used
effectively as a technique to screen out alternatives with
unsatisfactory payback periods.

VII. DISCOUNTED BREAK-EVEN ANALYSIS

Many times, costs associated with an alternative may be variable. In these situations, the system's cost may be directly proportional to the level of its operation. To properly measure the desirability of such systems, it is necessary to employ a methodology that will account for these varying levels of activity. Discounted Break-even analysis is such a method.

The concept of break-even analysis involves finding the point at which an alternative's revenues equal its total expenses. It is at this break-even point that a decision maker is indifferent as to whether to make an investment. Break-even analysis differs from discounted payback analysis in that its unit of measure is some form of output instead of increments of time. In break-even analysis, the decision maker is interested in such measures as units per day, hours per week, thousands per month, or cycles per second. Payback analysis, on the other hand, deals strictly in units of time such as months, years or quarters.

Information systems often require many different types of resources in order to accomplish their assigned tasks. Some of these resources will fall under fixed costs while others will be variable. Some typical variable costs that might be associated with information systems are:

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1. Direct labor

2. Supplies

3. Maintenance

4. Utility costs

5. Storage capacity.

Often, information systems operation involves many such variable costs, each one either increasing or decreasing with system operation. To illustrate how break-even analysis may be used to choose between a series of alternatives, consider the following example:

	STATUS QUO	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.	5 yrs.
Initial Cost	0	$11,500	$12,000
Operating Cost	$200/yr.	$120/yr.	$80/yr.
Maintenance	$4,000/yr.	$500/yr.	$500/yr.
Variable Costs	0	$.05/hr.	0

In this example, Alternative One has been modified to include a $.05 per hour variable cost. In other words, each hour of Alternative One's operation will cost the organization $.05. Also assume that, in order to keep up with demand, management has determined that the system chosen must operate a minimum of 1,920 hours a year. Calculations for discounted break-even analysis follows:

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	12,000	580	580	580	580	580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	12,000	553.32	502.86	457.04	415.86	378.16
TOTAL PV						$14,307.24

ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	11,500	620	620	620	620	620
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	11,500	591.48	537.54	488.56	444.54	404.24
TOTAL PV						$13,966.36

BREAK-EVEN ANALYSIS:

Break-even = PV(fixed costs) +
PV(variable costs)   = PV(total costs)

Total discounted fixed costs
of Alternative Two   = $14,307.24

Total discounted fixed costs of
Alternative One   = $13,966.36

Variable costs of Alternative One   = $ .05(X)

Discounted variable cost
of Alternative One   = [.05(X)] 3.977 = .20(X)

In order for Alternative One to be preferred, it must not exceed the total discounted costs of Alternative Two. To determine the break-even point between the two alternatives, simply plug the cost data into the discounted break-even equation as follows:

$$\$13,966.36 + \$ \ .20(X) \ = \ \$14,307.24 \quad =>$$
$$\$.20(X) \ = \ \$340.88 \quad\quad\quad\quad\quad =>$$
$$X \ = \ 1,704.40 \quad \text{hours per year}$$

Solving for x, it is found that if Alternative One operates 1,704.40 hours per year, it will be equal in cost to Alternative Two. Any level of operation beyond this amount will result in Alternative Two being the preferred system. Conversely, any operation below this level will make Alternative One the favored choice.

In this example, management specified that the chosen system must operate a minimum of 1,920 hours a year. Because the break-even point for Alternative One is only 1,704.40 hours a year, Alternative Two is considered to be the least costly alternative. To better illustrate this fact, simply compute the total costs for Alternative One at the required level of operation:

$$\$13,966.36 + \ \$ \ .20(1920) \ = \ \$14,350.36$$

Alternative One's total cost at the required annual operation level would be $14,350.36. This is $43.12 higher than the total cost of Alternative Two.

Because discounted break-even analysis takes the time value of money into account, the distribution of a project's cash flows can significantly effect an alternative's break-even point. To better understand this relationship, discounted break-even points will now be recalculated for the

two alternatives. In this case, however, the alternatives have been shifted from front-load to back-load to determine the effect of their cash flow distributions on the break-even analysis. Calculations for their discounted break-even points follow:

	STATUS QUO	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.	5 yrs.
Initial Cost	0	$11,500	$12,000
Operating Cost	$200/yr.	$120/yr.	$80/yr.
Maintenance	$4,000/yr.	$500/yr.	$500/yr.
Variable Costs	0	$.05/hr.	0

ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	0	620	620	620	620	12,120
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	0	591.48	537.54	488.56	444.54	7902.24
TOTAL PV						$9,964.36

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	0	580	580	580	580	12,580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	0	553.32	502.86	457.04	415.86	8,202.16
TOTAL PV						$10,131.24

BREAK-EVEN ANALYSIS:

Break-even = PV(fixed costs) +
PV(variable costs)   = PV(total costs)

Total discounted fixed costs
of Alternative Two   = $ 10,131.24

Total discounted fixed costs
of Alternative One   = $ 9,964.36

Variable costs of Alternative One   = $ .05(X)

Discounted variable
cost of Alternative One   = [$ .05(X)] 3.977 = .20(X)

By plugging the above numbers into the discounted break-even analysis formula, the following solution is obtained:

$9,964.36 + $ .20(X)   = $10,131.24   =>

$.20(X) = $166.88   =>

X = 834.40   hours per year

Note, that back-loading the fixed costs of the alternatives, has caused the discounted break-even point of Alternative One to drop significantly. Because the bulk of the fixed costs now occur in year five, their present value has dropped.   This drop, then makes it possible for Alternative One to break even with Alternative Two at a lower level of operation. Alternative Two, however, is still the preferred system. If, however, Alternative Two was changed back to being front-loaded, Alternative One's discounted break-even point would again rise.

Consider this example:

ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	0	620	620	620	620	12,120
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	0	591.48	537.54	488.56	444.54	7902.24
TOTAL PV						$9,964.36

ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	12,000	580	580	580	580	580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	12,000	553.32	502.86	457.04	415.86	378.16
TOTAL PV						$14,307.24

BREAK-EVEN ANALYSIS:

Break-even = PV(fixed costs) +
PV(variable costs)   = PV(total costs)

Total discounted fixed costs
of Alternative Two   = $ 14,307.24

Total discounted fixed costs
of Alternative One   = $ 9,964.36

Variable costs of Alternative One   = $ .05(X)

Discounted variable
cost of Alternative One   = [$ .05(X)] 3.977 = .20(X)

Thus we have:

$$\$ 9,964.36 + \$.20(X) = \$14,307.24 \quad =>$$

$$\$.20(X) = \$4,342.88 \quad =>$$

$$X = 21,714 \text{ hours per year}$$

Because Alternative Two has been front-loaded, its fixed costs are substantially higher than in the previous example.

As a result of this increase, Alternative One can endure higher levels of operation without reaching the break-even point. In this situation, Alternative One can meet the managers' 1,920 hour per year requirement with ease, making it the preferred alternative.

In the previous examples, only one of the alternatives had variable costs. Comparing two alternatives with variable costs, is simply a matter of setting their equations equal to one another. By modifying alternative two to include a $.02 per hour variable cost, the following illustration of this technique is possible:

	STATUS QUO	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.	5 yrs.
Initial Cost	0	$11,500	$12,000
Operating Cost	$200/yr.	$120/yr.	$80/yr.
Maintenance	$4,000/yr.	$500/yr.	$500/yr.
Variable Costs	0	$.05/hr.	$.02/hr.

ALTERNATIVE ONE:

Year	0	1	2	3	4	5
Cash Flow	11,500	620	620	620	620	620
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	11,500	591.48	537.54	488.56	444.54	404.24
TOTAL PV						$13,966.36

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ALTERNATIVE TWO:

Year	0	1	2	3	4	5
Cash Flow	12,000	580	580	580	580	580
PV Factor	1.0	.954	.867	.788	.717	.652
Present Value	12,000	553.32	502.86	457.04	415.86	378.16
TOTAL PV						$14,307.24

BREAK-EVEN ANALYSIS:

Break-even = PV(fixed costs) + PV(variable costs) = PV(total costs)

Total discounted fixed costs of Alternative Two = $14,307.24

Total discounted fixed costs of Alternative One = $13,966.36

Discounted variable
cost of Alternative Two   = [$ .02(X)] 3.977 = .08(X)

Discounted variable
cost of Alternative One   = [$ .05(X)] 3.977 = .20(X)

By setting the two alternatives equal to each other, the following equation is developed:

$13,966.36 + $.20(X)   = $14,307.24 + $.08(X)   =>

$.12(X) = $340.88   =>

X = 2,840.67 hours per year

In this example, the alternatives are equally desirable at an operational level of 2,840.67 hours per year. At a lower operational level, Alternative One is favored. Above this level, Alternative Two would be favored. Because management only requires 1,920 hours a year of operation,

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Alternative One would be selected. This may change, however, if the demand for the service expands in the future.

A. SUMMARY

As with other quantitative decision making techniques, discounted break-even analysis does not deal with non-monetary costs and benefits. It is, however, a useful decision aid when projects being evaluated have some type of variable costs associated with them. Because it incorporates the time value of money into its calculations, discounted break-even analysis is sensitive to the distribution of an alternative's cash flows. This feature makes it possible to accurately compare alternatives with different economic lives as well as different cash flows.

VIII.   INTERNAL RATE OF RETURN

At times, it may be necessary to know a project's rate of return. In such a case, it is appropriate to use the Internal Rate of Return (IRR) methodology for ranking alternatives. The objective of this technique, as Garrison (1988) points out, is to determine the true interest yield promised by a project over its life. When the cash flows of an alternative are uniform throughout its economic life, Garrison (1988), shows that its IRR can be calculated in two simple steps. The first step, is to divide the project's required investment by its annual cash inflows or savings. The second step involves looking up the result of this calculation, known as the time adjusted factor, on a present value of an annuity of $1.00 in arrears table (Appendix A).   The percentage rate that corresponds to the time adjusted factor represents the alternative's IRR.   To better understand this process, consider the following example:

	STATUS QUO	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.	5 yrs.
Initial Cost	0	$11,500	$12,000
Operating Cost	$200/yr.	$120/yr.	$80/yr.
Maintenance	$4,000/yr.	$500/yr.	$500/yr.

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ALTERNATIVE ONE IRR:

Investment required = $11,500

Yearly savings = $3580

Time adjusted factor = $11,500 / $3,580 = 3.21

Internal rate of return (Appendix A) = 16.87%

ALTERNATIVE TWO IRR:

Investment required = $12,000

Yearly savings = $3,620

Time adjusted factor = $12,000 / $3,620 = 3.31

Internal rate of return (Appendix A) = 15.54%

The initial investment required for Alternative One is $11,500. Dividing this amount by the project's annual savings of $3,580, reveals that the project has a time adjusted factor of 3.21. The IRR, in appendix A, is found to be 16.87%. Alternative Two's IRR is calculated in the same fashion and found to be only 15.54%. Thus investment in Alternative One will yield 16.87% interest over five years and investment in Alternative Two will yield 15.54%. Alternative One, therefore, has the highest IRR and is favored over Alternative Two.

Because, of the requirement that all of the project's cash flows be uniform, this technique does not deal well with irregular cash flows. In these situations it is necessary to calculate the alternative's IRR using trial-and-error. Such calculations can prove to be tedious. For this reason, it is

often more beneficial for decision makers to use other analysis techniques, such as present value analysis, when dealing with erratic cash flows.

Another way that IRR can be used by an organization is as a screening tool for perspective projects. Often, organizations require their investments to meet a minimum rate of return, such as the cost of capital, before they are considered to be feasible. In these cases, IRR can be used to screen out alternatives that do not meet this minimum requirement. In doing so, decision makers are able to spend their time more efficiently by looking only at feasible alternatives. This technique is illustrated in the following example. Assume that management has determined that any investment made by the organization will have to be greater than or equal to 16%. Calculations are as follows:

ALTERNATIVE ONE IRR:

Investment required = $11,500

Yearly savings = $3580

Time adjusted factor = $11,500 / $3,580 = 3.21

Internal rate of return (Appendix A) = 16.87%

16.87% - 16.00% = .87% => Accept investment.

ALTERNATIVE TWO IRR:

Investment required = $12,000

Yearly savings = $3,620

Time adjusted factor = $12,000 / $3,620 = 3.31

Internal rate of return (Appendix A) = 15.54%

15.54% - 16.00% = -.46% => Reject investment.

In this example, Alternative Two is rejected as soon as it is found not to meet the minimum return required for investments. Alternative One, being found feasible, can then be more closely examined to determine its overall desirability. In decision making scenarios that involve large numbers of alternatives, such a screening technique could save managers' time, and reduce the effort required to select the optimal investment.

A. SUMMARY

The IRR technique, provides decision makers with a useful analysis and screening tool. Its output is clear cut and easy to understand by most managers. It is, however, important to note that IRR does have its limitations.

Because IRR only considers a project's initial investment and subsequent cash flows, it may ignore other critical cash requirements of an alternative such as irregular maintenance costs. For this reason, it may be useful to use additional economic analysis techniques to get the full picture of an alternative's requirements. As with other quantitative techniques, IRR fails to take an alternative's qualitative costs and benefits into account. To incorporate these variables into the decision making process, it will be necessary to use techniques specifically suited to qualitative

analysis. The IRR technique also fails to calculate a project's costs. For example, an alternative may have a very high internal rate of return, but, be considered unacceptable because of its high cost.

IX. BENEFIT COST RATIO

At times, it will be necessary to measure the non-monetary benefits of an alternative in order to determine its desirability. In these situations, techniques such as present value analysis and break-even analysis will not help, as they concentrate on monetary costs and benefits. Benefit cost ratio analysis (BCR), however, can be used effectively to deal with non-monetary as well as qualitative costs and benefits. Calculating a project's BCR is a simple matter of dividing its benefits by its uniform annual cost (UAC). As Zimmerman (1980), points out the result of this calculation, represents the amount of benefit received per unit of cost. The project's UAC is used in the calculation, because it compensates for the time value of money as well as for differing economic lives. Because BCR is a ratio of benefits to costs, the alternative with the highest BCR is considered to be the most desirable.

A. QUANTIFIABLE BENEFITS

In order to comprehensively compare alternatives, decision makers must identify the projects' non-monetary benefits. While non-monetary, this type of benefit is nonetheless quantifiable. Some examples of quantifiable non-monetary outputs are:

1. Errors per page

2. Lines per hour

3. Pages per day

4. Calls per minute

5. Savings in dollars

6. Savings of time.

By using the BCR technique, decision makers can rank alternatives based on the level of these quantifiable non-monetary benefits. To illustrate how this is done consider the following example:

	ALTERNATIVE ONE	ALTERNATIVE TWO
Economic life	5 yrs.	5 yrs.
Initial Cost	$11,500	$12,000
Operating costs	$120/yr.	$80/yr
Cost of Maintenance	$500/yr.	$500/yr.
Output Per Year	$30,000 units	$25,000 units

In this example, each alternative's output per year is listed. This non-monetary variable cannot be measured by monetary analysis techniques, but, it is still vital to the decision making process. To determine the BCR's of the alternatives, it is necessary to first calculate their uniform annual costs. These calculation are as follows:

ALTERNATIVE ONE UAC: $13,562.12 / 3.326   = $4,077.60

ALTERNATIVE TWO UAC: $14,307.24 / 3.977   = $3,597.50

Now that the UAC's of the alternatives have been computed, it is possible to calculate their benefit cost ratios. The BCR calculations for the two alternatives are as follows:

BENEFIT COST RATIO = MEASURABLE OUTPUT / UAC

ALTERNATIVE ONE BCR: 30,000 / $4,077.60 = 7.35

ALTERNATIVE TWO BCR: 25,000 / $3,597.50 = 6.95

The BCR's for Alternatives One and Two are calculated as 7.35 and 6.95 respectively. Because Alternative One has the highest BCR, it is considered to possess more benefits per unit of cost than Alternative Two. For this reason, Alternative One would be the preferred choice according to BCR analysis. It is, however, important to note that the UAC calculations actually favored Alternative Two. The reason this is not in conflict with the BCR analysis is that, in this situation, benefits of the two projects are different. Remember that in present value analysis and uniform annual cost analysis, benefits are considered to be equal. This assumption is dropped for benefit cost ratio evaluations which are used only when benefits will differ. In this situation, UAC is not a valid evaluation tool by itself, because of the difference in the alternatives' benefits. It is, used in this situation, as only input into the BCR calculation. This fundamental observation is one of the key differences between BCR analysis and the monetary economic analysis techniques that have been discussed.

Because benefit cost ratio analysis uses an alternative's uniform annual cost as an input, the time value of money is incorporated into the result. For this reason, BCR's are sensitive to the cash flow distribution of the project being evaluated. The previous example dealt with two alternative with the bulk of their costs in the first period. To see how changing the distribution of cash flows affects the alternatives' BCR's , both projects are now back-loaded. In the following example, assume that payments in period zero are not due until the final period is completed. Calculations for the new benefit cost ratios are as follows:

ALTERNATIVE ONE UAC(Back-load): $10,307.62 / 3.326   = $3,099.10

ALTERNATIVE TWO UAC(Back-load): $10,131.24 / 3.977   = $2,547.46

Because the present values of the alternatives are smaller, the projects' UAC's also come out to be smaller. Calculations of the BCR's follow:

ALTERNATIVE ONE BCR: 30,000 / $3,099.10 = 9.68
ALTERNATIVE TWO BCR: 25,000 / $2,547.46 = 9.81

Because the uniform annual costs of the two projects decreased while their benefits stayed the same, the BCR's of both projects have increased. It is also important to notice that Alternative One is no longer the preferable project. Because Alternative Two's economic life is two years longer than Alternative One's, its initial investment has been

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discounted over two additional years. This causes a proportionally greater drop in Alternative Two's UAC than in Alternative One's. The larger drop in the second alternative's UAC is just enough to make its BCR rise beyond that of the first alternative.

If Alternative Two is shifted back to a front-end load project, the decision once again changes. Calculations follow:

ALTERNATIVE ONE UAC(Back-load) : $10,307.62 / 3.326 = $3,099.10

ALTERNATIVE TWO UAC(Front-load): $14,307.24 / 3.977 = $3,597.50

ALTERNATIVE ONE BCR: 30,000 / $3,099.10 = 9.68

ALTERNATIVE TWO BCR: 25,000 / $3,597.50 = 6.95

Making Alternative Two a front-end loaded project increased the present value of the project's initial investment. This increase, in turn, caused the alternative's UAC to increase, making its BCR decrease below that of Alternative One.

B. QUALITATIVE BENEFITS

The previous examples have shown BCR's sensitivity to a project's economic life, as well as to its cash flow distribution. Up to this point, however, we have only dealt with a project's quantitative benefits. Often alternatives have benefits that are of a more qualitative nature. Some examples of such benefits are:

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1. Worker satisfaction

2. Customer satisfaction

3. Increases in quality

4. Worker morale

5. Industry reputation.

Benefits such as these do not usually exist in a quantifiable form. They can have a significant effect on a project's desirability, however, and merit consideration. BCR analysis can be used in such situations, to determine the desirability of a project. To measure a qualitative benefit using BCR analysis, the benefit must first be converted into some equivalent quantitative form. One way to do this involves three simple steps. First, rank the benefits of a project from 1 to 3 according to their importance, with 3 being the most important and 1 being the least important.

After each benefit has been ranked, the second step involves assigning a number from 1 to 10 to each benefit representing its desirability, 10 being the most valuable. For the final step, multiply each benefit's desirability factor by the weight that you assigned it. The products of this calculation are then summed up and used in the numerator of the BCR formula. To better illustrate this process, consider the following illustration:

ALTERNATIVE ONE:

BENEFIT	WEIGHT		RANKING		PRODUCT
1. Product quality	3	X	8	=	24
2. Data accuracy	2	X	7	=	14
3. Worker acceptance	2	X	5	=	10
4. Ease of use	1	X	5	=	5

Summation 53
Alternative One UAC $4,077.60

ALTERNATIVE ONE BCR: 53 / $4,077.60 = .01

ALTERNATIVE TWO:

BENEFIT	WEIGHT		RANKING		PRODUCT
1. Product quality	3	X	9	=	27
2. Data accuracy	2	X	9	=	18
3. Worker acceptance	2	X	7	=	14
4. Ease of use	1	X	5	=	5

Summation 64
Alternative Two UAC $3,597.50

ALTERNATIVE TWO BCR: 64 / $3,597.50 = .02

In this example, the two alternatives are ranked on four qualitative benefits. Each of the benefits is assigned a

weighted from 1 to 3 based on its importance. Rankings from
0 to 10 are then assigned to each benefit to represent the
value that benefit has in that alternative. The products of
these two numbers for each benefit are then summed and divided
by the project's UAC. In this example, it is seen that
Alternative One has a BCR of .01 and Alternative Two has a BCR
of .02. Because Alternative Two's BCR is higher, it is the
desired alternative based on the qualitative benefits. It is
important to realize that, even though the qualitative
benefits in the previous example were placed into quantitative
form, they are still subjective in nature. To insure that the
weights and rankings assigned to these benefits are accurate
and realistic, it is essential that the decision maker be
aware of the project's capabilities as well as the
organization's objectives. It is also essential that
different alternatives being investigated are measured using
relative guidelines or standards. In the end, this type of
BCR analysis is only as good as the subjective benefit
rankings that it is based on. This fact should be kept in mind
at all times.

A. SUMMARY

When alternatives being compared, consist of different
levels of non-monetary benefits, BCR analysis can be a useful
tool. Unlike the monetary economic analysis techniques that
have been discussed, BCR analysis can be used to compare
quantitative as well as more subjective qualitative benefits.

If the benefits being measured are qualitative in nature, it is essential that they be assigned weights and rankings that accurately describe their effect on the project as well as the organization. Benefit cost ratios are also sensitive to the time value of money as well as the duration of alternative's economic life. If used properly BCR analysis can give the decision maker a unique view of the alterative's benefits not revealed by other, more monetary, techniques.

X. APPLICATION OF ANALYSIS TECHNIQUES

Now that each of the economic analysis techniques have been studied in detail, it is possible to construct a matrix that summarizes their individual properties. This matrix may then be used by decision makers to choose the appropriate analysis techniques for a particular decision making situation. The completed economic analysis technique matrix follows:

ECONOMIC ANALYSIS TECHNIQUE MATRIX

Properties	PV	UAC	SIR	BCR	PB	BE	IRR
Requires equal economic lives	X						
Discounts money to PV	X	X	X	X	X	X	X
Monetary costs/benefits	X	X	X	X	X	X	X
Qualitative cost/benefit				X			
Sensitive to cash flow distribution	X	X	X	X	X	X	
Output in dollars	X	X					
Output in time					X		
Output in % return							X
Output in ratio return			X	X			
Output in units						X	
Requires recurring and even cash flows		X			X		
Account for variable Cost						X	
Show return on investment			X				X

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To use this matrix, choose the properties on the left side that will be of most assistance in making the decision at hand. Once the desired properties have been determined, use the matrix to match them with the corresponding economic analysis techniques. Analysis techniques shown to be the most relevant to the decision at hand should be used in order to obtain the clearest possible presentation of the decision's alternatives. For example, suppose that an organization evaluates its information system purchases on rate of return. Looking at the economic analysis technique matrix, it is found that the IRR and SIR analysis techniques both provide decision makers with measures of return. These techniques could be useful for evaluating decisions for the organization, depending on the specific type of return information required. If, in addition, the organization desired to incorporate user satisfaction into the decision making criteria, the qualitative analysis row of the matrix would show that BCR analysis should also be used.

By grouping the major properties of each economic analysis technique onto this matrix, the time spent by decision makers choosing between various financial analysis techniques can be reduced. Though only some of the existing analysis techniques have been included in the matrix, it would be a simple matter for organizations to expand and tailor it to better suit their needs.

Though the matrix assists the decision maker in choosing the most suitable analysis techniques for a decision, using these techniques can still prove to be tedious and time consuming due to the caculations they require.

To compensate for this potential pitfall, the technique selection and calculation processes have been automated, using decision support and expert systems technology. By shifting the burdens of technique selection and calculation from the manager to the computer, human resources may be conserved while at the same time improving the decision maker's consistency.

A. EXPERT SYSTEM APPLICATION

The economic analysis technique expert system, COSTEX, was developed using the Intelligence Compiler expert system shell by Intelligence Ware Inc. This system is based on the analysis technique matrix and is designed to select the appropriate financial analysis techniques for the decision maker. The system learns the decision making criteria, from the user through a series of questions and answers. After accumulating sufficient data to select between alternative techniques, COSTEX provides the user with a listing of the preferred analysis techniques for a specific decision scenario. The decision maker would then apply the selected techniques in order to resolve the decision. The basic system consists of three major components:

1. The fact base

2. The rule base

3. The system driver.

   The fact base in appendix B, consists of the set of facts
that must be known about the decision scenario before
recommendations can be formulated. In this case, there are no
known facts prior to the inputs of the decision maker.
Therefore, the fact base consists of a series of questions
that must be answered by the user before processing can begin.
These questions deal with determining the decision making
criteria of the organization, and roughly correspond to the
economic analysis properties column of the analysis technique
matrix. When the COSTEX is run, the first thing that it does
is establish answers to the questions in its fact base. The
answers supplied by the user provide the system with the set
of facts necessary to evaluate that particular decision
scenario.

   The rule base in appendix B, is the collection of rules
used by the expert system to evaluate the facts provided to it
by the user. The rule base is composed of a series of if-then
rules and uses the principle of forward chaining to reach
conclusions. The expert system evaluates each fact or premise
against the rules. If a fact is found to meet the criteria of
a rule then a conclusion is reached. This conclusion is then
added to the fact base and may be applied as a premise to
other rules. After all facts have been evaluated by the rule

base, the resulting conclusions represent the expert system's solution to the problem. In this case the solution will be a list of analysis techniques that are applicable to a specific decision scenario.

The expert system driver in appendix B, contains the commands and functions necessary to operate COSTEX. Its function is to coordinate the activities of the expert system into a logical sequence, so that the system's goals can be achieved. It consists of introduction and instruction screens, it invokes the system knowledge base, and displays the system's results.

Together, these three modules form the knowledge base of COSTEX. As designed, COSTEX must be executed within the Intelligence Compiler environment. It is, however, possible to compile the system into an executable program by using the Intelligence Ware Compiler.

When executed, COSTEX presents the user with an opening screen explaining the system (Appendix C). After this screen is executed, the system begins developing its fact base by asking the user a series of true or false questions pertaining to the user's decision making criteria (Appendix C). Each question appears individually in its own pop up screen. As each question is answered, the next question appears within the screen. After all questions have been answered, COSTEX informs the user that all facts have been processed and the desired analysis techniques have been determined (Appendix C).

Each individual technique is then presented in its own pop up screen (Appendix C). After all desired techniques have been listed, COSTEX provides the user with a closing screen informing them that the process is over (Appendix C). For more detailed information on the operation of COSTEX, refer to the user's manual in appendix D.

By using an expert system such as COSTEX, the decision maker's job is simplified and standardized. COSTEX replaces the need for a decision maker to determine which types of economic analysis techniques best evaluate a decision. Even an inexperienced user will be able to arrive at an intelligent mix of analysis techniques by answering the system's questions.

B. DECISION SUPPORT APPLICATION

While COSTEX can be used to simplify the selection of an analysis technique, actually using the techniques can be time-consuming and cumbersome. To reduce the time and labor required for these calculations, the Basic Economic Analysis Decision Support (BEADS) system was developed.

The purpose of this system is to assist the decision maker by automating the economic analysis and providing formatted worksheets on which to compare alternatives. BEADS frees the decision maker of tedious calculations. It also provides users with an automated worksheet environment that enables them to compare alternatives quickly and in the same format. BEADS contains on-line tutorials for each technique so that

a decision maker can conceptually follow the processes being carried out. BEADS was designed using the Lotus 123 release 3.0 macro command language. Each of the analysis techniques represented on the economic analysis matrix, and in COSTEX, are addressed by the system. BEADS divides the individual analysis techniques into separate automated worksheets. Each worksheet is in turn divided into a tutorial on the specific technique and an analysis worksheet for evaluating decision alternatives.

To use the system, a user simply selects the desired technique from a bar menu and then selects either the tutorial or the analysis. The tutorials provide basic theories behind each analysis technique and briefly describe how they are calculated. The analysis sections of the worksheets provide the user with standardized automated worksheets on which alternatives being considered may be analyzed using a specific technique. To use these worksheets, the user simply enters the required data for each alternative and compares the results calculated by the system.

When BEADS is executed, the user is presented with an opening pop up screen and a Lotus style bar menu listing each analysis technique (Appendix E). When a specific technique is selected, an opening pop up screen for that technique is presented along with another bar menu allowing the user to either use that technique's tutorial or its analysis worksheet (Appendix E). If the user selects the tutorial section, a pop

up screen containing data on that particular technique appears (Appendix E). If the analysis worksheet is selected, the user is presented with a formatted automated template on which individual alternatives may be analyzed using that technique (Appendix E). For more detailed instructions on the operation of BEADS, refer to the user's manual located in appendix F. A complete listing of all cell codes for the system is also included in appendix G. BEADS is designed to run within the Lotus 123 environment, but may be compiled into an executable program using Lotus 123 compilers.

By using the BEADS system in conjunction with the COSTEX system, it will be possible for decision makers to automate their economic analysis procedures. Users will be able to select the optimal analysis techniques using COSTEX, and then analyze the decision's alternatives using the BEADS system.

Together, these systems would enable users to reach reliable and consistent decisions without the effort of manual analysis. Because these systems are both written in the macro languages of their environments, modifications to better suit an organization's needs could be easily implemented. Another benefit of such automation, might be the increased willingness of decision makers to use the proven analysis techniques over more subjective methods.

C. SUMMARY

By consolidating the individual economic analysis techniques onto a single matrix, it is clear that each technique possesses unique properties which may make it desirable in some circumstances and undesirable in others. The set of techniques that a decision maker uses to analyze a set of alternatives, depends on the nature of the decision as well as the acceptance criteria of the organization. If, for example, an organization's acceptance criteria for a new information system is increased user satisfaction, it would not benefit the organization to base its acceptance on present value analysis.

Because most capital expenditure decisions are much more complex than this, however, it is often useful for decision makers to select a series of economic analysis tools that will present alternatives in several different perspectives. The burden of choosing the proper analysis techniques for a specific decision can be considerably simplified by using a matrix such as the economic analysis technique matrix. By using such a tool, selection criteria for economic analysis techniques can be standardized and applied consistently by decision makers.

By automating the economic analysis selection process with the COSTEX expert system, the decision maker's job is further simplified. COSTEX, removes the burden of technique selection from the decision maker and transfers it to the computer. By

analyzing the users responses to a series of questions about specific organizational needs and decision criteria, COSTEX is able to provide the user with a list of suitable analysis techniques for a specific decision scenario.

To further assist decision maker's analysis of decisions, BEADS was developed. This decision support system is designed to provide users with an automated worksheet environment to analyze a decision's alternatives using specific economic analysis techniques. Users simply select the desired analysis technique from the system's menu, and insert the required data into the formatted worksheet. BEADS automatically calculates and displays the results of the alternatives so that they may be instantly evaluated by the decision maker. BEADS also supplies the user with on-line tutorials on each of the economic analysis techniques it includes.

By using COSTEX and BEADS in conjunction with each other, decision makers can automate, standardize, and simplify a significant portion of their economic analysis activities. Optimal analysis techniques chosen by COSTEX can then be used to evaluate alternatives using the BEADS system. Because both of these systems were written using off-the-shelf spreadsheet and expert system shells, it would also be a simple matter to modify them to suit the needs of particular organizations.

Use of these automated systems, however, does not eliminate the need for experienced decision makers. These systems only cover the basics of economic analysis. Many

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situations may still arise that could not be adequately measured by these systems. Broader factors influencing decisions such as ethics, intrinsic value, and sociological impact, will still rely heavily on past experiences and business knowledge to measure. For situations that do apply, however, these automated techniques can prove to be a valuable tool for analyzing capital expenditure alternatives.

XI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Information systems technology has grown to become vital part of an organization's operations. It, therefore, has become critical for organizations to choose the systems that best suit their needs. Because of the high monetary and non-monetary costs associated with such systems, it is essential for decision makers fully evaluate all potential alternatives in order to determine their desirability and suitability. To facilitate these evaluations, many different economic analysis techniques have been developed over the years. By using these techniques properly, decision makers are able to compare alternatives in a relative and analytical way. Improper use of these alternatives, however, can result in poor decisions which could prove costly as well as crippling.

After close examination, it is evident that each economic analysis technique discussed has its own unique properties. Present value analysis, for instance, may be used to evaluate the discounted cost of competing alternatives, that have equal benefits and economic lives. Uniform annual cost analysis, however, deals with alternatives that have differing economic lives. Benefit cost ratios, on the other hand, provide users with a useful tool for measuring a project's many non-monetary benefits.

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The ability of decision makers to choose optimal alternatives, directly relates to their ability to choose the proper analysis techniques for evaluating the alternatives. Once the correct economic analysis techniques have been chosen, however, it is also essential that decision makers be able to properly use them.

The analysis technique selection matrix has been developed to categorize the properties of individual economic analysis techniques and can be used by decision makers to choose techniques that best measure a specific decision's alternatives. Using this matrix to choose appropriate analysis techniques, can help to standardize and organizations selection criteria for analysis techniques, as well as help to focus attention on the critical strengths and weaknesses of each technique.

The COSTEX expert system, was designed to automate the analysis technique selection process provided by the matrix. This system gathers data on the organization's decision criteria by asking the decision maker a series of questions. When these questions have been answered, COSTEX provides the user with a listing of what it considers to be the optimal analysis techniques to use based on the input criteria. Using this system effectively removes the burden of technique selection from the decision maker to the computer. The decision maker is then freed to spend more time evaluating alternatives.

The BEADS system was designed to assist the decision maker use the economic analysis techniques after they have been selected. BEADS provides decision makers with automated worksheets and templates on which a decision's alternatives can be evaluated. It also contains a series of on-line tutorials that provide information on each individual technique. BEADS was designed using the Lotus 123 release 3 environment and operates with similar menus.

COSTEX and BEADS provide users with a convenient uncomplicated automated economic analysis system. Using these programs, decision makers with little computer or economic analysis experience will be able to arrive at timely and consistent capital expenditure decisions.

B. RECOMMENDATIONS

It has been established that each of the economic analysis techniques studied, serve a unique purposes and have unique properties. These different properties have been noted in the analysis technique selection matrix and applied in the COSTEX and BEADS systems.

Currently, COSTEX and BEADS are both available for use by interested parties. Appendix H provides information on how to receive copies of these systems. To run these systems, users need the Intelligence Compiler and Lotus 123 release 3 user environments. It is recommended that future development projects endeavor to compile these systems into stand alone executable programs, and develop a user shell for them.

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APPENDIX A

DISCOUNT TABLES

PROJECT YEAR DISCOUNT FACTORS

PROJECT YEAR	INDIVIDUAL FACTORS	CUMULATIVE FACTORS
	10%	10%
1	0.954	.954
2	0.867	1.821
3	0.788	2.609
4	0.717	3.326
5	0.652	3.977
6	0.592	4.570
7	0.538	5.108
8	0.489	5.597
9	0.445	6.042
10	0.405	6.447
11	0.368	6.815
12	0.334	7.149
13	0.304	7.453
14	0.276	7.729
15	0.251	7.980
16	0.228	8.209
17	0.208	8.416
18	0.189	8.605
19	0.172	8.777
20	0.156	8.933
21	0.142	0.074
22	0.129	9.203
23	0.117	9.320
24	0.107	9.427
25	0.097	9.524

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26	0.088	9.612
27	0.080	9.692
28	0.073	9.765
29	0.066	9.831
30	0.060	9.891

PRESENT VALUE OF AN ANNUITY OF $1 IN ARREARS

	4%	5%	6%	8%	10%	12%	14%	16%	18%	20%	22%	24%	26%	28%	30%	40%
1	0.962	0.952	0.943	0.926	0.909	0.893	0.877	0.862	5.842	0.833	0.820	0.806	0.794	0.781	0.769	0.714
2	1.886	1.859	1.833	1.783	1.736	1.690	1.647	3.605	1.566	1.528	1.492	1.457	1.424	1.392	1.361	1.224
3	2.775	2.723	2.673	2.577	2.487	2.802	2.322	2.246	2.174	2.106	2.002	1.981	3.923	1.868	1.816	1.589
4	3.630	3.546	3.465	3.312	3.170	3.037	2.914	2.798	2.690	2.589	2.404	2.404	2.320	2.241	2.166	1.879
5	4.452	4.330	4.212	3.993	3.791	3.605	3.433	3.274	3.127	2.991	2.864	2.745	2.635	2.532	2.436	2.035
6	5.242	5.076	4.917	4.623	4.355	4.111	3.889	3.685	3.459	3.326	3.167	3.020	2.885	2.759	2.643	2.168
7	6.002	5.786	5.582	5.206	4.868	4.564	4.288	4.039	3.812	3.605	3.416	3.242	3.038	2.937	2.802	2.263
8	6.733	6.463	6.210	5.747	5.335	4.968	4.639	4.344	4.078	3.837	3.619	3.421	3.249	3.076	2.925	2.331
9	7.435	7.108	6.802	6.247	5.759	5.328	4.946	4.607	4.303	4.033	3.786	3.566	3.366	3.786	3.019	2.379
10	8.111	7.722	7.360	6.710	6.145	5.650	5.216	4.833	4.594	4.192	3.923	3.682	3.605	3.269	3.092	2.414
11	8.760	8.306	7.887	7.139	6.495	5.988	5.453	5.029	4.656	4.127	4.035	3.776	3.546	3.335	3.167	2.438
12	9.385	8.863	8.384	7.536	6.814	6.194	5.660	5.197	4.793	4.639	4.127	3.851	3.606	3.387	3.170	2.496
13	9.986	9.394	8.853	7.904	7.103	6.424	5.842	5.342	4.910	4.533	4.203	3.912	3.656	3.427	3.223	2.468
14	10.563	9.899	9.295	8.244	7.367	6.628	6.002	5.468	5.008	4.611	4.265	3.962	3.695	3.459	3.249	2.477
15	11.118	10.380	9.712	8.559	7.606	6.811	6.142	5.575	5.008	4.675	4.315	4.001	3.726	3.483	3.268	2.484
16	11.652	10.838	10.306	8.851	7.824	6.974	6.265	5.669	5.162	4.730	4.357	4.033	3.851	3.503	3.283	2.430
17	12.166	11.274	10.477	9.122	8.022	7.120	6.373	5.749	5.222	4.775	4.391	4.059	3.771	3.518	3.295	2.492
18	12.659	11.690	10.828	9.372	8.201	7.250	6.467	5.816	5.273	4.812	4.419	4.080	3.786	3.529	3.304	2.464
19	13.134	12.085	11.158	9.604	8.365	7.366	6.550	5.877	5.316	4.844	4.442	4.097	3.799	3.539	3.316	2.496
20	13.590	12.462	11.470	9.818	8.514	7.469	6.623	5.929	5.353	4.870	4.439	4.110	3.606	3.546	3.316	2.497

APPENDIX B

COSTEX KNOWLEDGEBASE

FACTBASE

Service lives **are** equal?

Benefits of alternatives **are** equal?

Time needed to recover investment **is** important?

Relating benefits per dollar of expenditure **is** important?

Variable costs per unit **are** applicable?

Some benefits **are** impossible to quantify?

A specific rate of return **is** required?

IF

  SERVICE LIVES ARE EQUAL AND

  BENEFITS OF ALTERNATIVES ARE EQUAL

THEN

  PV IS GOOD;

IF

  NOT SERVICE LIVES ARE EQUAL AND

  BENEFITS ARE EQUAL

THEN

  UAC IS GOOD;

IF

  RELATING BENEFITS PER DOLLAR OF EXPENDITURE IS IMPORTANT

THEN

  SIR IS GOOD;

IF

  TIME NEEDED TO RECOVER INVESTMENT IS IMPORTANT

THEN

  PAYBACK IS GOOD;

```
IF

    VARIABLE COSTS PER UNIT ARE APPLICABLE

THEN

    BREAKEVEN IS GOOD;


IF

    SOME BENEFITS ARE IMPOSSIBLE TO QUANTIFY

THEN

    BCR IS GOOD;


IF

    A SPECIFIC RATE OF RETURN IS REQUIRED

THEN

    IRR IS GOOD;


IF

    PV IS GOOD OR

    UAC IS GOOD OR

    BCR IS GOOD OR

    SIR IS GOOD OR

    IRR IS GOOD OR

    PAYBACK IS GOOD OR

    BREAKEVEN IS GOOD

THEN

    POP-TEXT {I HAVE STUDIED YOUR OBJECTIVES AND OFFER THESE

            SUGGESTIONS. PRESS RETURN TO BEGIN OUTPUT};
```

```
IF

   PV IS GOOD

THEN

   POP-TEXT {USE THE PRESENT VALUE COSTING METHOD (PRESS
RETURN)};


IF

   UAC IS GOOD

THEN

   POP-TEXT {USE UNIFORM ANNUAL COST METHOD (PRESS RETURN)};


IF

   SIR IS GOOD

THEN

   POP-TEXT {USE SAVINGS INVESTMENT RATIO (PRESS RETURN)};


IF

   BREAKEVEN IS GOOD

THEN

   POP-TEXT {USE DISCOUNTED BREAKEVEN ANALYSIS METHOD (PRESS
RETURN)};
```

```
IF

  PAYBACK IS GOOD

THEN

  POP-TEXT {USE DISCOUNTED PAYBACK ANALYSIS METHOD (PRESS
RETURN) };


IF

  BCR IS GOOD

THEN

  POP-TEXT {USE BENEFIT COST RATIO ANALYSIS (PRESS RETURN)};


IF

  IRR IS GOOD

THEN

  POP-TEXT {USE INTERNAL RATE OF RETURN ANALYSIS (PRESS
RETURN) };


IF

  NOT PV IS GOOD AND

  NOT UAC IS GOOD AND

  NOT SIR IS GOOD AND

  NOT BCR IS GOOD AND
```

```
    NOT IRR IS GOOD AND

    NOT BREAKEVEN IS GOOD AND

    NOT PAYBACK IS GOOD

THEN

    POP-TEXT {WARNING!  I CANNOT MAKE A DECISION WITHOUT ANY

DATA!      (PRESS RETURN)};
```

COSTEX SYSTEM FILE

```
popup-on

pop-text {WELCOME TO COSTEX!....PLEASE PRESS RETURN TO START

ME!};

INVOKE COST

SHOW RESULT

POP-TEXT {END OF SUGGESTED COSTING METHODS..THANK YOU!}

POPUP-OFF
```

OPENING COSTEX SCREEN

Welcome to COSTEX!..Please press return to start me!

COSTEX QUESTION SCREEN

Is the statement:

Service lives of alternatives are equal.

True?

Yes   No   Why

END OF COSTEX QUESTION SCREENS

I have determined that the following

economic analysis techniques are optimal!

COSTEX ANALYSIS TECHNIQUE SCREEN

Use Present Value Analysis Methodology...Press Return

END OF ANALYSIS TECHNIQUE SCREENS

End of Suggested Analysis Techniques!

APPENDIX D

HOW TO USE COSTEX

1. Load the COSTEX files, into a subdirectory that can be accessed by the Intelligence Compiler shell.

2. Change to directory and access shell by typing IC <return>.

3. When COSTEX knowledge base is loaded, a window will appear with COSTEX listed as the current knowledge base. Press <return> to compile.

4. When system is compiled, select 'Top of File' from RUN section of the pull down menu to start COSTEX.

5. COSTEX will first provide you with an opening screen.

6. After the opening screen, COSTEX will begin to ask the user a series of questions. To answer these questions, highlight the one of the answers that appear in the bottom of the window and press return.

7. When all questions are answered, COSTEX will provide a series of screens that provide the user with the suggested analysis techniques.

8. When all analysis technique windows have been displayed, a closing window will appear. Pressing return at this point will return user to the Intelligence Compiler environment.

BEADS OPENING SCREEN AND MAIN MENU

PV   UAC   SIR   PAYBACK   BREAK-EVEN   BCR   IRR   QUIT

WELCOME TO THE
BASIC ECONOMIC ANALYSIS DECISION SUPPORT SYSTEM
B.E.A.D.S

This system is designed to automate the economic analysis
process for the decision maker. It also provides on-line
tutorials for each technique.

To use the BEADS, select the desired analysis technique
from the above menu by typing the first letter of the
technique and pressing return.

BEADS TECHNIQUE SCREEN AND MENU

EXPLANATION   DATA

SAVINGS / INVESTMENT RATIO

Choose tutorial or data analysis on menu above

Press ESC to return to main menu.

BEADS TUTORIAL SCREEN

The SAVINGS / INVESTMENT RATIO is designed to measure
the amount of savings that result from each dollar
of investment in an alternative. SIR is calculated by
using the following formula:

PV(Savings) / PV(investment) - PV(terminal value)
The present values can be calculated by using the PV

template provided in this system.

Press ESC to return to the SIR menu.

BEADS ANALYSIS SHEET SCREEN

```
┌─────────────────────────────────────────────────────────────┐
│                                                             │
│          COMPUTE THE SIR'S OF TWO ALTERNATIVES              │
│                                                             │
│      PROJECT 1                                              │
│    ENTER PV(SAVINGS)                              000.00    │
│    ENTER PV(INVESTMENT)                           000.00    │
│   ENTER PV(TERMINAL VALUE)                        000.00    │
│                                                             │
│    SIR OF PROJECT ONE                                       │
│                                                             │
│                                                             │
│                                                             │
│      PROJECT 2                                              │
│    ENTER PV(SAVINGS)                              000.00    │
│    ENTER PV(INVESTMENT)                           000.00    │
│   ENTER PV(TERMINAL VALUE)                        000.00    │
│    SIR OF PROJECT TWO                                       │
│                                                             │
│             Press ESC to return to SIR menu                 │
│                                                             │
└─────────────────────────────────────────────────────────────┘
```

APPENDIX F

HOW TO USE BEADS

1. Access the BEADS file with the Lotus 123 release 3 environment.

2. When in the Lotus 123 environment type "/fr".

3. When the files appear at the top of the screen, select the "BEADS.WK3" file with cursor.

4. Program will start when BEADS.WK3 is run.

5. The first screen that will appear is the BEADS opening screen. Located above this screen is the BEADS main menu. Use a mouse or cursor keys to select the desired analysis technique from the menu. You may also select a technique by typing the first letter of the menu option.

6. When a technique is selected, an opening screen for that specific technique will appear. Over this screen is the technique's option menu. If you wish to read the tutorial screen for the technique, select the "explanation" menu option. If you wish to use the analysis sheet for that technique, select the "data" option.

7. To scroll through the tutorial screen use the cursor arrows. When you are finished with the screen, you may exit by pressing Esc.

8. The analysis sheets will only allow you to enter data in certain cells. These cells are marked in green. To scroll between these cells, use the cursor keys. When you are finished with the analysis screens, you may return to the main menu by pressing Esc. twice.

9. To exit BEADS select quit on the main menu.

APPENDIX G

BEADS CELL CODES

```
C:B2:  'START
C:A3:  '\0
C:B3:  '{FIRSTCELL}{FRAMEOFF}{GOTO}curs1~{MENUBRANCH MAIN}
C:B4:  '{BEEP}{BRANCHSTART}
C:A7:  'MAIN
C:B7:  'SIR
C:C7:  'PV
C:D7:  'UAC
C:E7:  'BCR
C:F7:  'IRR
C:G7:  'BREAKEVEN
C:H7:  'PAYBACK
C:I7:  'QUIT
C:B8:  'example of SIR
C:C8:  'Example of Present Value Analysis
C:D8:  'Calculate Uniform Annual Cost
C:E8:  'Example of BCR
C:F8:  'Example on Internal Rate of Return
C:G8:  'Example of Break_even Analysis
C:H8:  'Example of Discounted Payback Analysis
C:I8:  'Save and exit
C:B9:  '{BRANCH SIRG}
C:C9:  '{BRANCH PVG}
C:D9:  '{BRANCH UAC}
C:E9:  '{BRANCH BCRG}
C:F9:  '{BRANCH IRRG}
C:G9:  '{BRANCH BEAG}
C:H9:  '{BRANCH DPAG}
C:I9:  '{BRANCH LEAVE}
C:F10: '
C:A12: 'SIRG
C:B12: '{GOTO}SIRF~{GOTO}SIRF1~{MENUCALL SIRM}
C:B13: '{BEEP}{BRANCH START}
C:A15: 'SIRM
C:B15: 'TUTORIAL
C:C15: 'WORKSHEET
C:B16: 'Explain SIR
C:C16: 'Enter data into SIR template
C:B17: '{BRANCH SIRE}
C:C17: '{BRANCH SIRD}
C:A19: 'SIRE
C:B19: '{GOTO}SIRE1~
C:B20: '{FORM SIRE1}
C:B21: '{BRANCH SIRG}
```

```
C:A23:  'SIRD
C:B23:  '{GOTO}SIRD1~
C:B24:  '{FORM SIRD1}
C:B25:  '{BRANCH SIRG}
C:A29:  'USEKEY
C:B29:  '{UP}{DOWN}{RIGHT}{LEFT}
C:A32:  'PVG
C:B32:  '{GOTO}PVA~{GOTO}PV1~{MENUBRANCH PVM}
C:B33:  '{BEEP}{BRANCH START}
C:A36:  'PVM
C:B36:  'TUTORIAL
C:C36:  'WORKSHEET
C:B37:  'Explain Present Value Technique
C:C37:  'Enter Data into Present Value Template
C:B38:  '{BRANCH PVE}
C:C38:  '{BRANCH PVD}
C:A40:  'PVE
C:B40:  '{GOTO}PVE1~
C:B41:  '{FORM PVE1}
C:B42:  '{BRANCH PVG}
C:A44:  'PVD
C:B44:  '{GOTO}PVD1~
C:B45:  '{FORM PVD1}
C:B46:  '{BRANCH PVG}
C:A48:  'UAC
C:B48:  '{GOTO}UACA~{GOTO}UAC1~{MENUBRANCH UACM}
C:B49:  '{BEEP}{BRANCH START}
C:A51:  'UACM
C:B51:  'TUTORIAL
C:C51:  'WORKSHEET
C:B52:  'Explain Uniform Annual Cost Technique
C:C52:  'Enter Data into UAC Template
C:B53:  '{BRANCH UACE}
C:C53:  '{BRANCH UACD}
C:A55:  'UACE
C:B55:  '{GOTO}UACE1~
C:B56:  '{FORM UACE1}
C:B57:  '{BRANCH UAC}
C:A59:  'UACD
C:B59:  '{GOTO}UACD1~
C:B60:  '{FORM UACD1}
C:B61:  '{BRANCH UAC}
C:A64:  'BCRG
C:B64:  '{GOTO}BCRA~{GOTO}BCR1~{MENUBRANCH BCRM}
C:B65:  '{BEEP}{BRANCH START}
C:A67:  'BCRM
C:B67:  'TUTORIAL
C:C67:  'QUANDATA
C:D67:  'NONQUANDATA
C:B68:  'Explain Benefit/ Cost Ratio Technique
C:C68:  'Enter data into Quantifiable BCR Model
C:D68:  'Enter data into Non-Quantifiable BCR Model
```

```
C:B69:  '{BRANCH BCRE}
C:C69:  '{BRANCH BCRQ}
C:D69:  '{BRANCH BCRN}
C:A71:  'BCRE
C:B71:  '{GOTO}BCRE1~
C:B72:  '{FORM BCRE1}
C:B73:  '{BRANCH BCRG}
C:A75:  'BCRQ
C:B75:  '{GOTO}BCRQ1~
C:B76:  '{FORM BCRQ1}
C:B77:  '{BRANCH BCRG}
C:A79:  'BCRN
C:B79:  '{GOTO}BCRN1~
C:B80:  '{FORM BCRN1}
C:B81:  '{BRANCH BCRG}
C:A84:  'IRRG
C:B84:  '{GOTO}IRR~{GOTO}IRRA~{MENUBRANCH IRRM}
C:B85:  '{BEEP}{BRANCH START}
C:A87:  'IRRM
C:B87:  'TUTORIAL
C:C87:  'WORKSHEET
C:B88:  'Explanation of IRR
C:C88:  'Enter data into IRR template
C:B89:  '{BRANCH IRRE}
C:C89:  '{BRANCH IRRD}
C:A91:  'IRRE
C:B91:  '{GOTO}IRRE1~
C:B92:  '{FORM IRRE1}
C:B93:  '{BRANCH IRRG}
C:A95:  'IRRD
C:B95:  '{GOTO}IRRD1~
C:B96:  '{FORM IRRD1}
C:B97:  '{BRANCH IRRG}
C:A99:  'DPAG
C:B99:  '{GOTO}DPA~{GOTO}DPAA~{MENUBRANCH DPAM}
C:B100: '{BEEP}{BRANCH START}
C:A102: 'DPAM
C:B102: 'TUTORIAL
C:C102: 'WORKSHEET
C:B103: 'Explanation of Discounted Payback Analysis
C:C103: 'Calculate Discounted Payback Analysis
C:B104: '{BRANCH DPAE}
C:C104: '{BRANCH DPAD}
C:A106: 'DPAE
C:B106: '{GOTO}DPAE1~
C:B107: '{FORM DPAE1}
C:B108: '{BRANCH DPAG}
C:A110: 'DPAD
C:B110: '{GOTO}DPAD1~
C:B111: '{FORM DPAD1}
C:B112: '{BRANCH DPAG}
C:A114: 'BEAG
```

```
C:B114: '{GOTO}BEA~{GOTO}BEAA~{MENUBRANCH BEAM}
C:B115: '{BEEP}{BRANCH START}
C:A119: 'BEAM
C:B119: 'TUTORIAL
C:C119: 'WORKSHEET
C:B120: 'Explain Break-Even Point
C:C120: 'Calculate Break-Even Point
C:B121: '{BRANCH BEAE}
C:C121: '{BRANCH BEAD}
C:A123: 'BEAE
C:B123: '{GOTO}BEAE1~
C:B124: '{FORM BEAE1}
C:B125: '{BRANCH BEAG}
C:A128: 'BEAD
C:B128: '{GOTO}BEAD1~
C:B129: '{FORM BEAD1}
C:B130: '{BRANCH BEAG}
C:A132: 'ANSWER
C:B132: 'y
C:A134: 'LEAVE
C:B134: '{GETLABEL "ARE YOU SURE YOU WANT TO QUIT? {Y/N}
        ",ANSWER}
C:B135: '{IF ANSWER="Y"}{BRANCH ENDIT}
C:B136: '{BRANCH START}
C:A138: 'ENDIT
C:B138: '{FRAMEON} {QUIT}
```

APPENDIX H

SOFTWARE ACQUISITION INFORMATION

To receive a copy of the COSTEX and BEADS systems contact:

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LIST OF REFERENCES

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