VEDAT ÖNDAŞ

# IT INVESTMENTS & STRATEGIES

## COST AND BENEFIT ANAYLYSIS

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Here we will define the Cost Benefit Analysis, looking at the stages, processes, clues, history and samples.

A cost benefit analysis finds, quantifies, and adds all the positive factors. These are the benefits. Then it identifies, quantifies, and subtracts all the negatives, the costs. The difference between the two indicates whether the planned action is advisable. The real trick to doing a cost benefit analysis well is making sure you include all the costs and all the benefits and properly quantify them[1].

Should we hire an additional sales person or assign overtime? Is it a good idea to purchase the new stamping machine? Will we be better off putting our free cash flow into securities rather than investing in additional capital equipment? Each of these questions can be answered by doing a proper cost benefit analysis.

Cost-benefit analysis is an important technique for project appraisal in the public sector[2]. In classical microeconomic theory the market system leads to maximum efficiency. In practice, there are many market failures (M. Mulreany 2002). There are various types of market failures: Externalities or spillover effects, absence of relevant property rights, monopoly power and taxation, for instance. None of these are generally taken into account in the production of or the demand for market products. The main technique for including these types of market failures is cost-benefit analysis. Since market-driven choices may lead to socially inferior outcomes, the cost-benefit analyst attempts to construct a set of "as if", or shadow prices; these represent the prices which, if they prevailed in the market, would lead enterprises and individuals to make economic choices that correspond to the optimal welfare of all (P. Honohan 2002). Cost-benefit analysis is the process of weighing the total expected costs vs. the total expected benefits of one or more actions in order to choose the best or most profitable option.

Often, this involves monetary calculations of initial expense vs. expected return. For example, a product manager may compare manufacturing and marketing expenses to projected sales for a proposed product, and only decide to produce it if he expects the revenues to eventually recoup the costs. Cost-benefit analysis attempts to put all relevant costs and benefits on a common temporal footing. A discount rate is chosen, which is then used to compute all relevant future costs and benefits in present-value terms. Most commonly, the discount rate used for present-value calculations is an interest rate taken from financial markets (R.H. Frank 2000).

During cost-benefit analysis, monetary values may also be assigned to less tangible effects such as risk, loss of reputation, market penetration, long-term strategy alignment, etc. This is especially true when governments use the technique, for instance to decide whether to introduce business regulation, build a new road or offer a new drug on the state healthcare. In this case, a value must be put on human life or the environment, often causing great controversy. The cost-benefit principle says, for example, that we should install a guardrail on a dangerous stretch of mountain road if the dollar cost of doing so is less than the implicit dollar value of the injuries, deaths, and property damage thus prevented (R.H. Frank 2000).

Cost-benefit calculations typically involve using time value of money formula. This is usually done by converting the future expected streams of costs and benefits to a present value amount.

Constructing plausible measures of the costs and benefits of specific actions is often very difficult. In practice, analysts try to estimate costs and benefits either by using survey methods or by drawing inferences from market behavior.

Cost-Benefit Analysis can be as simple as deciding to buy a new keyboard for your computer when the keyboard stops working after a drink is spilled on it.

Also Cost-Benefit Analysis should be commensurate with the size, complexity and cost of the proposed project, and project managers have to decide what level of analysis is necessary for a specific project in their IT management environment.

There Must Be a Common Unit of Measurement. In order to reach a conclusion as to the desirability of a project all aspects of the project, positive and negative, must be expressed in terms of a common unit; i.e., there must be a "bottom line." The most convenient common unit is money. This means that all benefits and costs of a project should be measured in terms of their equivalent money value. A program may provide benefits which are not directly expressed in terms of dollars but there is some amount of money the recipients of the benefits would consider just as good as the project's benefits. For example, a project may provide for the elderly in an area a free monthly visit to a doctor. The value of that benefit to an elderly recipient is the minimum amount of money that that recipient would take instead of the medical care. This could be less than the market value of the medical care provided. It is assumed that more esoteric benefits such as from preserving open space or historic sites have a finite equivalent money value to the public.

Not only do the benefits and costs of a project have to be expressed in terms of equivalent money value, but they have to be expressed in terms of dollars of a particular time. This is not just due to the differences in the value of dollars at different times because of inflation. A dollar available five years from now is not as good as a dollar available now. This is because a dollar available now can be invested and earn interest for five years and would be worth more than a dollar in

five years. If the interest rate is r then a dollar invested for t years will grow to be (1+r) t. Therefore the amount of money that would have to be deposited now so that it would grow to be one dollar t years in the future is (1+r)-t. This called the discounted value or present value of a dollar available t years in the future.

When the dollar value of benefits at some time in the future is multiplied by the discounted value of one dollar at that time in the future the result is discounted present value of that benefit of the project. The same thing applies to costs. The net benefit of the projects is just the sum of the present value of the benefits less the present value of the costs.

The choice of the appropriate interest rate to use for the discounting is a separate issue that will be treated later in this paper.

CBA Valuations Should Represent Consumers or Producers Valuations As Revealed by Their Actual Behavior.

The valuation of benefits and costs should reflect preferences revealed by choices which have been made. For example, improvements in transportation frequently involve saving time. The question is how to measure the money value of that time saved. The value should not be merely what transportation planners think time should be worth or even what people say their time is worth. The value of time should be that which the public reveals their time is worth through choices involving tradeoffs between time and money. If people have a choice of parking close to their destination for a fee of 50 cents or parking farther away and spending 5 minutes more walking and they always choose to spend the money and save the time and effort then they have revealed that their time is more valuable to them than 10 cents per minute. If they were indifferent between the two choices they would have revealed that the value of their time to them was exactly 10 cents per minute.

The most challenging part of CBA is finding past choices which reveal the tradeoffs and equivalencies in preferences. For example, the valuation of the benefit of cleaner air could be established by finding how much less people paid for housing in more polluted areas which otherwise was identical in characteristics and location to housing in less polluted areas. Generally the value of cleaner air to people as revealed by the hard market choices seems to be less than their rhetorical valuation of clean air.

Benefits Are Usually Measured by Market Choices. When consumers make purchases at market prices they reveal that the things they buy are at least as beneficial to them as the money they relinquish. Consumers will increase their consumption of any commodity up to the point where the benefit of an additional unit (marginal benefit) is equal to the marginal cost to them of that unit, the market price. Therefore for any consumer buying some of a commodity, the marginal benefit is equal to the market price. The marginal benefit will decline with the amount consumed just as the market price has to decline to get consumers to

consume a greater quantity of the commodity. The relationship between the market price and the quantity consumed is called the demand schedule. Thus the demand schedule provides the information about marginal benefit that is needed to place a money value on an increase in consumption.

Gross Benefits of an Increase in Consumption is an Area under the Demand Curve. The increase in benefits resulting from an increase in consumption is the sum of the marginal benefit times each incremental increase in consumption. As the incremental increases considered are taken as smaller and smaller the sum goes to the area under the marginal benefit curve. But the marginal benefit curve is the same as the demand curve so the increase in benefits is the area under the demand curve. As shown in Figure 1 the area is over the range from the lower limit of consumption before the increase to consumption after the increase.

When the increase in consumption is small compared to the total consumption the gross benefit is adequately approximated, as is shown in a welfare analysis, by the market value of the increased consumption; i.e., market price times the increase in consumption.

Some Measurements of Benefits Require the Valuation of Human Life. It is sometimes necessary in CBA to evaluate the benefit of saving human lives. There is considerable antipathy in the general public to the idea of placing a dollar value on human life. Economists recognize that it is impossible to fund every project which promises to save a human life and that some rational basis is needed to select which projects are approved and which are turned down. The controversy is defused when it is recognized that the benefit of such projects is in reducing the risk of death. There are many cases in which people voluntarily accept increased risks in return for higher pay, such as in the oil fields or mining, or for time savings in higher speed in automobile travel. These choices can be used to estimate the personal cost people place on increased risk and thus the value to them of reduced risk. This computation is equivalent to placing an economic value on the expected number of lives saved.

The Analysis of a Project Should Involve a With Versus Without Comparison. The impact of a project is the difference between what the situation in the study area would be with and without the project. This that when a project is being evaluated the analysis must estimate not only what the situation would be with the project but also what it would be without the project. For example, in determining the impact of a fixed guideway rapid transit system such as the Bay Area Rapid Transit (BART) in the San Francisco Bay Area the number of rides that would have been taken on an expansion of the bus system should be deducted from the rides provided by BART and likewise the additional costs of such an expanded bus system would be deducted from the costs of BART. In other words, the alternative to the project must be explicitly specified and considered in the evaluation of the project. Note that the with-and-without comparison is not the same as a before-and-after comparison.

Another example shows the importance of considering the impacts of a project and a with-and-without comparison. Suppose an irrigation project proposes to increase cotton production in Arizona. If the United States Department of Agriculture limits the cotton production in the U.S. by a system of quotas then expanded cotton production in Arizona might be offset by a reduction in the cotton production quota for Mississippi. Thus the impact of the project on cotton production in the U.S. might be zero rather than being the amount of cotton produced by the project.

Cost Benefit Analysis Involves a Particular Study Area. The impacts of a project are defined for a particular study area, be it a city, region, state, nation or the world. In the above example concerning cotton the impact of the project might be zero for the nation but still be a positive amount for Arizona.

The nature of the study area is usually specified by the organization sponsoring the analysis. Many effects of a project may "net out" over one study area but not over a smaller one. The specification of the study area may be arbitrary but it may significantly affect the conclusions of the analysis.

Double Counting of Benefits or Costs Must is avoided. Sometimes an impact of a project can be measured in two or more ways. For example, when an improved highway reduces travel time and the risk of injury the value of property in areas served by the highway will be enhanced. The increase in property values due to the project is a very good way, at least in principle, to measure the benefits of a project. But if the increased property values are included then it is unnecessary to include the value of the time and lives saved by the improvement in the highway. The property value went up because of the benefits of the time saving and the reduced risks. To include both the increase in property values and the time saving and risk reduction would involve double counting.

If the discounted present value of the benefits exceeds the discounted present value of the costs then the project is worthwhile. This is equivalent to the condition that the net benefit must be positive. Another equivalent condition is that the ratio of the present value of the benefits to the present value of the costs must be greater than one.

If there are more than one mutually exclusive project that have positive net present value then there has to be further analysis. From the set of mutually exclusive projects the one that should be selected is the one with the highest net present value.

If the funds required carrying out all of the projects with positive net present value are less than the funds available this means the discount rate used in computing the present values is too low and does not reflect the true cost of capital. The present values must be recomputed using a higher discount rate. It may take some trial and error to find a discount rate such that the funds required for the projects with a positive net present value is no more than the funds available.

Sometimes as an alternative to this procedure people try to select the best projects on the basis of some measure of goodness such as the internal rate of return or the benefit/cost ratio. This is not valid for several reasons.

The magnitude of the ratio of benefits to costs is to a degree arbitrary because some costs such as operating costs may be deducted from benefits and thus not be included in the cost figure. This may be done for some projects and not for others. This manipulation of the benefits and costs will not affect the net benefits and it will not raise the benefit cost ratio which is less than one to above one.

> The CBA time period should match the system life cycle.

## The system life cycle includes the following stages/phases:

1) Feasibility Study
2) Design
3) Development
4) Implementation
5) Operation
6) Maintenance

A system life cycle ends when the system is terminated or is replaced by a system that has significant differences in processing, operational capabilities, resource requirements, or system outputs. Significant differences is a very subject term, and some organizations may feel that a 10% change is significant, while others may that the change must be over 30% to be significant.

## ALTERNATIVES:

Analyses must consider at least three alternative means of achieving program objectives, one of which is to continue with no change. This provides a comparative baseline. Other alternatives could include:

1) In-House Development versus Contractor Development.
2) In-House Operation versus Contractor Operation.
3) Leasing Equipment versus Purchasing Equipment.
4) Current Operational Procedures versus New Operational Procedures.

5) One Technical Approach versus another Technical Approach.

* There is two type of excepted analysis.

## TWO TYPES OF ANALYSIS

Benefit-Cost Analysis (BCA) is a systematic, quantitative method of assessing the life cycle costs and benefits of competing alternative approaches. This includes determining which one of the alternatives is best.

A Cost-Effectiveness Analysis (CEA) is a simplified BCA, which can be done when either the benefits or the costs are the same for all alternatives. The analysis is greatly simplified because the best alternative is either the one with the most benefits (when the costs are the same for all alternatives) or the one with the lowest cost (when the benefits are the same for all alternatives).

## IDENTIFYING AND MEASURING BENEFITS AND COSTS

CBAs (Cost- Benefit Analysis) must include comprehensive estimates of the projected benefits and costs for all alternatives. Benefits to which a dollar value cannot be assigned (intangible benefits) should be included along with tangible benefits and costs. Intangible benefits should be evaluated and assigned relative numeric values for comparison purposes. For example, maximum benefit could be assigned a value of 5, average benefits a value of 3, and minimum benefits a value of 1. Evaluating and comparing benefits that have both dollar values and relative numeric values requires extra effort, but it allows subjective judgment to be a factor in the analysis.

CBAs should be explicit about the underlying assumptions used to arrive at estimates of future benefits and costs. For example, the number of users of an IT system might be assumed to increase at a rate of 10% each of the 6 years of the system life cycle.

Costs incurred in the past (Sunk Costs) and savings or efficiencies already achieved (Realized Benefits) should not be considered in a CBA. When a CBA is done on a project that is already underway, there may be pressure to compare all costs and benefits from the beginning of the project. In that situation, the question to be answered is whether or the benefits of proceeding justify the costs associated with continuing the project. The classic example of this is a situation where large amounts of money have been spent designing a system that has not been successfully implemented, and the project is being re-evaluated. The fact that a lot of money has been spent is no reason to continue spending. CBAs focus on the future; and decisions have to be based on the expected costs and benefits of the proposed alternatives. Past experience is relevant only in helping estimate the value of future benefits and costs.

## DECISION CRITERIA

Project should be initiated or continued only if the projected benefits exceed the projected costs. The only exception is if benefits are mandated by law.

Benefit-Cost Analysis - The standard criterion for justifying an IT project is that the benefits exceed the costs over the life cycle of the project. The competing alternative with the greatest net benefit (benefits minus costs) should be selected. When all benefits and costs cannot be assigned monetary values, relative values for costs and benefits can be used, and the alternative with the greatest net benefit (benefit values minus cost values) should still be selected.

Cost-Effectiveness Analysis - When comparing alternatives with identical costs and different benefits, the alternative with the largest benefits should be selected. When comparing alternatives with identical benefits and different costs, the alternative with the lowest costs should be selected.

# OVERVIEW OF THE CBA PROCESS

## WHEN IS A CBA REQUIRED?

A CBA is always required before a decision is made to initiate or continue an IT project; the only issue is the level of detail required for the analysis. The process described here is appropriate for a very large, complex, and costly IT project. Scaled down versions of the CBA would be appropriate for smaller, less costly projects; and your organization should provide guidelines to determine the amount of scaling that would be appropriate for IT projects based on their size, cost, and complexity.

## WHEN IS THE CBA PERFORMED?

A cost-benefit analysis should occur prior to initiating or modifying an IT system. Most of the activities described below are part of the IT management process and may be completed before the CBA is initiated, concurrently with the CBA, or as part of the CBA. The CBA is a key input for the investment review that should take place before a new project proceeds to the acquisition or development phase.

## DEFINE THE PROBLEM

Clearly define and document the problem. If possible, it should be described from a management perspective.

## REVIEW THE CURRENT WORK PROCESS DOCUMENTATION

If no documentation exists, it must be developed. If it is not clear and up-to-date, it should be updated to clearly describe the current work process. The information

processing requirements must be part of the documentation for the current work process or the current IT system.

## EVALUATE THE WORK PROCESS

There are two questions to address in the work process evaluation: Should We Be Doing This? And Can the Process Be Improved?

## DEFINE THE NEW PROCESSING REQUIREMENTS

Define the information processing requirements for the proposed work process at a general level. The security requirements should be addressed in terms of data integrity, reliable processing, privacy and confidentiality.

## DETERMINE IT PERFORMANCE MEASURES

Identify indicators for measuring and assessing performance of the process and the IT system in relation to the mission. Also determine the means of collecting and storing the performance data.

The Cost-Benefit Analysis for may have to be updated several times during the life cycle of a system. The first cut at a CBA may be quite brief, and can be used to get concept approval to proceed with a detailed CBA. After the detailed CBA has been completed, the development and implementation plans may call for a prototype system or a pilot phase to test the costs and benefits on a limited scale before the full system is implemented for all users. If that occurs, a third version of the CBA would reflect revised costs and benefits, and would be used to decide whether or not to proceed with full implementation of the system. The post-implementation review of a system may also require an updated CBA to determine if the expected benefits are being achieved, and to decide if the operation of the system should continue as implemented, or if the system should be modified to achieve benefits to justify continued operation.

* Clearly define and document the problem. If possible, it should be described from a management perspective.

One of the problems of CBA is that the computation of many components of benefits and costs is intuitively obvious but that there are others for which intuition fails to suggest methods of measurement. Therefore some basic principles are needed as a guide.

## HOW IS THE CBA PERFORMED?

This section briefly describes the steps required to perform a CBA for a large IT project.

### Determine/Define Objectives

The CBA should include the project objectives and other pertinent background information so that it stands on its own and can be understood by a reviewer who is not intimately familiar with the organization and its work process. The objectives should be designed to improve the work process so NIH can better perform its mission. If this information is available from previous steps of the IT management process, it should either be incorporated directly into the CBA or fully referenced in the CBA.

### Document Current Process

The baseline for any CBA is the current process. Because understanding the current process provides the basis for decisions regarding new alternatives, a CBA must thoroughly document the current process to ensure that everyone involved in the CBA preparation and review understands that process. The primary areas to be documented are Customer Services, System Capabilities, Technical Architecture, and System Costs.

### Estimate Future Requirements

Future customer requirements determine the system capabilities and architecture, and ultimately affect system costs and benefits. Thus, it is very important to accurately estimate the future requirements. The two key items to consider are the system life cycle and the peak life cycle demands. A number of useful forecasting methods are discussed in Section 4.

### Collect Cost Data

Cost data must be collected for estimating the cost and benefits of each project alternative. Six sources of data are historical organization experience, current system costs, market research, publications, analyst judgment, and special studies. This step is the preparation for the actually estimating costs and benefits in later steps.

### Choose at Least Three Alternatives

A CBA must present at least three alternatives. One alternative that should be always being included in the CBA is to continue with no change. During the Work Process Evaluation, a number of alternatives may be considered. Other alternatives are whether to do development, operations, and maintenance with in-

house personnel or contractors. Each technical approach that is a viable alternative from a work process perspective should be included as an alternative. However, the number of technical approaches may be limited if only one or two are compatible with the NIH IT architecture. Some alternatives can be addressed and rejected because they are not feasible for reasons other than costs and benefits.

## Document CBA Assumptions

Because a CBA often relies on many assumptions, it is important to document all of them, and, if possible, justify them on the basis of prior experiences or actual data. For example, you may assume that the PC hardware and software for a system will need to be upgraded every three years. This could be justified on the basis of the rapid increases in capacity and speed and decreases in cost for PCs over the past 15 years.

This can also be an opportunity to explain why some alternatives were not included in the analysis. Some alternatives are eliminated in the early stages of a CBA because of a conclusion that it is not feasible. If that conclusion is based on an assumption, the assumption must be clearly explained and justified.

## Estimate Costs

Many factors must be considered during the process of estimating the costs associated with competing alternatives in a CBA. All costs for the full system life cycle for each competing alternative must be included. The following factors must be addressed: Activities and Resources, Cost Categories, Personnel Costs, Direct and Indirect Costs (Overhead), Depreciation, and Annual Costs.

## Estimate Benefits

Benefits are the services, capabilities, and qualities of each alternative system, and can be viewed as the return from an investment. To estimate benefits, first identify the benefits for both the customers and the organization that provides the service(s) to the customers. Benefits to customers are improvements to the current IT services and/or the addition of new services. Some possible benefits for the servicing organization are productivity gains, staffing reductions, or improved organizational effectiveness.

After the benefits are identified, establish performance measures for each benefit. The final step is to estimate the value of the benefits. If a benefit cannot reasonably be assigned a monetary value, it should be valued using a more subjective, qualitative rating system (which assigns relative numerical values for the competing alternatives). All benefits for the full system life cycle for each competing alternative must be included.

## Discount Costs and Benefits

After the costs and benefits for each year of the system life cycle have been estimated, convert them to a common unit of measurement to properly compare competing alternatives. That is accomplished by discounting future dollar values, which transforms future benefits and costs to their "present value." The present value (also referred to as the discounted value) of a future amount is calculated with the following formula:

P = F (1/(1+I)n), where P = Present Value, F = Future Value, I = Interest Rate, and n = number of years. Section 4 provides an example that shows how the costs and benefits are discounted.

## Evaluate Alternatives

When the costs and benefits for each competing alternative have been discounted, compare and rank the discounted net value (discounted benefit minus discounted cost) of the competing alternatives. When the alternative with the lowest discounted cost provides the highest discounted benefits, it is clearly the best alternative. Most cases may not be that simple and other techniques must be used to determine the best alternative. Section 4 describes and provides an example for several different techniques.

When some benefits have dollar values assigned, but others do not, the non-cost values can be used as tie-breakers if the cost figures do not show a clear winner among the competing alternatives, and if the non-costed benefits are not key factors. If the non-costed benefits are key factors, the costed benefits can be converted to scaled numeric values consistent with the other non-costed benefits. The evaluation can then be done by comparing the discounted costs and the relative values of the benefits for each alternative. When the alternative with the lowest discounted cost provides the highest relative benefits, it is clearly the best alternative (the same basic rule used when you have discounted benefits). If that is not the case, the evaluation is more complex. Those techniques are addressed in Section 4.

If no benefits have dollar values, numerical values can be assigned (using some relative scale) to each benefit for each competing alternative. The evaluation and ranking are then completed in the manner described in the previous paragraph.

## Perform Sensitivity Analysis

Sensitivity analysis tests the sensitivity and reliability of the results obtained from the cost-benefit analysis. Since the CBA is normally the key document in the investment review process, reviewers want assurance that the analysis is reliable. Sensitivity analysis identifies those input parameters that have the greatest influence on the outcome, repeats the analysis with different input parameter values, and evaluates the results to determine which, if any, input parameters are

sensitive. If a relatively small change in the value of an input parameter changes the alternative selected, then the analysis is considered to be sensitive to that parameter. If the value of a parameter has to be doubled before there is a change in the selected alternative, the analysis is not considered to be sensitive to that parameter. The estimates for sensitive input parameters should be re-examined to ensure that they are as accurate as possible.

A system life cycle ends when the system is terminated or is replaced by a system with significant changes in processing, operational capabilities, resource requirements, or system outputs. Some of the factors to consider are the speed of hardware and software changes, the probability of major changes in system requirements, and the estimated costs of maintaining the system. Large, complex systems should have a life cycle of at least five years, and the maximum length of time for a CBA should normally be no more than 10 or 12 years.

## Estimate Life-Cycle Demands

The first step in estimating the user demands over the system life-cycle is to determine the best measures of the demand. Use those measures to determine what your demands were for several preceding years, calculate the change in demand from year to year, average this change, and use the average to make the predictions. For example, if you have averaged an increase in demand of 10 percent per year over the last five years, assume that this trend will continue, and demand will increase by 10 percent every year over the life cycle of the study. The example below uses one measure, and demonstrates a 10% average annual increase for the past four years.

The danger of this approach is that past history is not always a good indicator of the future. The mainframe computer centers that assumed mainframe usage would continue to increase in the 80's at the same rate as the 70's were not prepared for the PC explosion. Use this method when external factors have been evaluated to confirm that the past should be a good indicator of the future. Consult staff members who have been involved with the current system operation for a significant period of time.

A second method to determine life-cycle demands is to survey your customers. The advantage to the survey method is that it can identify major changes in customer requirements. Another possible outcome to a survey is that you will find that your customers have problems for which there is an IT solution. These "value added" solutions should be noted and quantified for inclusion under benefits. Surveying your customers properly requires time and expertise. Surveys must be prepared carefully and evaluated even more carefully to ensure that the results are interpreted properly. Consider hiring a professional survey organization unless in-house personnel with survey experience are available to perform the task or assist the CBA team.

In a complex situation that does not lend itself to the simple methods described above, sophisticated tools, such as time-series and regression analysis, can be used to forecast the future. Information on time series analysis can be found in books such as Applied Forecasting Methods by Nick Thomopoulos. A thorough treatment of regression analysis is provided by Norman Draper and Harry Smith in Applied Regression Analysis. Such tools should only be used by trained, experienced individuals.

## Other Considerations

If possible, make more than one forecast using different estimating methods. This will serve as a "sanity check" for the original forecast and add validity to the overall estimate.

Include averages and peak demands in your estimates. If the system is not designed to meet peak demands, there must be a good reason (usually cost) not to do so.

Use professional experience to temper the results of any forecast. Don't ignore this experience with regard to future demands and technology trends. Experience will enable you to identify and explore local IT issues and trends.

Get feedback from other IT professionals on your estimates. Other analysts can point out potential shortcomings in the estimate or provide confirmation of methods and results.

Try for an estimate range in addition to the point estimate. The point estimate is the basis for developing your alternative systems, but the high and low values are extremely important for the sensitivity analysis.

Document everything. Good documentation backs up your estimates, thus minimizing uncertainty during reviews. The documentation will also facilitate the (inevitable) updates to the estimate.

## CONCLUSION

By reducing the positive and-or negative impacts of a project to their equivalent money value Cost Benefit Analysis determines whether on balance the project is worthwhile. The equivalent money value are based upon information derived from consumer and producer market choices; i.e., the demand and supply schedules for the goods and services affected by the project. Care must be taking to properly allow for such things as inflation. When all this has been considered a worthwhile project is one for which the discounted value of the benefits exceeds the discounted value of the costs; i.e., the net benefits are positive. This is equivalent to the benefit/cost ratio being greater than one and the internal rate of return being greater than the cost of capital.

Example 1

# Samples

*From "**Thayer Watkins, Department Of Economics, San José State University"*

To illustrate how CBA might be applied to a project, let us consider a highway improvement such as the extension of Highway 101 into San Jose. The local four-lane highway which carried the freeway and commuter traffic into San Jose did not have a median divider and its inordinate number of fatal head-on collisions led to the name "Blood Alley." The improvement of the highway would lead to more capacity which produces time saving and lowers the risk. But inevitably there will be more traffic than was carried by the old highway.

The following is a highly abbreviated analysis using hypothetical data.

| TRIP DATA | No Extension, "Blood Alley" Only | 101 Extension and "Blood Alley" |
|---|---|---|
| **Rush Hours** | | |
| **Passenger Trips (per hour)** | 3,000 | 4,000 |
| **Trip Time (minutes)** | 50 | 30 |
| **Value of Time ($/minute)** | $0.10 | $0.10 |
| **Nonrush Hours** | | |
| **Passenger Trips (per hour)** | 500 | 555.55 |
| **Trip Time (minutes)** | 35 | 25 |
| **Value of Time ($/minute)** | $0.08 | $0.08 |
| **Traffic Fatalities (per year)** | 12 | 6 |

The data indicates that for rush-hour trips the time cost of a trip is $5 without the project and $3 with it. It is assumed that the operating cost for a vehicle is unaffected by the project and is $4.

The project lowers the cost of a trip and the public responds by increasing the number of trips taken. There is an increase in consumer surplus both for the trips which would have been taken without the project and for the trips which are stimulated by the project.

For trips which would have been taken anyway the benefit of the project equals the value of the time saved times the number of trips. For the rush-hour trip the project saves $2 and for the nonrush-hour trip it saves $0.80. For the trips

generated by the project the benefit is equal to one half of the value of the time saved times the increase in the number of trips.

The benefits per hour are:

| TYPE | Trips Which Would Be Taken Anyway | Trips Generated By the Project | Total |
|---|---|---|---|
| **Rush Hour** | 6,000.00 | 1,000.00 | 7,000.00 |
| **Nonrush Hour** | 400.00 | 22.22 | 422.22 |

To convert the benefits to an annual basis one multiplies the hourly benefits of each type of trip times the number of hours per year for that type of trip. There are 260 week days per year and at six rush hours per weekday there are 1560 rush hours per year. This leaves 7200 non-rush hours per year. With these figures the annual benefits are:

| TYPE | Trips Which Would Be Taken Anyway | Trips Generated By the Project | Total |
|---|---|---|---|
| **Rush Hour** | $9,360,000 | $1,560,000 | $10,020,000 |
| **Nonrush Hour** | $2,880,000 | $160,000 | $3,040,000 |
| **Total** | $12,240,000 | $1,720,000 | $13,960,000 |

The value of the reduced fatalities may be computed in terms of the equivalent economic value people place upon their lives when making choices concerning risk and money. If the labor market has wages for occupations of different risks such that people accept an increase in the risk of death of 1/1,000 per year in return for an increase in income of $400 per year then a project that reduces the risk of death in a year by 1/1000 gives a benefit to each person affected by it of $400 per year. The implicit valuation of a life in this case is $400,000. Thus benefit of the reduced risk project is the expected number of lives saved times the implicit value of a life. For the highway project this is 6x$400,000= $2,400,000 annually.

The annual benefits of the project are thus:

| TYPE OF BENEFIT | VALUE OF BENEFITS PER YEAR |
|---|---|
| **Time Saving** | $13,960,000 |
| **Reduced Risk** | $2,400,000 |

Let us assume that this level of benefits continues at a constant rate over a thirty-year lifetime of the project.

The cost of the highway consists of the costs for its right-of-way, its construction and its maintenance. The cost of the right-of-way is the cost of the land and any structures upon it which must be purchased before the construction of the highway can begin. For purposes of this example the cost of right-of-way is taken to be $100 million and it must be paid before any construction can begin. At least part of the right-of- way cost for a highway can be recovered at the end of the

lifetime of the highway if it is not rebuilt. For the example it is assumed that all of the right-of-way cost is recoverable at the end of the thirty-year lifetime of the project. The construction cost is $200 million spread evenly over a four-year period. Maintenance cost is $1 million per year once the highway is completed.

The schedule of benefits and costs for the project are as follows:

| TIME (year) | BENEFITS ($millions) | RIGHT OF WAY ($millions) | CONSTRUCTION COSTS ($millions) | MAINTENANCE ($millions) |
|---|---|---|---|---|
| **0** | 0 | 100 | 0 | 0 |
| **1-4** | 0 | 0 | 50 | 0 |
| **5-29** | 16.36 | 0 | 0 | 1 |
| **30** | 16.36 | -100 | 0 | 1 |

The benefits and costs are in constant value dollars; i.e., there was no price increase included in the analysis. Therefore the discount rate used must be the real interest rate. If the interest rate on long term bonds is 8 percent and the rate of inflation is 6 percent then the real rate of interest is 2 percent. Present value of the streams of benefits and costs discounted at a 2 percent back to time zero are as follows:

| | PRESENT VALUE ($ millions) |
|---|---|
| **Benefits** | 304.11 |
| **Costs** | |
| **Right-of-Way** | 44.79 |
| **Construction** | 190.39 |
| **Maintenance** | 18.59 |
| **Total Costs** | 253.77 |
| | |
| **Net Benefits** | 50.35 |
| **independent rounding* | |

The positive net present value of $50.35 million and benefit/cost ratio of 1.2 indicate that the project is worthwhile if the cost of capital is 2 percent. When a discount rate of 3 percent is the benefit/cost ratio is slightly under 1.0. This means that the internal rate of return is just fewer than 3 percent. When the cost of capital is 3 percent the project is not worthwhile.

It should be noted that the market value of the right-of-way understates the opportunity cost of having the land devoted to the highway. The land has a value of $100 million because of its income after property taxes. The economy is paying more for its alternate use but some of the payment is diverted for taxes. The discounted presented value of the payments for the alternate use might be more like $150 million instead of $100 million. Another way of making this point is that one of the costs of the highway is that the local governments lose the property tax on the land used.

Example 2

# Samples

*"*** From F. John Reh, Your Guide to Management."*

As the Production Manager, you are proposing the purchase of a $1 Million machine to increase output.

Before you can present the proposal to the Vice President, you know you need some facts to support your suggestion, so you decide to run the numbers and do a cost benefit analysis.

You itemize the benefits. With the new machine, you can produce 100 more units per hour. The three workers currently doing the stamping by hand can be replaced. The units will be higher quality because they will be more uniform. You are convinced these outweigh the costs.

There is a cost to purchase the machine and it will consume some electricity. Any other costs would be insignificant.

You calculate the selling price of the 100 additional units per hour multiplied by the number of production hours per month. Add to that two percent for the units that aren't rejected because of the quality of the machine output. You also add the monthly salaries of the three workers. That's a pretty good total benefit.

Then you calculate the monthly cost of the machine, by dividing the purchase price by 12 months per year and divide that by the 10 years the machine should last. The manufacturer's specs tell you what the power consumption of the machine are and you can get power cost numbers from accounting so you figure the cost of electricity to run the machine and add the purchase cost to get a total cost figure.

You subtract your total cost figure from your total benefit value and your analysis shows a healthy profit. All you have to do now is present it to the VP, right? Wrong. You've got the right idea, but you left out a lot of detail.

**Running the Numbers Means All the Numbers.**

Let's look at the benefits first. Don't use the selling price of the units to calculate the value. Sales price includes many additional factors that will unnecessarily complicate your analysis if you include them, not the least of which is profit margin. Instead, get the activity based value of the units from accounting and use that. You remembered to add the value of the increased quality by factoring in the average reject rate, but you may want to reduce that a little because even the machine won't always be perfect. Finally, when calculating the value of replacing

three employees, in addition to their salaries, are sure to add their overhead costs, the costs of their benefits, etc., which can run 75-100% of their salary. Accounting can give you the exact number for the workers' "fully burdened" labor rates.

In addition to properly quantifying the benefits, make sure you included all of them. For instance, you may be able to buy feed stock for the machine in large rolls instead of the individual sheets needed when the work is done by hand. This should lower the cost of material, another benefit.

As for the cost of the machine, in addition to its purchase price and any taxes you will have to pay on it, you must add the cost of interest on the money spent to purchase it. The company may purchase it on credit and incur interest charges, or it may buy it outright. However, even if it buys the machine outright, you will have to include interest charges equivalent to what the company could have collected in interest if it had not spent the money.

Check with finance on the amortization period. Just because the machine may last 10 years, doesn't mean the company will keep it on the books that long. It may amortize the purchase over as little as 4 years if it is considered capital equipment. If the cost of the machine is not enough to qualify as capital, the full cost will be expensed in one year. Adjust your monthly purchase cost of the machine to reflect these issues. You have the electricity cost figured out but there are some cost you missed too.

The typical failure of a cost benefit analysis is not including all the costs. In the case of the stamping machine, here are some of the overlooked costs:

**Floor Space**

Will the machine fit in the same space currently occupied by the three workers?

**Installation**

What will it cost to remove the manual stamper’s and install the new machine? Will you have to cut a hole in a wall to get it in or will it fit through the door? Will you need special rollers or machinists with special skills to install it?

**Operator?**

Somebody has to operate the machine. Does this person need special training? What will the operator's salary, including overhead, cost?

*** Environment**

Will the new machine be so noisy that you have to build soundproofing around it? Will the new machine increase the insurance premiums for the company?

## Accurate Cost Benefit Analysis

Once you have collected ALL the positive and negative factors and have quantified them you can put them together into an accurate cost benefit analysis.

Some people like to total up all the positive factors (benefits), total up all the negative factors (costs), and find the difference between the two.

Some prefer to group the factors together. It makes it easier for you, and for anyone reviewing your work, to see that you have included all the factors on both sides of the issues that make up the cost benefit analysis. For the example above, our cost benefit analysis might look something like this:

## Cost Benefit Analysis - Purchase of New Stamping Machine

(Costs shown are per month and amortized over four years)

| | |
|---|---|
| Purchase of Machine ..... | **-$20,000** |
| includes interest and taxes | |
| Installation of Machine ..... | **-3,125** |
| including screens & removal of existing stampers | |
| Increased Revenue..... | **27,520** |
| net value of additional 100 units per hour, 1 shift/day, 5 days/week | |
| Quality Increase Revenue ..... | **358** |
| calculated at 75% of current reject rate | |
| Reduced material costs ..... | **1,128** |
| purchase of bulk supply reduces cost by $0.82 per hundred | |
| Reduced Labor Costs..... | **18,585** |
| 3 operators salary plus labor o/h | |
| New Operator ..... - | **8,321** |
| Salary plus overhead. Includes training | |
| | |
| Utilities..... | **-250** |
| power consumption increase for new machine | |
| Insurance..... | **-180** |
| premiums increase | |
| Square footage..... 0 | |
| no additional floor space is required | |
| Net Savings per Month ..... | **$15,715** |

Your cost benefit analysis clearly shows the purchase of the stamping machine is justified. The machine will save your company over $15,000 per month, almost $190,000 a year.

This is just one example of how you can use cost benefit analysis determine the advisability of a course of action and then to support it once you propose the action.

## GLOSSARY OF TERMS

**Benefit-Cost Analysis (BCA):** A systematic quantitative method of assessing the desirability of Government projects or policies when it is important to take a long view of future effects and a broad view of possible side-effects.

**Benefit-Cost Ratio (BCR):** The Total Discounted Benefits of a project divided by the Total Discounted Costs of the project. If the value of the BCR is less than one, the project should not be continued.

**Capital Asset:** Tangible property, including durable goods, equipment, buildings, installations, and land.

**Cost-Benefit Analysis (CBA):** An evaluation of the costs and benefits of alternative approaches to a proposed activity to determine the best alternative. (Definition created for this document)

**Cost-Effectiveness Analysis (CEA):** A systematic quantitative method for comparing the costs of alternative means of achieving the same stream of benefits or a given objective.

**Discount Rate:** The interest rate used in calculating the present value of expected yearly benefits and costs.

**Discount Factor:** Discount factor translates expected benefits or costs in any given future year into present value terms. The discount factor is equal to $1/(1 + i)t$ where i is the interest rate and t is the number of years from the date of initiation for the program or policy until the given future year.

**Inflation:** The proportionate rate of change in the general price level, as opposed to the proportionate increase in a specific price. Inflation is usually measured by a broad-based price index, such as the implicit deflator for Gross Domestic Product or the Consumer Price Index.

**Information Technology:** Any equipment or interconnected system or subsystems of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception, of data or information.

**Life Cycle Cost:** The overall estimated cost for a particular program alternative over the time period corresponding to the life of the program including direct and indirect initial costs plus any periodic or continuing costs of operation and maintenance.

**Net Present Value:** The difference between the discounted present value of benefits and the discounted present value of costs. This is also referred to as the discounted net.

**Payback Period:** The number of years it takes for the cumulative dollar value of the benefits to exceed the cumulative costs of a project.

**Real or Constant Dollar Values:** Economic units measured in terms of constant purchasing power. A real value is not affected by general price inflation. Real values can be estimated by deflating nominal values with a general price index, such as the implicit deflator for Gross Domestic Product or the Consumer Price Index.

**Return:** The difference between the value of the benefits and the costs of a project. In a Cost-Benefit Analysis it is computed by subtracting the Total Discounted Costs from the Total Discounted Benefits, and is called the Total Discounted Net.

**Return on Investment (ROI):** Calculated by dividing the Total Discounted Net by the Total Discounted Costs. To express it as a percentage, it must be multiplied by 100. It can also be expressed as (Total Discounted Benefits minus Total Discounted Costs) divided by Total Discounted Costs. Note: Rate of Return on Investment (RROI) would be a more accurate name than ROI, but most people that are familiar with the term recognize that it is a percentage rate rather than an amount. The terms are often used interchangeably.

**Sunk Cost:** This cost incurred in the past that will not be affected by any present or future decision. Sunk costs should be ignored in determining whether a new investment is worthwhile.

**Resources:**

1- Robert Lagas, Deputy Chief Information Officer, US National Institutes of Health
2- Wikipedia, the free encyclopedia
**Thayer Watkins, Department Of Economics, San José State University
***F. John Reh, Your Guide to Management.