COST-BENEFIT ANALYSIS AND BUSINESS CASE DEVELOPMENT

People invest resources when they believe that the benefits of their investments will outweigh the costs. A cost-benefit analysis reveals whether a particular investment is worthwhile. However, cost-benefit analysis is more than financial analysis. Financial analysis is an effective decision-making tool, but it is only one tool. People and organizations do not base all investment decisions on financial projections. Some investments are made for strategic reasons (1). For example, an organization that places high value on safety may invest in equipment with a higher price tag than that of the accidents the equipment prevents. In this situation, the financial analysis would suggest that the equipment was a poor investment decision, but the strategic analysis would suggest otherwise. A complete cost-benefit analysis, or *business case,* is a combination of financial analysis and strategic analysis (2).

The financial analysis includes the following components:

- Detailed estimates of tangible costs and benefits, including descriptions of all underlying assumptions
- A complete schedule that aligns the costs and benefits over time, including any underlying assumptions about the schedule
- Identification of the estimates as future values or present values, including any assumptions about inflation and the cost of capital
- Calculation of the relationship between benefits and costs over the life of the investment [the simplest form of this calculation is illustrated in Eq. (1)]:

$$\text{Net Benefits} = \text{Total Benefits} - \text{Total Costs} \tag{1}$$

- Analysis of the sensitivity of the financial calculations to fluctuations in specific estimates and assumptions

Strategic analysis of an investment involves an evaluation of nonfinancial benefits. These benefits are compared to the mission, goals, and values of the person or organization making the investment decision (3). Investments that further important goals are said to be strategic. For example, consider an organization that manufactures electrical components for home appliances. The organization must choose between two investment alternatives: one that would increase the operating life of its existing products, and another that would expand its product line. If the two options have the same financial value, the organization is likely to select the investment that best matches its marketing strategy (4). If the company's primary goal is to build the loyalty of its current customer base, it will choose the investment that improves product life. On the other hand, if the company is pursuing a strategy of diversification, it will select the investment that broadens its product line.

A complete strategic analysis includes the following:

- Documentation of the mission, goals, and values that define the organization making the investment decision
- Documentation of all intangible benefits and costs
- Evaluation of the relationship of the intangible benefits and costs to the mission, goals, and values of the organization

COST-BENEFIT ANALYSIS AT ALL PROJECT STAGES

Cost-benefit analyses can be performed during any stage of a major project (5).

Preliminary Cost-Benefit Analysis

Organizations may perform a preliminary cost-benefit analysis to determine whether an investment idea merits serious consideration. Preliminary analyses use rough estimates of costs and benefits based on broad assumptions about a project. Preliminary cost-benefit analyses often accompany conceptual designs, feasibility studies, and white papers.

Cost-Benefit Analysis for Design Review

Many large projects require a detailed design prior to implementation. A detailed design allows decision makers to prepare cost and benefit estimates that are more accurate than anything possible at a conceptual planning stage. Many organizations update their cost-benefit analyses following the detailed design phases of their projects (1). The updated analyses are used to refine the designs and the implementation schedules in order to maximize net benefits.

Cost-Benefit Analysis as a Management Feedback Tool

Some organizations refine their cost and benefit estimates throughout the implementation of major projects. Ongoing cost-benefit analyses provide vital feedback to decision makers who are overseeing multiyear implementation projects.

Cost-Benefit Analysis at Project Closeout

Some organizations compile a final cost-benefit analysis at the close of a project. Unlike the analyses performed before and during a project, a closeout analysis does not directly guide investment decisions. Instead, these analyses reveal the accuracy of earlier cost and benefit estimates, and they help decision makers hone their estimation skills.

STEPS IN A COST-BENEFIT ANALYSIS

The steps in a cost benefit analysis are as follows:

- Estimate costs.
- Estimate benefits.
- Align costs and benefits over time.
- Conduct financial analysis.
- Prepare strategic analysis.

Each step requires the analyst to make assumptions about the investment, the organization, and the economy. The reliability of a cost-benefit analysis depends on the soundness of the underlying estimates and assumptions.

Estimating Costs

The first step in a cost-benefit analysis is to estimate the costs of the potential investment. These estimates are based on the organization's previous experience, observations of the marketplace, and forecasts from reliable sources. It is important to include all investment costs, including those associated with planning, design, testing, quality control, marketing studies, training, legal and financial review, and product development. In the case of information technology projects, it is important to include the cost of data development and conversion. Data conversion costs can account for as much as 80% of total technology project costs (6).

Internal Labor Costs. When estimating internal labor costs, base salaries should be augmented by fringe costs such as insurance, paid leave, and taxes. Fringe costs are typically quoted as an average percentage of salaries. These percentages are tracked by the personnel managers of large organizations. A full description of an internal labor cost estimate includes a stated assumption about the fringe percentage.

Future versus Sunk Costs. A cost-benefit analysis should target *true potential* costs as opposed to *sunk* costs. A sunk cost is a cost that has already been incurred and cannot be recovered (5). It should not be a factor in the mathematical analysis of the financial value of a future investment. However, previous investment (i.e., sunk costs) may affect the political or emotional response to an investment decision. For this reason, it may be worthwhile to document sunk costs while preparing estimates of the true potential costs that will be included in the financial analysis.

Capital versus Operating Costs. Most organizations separate their cost estimates into two categories: capital costs and operating costs. Typically, these costs are treated differently by an organization's accountants. *Capital costs* are one-time costs associated with investments such as the acquisition of new equipment. Accountants generally treat capital costs as assets that are depreciated over time. *Operating costs* are recurring costs associated with ongoing operations. Examples include regular payroll costs and software maintenance contracts. Accountants typically treat operating costs as expenses. For large investments, the difference in accounting practices is significant. Essentially, operating costs deplete the firm's book value faster than capital costs, and book value affects the cost and availability of new capital. Although the categorization of costs does not affect the financial analysis of an investment (7), it does affect the strategic analysis. For this reason, most cost-benefit analyses distinguish between the two categories of costs.

Politically Sensitive Costs. Cost estimation may become a political issue when internal labor is a large component of an investment's costs (8). In organizations that have substantially fixed payrolls due to union contracts, civil service rules, or the political climate, there may be considerable resistance to the quantification of internal labor costs for a specific project. Also, if organizations require managers to justify operating budgets by documenting the need for full utilization of each budgeted staff member, these managers may be unwilling to document the availability of staff members to work on additional projects. They may fear the loss of these positions if the project under study is rejected. If internal labor costs are removed from the financial analysis, care should be taken not to overstate productivity gains. In fact, it may be possible to account for internal labor costs by quantifying a productivity benefit that is the excess of the actual benefit over the internal labor cost. Table 1 illustrates this approach, which preserves the integrity of the financial analysis in a manner that may be more politically palatable.

In Table 1, the reduced annual productivity benefit is calculated as in Eq. (2):

$$\begin{aligned} \text{RAP} &= \text{OAP} - [\text{AIL} + (\text{OIL} \div \text{PP})] \\ &= \$1{,}200{,}000 - [\$300{,}000 + (\$2{,}800{,}000 \div 10)] \\ &= \$620{,}000 \end{aligned} \tag{2}$$

where

RAP = Reduced Annual Productivity Benefit ($620,000)
OAP = Original Annual Productivity Benefit ($1,200,000)
OIL = One-time Internal Labor Costs ($2,800,000)
AIL = Annual Internal Labor Costs ($300,000)
PP = Planning Period in Years (10)

This approach can be used to recast any politically sensitive cost as a reduced benefit.

Given Costs. When estimating the costs associated with an investment, care should be taken to exclude costs that would be incurred regardless of the investment decision. For example, consider an electric utility that has already decided to inspect every primary and secondary device in the field. To do this, an inspector must travel to each device. Therefore, the costs of physically accessing each device are *given costs.* If the utility is evaluating a potential project to survey the location of each device, it is possible that the same individual can conduct the survey while completing the inventory. If this is the case, then the relevant costs for the cost-benefit analysis are only those incurred *in addition* to the asset inventory project costs. These might include the cost of additional time spent at each device as well as the cost of any survey equipment. However, the inspector's transportation costs are given due to the inventory project, so these costs are excluded from the survey project's cost-benefit analysis. Although given costs are excluded from financial calculations, they provide a vital context for interpreting a cost-benefit analysis. For this reason, it is important to document assumptions about given costs.

Table 1. Internal Labor Costs Can Be Recast as a Reduced Productivity Benefit

Option 1: Labor as a Cost		Option 2: Labor as a Reduced Benefit	
Capital Costs		*Capital Costs*	
New equipment	$ 350,000	New equipment	$ 350,000
New software	$ 750,000	New software	$ 750,000
Design services	$1,275,000	Design services	$1,275,000
Internal labor	**$2,800,000**	—	
Implementation support	$1,050,000	Implementation support	$1,050,000
Annual operating costs (10-year horizon)		*Annual operating costs (10-year horizon)*	
Equipment maintenance	$ 80,000	Equipment maintenance	$ 80,000
Software maintenance	$ 225,000	Software maintenance	$ 225,000
Internal labor	**$ 300,000**	—	
Operational support services	$ 750,000	Operational support services	$ 750,000
Annual benefits		*Annual benefits*	
Litigation avoidance	$ 750,000	Litigation avoidance	$ 750,000
Increased sales	$2,500,000	Increased sales	$2,500,000
Internal productivity	**$1,200,000**	**Internal productivity**	**$ 620,000**

Intangible Costs. Some costs may be difficult to quantify. For example, an investment in plant automation may have a negative impact on employee morale, particularly if people believe they will be displaced by the new system (1). A thorough cost-benefit analysis documents these *intangible costs* for two reasons. First, they contribute to the overall context in which the financial analysis will be interpreted. Second, they may suggest additional tangible costs that were not originally included in the estimate. For example, the organization considering the plant automation investment may wish to add cost estimates for an employee retraining program to mitigate the intangible cost of lower morale. Documentation of these types of mitigating tangible costs reduces the negative impact of the intangible costs.

Estimating Benefits

The benefits of an investment may be tangible or intangible. A *tangible* benefit is one that can be quantified for use in financial calculations. An *intangible* benefit is one that cannot be measured numerically. A thorough cost-benefit analysis considers both types of benefits.

Tangible Sales Revenue Benefits. For investments that are expected to increase revenues, the quantification process should include a consideration of price, demand (or volume), and the relationship with other revenues. In a free market, revenues associated with the sale of a product or service are subject to the economic laws of supply and demand (5). Sales revenues are the product of sales volume and price. At a given level of potential demand, consumers are willing to buy more of a product or service as the price falls. At a given level of potential supply, suppliers are willing to sell more as the price rises. As illustrated in Fig. 1, sales volume is limited by the current levels of potential demand and potential supply. The free market price of a product or service is the point at which potential demand equals potential supply. If a new investment changes the underlying level of potential supply (i.e., suppliers' willingness to sell a product or service at a given price), the investment will affect both sales volume and market price.

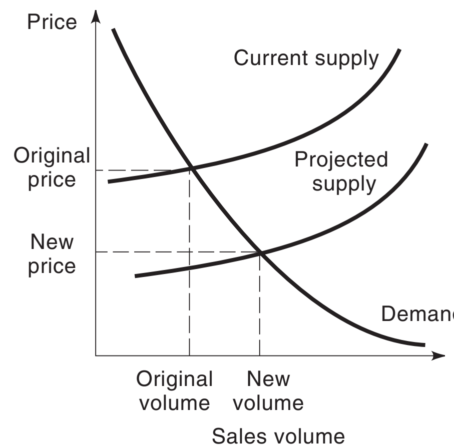

Figure 1. Market price and sales volume occur at the point where supply equals demand. An increase in potential supply (i.e., the willingness to sell more of a product or service at a given price) tends to decrease the market price while increasing total sales volume. Sales revenue is a function of both volume and price, so sales revenue benefit estimates must include both factors.

Marketing and pricing studies, demand forecasts, and projections of competitors' supplies are essential for the accurate estimation of sales revenues. Also, if a new product or service will supplant an existing product or service that would otherwise be marketable, it is important to incorporate the loss of revenue from the old product or service. Figure 2 illustrates this situation.

Improved Ability to Collect Revenues. Even if an investment does not directly affect a salable good or service, it may still provide revenue benefits. For example, a new customer information system or automated meter-reading system may increase a utility's collections from its customers. When an investment will improve revenue collection, the tangible benefit is the marginal increase in revenues, all other things being equal.

Improved Probability of Revenue Collection. If an investment will improve an organization's ability to collect cer-

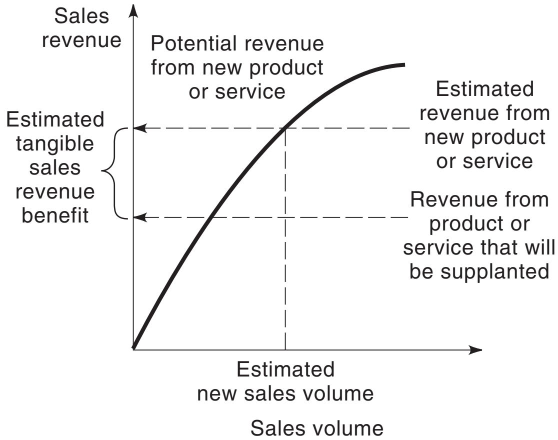

Figure 2. Tangible sales revenue benefit of a replacement product or service is the marginal increase over sales revenues from the product or service that is supplanted.

tain revenues, the tangible benefit can be estimated as the potential revenue multiplied by the probability of collection. For example, assume that an organization is evaluating the costs and benefits of competing for a manufacturing contract. If the estimated profit from the contract is $2,000,000 and the estimated probability of winning the contract is 25%, then the tangible profit benefit of competing for the contract is $500,000, as illustrated in Eq. (4):

$$\begin{aligned}\text{Tangible Profit Benefit} &= \text{Estimated Profit} \\ &\quad \times \text{Probability of Winning} \\ &= \$2.000.000 \times 0.25 \\ &= \$500.000\end{aligned} \tag{3}$$

Tangible Cost Avoidance Opportunities. A tangible cost avoidance benefit is a future cost that would be incurred if an investment were not made. For example, if a plant currently requires $2,000,000 of power per year and a potential new investment would reduce these requirements by 20%, then the investment carries a tangible cost avoidance benefit of $400,000, as in the following equation:

$$\begin{aligned}&\text{Tangible Cost Avoidance Benefit} \\ &\quad = \text{Future Cost} \times \text{Percent Reduction from Investment}\end{aligned} \tag{4}$$

If an investment reduces the probability of a future cost, that probability factors into the calculation of the benefit. For example, if an organization estimates that it will spend $1,000,000 on a particular lawsuit, and if a new investment would decrease the probability of this lawsuit from 80 to 60%, then the tangible cost avoidance benefit of $200,000 is as calculated in Eq. (6):

$$\begin{aligned}&\text{Tangible Cost Avoidance Benefit} \\ &= \text{Potential Cost} \times \text{Reduction in Probability of Potential Cost} \\ &= \$1.000.000(0.8 - 0.6) \\ &= \$200.000\end{aligned} \tag{5}$$

When cost avoidance benefits involve reduced personnel costs, special care should be taken when calculating and presenting these benefits.

If an organization has a fixed payroll due to union contracts, civil service rules, or the political climate, then a reduction in the labor required to perform certain work may not translate into actual cost avoidance. For example, if an organization employs 10 field inspectors at an annual cost of $70,000 per inspector, it incurs annual payroll costs of $700,000. If new automation would allow the organization to reduce its field inspection staff to seven, the organization could reduce its annual payroll cost by $210,000. This is a tangible cost avoidance benefit. However, if the organization is unable to reduce its field inspection staff, then it cannot realize this benefit.

For some organizations that have fixed payroll costs, staff are able to perform a variety of duties. These organizations may be able to realize tangible productivity benefits in cases where cost avoidance benefits are not possible. In the previous example, if the organization assigns preventive maintenance duties to the three displaced field inspectors, and if these duties are valuable enough to the organization to account for the inspectors' payroll costs, then the organization can document a tangible productivity benefit of $210,000.

Tangible Productivity Benefits. Productivity is a measure of the work performed by a person or machine in a given amount of time. When the person or machine performs repetitive tasks, productivity measurements are straightforward (9). A person who produces 10 widgets in the same amount of time it takes another person to produce 5 widgets of the same quality is twice as productive as that other person. Productivity is harder to measure when people or machines perform a variety of different tasks that may have different value to the organization.

A productivity benefit can be quantified as one of the following:

- The reduction in cost for a given amount of work that is required
- The value of additional work that can be performed for a fixed cost [see Lerner (10) for detailed methodology]

A tangible productivity benefit is not the same thing as a productivity increase. For example, assume an organization can sell or use a maximum of 15 widgets per day, and assume that these widgets cannot be stored for future sale or use. The organization owns a machine that produces 10 widgets per day. An upgrade to the machine would double its productivity; in other words, it would allow the machine to produce 20 widgets per day at the same operating cost. Although productivity would double, the tangible productivity benefit would not reflect the full productivity increase of 10 additional widgets per day. Instead, the benefit would be based on the value of the extra 5 widgets that the organization can use or sell.

The value of productivity improvements is frequently represented as tangible revenue benefits or tangible cost avoidance benefits (11). Care should be taken not to double-count these benefits. However, in certain situations, tangible benefits are best represented in terms of productivity.

When an organization cannot or will not eliminate jobs, then an investment that reduces the labor required for specific work actually produces surplus labor. If the hours of available labor can be redirected to other valuable tasks, then the organization realizes a productivity benefit because more valuable work is accomplished for the same level of payroll costs. The easiest way to account for the tangible productivity benefit is to assume that the value of the new work is equal to the cost of the surplus time. In other words, if an organization assigns preventive maintenance duties to three displaced field inspectors, each of whom cost $70,000 per year, then the organization realizes a tangible productivity benefit of $210,000. However, care should be taken not to overstate a productivity benefit. If workers who are displaced by a new investment are assigned tasks that could have been performed by employees with lower wages, then the tangible benefit should reflect the lower wages (the true value of the work).

Intangible Benefits. By definition, intangible benefits are difficult to quantify. Examples of intangible benefits include

- Improved customer goodwill
- Competitive advantage
- Enhanced image
- Greater employee satisfaction
- Safer operations
- Better customer service
- Compliance with external mandates such as federal regulations
- Cleaner environment
- Better corporate decisions

Theoretically, it is always possible to quantify a benefit. The following examples illustrate this point:

- A competitive advantage or improved customer goodwill, corporate image, or customer service might be translated into sales revenue benefits.
- Greater employee satisfaction might be quantified as a tangible productivity benefit or a cost avoidance benefit that reflects lower payroll requirements.
- Safer operations might result in cost avoidance benefits associated with reduced insurance claims.
- Compliance with external mandates and preservation of a cleaner environment might be quantified as a cost avoidance benefit due to a reduced probability of fines or litigation.
- Better corporate decisions might be quantified by separating the benefit into specific types of decisions with clear impacts on revenues or costs.

However, an organization may be hard pressed to develop realistic estimates of these tangible benefits (4). When this occurs, the organization may choose to treat the benefit as an intangible. Intangible benefits support strategic analysis, so it is equally as important to document them as it is to document the tangible benefits.

Nonfinancial Metrics and the Benefits of Technology. Benefit estimation for technology investments can prove especially difficult (10). Technology can improve productivity and enhance the quality of a product or service, but these benefits are difficult to quantify. However, the level of service or quality afforded by a new technology may become the benchmark by which people measure an organization against its competitors. For this reason, strategic advantage and competitiveness are frequently cited as intangible benefits of technology investments (1). In some cases, these benefits are convincing enough to justify a technology investment even when the financial analysis is not persuasive.

As a result, some organizations are expanding their analyses of potential technology investments to include nonfinancial metrics. These nonfinancial metrics quantify factors such as customer satisfaction and public safety. For example, many organizations use a scale of points to measure customer satisfaction. Through controlled surveys of customers, organizations can develop statistical information on the level of satisfaction. Nonfinancial metrics help decision makers deal more objectively with evaluations of alternative technology investments. Nonfinancial quantification can enhance any cost-benefit analysis.

Aligning Benefits and Costs over Time

Most investments have a predictable life span. This life span limits the ongoing costs and benefits of an investment. For example, if an organization determines that a new product, technology, or service will be obsolete in 10 years, then the ongoing costs and benefits are limited to a 10-year horizon.

All costs and benefits occur at some point in an investment's life span. The timing depends on the investment's implementation schedule. Complete cost and benefit estimates include this timing information. Timing information can be included in the text descriptions of intangible costs and benefits. For tangible costs and benefits, the associated cash flows are shown for each year of the investment's life. Costs are depicted as negative cash flows, and benefits are depicted as positive cash flows. Table 2 depicts cash flow amounts and timing for a theoretical project.

Time Value of Money. The timing of benefits and costs has an impact on their current value. A given sum of money is more valuable if it is in hand today than if it will not be available for one year. This is because money can be invested during the year and will return a greater amount at year's end. The method of accounting for the time value of money depends on whether cash flows are presented as future values or present values.

Future Values. A *future value* is the actual cash flow that will be realized at the time shown. Table 2 depicts future values. For example, in Year 4, the actual cash outflow for equipment operating costs is $87,000. When preparing cost and benefit estimates, it may be easier to think in terms of future value. However, the actual cash flows that occur in different years cannot be compared or aggregated without first accounting for the time-related differences in their

Table 2. Future Values of Costs and Benefits over a 10-Year Project Life

(000s of Future $)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital costs										
Equipment	(350)									
Software	(750)									
Design services	(675)	(618)								
Internal labor	(500)	(515)	(424)							
Implementation	(500)	(515)	(53)							
Total capital costs	**(2,775)**	**(1,648)**	**(477)**							
Operating costs										
Equipment			(85)	(87)	(90)	(93)	(96)	(98)	(101)	(104)
Software		(232)	(239)	(246)	(253)	(261)	(269)	(277)	(285)	(294)
Internal labor		(309)	(318)	(328)	(338)	(348)	(358)	(369)	(380)	(391)
Operational support		(773)	(796)	(820)	(844)	(869)	(896)	(922)	(950)	(979)
Total operating costs		**(1,314)**	**(1,438)**	**(1,481)**	**(1,525)**	**(1,571)**	**(1,619)**	**(1,666)**	**(1,716)**	**(1,768)**
Benefits										
Litigation avoidance		773	796							
Increased sales			530	1,093	2,251	2,898	2,985	3,075	3,167	3,262
Internal productivity			1,273	1,311	1,351	1,391	1,433	1,476	1,520	1,566
Total benefits		**773**	**2,599**	**2,404**	**3,602**	**4,289**	**4,418**	**4,551**	**4,687**	**4,828**

current value.

Present Values. The *present value* of a future cost or benefit is the value *today* of experiencing that cost or benefit at the projected time in the future. Present values are useful because they allow analysts to compare and aggregate costs and benefits that occur in different time periods. Present value calculations discount future benefits to reflect the fact that a smaller sum of money today would be just as beneficial as the larger sum in the future due to the fact that the money in hand today could be invested to grow to the future value. In the same way, future costs are discounted as negative cash flows. The factor used to discount future cash flows is called the *discount rate.* Equivalent, commonly used terms include *hurdle rate, cutoff rate, required rate of return,* and *opportunity cost of capital* (7).

Discount Rates. The *nominal discount rate* is generally defined as the annual rate of return that could be earned on an alternative investment. When choosing a discount rate for cost-benefit analysis, some organizations use the interest rate available on secure government bonds. Others prefer a rate of return that has been observed for investments with a risk level similar to that of the investment under consideration. It is advisable to consult with an organization's financial managers when selecting a discount rate for a cost-benefit analysis. Equation (7) illustrates how a nominal discount rate is applied to a future value to calculate a cash flow's present value:

$$\mathbf{PV} = \mathbf{FV}_n \div (1 + \mathbf{DR})^{n-1} \qquad (6)$$

where

$\mathbf{PV}$ = Present value of the cash flow

$\mathbf{FV}_n$ = Future value estimated for year n

$\mathbf{DR}$ = Annual nominal discount rate [see Horngren (7) for equations that allow more frequent compounding of rates]

n = The year of the future cash flow (e.g., $n = 1$ for current period cash flows, $n = 2$ for next year's cash flows)

Inflation and the Time Value of Money. *Purchasing power* is the amount of real goods or services that can be acquired for a given sum of money. Inflation reduces purchasing power over time. When the inflation rate is high or the investment life span is longer than a couple of years, inflation can have a significant impact on the purchasing power of future cash flows (5).

When estimating future values of costs and benefits for long projects, it is important to consider inflation and to document whether or not it is included in the estimates. Inflation should be treated consistently throughout the analysis. In other words, it should be included in all cash flow estimates or in none of them. If future values of cost and benefit estimates do not include an inflation factor, then this fact should be stated in the analysis. When inflation is excluded from the numbers, then present values can be calculated as shown in Eq. (7). However, if the future values of estimates include an inflation factor, then the assumed inflation rate must be documented and used to adjust the nominal discount rate. Otherwise, the nominal discount rate will overstate the growth in the purchasing power of the cash flows. Equation (9) shows how to adjust the discount rate by the assumed inflation rate in order to calculate present values for future cash flows that incorporate inflation:

$$\mathbf{PV} = \mathbf{FV}_n[(1 + \mathbf{IR}) \div (1 + \mathbf{DR})]^{n-1} \qquad (7)$$

where

$$\mathrm{PV} = \text{Present value of the cash flow}$$
$$\mathrm{FV}_n = \text{Future value estimated for year } n$$
$$\mathrm{IR} = \text{Assumed annual inflation rate [see Brealey (12) for analysis with multiple inflation rates]}$$
$$\mathrm{DR} = \text{Annual nominal discount rate}$$
$$n = \text{The year of the future cash flow (e.g., } n = 1 \text{ for current period cash flows, } n = 2 \text{ for next year's cash flows}$$

When the nominal discount rate is reduced by the assumed inflation rate, the resulting factor is often called the *real discount rate.*

Table 3 shows the present values (i.e., the Year 1 equivalent values) of the sample cash flows that were presented in Table 2. The present value calculations in Table 3 assume a 3% inflation rate and a 10% nominal discount rate. If Eq. (9) is applied to the Year 4 future value of $87,000 for equipment operating costs, the result is the present value of $71,000 shown in Table 3.

FUNDAMENTALS OF FINANCIAL ANALYSIS

There are many ways to measure the financial value of an investment. The method preferred by financial managers is net present value (12). Managers may also be interested in the internal rate of return, return on investment, benefit-cost ratios, break-even point, and payback period. Each of these methods requires the use of present values because costs and benefits from multiple time periods are compared and aggregated.

Net Present Value

The net present value (*NPV*) of an investment is the value today of all future investment benefits less the value today of all future investment costs (11). The NPV formula builds on the basic financial analysis formula in Eq. (1). Table 4 and Eq. (11) illustrate the calculation of NPV using the investment that was presented in Table 3:

$$\begin{aligned} \mathrm{NPV} &= \Sigma\ \text{Present Values of all Cash Flows} \\ &= (\$4{,}736{,}000) + (\$10{,}145{,}000) + \$22{,}124{,}000 \\ &= \$7{,}242{,}000 \end{aligned} \tag{8}$$

A positive NPV indicates that the investment is financially beneficial, while a negative NPV indicates that the investment is financially unsound. The larger the positive NPV, the greater the magnitude of the financial benefit. This property of the NPV calculation is unique and valuable. Other financial metrics vary with an individual analyst's decisions about cost and benefit classification and itemization, but NPV is consistent across variations in analytical style (14). Organizations can use NPV to compare mutually exclusive investment opportunities. NPV is also a good tool for selecting the most beneficial opportunities from a pool of potential investments. For this reason, the financial analysis portion of a cost-benefit analysis should always include NPV.

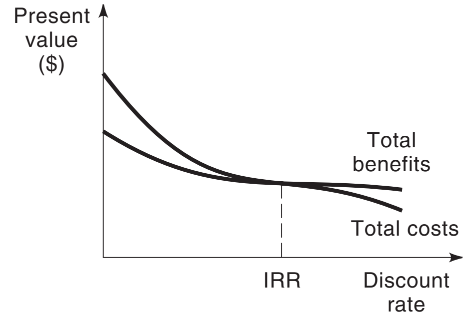

Figure 3. The IRR is the discount rate for which the present value of total costs equals the present value of total benefits.

Internal Rate of Return

The internal rate of return (*IRR*) for an investment is the discount rate that would have to be applied to generate an NPV of 0. In other words, it is the discount rate that would make the present value of all future costs equal to the present value of all future benefits. There are special financial calculators and computer programs that solve for IRR. Without these tools, the only way to calculate IRR is to experiment with different discount rates, plot the cumulative costs and benefits, and estimate the rate that corresponds to the intersections of the two curves. Figure 3 illustrates this method. Table 5 shows how experimentation with the discount rate produces an IRR of 31% for the investment presented in Table 3.

When IRR is greater than the minimum rate of return that an organization requires for its investments, this indicates that a potential investment is financially beneficial. However, IRR is not an effective tool for comparing alternative projects (12). The reason is that a small investment can have a high IRR but a low NPV while a larger investment with a lower IRR may actually yield a higher NPV. When faced with these two investment choices, the better financial decision is to maximize net benefits (NPV). This means selecting the project with the higher NPV and the lower IRR.

Return on Investment

Return on investment (*ROI*) measures the ratio of net benefits to total costs. Equation (12) is the formula for calculating ROI. When applied to the investment presented in Table 4, Eq. 12 yields an ROI of 49%.

$$\begin{aligned} \mathrm{ROI} &= -(\mathrm{NPV} \div \text{Present Value of Total Costs}) \\ &= -(\$7{,}242{,}000 \div (-\$4{,}736{,}000 + -\$10{,}145{,}000)) \\ &= 0.49 \end{aligned} \tag{9}$$

A positive ROI indicates that an investment is financially beneficial. However, ROI is not an effective tool for comparing alternative projects. The main shortcoming of ROI is its dependence on an analyst's subjective classifications of costs or benefits. For example, consider an investment in a new computer system. The new system will save an Engineering Department $200,000 per year in internal labor costs. It will require $50,000 of internal labor to support and maintain the system each year. One analyst might classify $200,000 as a productivity benefit and $50,000 as

Table 3. Present Values Over a 10-Year Project Life with 3% Inflation and 10% Discount Rate

(000s of Future $)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Capital costs										
Equipment	(350)									
Software	(750)									
Design services	(675)	(579)								
Internal labor	(500)	(482)	(372)							
Implementation	(500)	(482)	(46)							
Total capital costs	**(2,775)**	**(1,543)**	**(418)**							
Operating costs										
Equipment			(75)	(71)	(69)	(67)	(65)	(62)	(60)	(58)
Software		(217)	(210)	(202)	(194)	(188)	(181)	(175)	(168)	(163)
Internal labor		(289)	(279)	(269)	(260)	(250)	(241)	(233)	(225)	(216)
Operational support		(724)	(698)	(673)	(649)	(626)	(604)	(582)	(561)	(542)
Total operating costs		**(1,230)**	**(1,262)**	**(1,215)**	**(1,172)**	**(1,131)**	**(1,091)**	**(1,052)**	**(1,014)**	**(979)**
Benefits										
Litigation avoidance		724	698							
Increased sales			465	897	1,730	2,086	2,012	1,941	1,872	1,805
Internal productivity			1,116	1,076	1,039	1,001	966	932	989	867
Total benefits		**724**	**2,279**	**1,974**	**2,769**	**3,087**	**2,978**	**2,872**	**2,770**	**2,672**

Table 4. Net Present Value Calculation

(000s of Future $)	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Cumulative Present Value
					Present Value of Cumulative Cash Flows						
Total capital costs	(2,775)	(1,543)	(418)								(4,736)
Total operating costs		(1,230)	(1,262)	(1,215)	(1,172)	(1,131)	(1,091)	(1,052)	(1,014)	(979)	(10,146)
Total benefits		724	2,279	1,973	2,769	3,087	2,978	2,873	2,770	2,672	22,125
NPV											7,243

Table 5. Deriving Internal Rate of Return by Experimenting with Different Discount Rates

	10%	20%	30%	**30.5%**	**31%**	33%	40%
Present value of total costs	$14,881,000	$11,396,000	$9,363,000	**$9,285,000**	**$9,060,000**	$8,918,000	$8,076,000
Present value of total benefits	$22,124,000	$13,982,000	$9,505,000	**$9,339,000**	**$8,865,000**	$8,568,000	$6,851,000

an investment cost. A second analyst might combine the two into a productivity benefit of $150,000. Both analysts will derive the same NPV. However, the analyst who itemizes the $50,000 cost will calculate a lower ROI [see Lerner (14) for more detailed examples]. A second shortcoming of ROI is that it ignores the magnitude of net benefits. As with IRR, a small investment can have a high ROI but a low NPV while a larger investment with a lower ROI may actually yield a higher NPV (8). When faced with these two investment choices, the better financial decision is to maximize net benefits (NPV). This means selecting the project with the higher NPV and the lower ROI.

Benefit–Cost Ratios

Benefit–cost ratios show the units of benefits per one unit of cost for a given time period. The ratios can be calculated for single-period cash flows or for cumulative cash flows. Equation (13) shows the calculation of a single period benefit–cost ratio for a given period (p):

$$\textbf{Single-Period Benefit–Cost Ratio}_p = -(\textbf{Present Value of all Benefits}_p \div \textbf{Present Value of all Costs}_p) \quad (10)$$

Equation (14) is the formula for calculating the cumulative benefit–cost ratio for a given period (p):

$$\textbf{Cumulative Benefit–Cost Ratio}_p = -(\Sigma\, \textbf{Present Value of all Benefits}_n \div \Sigma\, \textbf{Present Value of all Costs}_n) \quad (11)$$

where Σ = sum of all values for $n = 1$ through p.

Table 6 presents annual and cumulative benefit–cost ratios for the investment presented in Table 4. Annual benefit–cost ratios that exceed 1 indicate that the present value of benefits incurred that period exceed the present value of costs incurred during the same period. Cumulative benefit–cost ratios that exceed 1 indicate that the present value of total benefits up to that period exceed the present

Table 6. Annual and Cumulative Benefit–Cost Ratios

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total costs	(2,775)	(2,773)	(1,680)	(1,215)	(1,172)	(1,131)	(1,091)	(1,052)	(1,014)	(979)
Total benefits	0	724	2,279	1,973	2,769	3,087	2,978	2,873	2,770	2,672
Annual benefit–cost ratio	**0.00**	**0.26**	**1.36**	**1.62**	**2.36**	**2.73**	**2.73**	**2.73**	**2.73**	**2.73**
Cumulative costs	(2,775)	(5,548)	(7,228)	(8,443)	(9,616)	(10,746)	(11,837)	(12,889)	(13,903)	(14,882)
Cumulative benefits	0	724	3,003	4,976	7,745	10,832	13,810	16,683	19,453	22,125
Cumulative benefit–cost ratio	**0.00**	**0.13**	**0.42**	**0.59**	**0.81**	**1.01**	**1.17**	**1.29**	**1.40**	**1.49**

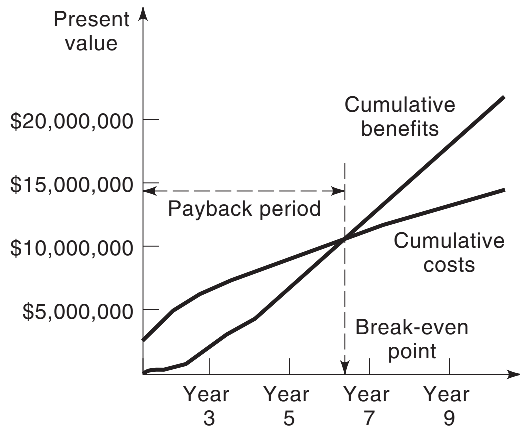

Figure 4. The break-even point is the point in time at which the present value of cumulative benefits equals the present value of cumulative costs. The payback period is the period of time between the start of the investment and the break-even point.

value of total costs. Annual benefit–cost ratios do not provide information on the financial soundness of a particular investment. If the cumulative benefit–cost ratio at the end of a project life span is greater than 1, this indicates that the investment is financially sound. However, cumulative benefit–cost ratios are not effective tools for comparing alternative investments (8). As with IRR and ROI, the benefit–cost ratio for a small investment with a small NPV might be higher than the ratio for a large investment with a large NPV. When faced with these two investment choices, the better financial decision is to maximize net benefits (NPV). This means selecting the project with the higher NPV and the lower cumulative benefit–cost ratio.

Break-Even Point and Payback Period

The break-even point of an investment is the point at which cumulative benefits equal cumulative costs. In other words, it is the point at which the cumulative benefit–cost ratio is 1.0. The break-even point is a simplified measure of the point in time at which an investment begins to produce a positive income stream. The payback period is the time it takes to achieve the break-even point. Figure 4 illustrates these two concepts using the investment presented in Table 6.

Some investments may have irregular benefit and cost streams that result in cumulative benefits and costs accruing at different rates over the life span of the investment. This may result in multiple intersections on the cumulative benefit and cost curves. In these instances, the final point at which cumulative benefits exceed cumulative costs is the one used to determine the break-even point and payback period.

The break-even point and payback period indicate the length of time it will take to recover the costs of an investment. If an investment never achieves payback, it is not financially sound. Lengthy payback periods may not appeal to decision makers for strategic or political reasons. However, the break-even point and payback period are not effective tools for comparing the financial attractiveness of alternative investments because projects with high NPVs can have lengthier payback periods than projects with low NPVs (12).

Sensitivity Analysis

Cost–benefit analyses are based on estimates and assumptions. If the actual costs and benefits differ from these estimates, the results of the investment will differ from those predicted by the analysis. A sensitivity analysis reveals the risk associated with the possibility of errors in specific estimates and assumptions. It is important to understand this risk before making an investment decision. Every person and organization has a certain level of risk tolerance. This means that given two investment alternatives, a person or organization may prefer the option with the lower net present value if it comes with a considerably lower level of risk.

To perform a complete sensitivity analysis, all estimates and assumptions must be fully documented. These estimates and assumptions are variables in the investment decision. Once the base analysis is completed, decision makers can evaluate its sensitivity to fluctuations in one or more variables. This is achieved by observing the impact of different values for one or more selected variables while holding all other variables at their original levels [see Brealey (12) for a discussion of break-even analysis techniques in sensitivity analysis]. For example, Table 4 illustrated a base financial analysis for a particular investment. One of the variables in this analysis was the estimate of a tangible benefit from increased sales revenues. Table 7 shows variations of the analysis with different levels of sales revenues. This example of financial sensitivity analysis shows that, all other things being equal, the investment continues to be financially sound (with a positive NPV) even if sales revenue estimates are off by 50%.

A thorough sensitivity analysis also explores the risks associated with nonfinancial assumptions. For example, an organization may base some of its tangible benefit estimates on the assumption that all employees will receive

Table 7. Sensitivity of Net Present Value to Accuracy of Sales Revenue Benefit Estimates

Sales Revenue Benefit	NPV
50% of current estimates	$ 838,000
75% of current estimates	$ 4,040,000
As estimated	$ 7,242,000
25% above current estimates	$10,444,000
50% above current estimates	$13,646,000

training on new equipment within a certain time period. To illustrate the risks associated with delays in the training, the organization may reestimate its benefits to reflect the impact of the delays. The resulting financial analyses then illustrate the sensitivity of the investment to the nonfinancial assumption about training schedules.

A complete cost–benefit analysis presents all assumptions underlying tangible cost and benefit estimates as well as thorough financial analysis and sensitivity analysis for significant variables. It also presents the strategic case for the investment. The strategic case begins with documentation of an organization's mission, goals, and core values (13). The mission and goals provide a framework for describing intangible benefits and costs and assessing their value to the organization.

Interrelationships Among Investments

The strategic portion of a business case may describe the relationship of the potential investment to other projects under consideration. Certain types of investments yield minimal tangible benefit in and of themselves. Yet these investments are prerequisites for more profitable future ventures. For example, an investment in an advanced degree does not provide much tangible benefit when considered in isolation. However, the degree may enable a person to secure a higher-paying job, so the investment in education has strategic value. In a similar fashion, infrastructure projects can hold strategic value for investors. A city may invest in a landscaping and beautification program not because of any direct tangible benefit but because of the intangible possibility of attracting new development, which would expand the tax base and increase future tax revenues. A company may invest in a computer network not because of the tangible benefits of electronic mail but rather because of the potential for future investments in valuable computer systems that would require the network infrastructure.

The boundaries that separate investment alternatives are defined by humans. Sometimes the boundaries are clear. However, the web of interrelationships among major projects can complicate the process of defining the scope of a particular project or investment. The art of cost-benefit analysis includes the ability to divide the world of investment opportunities into reasonable segments. A business case is most effective when decision makers can view it in the context of a clear set of alternatives.

CONCLUSION

Cost-benefit analysis is an essential step in every investment decision. It includes the following basic steps:

- Estimate the value and timing of costs and benefits
- Determine the net present value (NPV) of the costs and benefits
- Prepare a financial analysis that considers the sensitivity of the NPV projection to key assumptions about cost and benefits
- Prepare a strategic analysis that considers the investment's impact on the organization's mission and goals

A business case compiles the results of each of these steps into a comprehensive evaluation of an investment's value.

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NANCY B. LERNER
DAVID P. DISERA
EMA, Inc., San Antonio, TX
First Insurance Company, San Antonio, TX